HANDBOOK FOR

GENERAL DENTAL TECHNICIANS

NAVY TRAINING COURSES

NAVPERS 10686

HANDBOOK FOR GENERAL DENTAL TECHNICIANS

Prepared by

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PREFACE

This is a handbook for the basic training of dental technicians, and, as one of the series of NAVY TRAINING COURSES, is designed to give personnel of the dental technician rating group of the Navy the background information necessary for advancement in rating.

The first *Handbook for Dental Technicians—General* was prepared and published at the U. S. Naval Dental School, National Naval Medical Center, Bethesda, Maryland, in 1942, primarily as a text for courses of instruction leading to the certificate of Dental Technician (General). Second and third revised editions were similarly published, the last of which was entitled *Handbook for Dental Technologists* (*General*), Revised 1945.

This edition is designed to meet the present need for a basic text for U. S. Naval Dental Technician Schools, and to serve as a guide and reference book for the dental technician rating group. The subject matter has been completely revised, and the text has been rewritten. Material concerning clerical forms and procedures has been omitted, falling more logically within the scope of *The Handbook for Dental Administration,* which is projected as a separate title in the Navy Training Courses. Likewise, much essential information which is promulgated in the *Manual of the Medical Department,* the *Handbook of the Hospital Corps* and other official publications, has been omitted from this book.

The material for this book was prepared by members of the staff of the U. S. Naval Dental School, under authority of the Dental Division, Bureau of Medicine and Surgery. Previous editions were freely referred to as guides, and numerous standard textbooks and periodicals were consulted for general information. Throughout all phases of its preparation, the officers of the Dental Division, Bureau of Medicine and Surgery, made generous contributions of encouragement and advice, reviewing and revising considerable portions of the text. Valuable assistance was also obtained from members of the staffs of the U. S. Naval Dental Technicians Schools at Great Lakes, Ill., and San Diego, Calif., who reviewed all portions of the text and illustrations and made comments and suggestions prior to the final revision. The collaboration of the Training Publications Section of the Bureau of Naval Personnel was invaluable, particularly in the final stages of preparation and publication.

ACKNOWLEDGMENTS

Appreciation and thanks are expressed herewith for the courtesy of the W. B. Saunders Company of Philadelphia for permitting the use of the following illustrations taken from *A Textbook of Histology* by A. A. Maximow and W. Bloom, which appear in this book: figures 4, 5a, 5b, 5c, 5d, 5e, 5f, 6, 8, 9, 16 and 106.

The Handbook of the Hospital Corps, United States Navy, 1939, published by the Bureau of Medicine and Surgery and the *Handbook for Dental Technologists* (*General*), 1945, published by the U. S. Naval Dental School, National Naval Medical Center, Bethesda, Md., were the source of much of the material presented in this book.

Acknowledgment is also made for helpful reference provided by the following: *Physical Properties of Dental Materials* by W. Souder and G. C. Paffenbarger (Circular of the National Bureau of Standards C433) issued February 6, 1942, published by the U. S. Government Printing Office; *The Science of Dental Materials* by E. W. Skinner, third edition, published by W. B. Saunders Company, Philadelphia; *Accepted Dental Remedies,* fifteenth edition, published by the American Dental Association, Chicago.

Further acknowledgment is made to all unidentified authors whose work may have found its way into this book.

The materials and equipment pictured in the text appear only because they are carried in the *Armed Services Catalog of Medical Matériel* at this time and are in common use throughout the Navy. Inasmuch as all supplies and equipment used in the Navy are procured by bid, materials of other manufacturers frequently will be found to have replaced those pictured herein.

INTRODUCTION

In carrying out its mission to promote oral health and to mitigate the results of dental disorders, the dental profession has come to rely on men and women especially trained to assist in the operating room, in the laboratory and in the office. The services of such assistants are invaluable in modern dental practice, permitting dentists to increase their own efficiency and to extend their professional services to larger numbers of patients.

The United States Navy, recognizing the great value of well trained dental assistants, includes in its enlisted personnel rating structure the general service rating group of "Dental Technicians," as well as several emergency service ratings covering the specialized aspects of such work.

In the Navy of today, dental technicians perform dental clinical and administrative duties, assisting dental officers in the treatment of patients, rendering first aid, preparing and carrying on dental department administrative assignments, and giving oral prophylactic treatment under supervision of dental officers. In addition, they may be trained and qualified in various dental technical specialties such as dental prosthetic technic.

Dental technicians have a most important role in the Navy, and their responsibilities are great. Opportunities for advancement in rating and promotion to officer status are open to those who possess and develop the requisite qualifications by applying themselves to their duties and their studies.

Dental technicians should, of course, be familiar with much of the material available in *U. S. Navy Regulations*, the *Manual of the Medical Department*, the *Handbook of the Hospital Corps*, and other official publications, including Navy Training Courses. They should refer to such sources for additional information, and are urged to supplement their studies by reference to the textbooks and professional periodicals which are usually available in the dental departments of ships and stations.

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HANDBOOK

FOR

GENERAL DENTAL TECHNICIANS

CHAPTER 1

ANATOMY AND PHYSIOLOGY

BIOLOGY

Biology is the science which deals with the phenomena of life in general.

All objects existing in nature belong to one of three kingdoms—the animal kingdom, the vegetable kingdom or the mineral kingdom. Biology is concerned only with the animal and vegetable kingdoms. Objects in these two groups are organized for living. They are organisms or parts of organisms with an arrangement of material that can be developed only through the process of life. Objects in the mineral kingdom, on the other hand, are not organized for the business of living, and therefore will not be considered further in this chapter.

Animal life is built up through the processes of absorption and oxidation of such substances as proteins, carbohydrates and fats. Vegetable life builds up its structures using water of the soluble materials from the soil and carbon dioxide from the air, using sunlight as a catalyst.

Animal and plant life are dependent upon each other. An excellent example of this interdependence operates in the goldfish bowl. The fish produces carbon dioxide as a waste product. The plant life takes up the gas, separates the carbon and the oxygen, utilizes the carbon for plant growth and discards the oxygen which the fish needs. The goldfish breathes the oxygen and eats the plant to get the carbon in its organic form. The carbon in turn is made part of the tissue of the goldfish, thus completing the carbon cycle.

Cells

All the tissues of the body are built up of individual building blocks, the CELLS. Each tissue is a group of cells, similarly specialized and united in the performance of a particular function.

The cell is usually microscopic in size, consisting of a small mass of PROTOPLASM called the cell body or CYTOPLASM. Within the cytoplasm is a smaller body of modified protoplasm, called the NUCLEUS. The cytoplasm is enclosed by a cell wall or cell membrane.

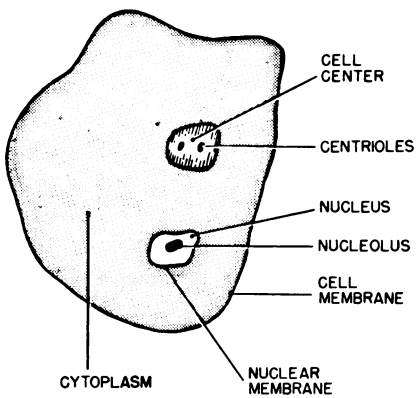


Figure 1.—Typical cell.

The cell membrane

The surface of the cell is covered by a thin envelope, the cell membrane. The nature of the cell membrane is still in doubt. In many cells it is invisible, but its presence is demonstrated by the

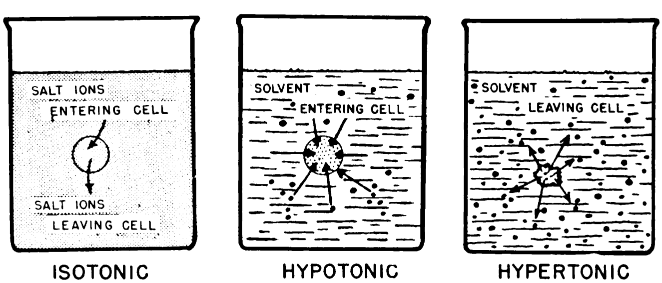


Figure 2.—Cell permeability.

fact that cells swell in a hypotonic solution (a solution containing a lower salt concentration than the protoplasm), and will shrink in a hypertonic solution (one having a higher salt concentration). The membrane is said to be semipermeable, since it permits water to pass but holds back salts and their ions.

The cytoplasm

The cytoplasm consists of a colloidal solution of salts, proteins, fats and carbohydrates. In living cells it is usually a fine-grained structure in which large and small particles, and sometimes VACUOLES (spaces or cavities), may be found. Within the cytoplasm are centrioles and fibrils.

In practically every cell of the mammalian organism, usually close to the nucleus, there is a small condensed mass of protoplasm, known as the CELL CENTER, containing two dots which are called CENTRIOLES. They have a most important part in the process of cell division known as MITOSIS. The fibrils are thought to afford stability to the cell.

The nucleus

The nucleus is surrounded by a membrane, the NUCLEAR MEMBRANE. This is quite tough in comparison to the outer cell membrane. The nucleus varies in shape according to the type of cell, but is usually globular or ovoid. CHROMATIN granules are masses

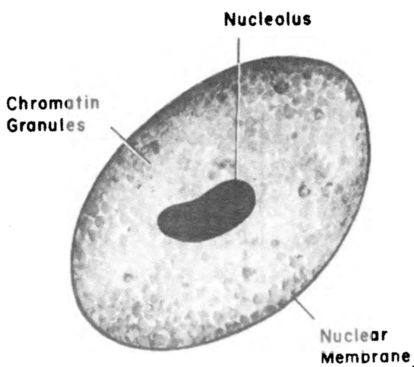


Figure 3.—Typical nucleus.

which appear suspended in a network known as the LININ NETWORK. Acidophilic bodies may be found in the nucleus. These bodies are termed NUCLEOLI.

Unicellular organisms

The simplest forms of both animal and vegetable life are made up of only one cell. Such a cell is called a SIMPLE cell, or an unspecialized or undifferentiated cell. Yeast and bacteria are unicellular vegetable organisms. The amoeba is a unicellular animal organism.

In an organism composed of only one cell, that cell must necessarily have the full variety of characteristics that will enable it to grow, mature and carry out all the processes of life for the organism.

Cell processes

A simple animal cell carries on many basic life processes. It is capable of RESPIRATION, the exchange of carbon dioxide for oxygen; the assimilation of foodstuffs—that is, the conversion of food into the substance of the cell and the yielding of energy; EXCRETION, in which all the waste products—that is, carbon dioxide, urea and water—are eliminated. The end products all pass readily through the cell membrane.

MOVEMENT is also a characteristic of certain types of cells. One type of action, termed AMOEBOID, could be likened to filling a

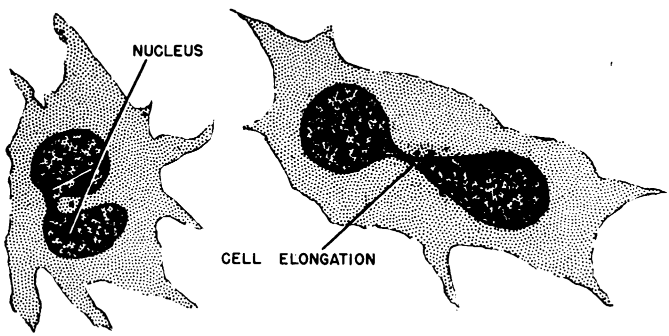


Figure 4.—Fission. (First step.)

balloon almost to capacity with water, and then allowing it to roll down an inclined surface. The balloon would bulge in the direction of the flow, and the posterior portion would attempt to catch up with the first section.

Reproduction in a simple cell such as a bacterium or an amoeba is by direct division, or fission. In fission, the cell elongates, the nucleus and cytoplasm become constricted in the center, and the cell divides and forms two cells. When the nucleus divides into two halves, a nucleolus goes to each daughter nucleus.

Cell IRRITABILITY can be demonstrated by mechanical, chemical, and nervous forms of stimulation. A single cause is known as a STIMULUS (plural—stimuli). The result of cell stimulation may be noted as a movement or alteration of the shape of the cell, as in muscular movements, and by the liberation of substances secreted by the cell. A stimulus exciting any cell of the body into activity produces an impulse. This impulse is carried by the nerves to the cell or may also be the chemical substance which reaches the cell from the blood and the tissue fluid.

The REPRODUCTION of cells in the human body occurs most rapidly during the period when the organ or tissue, of which the cell is a part, is growing. After the maximum growth of the whole body has been reached, cells reproduce to replace those that die or are destroyed by disease or injury. Cell reproduction takes place through the action of the parent cell dividing into two daughter cells. The typical process of cell division now to be described is INDIRECT division or MITOSIS. It is a more complex type of reproduction than FISSION or AMITOSIS, the mode of division previously described for unicellular organisms.

When a cell reproduces by indirect division, the process begins by elongation of the chromatin in the nucleus into structures called chromosomes. The number of chromosomes in a cell is constant.

This first stage in mitosis is termed the PROPHASE. While the chromatin is elongating, the centrosome near the nucleus develops into two star-shaped structures called asters, each of which has a central mass that becomes the centrosome in the new cell. From the asters there extend radiating fibers called aster rays.

The second stage is termed the METAPHASE. The aster rays begin to penetrate the space occupied by the chromatin threads as each

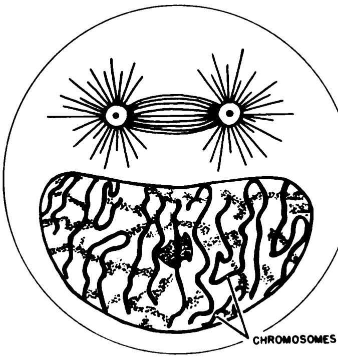


Figure 5A.—Prophase (spireme) showing chromosomes.

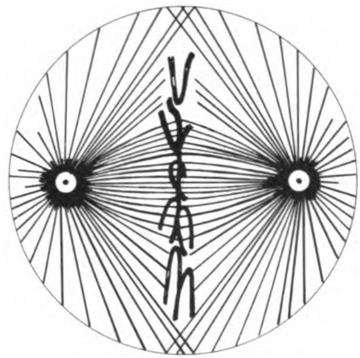


Figure 5B.—Metaphase, longitudinal splitting of chromosomes.

chromosome splits into two equal parts.

The asters move out toward the cell membrane, their fibers forming a spindle-like arrangement, with the nuclear membrane bursting.

The third stage is the ANAPHASE, in which the divided halves of the chromosomes separate and are drawn toward the two centrioles which are seen at the opposite ends of the cell. These areas are now called the poles of the cell.

The fourth stage is the TELOPHASE, in which the chromosomes are grouped at the spindle poles, the aster rays are disappearing, and the cell body as a whole begins to divide. The formation of the two daughter nuclei takes place.

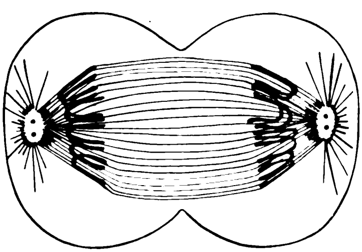


Figure 5C.—Anaphase, separation of the split chromosomes and Diaster.

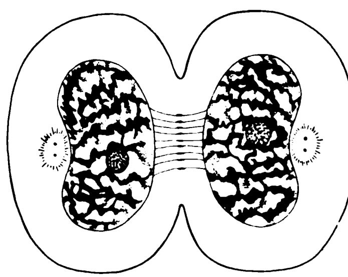


Figure 5D.—Telophase with reconstruction of the daughter nuclei.

The constricting cell membrane completes the division of the cytoplasm into two masses, each surrounding a daughter nucleus. Reproduction by mitosis has taken place.

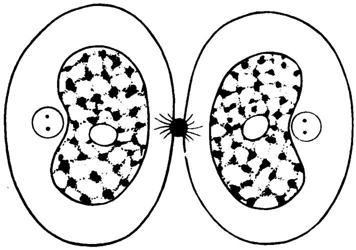


Figure 5E.—Daughter cells connected only by the intermediate body of Flemming.

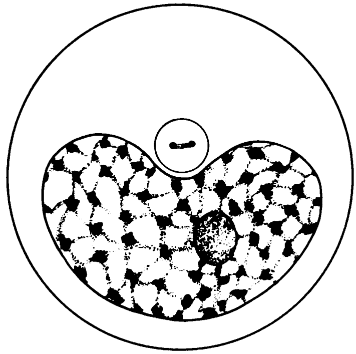


Figure 5F.—Resting cell.

Tissues

A tissue may be defined as "an aggregation of similarly specialized cells united in the performance of a particular function." The tissues of the human body may be grouped into five classes—epithelium, connective tissue, muscular tissue, blood and lymph (to be discussed in a later section on physiology), and nerve tissue.

Epithelium

Epithelium forms the free surface of the skin, the linings of the digestive, respiratory and urinary tracts, the blood vessels, liver and kidneys. The cells of these tissues are further specialized for variations in function into various shapes; CUBOIDAL, in which the height is about equal to the width; SIMPLE SQUAMOUS, in which the cells are flat or thin in appearance; and COLUMNAR, in which the height exceeds the width and the cells appear as tall irregular prisms. The location of the nucleus will vary according to cell shape.

Epithelial cells are further classified as secreting, or protective. An example of location of the former would be in the kidney, and

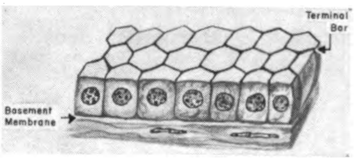


Figure 6.—Semischematic diagram of simple cuboidal epithelium.

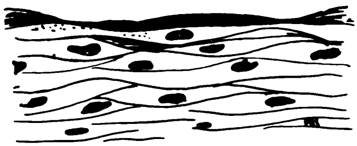


Figure 7.—Simple squamous epithelium.

of the latter, the skin of the hand. The cells are arranged in layers much like the bricks on a wall. If there is but a single layer of cells, one thin sheet, the tissue is known as simple epithelium.

If the free surface of a tissue has cilia (tiny hair-like processes), this surface is called CILIATED epithelium. When the cilia move, the appearance is much the same as that of a field of wheat over which a gentle wind is blowing. This has a most important relationship to the functions of epithelium in the nasal passages, for example. In the respiratory passages the mucus is driven toward the mouth by the beating of the cilia, and this action causes the elimination of particles of dust which have been inhaled.

When there are several layers of cells, one upon the other, the surface is called STRATIFIED epithelium.

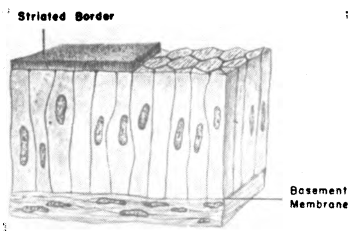


Figure 8.—Semischematic diagram of columnar epithelium.

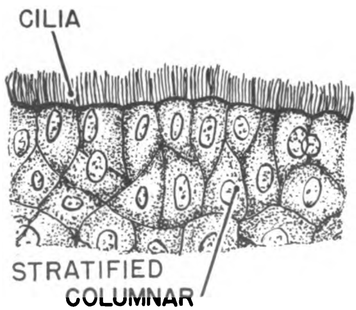


Figure 9.—Stratified columnar ciliated epithelium.

Following the study of the illustrations, the student now justly asks the question, "What holds the cells together?" On this subject there are several schools of thought, one that the superficial cytoplasm of each cell contains adhesive properties. Another tenet is that the protein molecules (inclusions) in the cell cytoplasm may have interaction with protein molecules of other cells. Another theory is that the cells are held together by the aid of intercellular bridges—protoplasmic processes which extend from one cell body to the other. The above theories agree on one level—that the cohesion between epithelial cells, including those of the oral cavity, is so great that strong mechanical pressure is necessary to separate them.

One of the functions of epithelial tissue is to take part in the active metabolism of the body by participating in the ingestion and digestion of food and the elimination of the end products of metabolism. Another function is that of protecting underlying tissues from external harm.

Connective tissue

The connective tissue is the supporting tissue of the body, and hence the most widespread and abundant. Unlike epithelial tissue, in which cells predominate, connective tissue has few cells, with a higher amount of intercellular substance. The intercellular substance may contain collagenous fibers, elastic fibers, ground substance, cartilage, reticular fibers and bone.

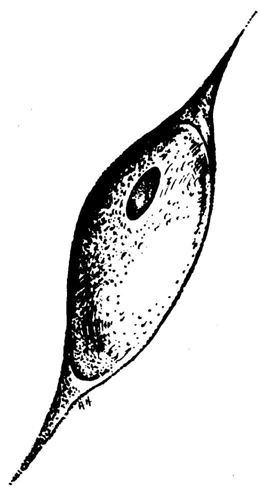


Figure 10.—Fibroblast.

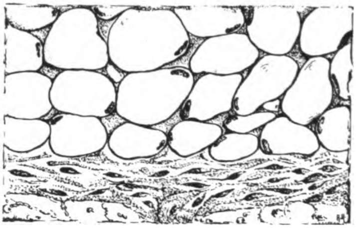


Figure 11.—Adipose tissue.

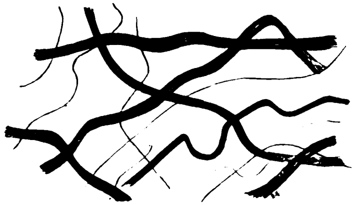


Figure 12.—Areolar connective tissue.

Throughout the entire mass of fibers will be found the predominant cell, the FIBROBLAST, so called because it is thought to be responsible for the formation of the fibers.

The principal forms of connective tissue are: ADIPOSE or fat, in which fat cells are lodged in meshes of areolar tissue, and fat replaces most of the cytoplasm; AREOLAR, found between muscle fibers, in which the cells are enmeshed in a loose framework of delicate interlacing fibers; CARTILAGINOUS, in which the cells lie in cavities of an intercellular substance called the matrix, which may be fine-grained and translucent or may contain a network of yellow elastic fibers; ELASTIC, found in trachea, bronchi and inner coats of blood vessels, consisting of yellow elastic fibers branching and connecting with each other; FIBROUS, found in tendons, ligaments and the intercellular substance and consists of bundles of closely packed parallel white fibers bound firmly to-

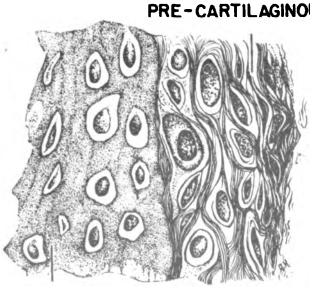


Figure 13.—Cartilaginous tissue.

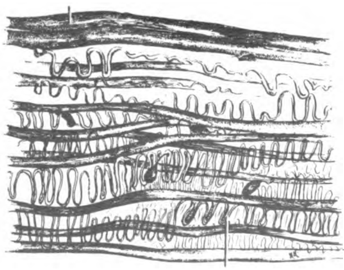


Figure 14.—Elastic tissue.
(Diagrammatic.)

Figure 15.—Fibrous tissue.

gether; LYMPHOID, found in the tonsils and spleen, in which the intercellular substance is largely fluid and consists of a loose network of white fibers containing lymphoid cells; OSSEOUS, in which the intercellular substance is in layers and may be regarded as white fibrous tissue in which calcium and other mineral salts have been, or will be, deposited.

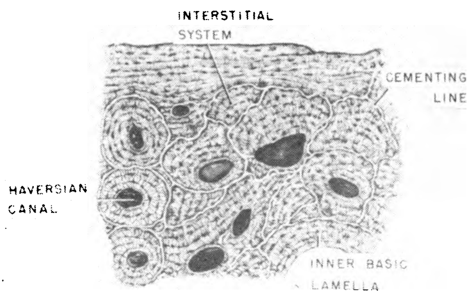


Figure 16.—Compact osseous connective tissue.

Bone

Osseous connective tissue (bone) in the form of a skeleton, supports the body, protects delicate organs from injury and affords attachments for muscles. It protects the brain within the skull and supports the teeth in the mandible and maxillae. Bone is formed in one of two ways and is classified accordingly as INTRAMEMBRANOUS, in which the bone is preformed in membranes, as are the parietal bones of the skull—and as INTRACARTILAGINOUS, in which it is preformed in rods of cartilage, as in the humerus of the arm. Bone is composed of two kinds of tissue: one compact, which is dense and white, resembling ivory, and the other cancellous, which presents a trellis-like effect. With the exception of the articular or joint end, which is cartilage, the bone is covered with a membrane termed the PERIOSTEUM. When a fracture occurs in adult bone, the periosteum functions to repair the fracture with new bone through the action of the osteoblasts (bone builders). The lime salts are deposited in the fibers and matrix and the fibers grow, sending out spicules (sharp, needle-like points) of bone. Thus a network is formed which encloses the osteoblasts and blood vessels. The spaces in the network are being continually filled up by fresh layers of bone formed by the osteoblasts. Bone marrow fills the cavities of the bones. In the long bones the cavities are filled with yellow marrow, which consists, for the most part, of fat cells. In the articular ends of the long bones, flat and short bones, sternum and ribs, the bone cavities are filled with red marrow. Red marrow is a site for the production of erythrocytes and the granular leukocytes. Through the marrow of the bones runs the nutrient or medullary arteries accompanied by one or more veins and nerves. From this main channel run numerous branches to the cancellous and compact tissues composing the bone structure.

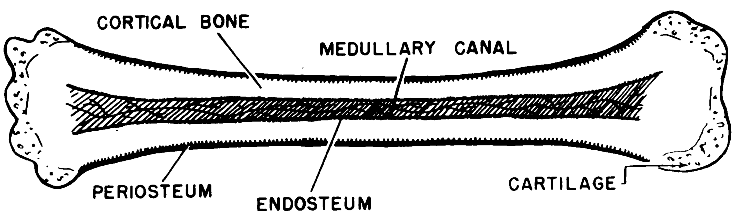


Figure 17.—Normal long bone. (Diagrammatic.)

If a bone is fractured, granulation tissue makes its appearance between the approximated fragments after they are reduced, or set. This granulation tissue changes into connective tissue, this in turn differentiating into a fibrocartilaginous callus (thickening).

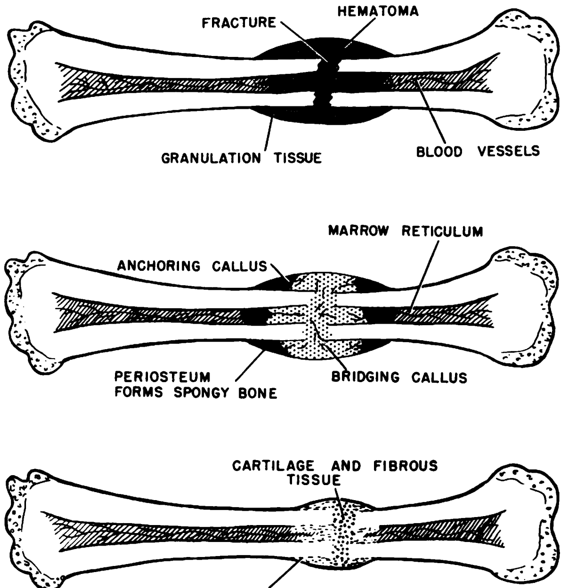


Figure 18.—Healing of a fractured long bone. (Diagrammatic.)

Then, new spongy bone forms from the layer of the periosteum, and there is a bony union where the spongy bone from both sides of the fracture meets and unites.

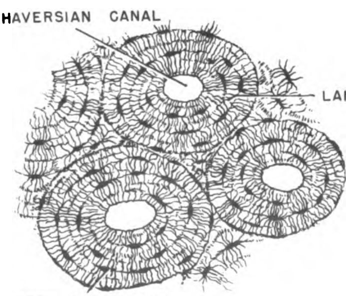


Figure 19.—Haversian system.

The maxillae are formed from membrane, but the mandible undergoes preformation in cartilage (Meckel's cartilage) which merely serves as a base upon which the connective tissue produces bone.

If a section of bone is examined under the microscope, the Haversian systems can be seen, each of which has concentric lamellae, the innermost of which is a central hole called the Haversian canal. Between the lamellae are LACUNAE (small pits) which are connected to the central hole by smaller canals termed CANALICULI.

Muscle tissue

Muscle tissue exhibits the following characteristics: IRRITABILITY or response to stimulations, usually received from nerves; CONTRACTILITY, the power to become shorter and thicker; TONICITY, a mild sustained contraction giving the skeletal muscles firmness and maintaining a slight steady pull on their attachments; and EXTENSIBILITY, the ability to be stretched.

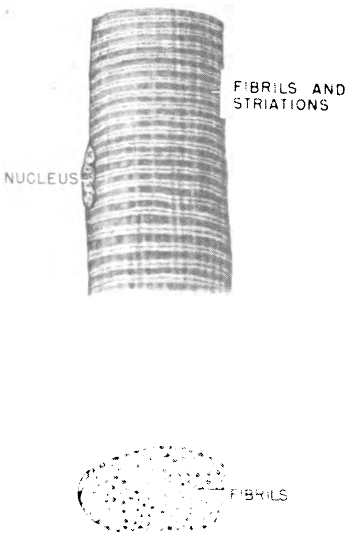


Figure 20.—Striated or voluntary muscle tissue.

The muscle tissue of the body can be divided into two classes: striated or voluntary, and nonstriated or involuntary. The voluntary muscles are so called because they can be controlled by the will of the individual.

Examples are such muscles as those of the arm, which can be controlled when one athlete is demonstrating his physical build-up to another. The nonstriated, involuntary muscles are those which cannot be controlled by the will. An example is the heart.

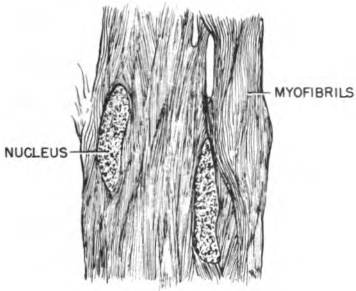


Figure 21.—Nonstriated or involuntary muscle tissue.

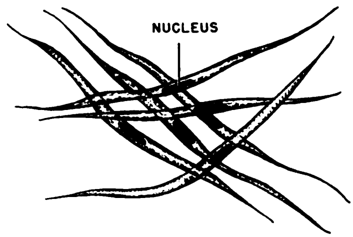


Figure 22.—Involuntary muscle cell.

Under the microscope the smooth (involuntary) muscle cell appears as a long, spindle-shaped body. It is thickened in the center, where the nucleus can be seen, and tapers toward the ends. The cells are surrounded by reticular tissue, and this all in turn is bound together by connective tissue. When a smooth muscle cell

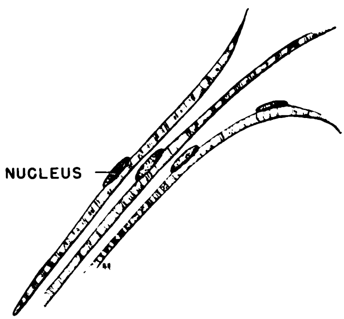


Figure 23.—Voluntary muscle cell.

contracts, the movement starting within the cell is passed to the reticular tissue which envelops the cell, and this in turn is passed to the connective tissue which has bundled up all the smooth cells.

The difference in appearance of the striated muscle cell under the microscope is illustrated.

There are many nuclei, the number depending upon the fiber length. They appear as long cylinders. The contractility of the muscle will be dependent upon the nerve impulse sent to the muscle by the brain.

Nerve tissue

As stated earlier in this chapter, all living matter possesses the property of irritability. Nerve tissue is made up of nerve cells, which have the now familiar nucleus, and cytoplasm. In addition they have characteristic processes or extensions. These are the axons and the dendrites.

The nerve cell is called a NEURON. Its shape is determined chiefly by the function of that particular neuron. The nerve fiber is the axon of a nerve cell. A typical axon will be described. The outer sheath is the neurilemma, which serves much in the fashion of the outer covering of an electric wire, acting as an insulator. The

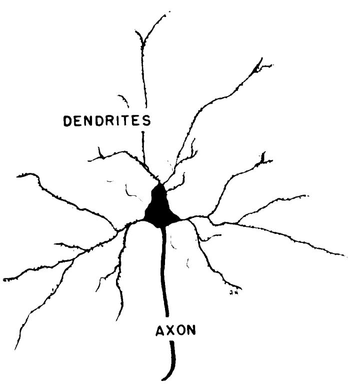


Figure 24.—Neuron.

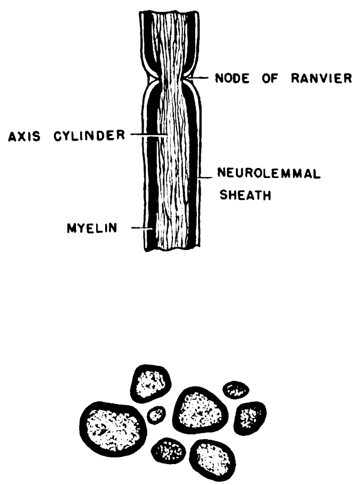


Figure 25.—Nerve fiber.

next covering is the myelin sheath, which also serves as an insulator and is characterized by little indentations or constrictions known as the nodes of Ranvier. The next layer is the axon or axis-cylinder. This is the highly irritable conductor which, under normal conditions, transmits the impulse in one direction. In the section on the Nervous System, the properties and functions of the nerve cells will be discussed in more detail.

OSTEOLOGY

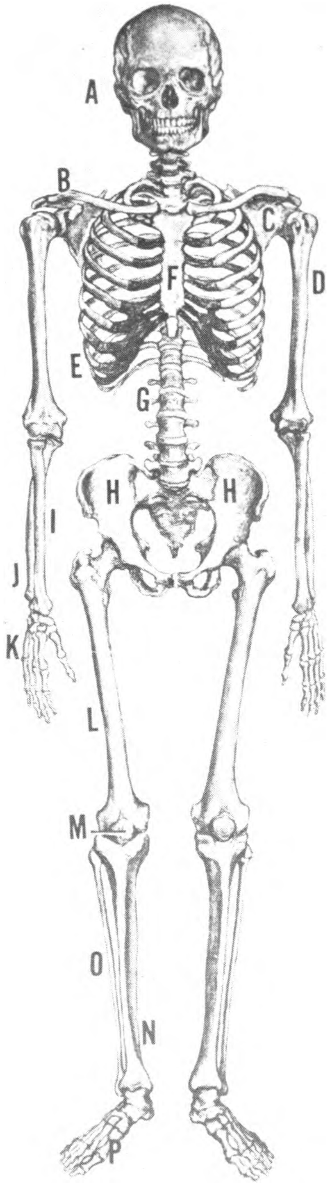
Osteology is that science which deals with the study of the bones of the body. The bones form the skeleton of hard material which serves to hold some structures in position, provides attachments for others, maintains and protects the organs, and establishes a basic body shape. Adults possess 206 distinct bones; children have 213. Fewer bones in the adult result from fusion of the lower vertebrae during growth. In the table following, the bones of the adult skeleton are grouped according to their positional relationship.

Bones of the upper extremities	64
Bones of the lower extremities	62
Bones of the vertebral column	26
Bones of the skull	22
Ribs	24
Bones of the ears	6
Hyoid bone	1
Sternum	1
	206

In addition to the various groups such as those listed in the foregoing table, bones are further classified by shape as: long, short, flat and irregular.

A LONG bone has two extremities and a somewhat tubular shaft. The wall of the shaft is thicker in the middle where the bone is the most slender and the strain the greatest; it is hollowed out in the interior to form a central medullary canal. The femur in the thigh and the humerus in the arm are long bones.

SHORT bones are small, irregularly shaped, and are made of cancellous tissue throughout except for a thin layer of compact tissue covering the surface. The bones of the ankle and wrist are short bones.



A. Skull
B. Clavicle
C. Scapula
D. Humerus
E. Ribs
F. Sternum
G. Spinal column
H. Innominate bone
I. Radius
J. Ulna
K. Carpus, metacarpus, phalanges
L. Femur
M. Patella
N. Tibia
O. Fibula
P. Tarsus, metatarsus, phalanges

Figure 26.—Skeleton, anterior view.

FLAT bones have broad or elongated flat plates of compact tissue enclosing a variable amount of cancellous tissue. Bones of this type afford protection for delicate structures as well as broad attachments for the muscles. Examples of this type are bones of the skull. Another example is the sternum as seen in figure 26. The sternum protects the heart and the roots of the great vessels.

IRREGULAR bones are those which cannot be placed in any other class because of their peculiar shape. They consist largely of cancellous tissue with a thin layer of compact tissue covering the surface. The mandible, the lower jawbone, is an irregular bone as are the vertebrae.

The Skull

The skull rests upon the spinal column and is the bony framework of the head. It is oval shaped, wider behind than in front,

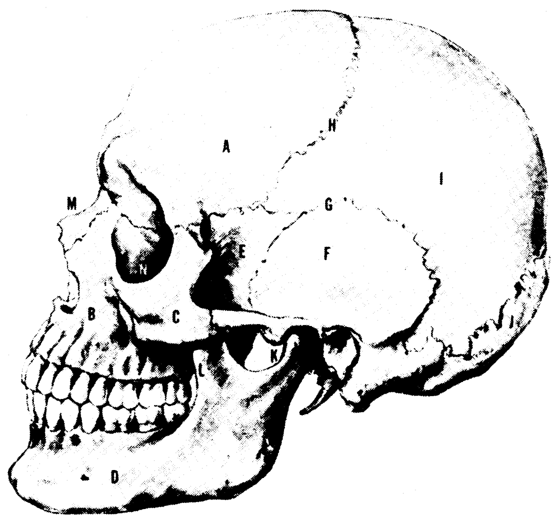


Figure 27.—Skull, lateral view.

A. Frontal
B. Maxilla
C. Zygoma
D. Mandible
E. Sphenoid
F. Temporal
G. Squamosal suture
H. Coronal suture
I. Parietal
J. Occipital
K. Condyloid process
L. Coronoid process
M. Nasal
N. Orbit

Figure 28.—Skull, anterior view.

A. Frontal	**D. Mandible**
B. Zygoma	**E. Ramus**
C. Maxillae	**F. Temporal**

and is composed of a series of bones which are irregular in shape, and with one exception (the mandible) are immovably joined together.

The skull consists of two parts: (1) the CRANIUM, which lodges and protects the brain, and is composed of 8 bones, (2) the FACE composed of 14 bones. Where two bones of the skull are joined together, the line formed is termed a SUTURE. Sutures are named according to the region where the bones are joined, such as the coronal suture, sagittal suture, and lamboidal suture. The upper part, or arched covering of the cranial cavity, is called the VAULT of the skull, while the floor of the cranial cavity is called the BASE.

In the base is located the foramen magnum, through which pass the spinal cord and its coverings, the spinal accessory nerves and the vertebral arteries.

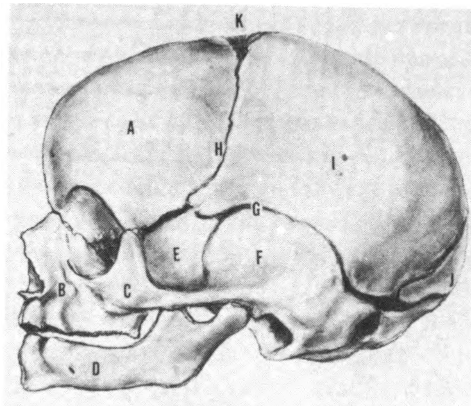


Figure 29.—Skull at birth.

A. Frontal	F. Temporal
B. Maxilla	G. Squamosal suture
C. Zygoma	H. Coronal suture
D. Mandible	I. Parietal
E. Sphenoid	J. Occipital
	K. Frontal fontanelle

The cranium

The eight bones of the cranium are: occipital (1), parietal (2), frontal (1), temporal (2), ethmoid (1) and sphenoid (1).

The OCCIPITAL bone is situated at the back and base of the skull. It is an irregular, four-sided bone which is curved upon itself somewhat in the manner of a scoop and is characterized by a large opening, the foramen magnum. The external surface is convex and presents, midway between the summit of the bone and the foramen magnum, a projection which can be felt through the scalp. This projection is termed the external occipital protuberance.

The two PARIETAL bones, right and left, form the greater part of the sides and roof of the skull. Each bone is irregularly four sided in form, with its external surface convex and its internal surface concave. Corresponding to the shape of the brain are numerous depressions. Grooves on the internal surface give lodgment to arteries and veins supplying blood to the dura mater of the brain.

The FRONTAL bone forms the forehead, part of the roof of the orbits and the nasal cavity. The arch, formed by part of the frontal bone over the eye, is sharp and prominent and is known as the supra-orbital margin. This arch serves to protect the eyes which are located just below. The frontal sinuses are located just above the supra-orbital margins and are large hollow spaces filled with air. The lacrimal glands, which secrete tears, are found in the upper and outer angle of each orbit.

The TEMPORAL bones, right and left, are situated at the sides and base of the skull. Each bone is divided into five portions—the squama, the petrous, mastoid, and tympanic parts, and the styloid process.

The squama is a thin, expanded portion and forms the anterior and upper part of the bone. Projecting from the lower part of the squama is the long, arched zygomatic process, which articulates with the temporal process of the zygomatic bone.

The petrous portion is shaped like a pyramid and is wedged in the base of the skull between the sphenoid and occipital bones. It contains the inner ear, the essential part of the organ of hearing, and also the mandibular fossa, a socket for the reception of the condyle of the mandible.

The mastoid portion projects downward from the opening of the meatus. It is filled with a number of connected spaces called mastoid sinuses, which contain air and communicate with the cavity of the middle ear.

The tympanic portion is a curved plate of bone below the squama and in front of the mastoid process.

The styloid is a slender, pointed process that projects downward from the undersurface of the temporal bone. Ligaments and some of the muscles of the tongue are attached to its distal part.

The ETHMOID bone is a light cancellous bone consisting of a horizontal or cribriform plate, a perpendicular plate, and two lateral masses or labyrinths. The horizontal plate forms the roof of the nasal cavity and the anterior part of the base of the cranium.

It is pierced with many foramina, through which the olfactory nerve fibers pass to the mucous membrane of the nose. Descending from the horizontal plate is the perpendicular plate, which helps to form the upper part of the nasal septum. On either side, the lateral masses form part of the corresponding nasal cavity. These lateral masses contain a number of thin-walled cavities, the ethmoid cells or sinuses, which communicate with the nasal cavity. Descending from the horizontal plate on either side of the septum are two processes of thin, cancellous, bony tissue. These are the superior and middle conchae.

The SPHENOID bone is situated at the anterior part of the base of the skull and aids in binding the other cranial bones together. It consists of a body, two great and two small wings extending outward from the sides of the body, and two pterygoid processes which project downward. The body is joined to the ethmoid in front and the occipital behind. It contains cavities or air spaces called SPHENOIDAL SINUSES, which communicate with the nasopharynx. The upper portion of the body presents a fossa with anterior and posterior eminences. This is called the SELLA TURCICA from its resemblance to a Turk's saddle.

The face

The bones of the face are: nasal (2), vomer (1), inferior nasal concha (2), lacrimal (2), zygoma (2), palatine (2), maxilla (2) and mandible (1).

The NASAL bones are two small oblong bones placed side by side at the middle and upper part of the face, forming, by their junction, the upper part of the bridge of the nose—the lower part being formed by the nasal cartilages.

The VOMER is a single bone placed at the lower and back part of the nasal cavity, forming part of the septum of the nasal cavity. It is thin and varies in different individuals, being frequently bent to one or the other side, thus making the nasal chambers of unequal size.

The INFERIOR NASAL CONCHAE are situated in the nostrils on the outer wall of each side. Each consists of a layer of thin, cancellous bone curled upon itself like a scroll. They are below the superior and middle conchae of the ethmoid bone.

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The LACRIMAL bones are situated at the front part of the inner wall of the orbit and somewhat resemble a fingernail in form, thinness and size. They are named lacrimal because they contain part of the canal through which passes the tear duct.

The ZYGOMATIC, or MALAR, bones form the prominence of the cheeks and part of the outer wall and floor of the orbits. A long, narrow and serrated process of each zygomatic process of the temporal bone helps to form the zygomatic arch of each side.

The PALATINE bones, right and left, are "L" shaped and consist of a horizontal part, a vertical part and three processes: the pyramidal, orbital and sphenoidal processes. They are situated at the back part of the nasal cavity, between the maxillae and the pterygoid processes of the sphenoid, and help to form: (1) the back part of the roof of the mouth, (2) part of the floor and outer walls of the nasal cavities and (3) a very small portion of the floor of the orbit.

The MAXILLAE are two in number and form the upper jaw by their union. Each bone consists of a body and four processes. The Antrum of Highmore (maxillary sinus) is located within the body of each maxilla. This sinus is pyramidal in shape and has very thin walls. The floor, on cross section, presents an irregular outline due to the inward projections of the apical portions of the roots of the bicuspids and the first molar tooth. The alveolar process is the portion which contains the eight sockets, or alveoli, in which the teeth are supported. The palatine processes of each maxilla form the incisive foramen in the anterior portion of their junction. The orbital surface forms most of the floor of the orbit. This surface contains the infra-orbital canal, through which a portion of the maxillary nerve travels and gives off branches to the upper teeth. The facial surface of the body presents the terminal orifice of the infra-orbital canal, the infra-orbital foramen. The infra-orbital plexus of nerves is located at this opening.

The MANDIBLE or lower jawbone is also known as the inferior maxillary bone. It consists of a curved horizontal portion, the body, and two perpendicular portions, the ascending rami. The BODY curves somewhat like a horseshoe. The superior or alveolar border contains spaces for the roots of the 16 teeth which form the lower dentition of the normal adult. Each ramus has in its medial surface the opening for the mandibular nerve, the mandibular foramen. The upper border of the ramus presents three distinct features: the coronoid process, the mandibular (sigmoid) notch and the condyloid process. The latter process consists of a neck and a condyle. The condyle of the mandible normally rests in the mandibular fossa of the temporal bone.

The skull consists of 22 bones. Before birth, membranous tissue fills the spaces between the uncompleted angles of the parietals and the neighboring bones. Such an interval or space is named a FONTANELLE, meaning little fountain—so called because it shows a rhythmical pulsation produced by the flow of blood in the brain. In the human fetus there are six such openings. The largest one is the anterior or bregmatic, situated at the junction of the coronal and sagittal sutures. This opening remains for approximately 18 months to 2 years after birth. At birth, the skull is much larger in

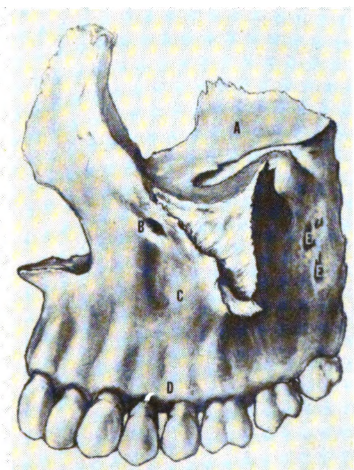


Figure 30.—Left maxilla.

A. Orbital surface
B. Infra-orbital foramen
C. Maxillary sinus (outer wall)
D. Alveolar process
E. Alveolar canals

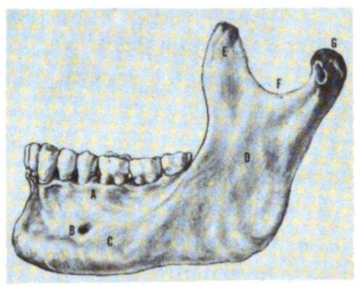


Figure 31.—Mandible, lateral view.

A. Alveolar process
B. Mental foramen
C. Body
D. Ramus
E. Coronoid process
F. Mandibular notch
G. Head of condyle

relation to the other bones of the body. As old age is reached the skull tends to show a decrease in the size of the mandible and the maxillae. This is the result of the loss of the teeth and a shrinking or resorption of the alveolar processes which have supported the teeth.

The HYOID bone bears a peculiar relationship to the rest of the skeleton in that it is suspended from the styloid processes of the left and right temporal bones. It affords attachment to many of the muscles of the tongue and can be located by palpation just above the so-called Adam's apple (laryngeal prominence).

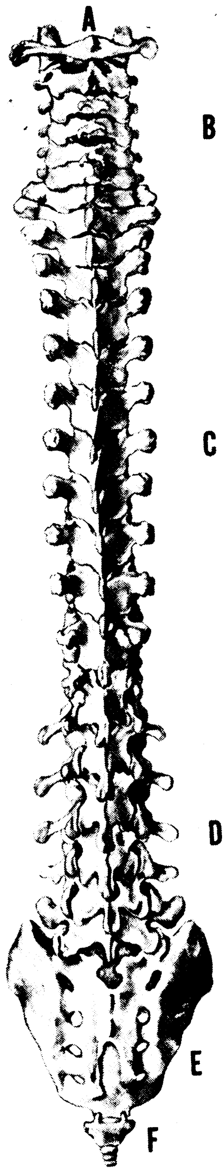
The Trunk

The bones of the vertebral (spinal) column, the sternum, and the ribs compose the anatomical grouping known as the trunk.

The spinal column is formed of bones which are known as vertebrae. The average length of the spinal column in the adult male is about 28 inches. In youth there are 33 vertebrae, which are grouped as follows: cervical (7), thoracic (12), lumbar (5), sacral (5) and coccygeal (4). The cervical, thoracic and lumbar vertebrae are termed TRUE or movable vertebrae, whereas the sacral and coccygeal vertebrae are known as FALSE, or fixed, vertebrae. In the adult, the sacral and coccygeal vertebrae are fused, the sacral forming the SACRUM and the coccygeal, the terminal bone known as the COCCYX. Thus, with a grouping of the lowest nine vertebrae into two units in the adult, a total of 26 bones makes up the vertebral column.

A typical vertebra consists of an anterior portion, the BODY, and a posterior portion, the VERTEBRAL ARCH. Both serve to enclose a foramen, the vertebral foramen, through which passes the spinal nerve tissue. The vertebral arch is made up of two pedicles and a pair of laminae. This arch supports four articular processes, two transverse processes, and one spinous process. When the vertebrae are articulated, they form a strong flexible column. Between the vertebrae are intervertebral fibrocartilages which act as cushions. Muscles and ligaments are attached to the rough surfaces of the laminae and to the spinous and transverse processes.

The sternum and ribs form a cage of bones. This cage contains and protects the main organs of circulation and respiration.



A. Atlas
B. Cervical—(7)
C. Thoracic—(12)
D. Lumbar—(5)
E. Sacrum—(5)
F. Coccyx—(4)

Figure 32.—Vertebral column.

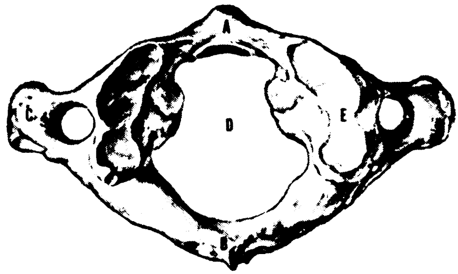


Figure 33.—First cervical vertebra.

A. Anterior arch
B. Posterior arch
C. Transverse process
D. Vertebral foramen
E. Articular process

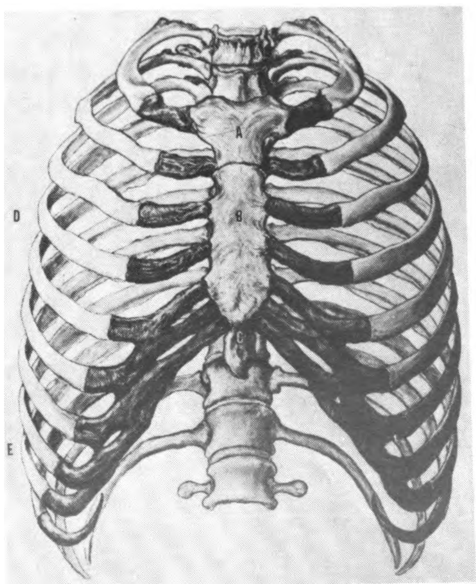


Figure 34.—Thorax.

Sternum
- A. Manubrium
- B. Gladiolus
- C. Xiphoid process

Ribs
- D. True—(7)
- E. False—(5)

THORAX is the name applied to the cage, and the thoracic cavity is within the thorax. The sternum (breastbone) is located in the median line and serves to protect the great vessels. The upper portion of the sternum is the manubrium. The middle and largest section is the gladiolus, and the lower end is the xiphoid process. The anterior ends of the seven costal cartilages are attached to the sternum. These serve to connect the sternal ends of the first seven ribs, the TRUE ribs. There are 24 ribs, 12 on each side. The first seven on each side are fixed to the sternum in front and to the thoracic vertebrae in back. The lower five on each side are called FALSE ribs. Each of the first three of these is attached to the costal cartilage of the rib immediately above, on the front or anterior end. The lower two are free at their anterior ends and thus are often called FLOATING ribs.

The Upper Extremities

The upper extremities consist of 64 bones, namely: clavicle (2), scapula (2), humerus (2), ulna (2), radius (2), carpus (16), metacarpus (10) and phalanx (28) (plural—phalanges).

The CLAVICLES (collar bones) and SCAPULAE (shoulder blades)

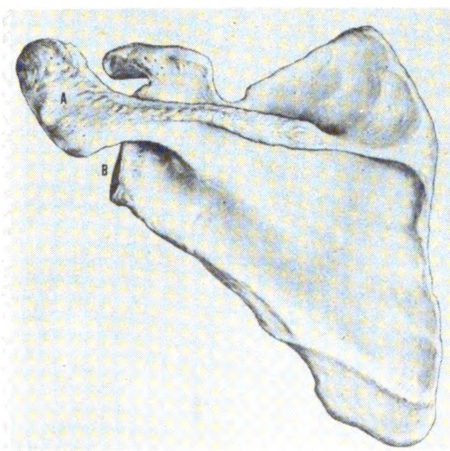


Figure 35.—Scapula.
A. Acromion process
B. Glenoid fossa

form the shoulder girdle, which is so termed because the bones of the upper extremity are attached to the trunk. The clavicle is attached at its medial end to the manubrium of the sternum and the attachment laterally is to the scapula. It acts as a fulcrum, enabling the muscles to give lateral motion to the arm.

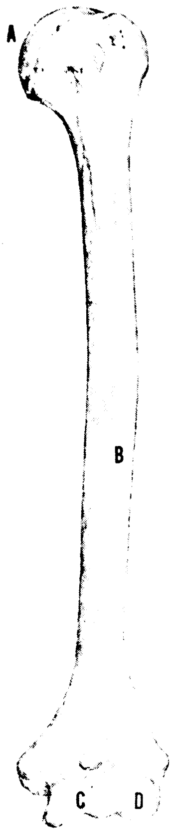


Figure 36.—Humerus.
A. Head
B. Body
C. Trochlea
D. Capitulum

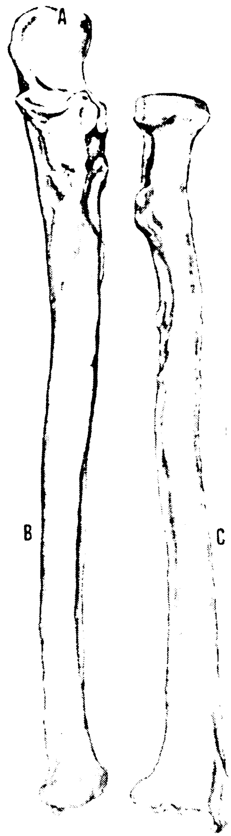


Figure 37.—Ulna-radius.
A. Olecranon process
B. Ulna
C. Radius

The SCAPULA is a large, flat, triangular bone which forms the posterior part of the shoulder girdle. The scapula articulates with the clavicle in a large oblong process, the ACROMION PROCESS, and with the head of the humerus in a shallow depression, the GLENOID FOSSA.

The HUMERUS is the longest and largest bone of the upper extremity. The upper end of the bone consists of a rounded portion, termed the HEAD, which articulates with the glenoid cavity of the scapula. The lower extremity of the bone articulates with the radius and the ulna, the bones of the forearm.

The ULNA is the larger bone of the forearm and is located on the little finger side. On its upper extremity it articulates with the humerus and on the lower with the fibrocartilaginous disk which separates it from the wrist. The large prominence on the upper

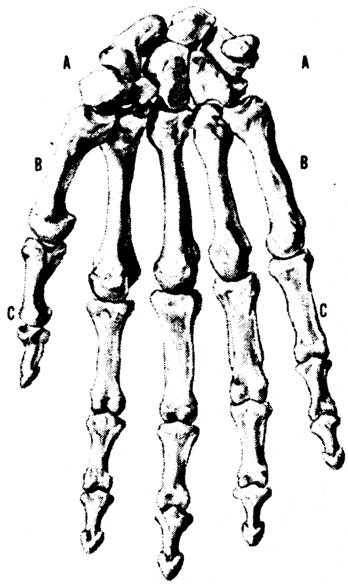


Figure 38.—Bones of the hand.
A-A. Carpals—(8)
B-B. Metacarpals—(5)
C-C. Phalanges—(14)

end of the ulna is termed the OLECRANON PROCESS and is part of the elbow.

The RADIUS lies parallel to the ulna in the forearm. The upper end articulates with the ulna and the humerus. The lower end of the radius is in contact with the ulna, the navicular and lunate bones of the wrist.

The bones of the hand may be divided into three groupings: the carpus (wrist bones), the metacarpus (bones of the palm) and the phalanges (bones of the fingers). The eight CARPAL bones are set up in two rows. In their appearance they are rough, cuboidal and tuberculated. They are united by ligaments, thus allowing freedom of motion without displacement. The five metacarpal bones are elongated, presenting a body and two extremities. There are 14 PHALANGEAL bones, each finger possessing 3, the thumb, 2.

The Lower Extremities

The bones of the lower extremities are 62 in number and are classed as follows: Hip bone (2), femur (2), patella (2), tibia (2), fibula (2), tarsus (14), metatarsus (10) and phalanx (28).

The HIP BONES are large and flat shaped. They form the sides

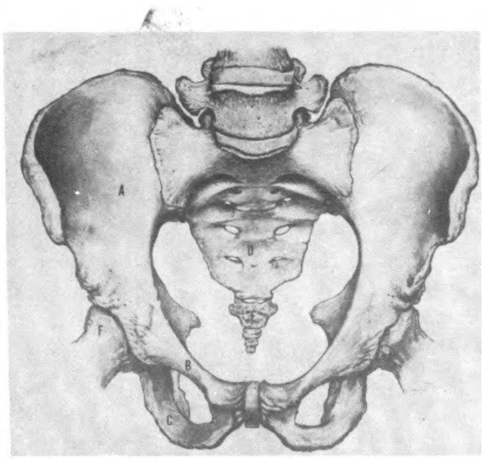


Figure 39.—Pelvis.

A. Ilium
B. Pubis
C. Ischium
D. Sacrum
E. Coccyx
F. Head of femur

and wall of the pelvic cavity. The innominate bone (hip) consists of three parts: the ilium, ischium and pubis. In the child, the bones may be recognized as three distinct units; in the adult they are fused together. The ACETABULUM is formed by a portion of each of the above component units and serves as a cup-shaped receptacle for the head of the femur. The PELVIS bears a close resemblance to a basin. This bony structure is interposed between the movable vertebrae of the spinal column which it supports and the lower extremities upon which it rests. The two hip bones, laterally and anteriorly, make up the front part of the pelvis; the sacrum and coccyx behind serve to complete the bony circle.

The FEMUR is the longest and strongest bone in the skeleton.

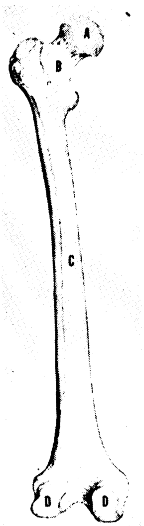


Figure 40.—Femur.

A. Head, articulation with acetabulum
B. Neck
C. Body
D. Condyles, articulation with patella—tibia

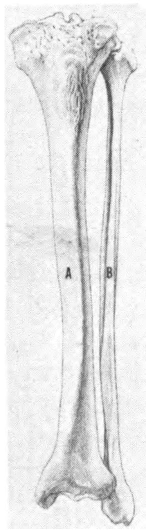


Figure 41.—Tibia-fibula.

A. Tibia
B. Fibula

Like other long bones, it is composed of three parts: two extremities and a body. The head of the upper extremity articulates with the acetabulum of the innominate bone. The lower extremity has two condyles which articulate with the patella and the tibia.

The PATELLA, kneecap, is a flat, triangular bone which is situated at the front of the knee joint and articulates with the femur. The

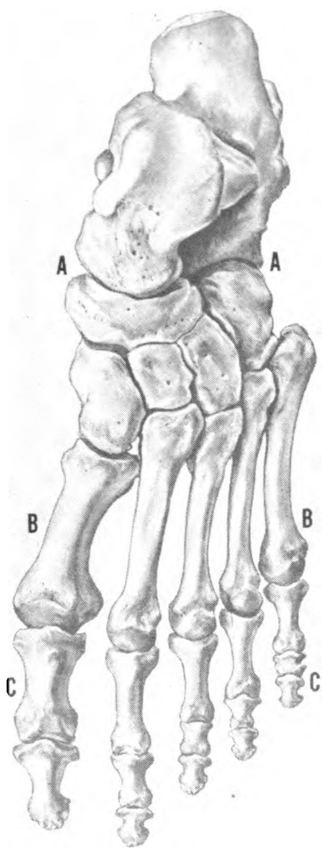


Figure 42.—Bones of the foot.
A-A. Tarsals—(7)
B-B. Metatarsals—(5)
C-C. Phalanges—(14)

articulation is surrounded by many sac-like cavities filled with a fluid which acts as a lubricant to prevent friction between the moving parts.

The TIBIA (shin bone) is situated on the medial or inner aspect of the leg. Like the femur, it too has a shaft or body and two extremities. The upper extremity articulates with the femur and the fibula, and the lower with the fibula and the talus.

The FIBULA (calf bone) is located on the lateral side of the tibia. The upper end articulates with the tibia and the lower end with the talus and tibia.

The bones of the foot are divisible into three groups: the tarsus, metatarsus and phalanges. There are seven tarsal bones, which are irregularly cuboidal in shape.

When compared to the carpal bones of the wrist, the tarsal bones are larger. The calcaneus (the heel bone), is the largest of the tarsal bones. The sole of the foot contains five metatarsal bones. As in the hand, the separation of the bones allows for the attachment of ligaments and the presence of synovial sacs with their lubricating fluid. The 14 phalangeal bones are distributed: two in the big toe, and three in each of the other toes.

MYOLOGY

Myology is the study of the structure and function of muscles. Muscles are organs composed chiefly of muscle tissue, and every motion in the body, whether conscious or unconscious, is due to their action. They constitute a large part of the fleshy portions of the body, enter into the structure of many of the internal organs, form from 40 percent to 50 percent of the body weight and vary in shape according to the type of work they have to perform. The attachment of a skeletal muscle which is stationary during use is known as the ORIGIN and the attachment which moves is called the INSERTION. TENDONS are made up of closely packed, parallel bundles of dense, nonelastic fibrous tissue with a very small amount of areolar tissue separating the bundles. The tendons unite with the periosteum of the bones to form secure attachments for the muscles. Because of the slight compact form of the tendons, their presence is desirable about the joints and movements are more easily accomplished than if there were groups of bulky muscles. Muscles seldom act alone and the performance of a very simple motion is usually due to the action of a whole group of muscles. This can be readily noted in closure of the mouth; the masseter, temporalis and internal pterygoid muscles all assist in this relatively simple act.

Muscles and groups of muscles are named according to the type of motion which they produce; as the EXTENSOR muscles of the hand and the ADDUCTOR muscles of the thigh. For each group of muscles which produce one type of action there is another which opposes, or acts antagonistically to, the action of the first group. The FLEXION group of the forearm would cause bending, as in raising the forearm on the upper arm while the opposite would be the EXTENSION group which would cause the straightening or unbending of the forearm. The bending of the forearm is made possible by the action of muscle and the presence of the elbow joint. Joints are ARTICULATIONS or places of union between two or more bones which permit the movements of the skeletal parts. Some types of movements are defined as follows:

Abduction: Moving away from the midline of the body.

Adduction: Moving toward the midline of the body.

Rotation: Turning on its own axis, as the action in turning of the head.

Pronation: Turning downward, as in turning the palm of the hand downward.

Supination: Turning upward as in turning the palm of the hand upward.

Eversion: Turning outward, as in turning the foot outward when sitting down.

Inversion: Turning inward, as in turning the foot inward when sitting down.

Layers of fibro-areolar tissue called FASCIA keep muscles in position and place during movement. The fasciae vary in density, structure and thickness, and in some places form considerable masses. They are of two types: superficial and deep. The superficial type lies immediately beneath the skin and usually contains considerable fat, blood and lymph vessels. The deep type is dense, tough, and in addition to covering muscles, covers delicate and specialized structures such as organs and blood vessels. In many portions of the body the fasciae lie between adjacent groups of muscles, thereby permitting the different groups to act independently and still remain in place.

Each muscle has a nerve supply. A muscle is brought into activity and its action coordinated with that of other muscles usually through the action of a nerve. Such a nerve is called a MOTOR nerve and if it is destroyed by disease or injury, the muscle generally becomes inactive and wastes away. In addition to receiving normal stimulation through their nerves, muscles may also be activated by mechanical, chemical, electrical and thermal stimuli.

When a muscle contracts, it uses a definite amount of energy to perform its work. In this action, the protoplasm in the muscle cells breaks down, and toxic chemical waste products are produced. If these waste products accumulate, the phenomena of fatigue result and in some cases muscular cramps occur. To supply the energy required and to restore the muscle protoplasm, carbohydrates are taken from the blood and oxidized in the muscles. During contraction or work, carbon dioxide and water are formed by oxidation and are removed as waste products by the blood which also returns oxygen necessary for the restoration of muscle tissue. In ordinary movements the blood supply to the musculature is increased, thereby supplying food and carrying away waste products. Such action permits the working muscles to build themselves up and to restore the tissue to its efficiency. When muscle substance dies it becomes solid and rigid, losing its power to react to stimulation. This coagulation of muscle plasma which occurs after death is termed RIGOR MORTIS.

A complete study of the individual skeletal muscles will not be presented in this section. It is desired only to show the way in which they should be studied. A few that form important anatomical landmarks and typify the action of muscles in general, will be described briefly.

For the purpose of study the muscles of the body are divided into the following groups: head and neck, chest, thorax, abdomen, back, upper extremity and lower extremity.

Head and Neck

This group consists of numerous small muscles which act together in the movements of the eyes, face and scalp and which assist in mastication, deglutition, talking and expression. The movement of the head from side to side, backward and forward, and auxiliary action in respiration are accomplished by the action of muscles belonging to this group.

Muscles of Mastication

Muscle	*Origin*	*Insertion*	*Action*
Temporalis	Temporal fossa, fascia, side of the head.	Coronoid process, mandible.	Closes mouth, retracts mandible.
Masseter	Zygomatic arch, malar process.	Angle and ramus of mandible.	Closes mouth.
Internal pterygoid	Pterygoid fossa of sphenoid bone, tuberosity of maxilla.	Angle and inner surface ramus.	Raises and draws mandible forward.
External pterygoid	External pterygoid plate, great wing of sphenoid.	Condyle of mandible.	Draws mandible forward.

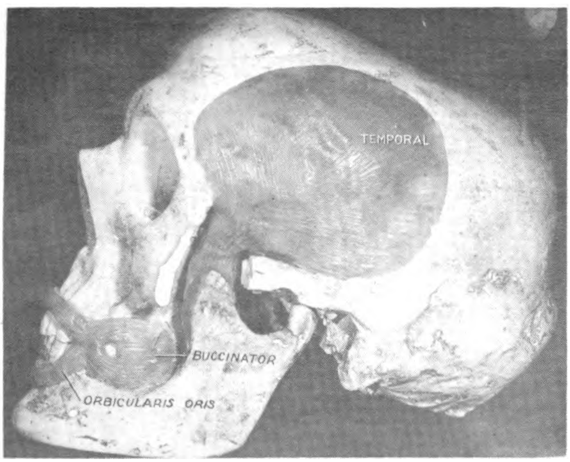


Figure 43.—Temporal muscle viewed after partial removal of zygomatic arch.

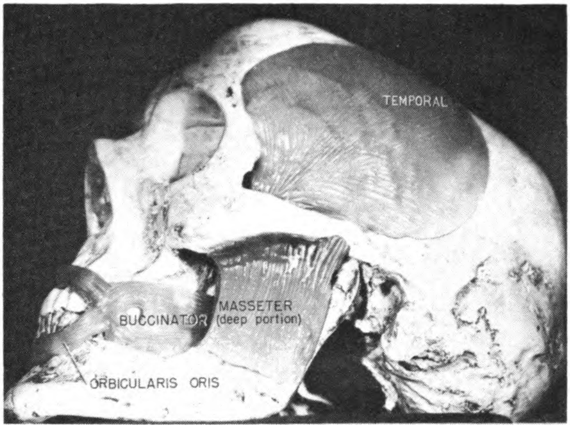


Figure 44.—View of deep masseter muscle after removal of superficial portion.

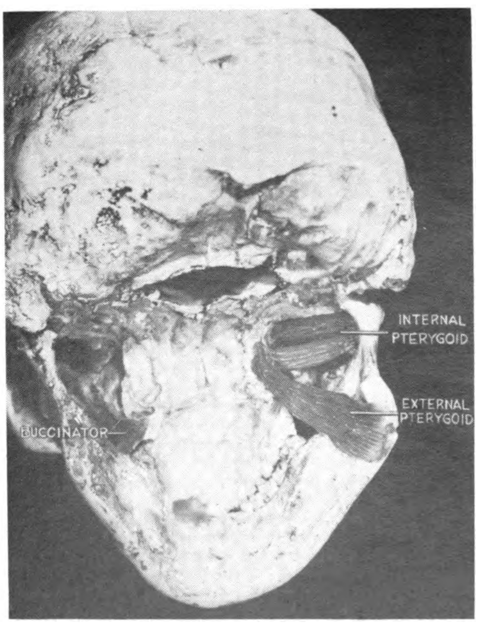


Figure 45.—Posterior-inferior view of pterygoid muscles.

For the purposes of study, other muscles in the head and neck group include:

Muscle	*Origin*	*Insertion*	*Action*
Buccinator	Alveolar processes of mandible, maxilla, pterygomandibular raphe.	Orbicularis oris.	Compresses cheeks and retracts angle of mouth.
Mylohyoid	Mylohyoid ridge of mandible.	Hyoid bone.	Raises hyoid, aids in depressing mandible and assists in forming floor of mouth.
Orbicularis oris.	Nasal septum, canine fossa of maxilla.	Angle of mouth.	Closes mouth, wrinkles lips.
Sternocleidomastoid.	Two heads, from sternum and clavicle.	Mastoid process and superior oblique line of occipital.	Depresses, rotates head, flexes head and neck.

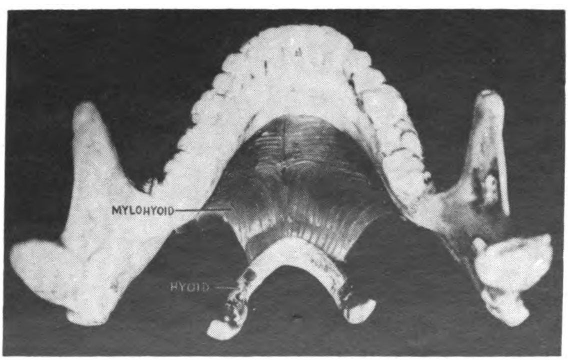


Figure 46.—Superior view of mylohyoid muscle.

Chest and Thorax

The muscles of this group, including the diaphragm—the great muscle which separates the thoracic and abdominal cavities—are chiefly respiratory muscles. These muscles, with the exception of the diaphragm, assist in movements of the trunk, neck and upper extremities.

Muscle	*Origin*	*Insertion*	*Action*
Pectoralis major	Sternum, clavicle, costal cartilages, etc.	Anterior bicipital ridge of humerus.	Draws arm downward, forward, aids to expand chest.
Pectoralis minor	3rd, 4th, 5th ribs aponeurosis.	Coracoid process of scapula.	Depresses point of shoulder and scapula.
Diaphragm	6 or 7 lower ribs, lumbar vertebrae, etc.	Central tendon.	Respiration and expulsive acts.

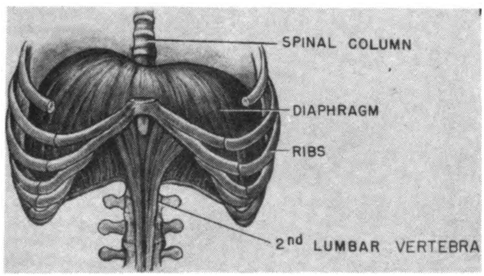


Figure 47.—Diaphragm muscle.

Abdomen

These muscles form the sides and front of the abdominal wall. They assist in micturition and defecation by compressing the abdominal viscera. In addition, they further aid in respiration in flexing the thorax on the pelvis and in lateral rotation of the spine. The external oblique, internal oblique, rectus abdominis and transversus abdominis make up this grouping.

Back

The muscles of the back are divided into five layers: one superficial and four deep layers. They act upon the spinal column to keep the trunk in an erect posture and to permit movements from side to side, forward and backward and allow a moderate amount of turning. Two of the prominent muscles will be studied.

Muscle	*Origin*	*Insertion*	*Action*
Latissimus dorsi	Spinous processes of 6 lower dorsal, lumbar sacral vertebrae. Crest of ilium, 4 lowest ribs.	Bicipital groove of humerus.	Draws arm downward, backward and rotates it.
Trapezius	Superior curved line of occipital bone, soinous processes of last cervical and all thoracic vertebrae.	Clavicle, spine and acromion process of scapula.	Draws head backward, sideward; rotates scapula.

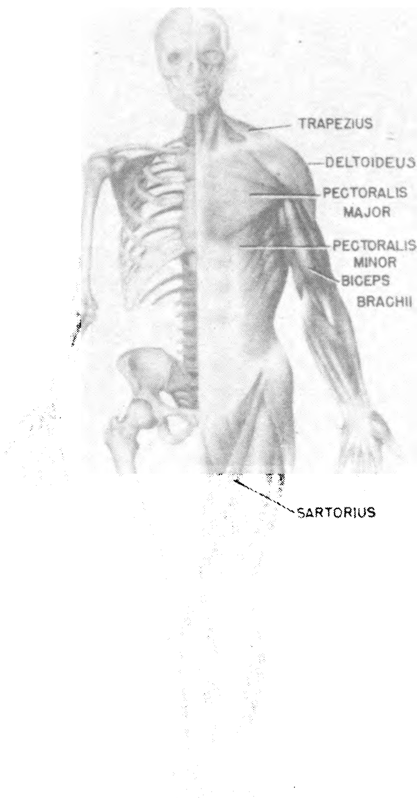


Figure 48.—Anterior view of relation of muscles to the skeleton.

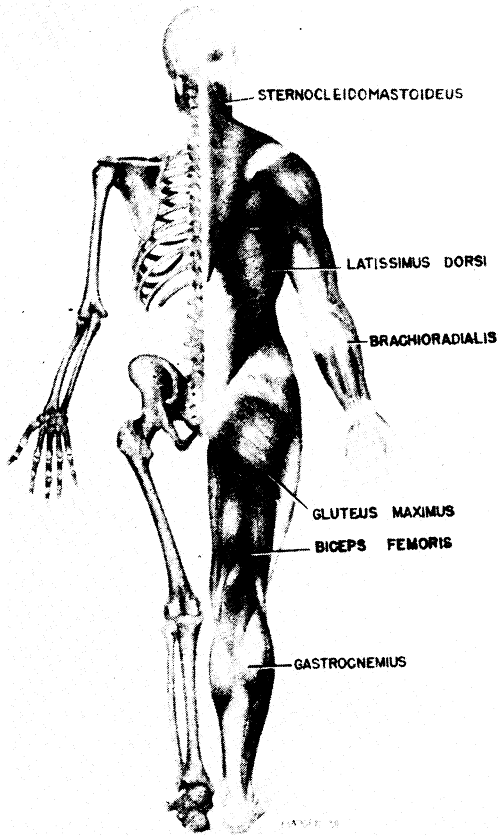


Figure 49.—Posterior view of relation of muscles to the skeleton.

Upper Extremity

The muscles of the upper extremity may be divided into those of the shoulder, the arm, the forearm and the hand. The muscles on the front of the arm flex the forearm; those on the back extend it. The same principle applies generally to the muscles which arise from the forearm and are attached to the bones of the hands or fingers.

Muscle	*Origin*	*Insertion*	*Action*
Deltoid	Clavicle, spine and acromion of scapula.	Middle of outer side, shaft of humerus.	Raises arm, aids in carrying it forward and backward.
Biceps brachii	Long head, upper margin glenoid cavity, short head, coracoid process.	Bicipital tubercle of radius and fascia forearm.	Flexes and supinates forearm, flexes and adducts arm.
Brachioradialis	External supracondyloid• ridge of humerus.	Styloid process of radius.	Flexes forearm and assists supination.

Lower Extremity

The muscles of the lower extremity can be divided into those of the hip, thigh, leg and foot. The muscles on the anterior side of the hip flex the thigh on the abdomen, those on the posterior extend, those on the medial side adduct and the ones on the lateral side abduct. Combinations of these actions produce circumduction of the lower extremity.

Muscle	*Origin*	*Insertion*	*Action*
Gluteus maximus	Superior curved line, crest of ilium, sacrum and coccyx.	Femur below great trochanter.	Extends, abducts and rotates thigh outward.
Sartorius	Anterior superior spinous process of ilium.	Upper part of inner side shaft of tibia.	Flexes hip, knee; rotates leg in, hip out.
Biceps femoris	Long head from ischial tuberosity. Short head from middle third shaft of femur.	Head of fibula. Head of tibia.	Flexes knee and rotates it outward.
Gastrocnemius	Condyle of femur.	Os calcis by Achilles tendon.	Extends foot, flexes leg.

THE BLOOD AND THE BLOOD VASCULAR SYSTEM

Nature's great transportation system is the blood vascular system. In simple unicellular organisms, food is absorbed directly from the outside, and waste products are eliminated, without the use of a circulatory system. In animals with many thicknesses of cells, it is necessary to have a system of transportation for these products, hence the evolution of the circulatory system.

Functions

In the performance of its numerous functions, the blood serves:

1. As a medium for the exchange of gases, carrying oxygen to the tissue cells and removing carbon dioxide from them.
2. As a medium for the interchange of nutritive and waste materials, carrying food materials absorbed from the digestive tract to the tissue cells and removing waste products from them for elimination by the excretory organs.
3. As a medium for the transmission of hormones.
4. In equalizing and maintaining body temperature.
5. In protecting the body against infection by contributing cellular and fluid factors to the defense mechanism of the body.

The term blood plasma should not be confused with the term blood serum for the two terms refer to quite different substances. The PLASMA is the liquid part of the blood before coagulation takes place. (When blood escapes from a vessel it normally coagulates or clots. When the clot forms, a clear, light yellow liquid, known as serum is left behind.) Plasma passes through the walls of the capillaries into the tissues where it is known as LYMPH.

Formed elements

Red blood cells or ERYTHROCYTES, are circular, biconcave, nonnucleated disks that give the blood its characteristic color. They are about 1/3200 of an inch in diameter and in the adult male number about 5,000,000 per cubic millimeter of blood. Their red color is due to the presence of hemoglobin, a substance composed of an iron salt and a protein. Hemoglobin has the power of combining easily with oxygen to form oxyhemoglobin, by which oxygen is carried in the blood from the lungs to the tissues. Hemoglobin also possesses the power of readily combining with carbon dioxide and carries it from the tissues to the lungs. The affinity of oxygen and carbon dioxide for hemoglobin depends upon the concentration of these gases at the point of exchange. In the lungs, where oxygen is at a greater concentration than carbon dioxide, the hemoglobin exchanges its carbon dioxide for oxygen and forms oxyhemoglobin; but in the body tissues carbon dioxide is at greater concentration than oxygen, and the hemoglobin exchanges its oxygen for carbon dioxide, forming carbohemoglobin.

In the adult, red blood cells are reproduced in the red marrow of the bone. These cells have a nucleus which they lose before entering the peripheral blood stream. A large number of red blood cells are destroyed daily—in what manner, it is not definitely known. The destruction may take place in the liver, the spleen or in the lymph nodes, and it may be that many are destroyed by the buffeting they receive in the circulation. A certain amount of hematin, a decomposition product of hemoglobin is excreted in the bile, a fact which apparently substantiates the belief that some red blood cells are destroyed in the liver.

Red blood cells depend upon the percentage of salt or sodium chloride present in the blood plasma for their maintenance of form. Normally the amount of salt is equivalent to about a $\frac{9}{10}$ of 1 percent sodium chloride solution. This solution is isotonic and has the same osmotic pressure as the tissue fluids. If the percentage of salt is less, the red cells will absorb water, swell and burst, and their hemoglobin is discharged. This action is called HEMOLYSIS and may be caused by certain bacterial products called HEMOLYSINS. If the percentage of water is above normal, water is extracted from the red cells and they shrink or become *crenated.* In the human being, the color of the blood in the arteries is bright red because the hemoglobin is combined with oxygen. Blue or dark blood is found in the veins because the oxygen in hemoglobin has been replaced by carbon dioxide.

White blood cells, or LEUKOCYTES, are nucleated blood cells. They vary in size and shape. They are almost colorless, and somewhat larger than red cells. The white cells number from 6,000 to 8,000 per cubic millimeter of blood under normal conditions. This number may increase for various reasons; such an increase is termed LEUKOCYTOSIS. When the number of white cells drops below the normal standard, the condition is known as LEUKOPENIA. The principal function of the white cells is to combat disease. They do this by forming antibodies and by ingesting and destroying bacteria through a process called PHAGOCYTOSIS. They also aid in the absorption of digested fat and proteins, and in the clotting of blood. Leukocytes have the striking property of ameboid movement which enables them to alter their shape, ingest and destroy bacteria, move themselves and pass through the walls of blood vessels into the surrounding tissues. The passage of leukocytes through the unruptured walls of vessels is known as DIAPEDESIS.

White blood cells are divided into three distinct groups known as GRANULOCYTES, LYMPHOCYTES and MONOCYTES which differ from one another in origin, structure and function. When stained for microscopic examination and differential counting, white blood cells show many variations of color in the nucleus and cytoplasm. It is by these variations that the various kinds of white cells are recognized. When a differential count made in acute infections shows an increase in the percentage of immature white cells, it is considered roughly proportionate to the severity of the infection. Such an increase of immature white cells, which enter the peripheral circulation prior to their complete development, is due to the small supply of mature cells available to combat the infection. It demonstrates a strain on the blood cell-forming structures (hematopoietic system). During successful treatment of an infection the immature cells tend to decrease in number (proportionately) and the appearance of more mature cells represents a favorable blood picture which indicates high resistance on the part of the patient.

BLOOD PLATELETS or thrombocytes are round or oval bodies in the blood that consist only of cytoplasm. They vary in size and shape, have no nucleus, are smaller than red cells and number from 300,000 to 800,000 per cubic millimeter of blood, depending on the method used in counting them. They are an essential element in clotting. They mix with the fibrin to form a firm clot and are believed to be fragments of the cytoplasm of multinuclear giant cells of the bone marrow (megakaryocytes) that have been pinched or broken off.

Blood plasma

The composition of blood plasma is about 90 percent water and 10 percent solids. In addition to water its constituents are:

1. GASES: oxygen, carbon dioxide and nitrogen.
2. PROTEINS: fibrinogen, globulins, albumins and cell proteins, excluding hemoglobin.
3. PIGMENTS: hemoglobin and bilirubin.
4. NONPROTEIN NITROGENOUS BODIES: (NPN) urea, uric acid, creatinine, amino acids and ammonium salts.
5. NON-NITROGENOUS BODIES: sugar, lactates, phenols, cholesterol and lipoids, together with the intermediate products of fat metabolism.
6. INORGANIC SALTS: chlorides, carbonates, sulfates and phosphates of sodium, potassium, calcium, magnesium and iron.
7. ENZYMES AND ANTI-ENZYMES: glycolase, lipase, enterase and oxidase.
8. SPECIAL SUBSTANCES: hormones, immune bodies and opsonins. Of the above substances, the sugar, fat and lactates are oxidized to carbon dioxide and water. Urea, uric acid and ammonia salts are excreted (together with the water) by the kidneys. Amino acids are used in part as building blocks for proteins; the remainder are excreted by the kidneys.

Acid base equilibrium

The normal metabolic processes of the body result in the continuous production of acid and other products which tend to alter the equilibrium of the blood. Oxidation in all tissues produces carbon dioxide which has acid properties; muscular activity produces lactic acid; sulfuric and phosphoric acids are formed in the oxidation of proteins containing sulfur and phosphorus. In spite of such acid substances being constantly added to the blood, its slightly alkaline reaction remains remarkably uniform and constant.

This constant equilibrium between acid and base can be measured. Blood has a normal value of pH 7.4. In chemistry, a pH of 7.0 is a neutral solution. Solutions with pH above 7 are basic; those with pH below 7 are acid. Blood is always slightly alkaline and it tends to remain so. The maximum variation, without danger to life, is only 0.8 pH UNITS.

Maintaining the alkaline reaction of the blood within those limits is known as ACID BASE EQUILIBRIUM, or balance. This is accomplished in three ways: (1) by neutralization of the acid products as soon as they are formed in the tissues, (2) by the prompt elimination of the excess acid through the regulating action of the lungs and kidneys, and (3) by the presence in the blood of substances called BUFFERS.

A buffer is any substance which, when present in a solution, tends to prevent the reaction of the solution from changing even when alkali or acid is added to it. All buffers are mixtures of a weak acid and its basic salts, or a weak base and its acid salts. Among the substances present in the blood which act as buffers are: carbonic acid and its basic, bicarbonate salts; and hemoglobin and its basic salts. These salts react with stronger acids to form sodium salts of the stronger acids and at the same time liberate the weaker acids. In this way the effect of the stronger acids is greatly weakened and an increase in acidity which would tend to make the reaction of the blood less alkaline is prevented. The combination of sodium with a weak acid, as sodium bicarbonate, constitutes the principal buffering mechanism of the blood, and the amount of sodium that is so combined and available for use in neutralizing stronger acids is spoken of as the alkali reserve.

The principal acid added to the blood as the result of the metabolic processes is carbonic acid, a great deal of which is formed when waste carbon dioxide enters the blood stream from the tissues. As soon as this acid is formed, most of it combines with the sodium chloride present in the blood plasma and forms sodium bicarbonate. The remainder diffuses into the red blood cells where it unites with the potassium, present as potassium hemoglobinate, and forms potassium bicarbonate. The chlorine liberated in the formation of sodium bicarbonate passes to the red blood cells where it combines with the hemoglobin. The result of these reactions is an increase in the amount of bicarbonates which are available for the neutralization of acids.

On reaching the lungs the blood becomes oxygenated or purified, and the hemoglobin gives up the chlorine it had taken up. The liberated chlorine passes into the blood plasma, reacts with the sodium bicarbonate to form sodium chloride and carbon dioxide is liberated and exhaled. Should there be any tendency toward an increase in the acidity of the blood, such as would follow an increase in the carbon dioxide content, the respiratory center in the brain is stimulated and respiration becomes more rapid with consequent increased elimination of carbon dioxide.

Since neutralization of acids cannot be accomplished without lowering the alkali reserve (acids are continually being added by foods and by action within the body), it is necessary to eliminate this excess acid without losing any base. This is done through the functions of the kidney.

The normal acid reaction of urine, compared with the slightly alkaline reaction of blood, is due to the selective ability of the kidneys to excrete weak acids and acid salts. At the same time they hold back a large part of the alkali with which these acids and salts are combined in the blood. Acid elimination takes place in the kidneys largely in the form of combined acid phosphates. In some cases as much as 50 percent of the excreted acid may be free acid. Should the alkali reserve begin to be depleted in spite of this excretion, the kidneys break up urea; this is accompanied by the production of ammonia. The ammonia, which is basic in reaction, is then used instead of alkali reserve to neutralize much of the acid, which is excreted in the form of ammonia salts. This neutralizing mechanism may be so taxed as a result of disease or by ingestion of large amounts of acid or alkali, that there occurs a noticeable change in the blood reaction. The condition in which there is a lowered blood carbonate is known as ACIDOSIS. Conversely, an increase in blood carbonate results in the condition known as ALKALOSIS.

Blood coagulation

One of the most striking properties of blood is its power to coagulate or clot. Undisturbed blood circulates in the blood vascular system of the healthy body without showing any tendency to clot, but on escaping from the blood vessels it normally begins to clot immediately. Clotting is the body's method of preventing excessive loss of blood. When blood escapes from the blood vessels it leaves its normal environment and its normal physical state is changed by exposure to changes in temperature, by changes in its gas and acid balances, and by contact with objects foreign to its natural surroundings such as the air and skin.

The blood which forms a clot is at first fluid, then viscous and then sets into a soft jelly which quickly becomes firm enough to act as a plug. The clot becomes more compact and gradually shrinks in volume, at the same time squeezing out the blood serum. The essential part of the clot is an insoluble protein substance called FIBRIN which is not present in normal blood but is produced from substances in the blood plasma, blood cells and tissues when the formation of a clot is necessary.

Among the protein constituents of the blood plasma is FIBRINOGEN, the essential chemical factor in the formation of fibrin. Fibrinogen is a protein of the globulin type, probably produced in the liver, and by itself is inert or inactive. In the generally accepted theory of clotting, when fibrinogen comes in contact with THROMBIN (formed from prothrombin by the action of calcium salts) the two interact and fibrin is formed. For prothrombin to be converted into thrombin by the action of calcium salts, a third substance known as THROMBOPLASTIN must be present. This substance, called a thromboplastic agent, neutralizes the substance HEPARIN which is present in the blood. Normally, heparin prevents the activation of prothrombin, and is released from the injured tissues and from blood platelets. The platelets disintegrate when exposed to air.

Fibrin is formed in the shape of fine threads which form a mesh encircling groups of cells. As the meshes of the fibrin network draw closer together, the cells are packed tightly, so that the blood serum is squeezed out, and a CLOT or COAGULUM is formed. One theory of the clotting process is as follows:

Thromboplastin + Heparin ⇝ Prothrombin + Calcium salts = Thrombin
Thrombin + Fibrinogen = Fibrin

A clot closes the opening of the wounded blood vessel, thus preventing great losses of blood. A clot also closes the opening in a wound and is the basis for the growth of new tissue in the process of healing. The clotting power differs in various individuals. Normally three to five minutes is sufficient time for a clot to form. A congenital condition exists, although fortunately rare, in which there is a delayed clotting power of blood and a consequent difficulty in checking hemorrhage. This is known as hemophilia. It is inherited by males through the mother. Persons so affected are called hemophiliacs or "bleeders." Pseudohemophilia may be found in persons who for various other reasons, may show tendencies toward delayed blood clotting.

The Blood Vascular System

The organs of the blood vascular system are the heart, arteries, capillaries and veins. These organs form a closed passageway of tubes called VESSELS, through which the blood circulates. The heart is a muscular pump which propels the blood through these vessels. It is a hollow organ located in the front and center of the thoracic cavity of the chest, between the lungs; a large part of it lies directly back of the sternum (breastbone). It is about the size of a closed fist and its shape that of a strawberry. The base of the heart points upward, backward and to the right, and the pointed end or apex points downward, forward and to the left.

The heart is enclosed in an inverted sac of fibroserous membrane called the pericardium, the inner layer of which adheres closely to the musculature of the heart. The outer surface of the pericardium turns back over the inner layer and forms a cavity which contains a small quantity of fluid known as the pericardial fluid, which lubricates the surface of the pericardium and prevents friction during the movements of the heart. The inside of the heart is lined with a delicate, serous membrane called the endocardium.

The main portion of the heart is composed of muscle tissue called the myocardium. This muscle tissue is of a type found only in the heart, being striated but involuntary. Some of the muscles of the heart run transversely, others obliquely, and even others in spirals. This intricate arrangement makes possible an even and complete closing of the heart cavities or chambers during contraction.

The interior of the heart is completely separated into right and left halves by a longitudinal, muscular septum and each half is divided into an upper receiving chamber, the AURICLE, and a lower ejecting chamber, the VENTRICLE. There are four cavities in the heart: right auricle, left auricle, right ventricle, left ventricle. Each auricle communicates with its corresponding ventricle by means of an oval aperture called the auriculoventricular opening or valve. During fetal life there is an opening between the auricles of the heart known as the foramen ovale, which normally closes immediately after birth. The walls of the auricles are thinner than those of the ventricles, for they act as reservoirs to receive the blood whereas the ventricles act as the pumping stations, and must have stronger walls.

Each of the four cavities of the heart is lined with endocardium, which, by folding back upon itself, forms the valves of the heart. These valves allow the free passage of blood in the proper direction but effectually prevent its backflow. The valves differ in the number and shape of their cusps or segments and take their names from the openings which they serve. The right auriculoventricular valve is also known as the tricuspid valve since it has three triangular-shaped cusps; the left auriculoventricular valve is also known as the bicuspid or mitral valve. It has two triangular-shaped cusps. Both the pulmonary valve and the aortic valve open respectively into the pulmonary artery and the aorta. They are known as the semilunar valves because they have half-moon-shaped cusps.

The heart is nourished by the blood supplied to it through the right and left coronary arteries and its nerve supply is from the pneumogastric nerve and the sympathetic nervous system. The heart action consists of wavelike contractions, beginning in the auricles and passing to the ventricles, followed by dilations. These contractions and dilations are alternate, continuous, and occur normally at the rate of about 72 per minute. This rate will vary according to age, sex, exercise, temperature and in pathologic conditions. Contraction or SYSTOLE as it is called, is a period of work; dilation or DIASTOLE is a period of rest.

The time from the appearance of any feature of heart action to the appearance of that action again is known as a complete CARDIAC CYCLE, during which blood is received into and ejected from the heart cavities. In brief, a cycle is as follows: the ventricles contract and eject the blood, then quickly relax, and the semilunar valves in the ventricles close. The auriculoventricular valves have been closed since the last filling of the ventricles with blood, and the auricles are now being steadily filled with blood from the large veins while the ventricles are resting. During this period of relaxation, all the valves in the ventricles are closed and the ventricles are completely shut off on both sides at one time. By the time the relaxation of the ventricles is complete, the pressure of blood in the auricles has caused the auriculoventricular valves to open; and from then to the beginning of the brief auricular contraction, blood from the large veins is flowing into and filling both the auricles and the ventricles. Soon the ventricles become more tense as the quantity of blood in them increases, the auriculoventricular valves float into position for closing and the auricular contraction begins. At the end of the brief contraction of the auricles a sudden wave of blood is sent into the ventricles, completely filling them, the auriculoventricular valves close, and con-

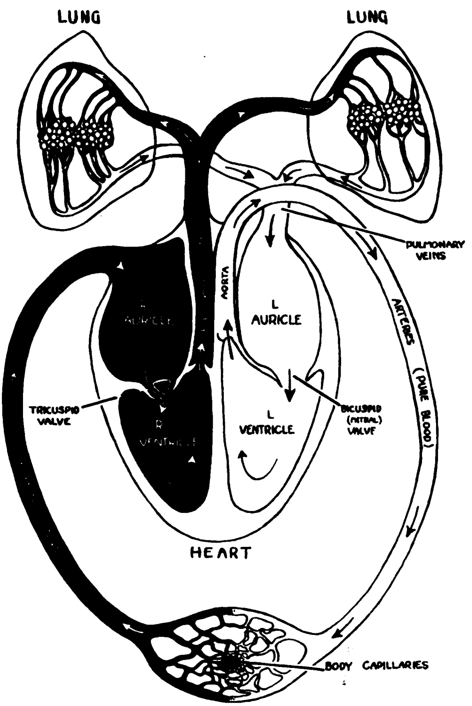


Figure 50.—Circulation of the blood. (Diagrammatic.)

traction of the ventricles begins. At this point once more the ventricles are shut off on both ends with all their valves closed. The increasing pressure of the blood from the ventricular contraction causes the semilunar valves to open and blood to be forced into the aorta while the contraction lasts. The action of a normal heart produces two distinct sounds which may be heard by applying the ear to the chest. One is a long booming sound caused when the auriculoventricular valves close and the ventricles contract; the other is a short, sharp sound attributed to the closing of the semilunar valves.

Arteries are hollow, elastic tubes that carry the blood away from the heart to the tissues of the body. They have a certain amount of rigidity and consist of three layers: an inner lining of vascular endothelium, a middle muscular layer composed of involuntary muscle tissue and an outer fibrous tissue coat. Arteries have a nerve supply from the sympathetic nervous system by which the size of the lumen in the arteries may be enlarged or constricted. The smaller divisions of the arteries are known as arterioles.

The capillaries are minute, hair-sized vessels through which the blood passes from the arteries to the veins. They have very thin walls of endothelium only, communicate with each other and form a dense interlacing network in all parts of the body. In passing through the capillaries the blood gives its nutritive materials to the tissues and takes from the tissues the various waste products that are to be carried away.

Veins are hollow, collapsible tubes that carry blood to the heart. Their structure is similar to that of the arteries but their walls are much thinner, the middle layer containing much less muscle tissue. In many of the veins there are paired valves which act to prevent the backward flow of the blood. The arteries, however, have no valves.

In tracing the circulation of the blood, it is necessary to begin and return to a certain point. In this case the given point will be the RIGHT AURICLE where venous or waste-carrying blood is entering from the inferior and superior venae cavae. This venous blood passes from the right auriculoventricular opening past the tricuspid valve into the right ventricle. When the right ventricle contracts, the tricuspid valve closes and the blood is forced past

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the pulmonary semilunar valve into the pulmonary artery. This artery divides into two branches, one going to each lung where it divides into smaller arterioles and capillaries which surround the air sacs (alveoli) of the lungs.

During its circulation in the lungs the blood becomes aerated, gives off carbon dioxide and is returned through small vessels to the four pulmonary veins (two from each lung) which empty into the left auricle. From the left auricle, the blood passes through the left auriculoventricular opening, past the bicuspid or mitral valve into the left ventricle where, upon contraction of the ventricle, the blood is forced past the semilunar valves into the aorta and thence to the other arteries for distribution throughout the body. The blood is returned to the veins by the capillaries and finally reaches the right auricle through the venae cavae.

The contraction of the left ventricle forcing the blood into the arteries, causes wavelike expansions of the arteries which are synchronous with the heart beat. This is called the pulse and may be felt at certain points where the arteries approach the surface of the body. The most common location is at the wrist where the radial artery passes over the distal end of the radius.

BLOOD PRESSURE is the force of the blood exerted against the walls of the blood vessels. Although the term includes the pressure in the arteries, veins and capillaries, the usual application of the term is in regard to arterial pressure alone. The highest pressure is that produced by the forceful propulsion of the blood through the arteries at each contraction of the ventricle. This is known as systolic pressure. Under normal conditions in the young adult this pressure is equivalent to about 120 millimeters of mercury but varies as to age, weight, sex and condition of the arteries and heart. Systolic pressure roughly equals 100 plus the age of the individual. A certain amount of pressure is maintained in the arteries during the period of cardiac relaxation. This is caused by the elasticity and tonicity of the arteries, and by the peripheral resistance. This pressure is known as the diastolic blood pressure. In normal young adults it is equivalent to from 70–90 millimeters of mercury. The difference between the systolic and diastolic pressures is called the PULSE PRESSURE.

The Blood Vessels

The system of arteries and arterioles may be compared to a tree with the trunk giving off main branches which divide and subdivide until they are but minute twigs. The arteries in many locations join together to form a union (anastomosis), a good example of which can be found in the hand.

The main trunk of the arterial tree is the AORTA, which arises from the left ventricle of the heart, arches backward above the root of the left lung, and descends along the spinal column through the diaphragm to terminate at the level of the fourth lumbar vertebra. It then divides into the right and left common iliac arteries. During its entire course the aorta is a single trunk which

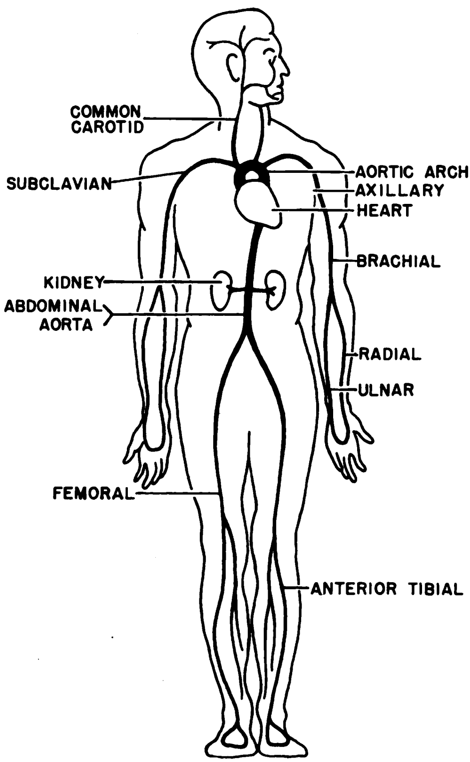

Figure 51.—Arterial system. (Diagrammatic.)

gradually diminishes in size giving off branches at various points. The portion of the aorta which is situated in the thorax is called the thoracic aorta and consists of the ascending aorta, the arch, and part of the descending aorta; the remaining portion is called the abdominal aorta.

The ascending aorta gives off the right and left coronary arteries which supply the heart with nourishment. The arch of the aorta gives off the branches indicated on the chart as the innominate, the left common carotid and the left subclavian. The innominate divides into the right subclavian and the right common carotid. The common carotid arteries ascend obliquely on each side of the neck to the level of the laryngeal prominence where they divide into the external and internal carotid. The external carotid supplies the throat, tongue, face, ears and walls of the cranium. The internal carotid gives branches to the brain and eyes.

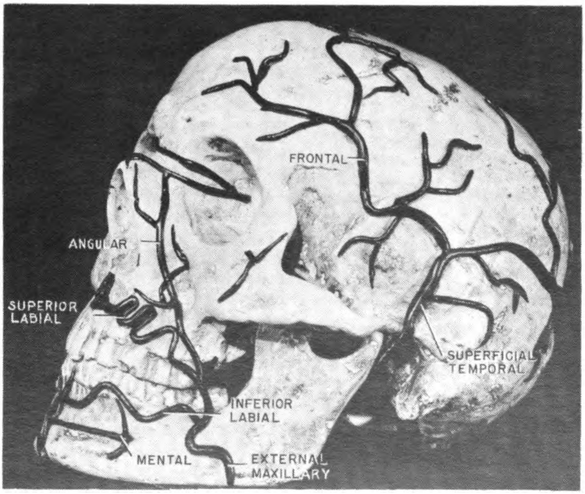

Figure 52.—Superficial arteries of face and scalp.

Arteries of the face

The EXTERNAL MAXILLARY ARTERY, springing from the external carotid artery, is a tortuous vessel which enters the face at the lower anterior border of the masseter muscle, where it is comparatively superficial, being covered by the skin, superficial fascia, and platysma muscle. The artery is easily compressed against the lower border of the mandible at this point. From here it runs forward and upward to the angle of the mouth where a more vertical course is assumed. At this point the external maxillary artery becomes the angular artery, which ascends in the substance of the angular head of the levator labii superioris muscle to the medial commissure of the eyelids, and there terminates. The principal branches are: the communication with the mental, inferior labial, superior labial, lateral nasal and angular arteries.

The SUPERFICIAL TEMPORAL ARTERY is the smaller of two terminal branches of the external carotid artery. This artery arises behind the neck of the condyle, passes upward under cover of the upper portion of the parotid gland, crosses superficially posterior to the end of the zygomatic arch and ascends on the superficial surface of the temporal fascia anterior to the auricle. Its principal branches are the frontal and parietal arteries and the transverse facial artery. Other arteries of the face are: buccinator and infra-orbital arteries from the internal maxillary artery, and frontal and supra-orbital arteries from the ophthalmic artery.

The INTERNAL MAXILLARY ARTERY is the larger of two terminal branches of the external carotid artery. This artery originates immediately posterior to the neck of the condyle and passes forward to the anterior part of the infratemporal fossa, where it disappears from view by dipping between the two heads of the lateral pterygoid muscle. It finally enters the pterygopalatine fossa. The principal branches are: inferior alveolar, middle meningeal, buccinator, deep temporal, posterior superior alveolar, descending palatine, sphenopalatine and infra-orbital. The infra-orbital artery terminates as the anterior superior alveolar artery and supplies the anterior maxillary teeth.

The INFERIOR ALVEOLAR ARTERY runs downward along the lateral surface of the sphenomandibular ligament to enter the mandibular foramen. It is posterior to the inferior alveolar nerve. Just before entering the foramen the artery gives off the slender mylohyoid artery which runs downward and forward, with the corresponding nerve, upon the medial aspect of the mandible to the digastric triangle of the neck.

The BUCCINATOR ARTERY, accompanied by the buccinator nerve, is distributed to the buccinator muscle and the mucous membrane of the cheek. It anastomoses with the external maxillary artery.

The POSTERIOR SUPERIOR ALVEOLAR ARTERY descends upon the posterior aspect of the maxilla and sends branches through the alveolar canals to supply the upper molar and bicuspid teeth. Some small branches go to the mucous membrane of the mouth, and others supply the lining of the membrane of the maxillary sinus.

The SUBCLAVIAN ARTERIES (beneath the collarbone) form the first part of the arterial trunk, supplying the upper extremities. They give off branches to the back, chest, neck and brain. The principal artery is the vertebral which runs upward through the vertebrae to supply the brain. The carotid and the subclavian can be used to control bleeding in an emergency by finger or hand pressure. The points where pressure is applied are known as pressure points.

The subclavian arteries pass over the first ribs and continue laterally as the axillary arteries which give off branches to the chest, shoulders and arms. After passing the armpit the axillary artery becomes the brachial, which gives off branches to the bone and muscles of the arm. Just below the elbow the brachial artery divides and becomes the ulnar and radial arteries. The radial and ulnar arteries continue down the forearm to the palm of the hand where they form the volar arches. The ulnar artery runs on the inner aspect (medial) of the forearm while the radial extends along the outer side. About in the middle of the arm the brachial artery may be felt; here also is a pressure point for emergency control of hemorrhage as well as a point for the application of a tourniquet.

The DESCENDING AORTA extends from the arch of the aorta to the diaphragm. The latter separates the thoracic cavity from the abdominal cavity. The abdominal aorta begins at the aortic opening in the diaphragm and terminates at the level of the fourth lumbar vertebra. It divides into the common iliac arteries.

The COMMON ILIAC ARTERIES run downward for about two inches where they divide into the hypogastric and external iliac arteries. The hypogastric supplies the pelvic region and the buttocks. The external iliac artery forms the first part of a continuous arterial trunk which supplies the lower extremity and extends to the lower border of the inguinal ligament where it passes from the abdomen through the femoral opening and becomes the FEMORAL ARTERY. This is the main artery of the leg. Midway down the leg the femoral artery can be used as both a pressure point and as a point where the application of a tourniquet would control bleeding. The femoral artery runs an oblique course along the femur, inward and backward in the upper three fourths of the thigh to the posterior surface of the knee joint where it becomes the popliteal artery. The femoral artery supplies branches to the bone and muscles of the thigh. The popliteal artery, after giving off branches to the knee joint, divides into the anterior and posterior tibial arteries. The anterior runs down the front of the leg to the top of the foot, and the posterior runs down the back of the leg to the ankle, where it divides into two branches, both of which supply the sole of the foot.

Veins

The veins begin as small branches (venules) which unite to form larger vessels. Veins differ from arteries in that they have a larger capacity, thinner walls and contain valves which assist in supporting the column of blood. This is necessary because most of the cardiac impulse is lost during the course of the blood through the capillaries. The veins are divided into the pulmonary, the systemic and the portal systems.

The pulmonary arteries end as capillaries in the walls of the alveoli of the lungs. After the blood has been oxygenated, it is collected by the venules which unite to form a vein from each of the five lobes of the lung. There are four pulmonary veins carrying blood from the lungs to the left auricle of the heart. These are the only veins which carry arterial or oxygenated blood.

The veins of the systemic circulation are arranged in two sets: the deep and the superficial. The deep veins as a rule accompany their corresponding arteries and are usually called by like names. The superficial veins of the head which drain the venous blood from the scalp and face empty into the right and left external jugular veins. The external jugular veins empty into the subclavian veins.

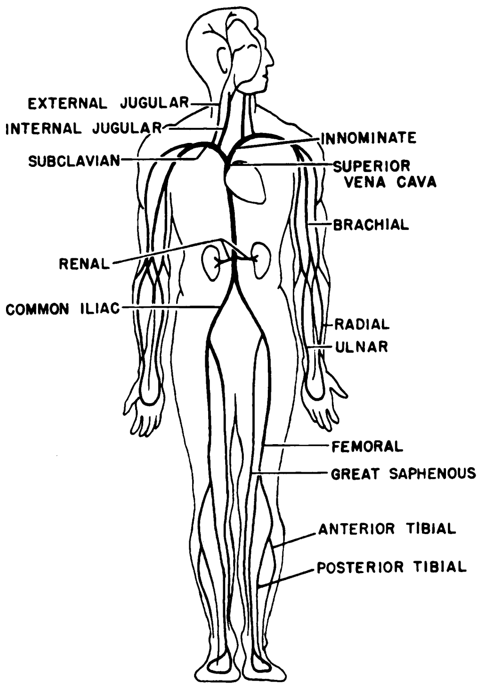

Figure 53.—Venous system. (Diagrammatic.)

Venous blood from the brain and the interior of the skull drains into venous channels situated between two layers of the dura mater of the brain. These channels have the same lining as the veins which empty into them. They are also known as VENOUS SINUSES. The most important ones are the superior sagittal sinus running from front to back across the top of the brain, the two transverse or lateral sinuses, one on each side of the brain, and the two cavernous sinuses. The cavernous sinuses communicate with the veins of the face through the veins of the orbits. Infections in and about the nose and cheeks can readily enter the sinuses through this direct association. The sagittal and cavernous sinuses empty into the transverse sinuses, and they in turn empty into the internal jugular veins, one on each side of the neck.

Veins of the face

The ANTERIOR FACIAL VEIN, which empties into the posterior facial vein and finally into the external jugular vein, is described from below upward. As it passes upward through the infra-orbital region it communicates with the inferior ophthalmic vein which enters the cavernous sinus through the inferior orbital fissure. The upper continuation of this vein, as it crosses the anterior surface of the body of the mandible, is termed the angular vein. This latter vein has its commencement at the medial commissure of the eyelids and is formed by the union of the frontal vein and the supra-orbital veins. There is an orbital emissary vein connecting the angular vein with the cavernous sinus that serves as a by-pass which is completed by the superior ophthalmic vein.

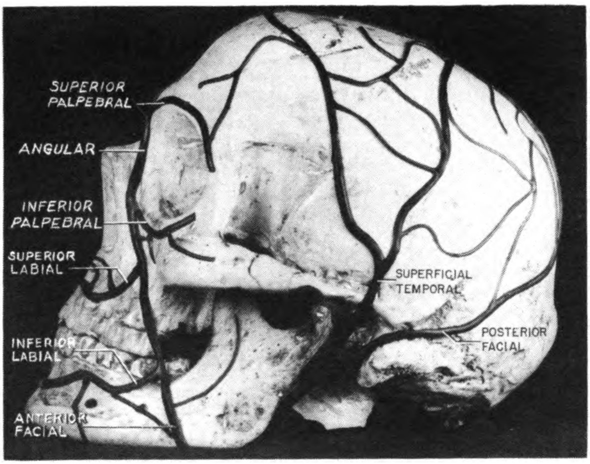

Figure 54.—Superficial veins of face and scalp.

Above, the ophthalmic sinus is connected by the angular vein with the cavernous sinus. Both are pathways of infection from the face and maxillary region. Below, the anterior facial vein communicates with the pterygoid plexus through the deep facial vein. This plexus is connected inferiorly with the pterygopalatine fossa to join the inferior ophthalmic vein and an emissary vein traversing the foramen ovale to reach the inferior and posterior aspect of the cavernous sinus.

The PTERYGOID PLEXUS is a mass of small veins, constituting a dense network around the lateral pterygoid muscle. Tributaries, corresponding to the branches of the internal maxillary artery, open into the network, while the blood is led away from its posterior part by a short, wide trunk, the internal maxillary vein. This vein enters the parotid gland, where it joins the posterior facial vein behind the neck of the condyle. The plexus is connected with the anterior facial vein by an anastomosing channel, the deep facial vein, which descends across the superficial surface of the buccinator muscle.

The inferior labial vein drains the structures in the chin region and passes posteriorly along the lower border of the mandible where it joins with the anterior facial vein to form the posterior facial vein. The latter empties into the external jugular vein.

The SUPERFICIAL VEINS of the UPPER EXTREMITY arise from the dorsal venous arch and the volar venous plexus of the hand and consist of the cephalic, basilic, median and tributary veins. The deep veins of the upper extremity arise from the smaller veins in the hand as the radial and ulnar veins. They meet in front of the elbow to form the brachial veins which continue up the arm to the armpit where they become the axillary vein by uniting with the basilic vein of the superficial set. The axillary vein continues to become the subclavian which unites with the internal jugular to become the innominate vein. The innominate veins continue on down toward the sternum and unite to form the superior vena cava which returns to the heart all venous blood above the diaphragm.

The SUPERFICIAL VEINS of the LOWER EXTREMITY are the long and short saphenous veins. The former arises from the inner aspect of the foot and runs up the leg and thigh to terminate just below the groin in the femoral vein; on the outer side of the leg the short saphenous vein does not go to the groin but terminates just behind the knee in the popliteal vein. The deep veins of the lower extremity—the anterior and posterior tibial—start from smaller veins in the foot and run upward and unite behind the knee to form the popliteal. The popliteal extends up through the lower part of the thigh where it becomes the femoral. The femoral extends upward through the upper two thirds of the thigh and then becomes the external iliac vein, being joined just before its termination by the long or great saphenous vein.

The external iliac vein runs along the brim of the pelvis to join the internal iliac vein to become the common iliac vein. The common iliac veins, one from each side of the body, unite in the region of the fifth lumbar vertebra to form the inferior vena cava which returns to the heart all the venous blood from below the diaphragm.

The PORTAL SYSTEM contains veins which drain the blood from the stomach, intestines, spleen, pancreas and gallbladder. The purpose of the portal system is to subject the blood containing the end products of digestion to the special action of the liver prior to entering the general circulation.

The Lymph and the Lymph Vascular System

LYMPH is a colorless fluid, rich in white blood cells with essentially the same composition as blood plasma, and largely the product of the filtration of the blood plasma through the walls of the capillaries. It is found in the lymph vessels and in all the tissue spaces of the body. Lymph serves as a medium for carrying nourishment and oxygen to, and waste products from, the tissues. The tissues and organs of the body are bathed in lymph which acts as a lubricant in aiding movement. The lymph coming from the small intestine after a meal has a milky appearance because it contains emulsified fat. This milky fluid is called chyle.

The lymph vascular system consists of lymph vessels and lymph nodes (so-called glands) which form a network throughout the body and communicate with serous and tissue spaces. The flow of lymph is always from the tissue toward the terminal lymph vessels and is maintained in this direction primarily by the difference in pressure at the two ends of the system. The terminal lymph ducts are the thoracic duct and the right lymphatic duct which empty into the left and right subclavian veins, respectively.

In many respects the lymph vessels resemble veins. They find their beginning in the tissues and organs of the body where they are known as lymphatic capillaries, and they unite to form larger vessels.

The thoracic duct is the large lymph vessel which receives the lymph from all lymphatic vessels of the body except those from the right side of the head, the right upper extremity, the right chest, the right side of the diaphragm; these latter all empty into the right lymphatic duct. The thoracic duct empties into the left subclavian vein, and the right lymphatic duct empties into the right subclavian vein.

The lymph glands are small bean-shaped bodies that occur in groups of from 2 to 15 along the courses of the lymph vessels, except for a few in the subcutaneous tissue which are single. These groups of lymph glands vary in size and are more correctly known as lymph nodes. They act as filters for the removal of infective organisms and particles from the lymph stream. They also serve as the origin of most of the white blood cells known as LYMPHOCYTES.

THE RESPIRATORY SYSTEM AND RESPIRATION

Respiration is a characteristic of all living organisms. Without it, life cannot survive. It may be defined as the process of gaseous exchange between a living organism and the medium in which the organism lives. The medium in which the animals and plants of the earth live is air, the mixture of gases which surround the earth. The environment of marine animals and plants is water. Among the gases in the air and water is oxygen, which both animals and plants require for their vital processes. These vital processes upon which life itself depends can be summed up in the one word METABOLISM. Metabolism is the sum of all physical and chemical processes by which living organized substance is produced and maintained. Metabolism includes the liberation of energy and elimination of waste. One of the waste products is the gas, carbon dioxide, which is exchanged for oxygen in the process of respiration. In the single-celled animals and plants, the exchange takes place directly between the organism and the surrounding medium; in the more complex animals, with their many layers of intervening cells, some form of respiratory apparatus is necessary. Man and the air-breathing vertebrates are therefore provided with lungs or gills, as in the case of fish, where carbon dioxide is exchanged for oxygen present in the surrounding medium.

The Respiratory Apparatus

In man the respiratory apparatus consists essentially of the lungs and the air passages leading into them—the nasal chambers, the mouth, the pharynx, the larynx, the trachea and the bronchi.

The thorax, the ribs, the diaphragm and other respiratory muscles taking part in respiratory movements may be considered as accessory respiratory apparatus.

The nasal chambers constitute the normal entrance for air to the respiratory tract. They are irregular, wedge-shaped cavities having a vestibule, a respiratory region, and an olfactory region and are covered with a highly vascular mucous membrane, which in the respiratory region serves to warm and moisten the air that has just been inhaled. In the respiratory region there are many fine hairs called cilia which act as filters to remove dust particles from the air passing them. The nasal septum separates the two chambers, both of which communicate with the pharynx.

The mouth, strictly speaking, is a part of the alimentary canal, or digestive tube, but because the back of the mouth connects with the pharynx and respiration can be carried on when the mouth is open, it is sometimes considered a part of the respiratory apparatus.

The pharynx, like the mouth, is also a part of the alimentary canal—the expanded upper part. In the respiratory system it serves merely as a passageway for the air as it connects above with the nasal chambers and below with the larynx.

The larynx, or organ of voice, lies in the upper and front part of the neck, between the trachea and the hyoid bone. Above, it opens into the pharynx, and below, it becomes continuous with the trachea. It is a triangular, boxlike structure made up of several cartilages connected together at certain points by ligaments and membranes; the upper portion of the largest of these cartilages, the thyroid, forms a marked prominence in the midline of the neck which is the so-called Adam's apple. In the upper part of the larynx there is a space commonly called the glottis. Along the sides of this space, extending from front to back and projecting into it, are two pairs of elevated folds of mucous membrane. The folds in the upper pair are called the FALSE vocal cords while those of the lower, more definite pair, are the TRUE vocal cords, the chief agents in the production of voice. Extending upward and backward over the upper opening of the larynx is a thin, leaflike flap of fibrous cartilage called the epiglottis, which, in the act of swallowing, directs the material being swallowed into the opening of the esophagus.

The trachea, or windpipe, is a wide, fibro-muscular tube which extends downward from the larynx about four to four and a half inches, and there divides into the right and left bronchi. It lies in front of the esophagus and its walls consist of fibro-elastic membrane and muscular tissue with a thin lining of mucous membrane. Because of the elasticity of its walls, the trachea has considerable mobility, but to prevent tension on the roots of the lungs during movements of the head and neck, the lower end is fixed in position. Embedded in the fibro-elastic membrane of the trachea is a series of from 15 to 20 horseshoe-shaped cartilaginous bars, which strengthen the tube and keep it patent. These rings are complete in front, but incomplete behind, and consequently, the back wall of the trachea is flattened. In the mucous membrane lining of the trachea are many cilia which help to carry upward and outward any small particles of dust, bacteria, or food which have been aspirated.

The bronchi begin at the two terminal branches of the trachea and are known individually as the right or the left bronchus. They are structures similar to the trachea, but have cartilaginous plaques instead of bars, and each bronchus enters into the corresponding lung. There they branch and rebranch, much like a tree, and the smallest branches, the bronchioles, end in tiny membranous sacs called air vesicles or alveoli. These air cells make up the larger part of the lung substance. The right bronchus is larger, shorter and more vertical than the left, and thus foreign bodies dropping through the trachea are likely to be directed toward it. The alveoli have very thin walls in which blood capillaries are distributed in such numbers that they form the densest plexus of capillaries found anywhere in the body. Hence, on one side of a very thin membrane, there are capillaries containing blood, while on the other side of this membrane is the air. It is through this membrane that the gaseous interchange of the oxygen and the carbon dioxide takes place.

The lungs, two in number, occupy practically all of the thoracic cavity which is divided by the mediastinal septum. One lung is located in each of the resulting two chambers called pleural cavities. The lungs are light, soft, spongy organs made up of alveoli, bronchial tubes, blood vessels, lymphatics and nerves, all held together by connective tissue. They have no intrinsic ability to retain their shape which is dependent upon the absence of air in the cavities which contain them. Should the thoracic wall be perforated, thus allowing atmospheric air to enter the pleural cavity, the lung on that side will collapse. The right lung has three lobes and is larger, broader and shorter than the left, which has only two. The surfaces of the lung next to the ribs are convex and fit the curvature of the thorax; other surfaces are concave and fit the various organs which are in contact with the lungs, one of which is the heart. The heart, of course, is located within the pericardial cavity which separates it from the lungs. Above and behind the heart there is a wedge-shaped depression on each lung known as the hylum within which the bronchus, blood vessels, nerve and lymph vessels enter and leave. These structures are bound together by a sheath of pleura that forms a pedicle or stem by which the lung is attached to the mediastinal wall of the pleural cavity. This stem is called the root of the lung.

There are two types of circulation in the lung: the pulmonary, which brings the blood from the right heart to the lungs for the exchange of gases, and returns it to the left heart; and that from the bronchial branches of the aorta, which supplies the lung tissue itself.

The nerve supply of the lung is from the vagus and the sympathetic nervous system. The pleura is a serous membrane which envelops the lungs and lines the walls of the thoracic cavity. There are two pleurae, right and left, entirely shut off from each other. The inner surface of the pleura has a smooth, glossy appearance, and is moistened with a small amount of serous fluid. The portion of the pleura which covers the lungs is known as pulmonary or visceral pleura and is very firmly bound down to the surface of the lung. It is very thin and completely covers the entire surface of the lung. At the root of the lung, the pulmonary pleura turns back on itself to line the walls of the pleural cavity, and is then known as the parietal pleura. The parietal pleura, according to the different parts of the thoracic cavity it lines, is also known as the costal pleura, the diaphragmatic pleura, the mediastinal pleura and the cervical pleura. The serous fluid of the pleura acts as a lubricant and facilitates respiratory movements of the lungs with little, if any, friction. The inner surface of the pleura sometimes becomes roughened by inflammation; this condition is known as PLEURISY.

The Process of Respiration

To explain the process of respiration the behavior of gases in contact with liquids must be considered first. If a glass of water were placed in a closed cabinet containing oxygen gas, a definite amount of oxygen would dissolve in the water. The amount dissolving would depend on the temperature of the water and the pressure of the oxygen. In case anything else in the water reacted with it, more oxygen would dissolve in an attempt to keep the water saturated. Placing a new portion of water in the cabinet would result in the oxygen trying to keep this new portion saturated also. The speed of solution of the gas would depend on the amount of surface area of water exposed—the greater the surface, the faster the solution.

Taking the opposite case in which the liquid contains a dissolved gas and the atmosphere is not saturated with that gas, the gas will come out of solution and try to saturate the atmosphere. A good example of this is the carbonated beverage. Carbon dioxide (CO_2) has been forced to dissolve in the liquid at high pressure and then is held there by the cap. Pulling the cap releases this pressure and the beverage at once attempts to reach an equilibrium pressure of CO_2 with the air. Because air normally has only a small amount of CO_2, the drink loses virtually all its CO_2 and goes flat.

The lungs may be considered as very large surfaces over which the blood is spread and at the same time contained in capillaries. The capillaries are sufficiently porous to allow gases to pass through them in either direction. When a breath is taken the air is in contact with the blood, and all gases in the air attempt to saturate the blood. Oxygen is taken up by hemoglobin as fast as it goes into solution so that much more than the amount necessary to saturate the blood is actually taken up. At the same time the blood is rich in CO_2 and tries to saturate the air with this gas. Water is also in excess in the lung and this passes into the air as water vapor. When a breath is expelled, then, the air leaving the lungs contains less oxygen than it carried in and more CO_2 and water vapor. The whole process is external respiration. The similar exchange that occurs in capillaries between the blood and the tissues of the body may be called internal or TISSUE RESPIRATION. Tissue respiration is the respiration truly vital to life. In the preceding section on blood, it was stated that the blood carries oxygen from the lungs to the body tissues, and carbon dioxide from the tissues to the lungs. The oxygen required by the tissues is carried to them principally in chemical combination with the hemoglobin in the red blood cells.

Only a very small amount is carried in physical solution for oxygen is a comparatively insoluble gas. In oxyhemoglobin which is formed by the chemical combination of hemoglobin and oxygen, the hemoglobin is almost completely saturated with oxygen. The carbon dioxide produced in the tissues during metabolic activities is removed from the tissues in chemical combinaton wth hemoglobin, with constituents in the plasma, and in physical solution in the plasma. Carbon dioxide is a very soluble gas, and upon reaching the plasma, some of it dissolves to form carbonic acid, which reacts with sodium chloride in the plasma and produces sodium bicarbonate. A small amount is retained in the plasma in simple physical solution. The remaining carbon dioxide enters into chemical combination with hemoglobin to form carbohemoglobin. Oxygenated blood reaches the tissues through the blood capillaries where the oxygen content, and consequently its pressure, is higher than in the tissues. This difference in oxygen pressure causes the oxyhemoglobin, which under those conditions has the property of disassociation, to give off free oxygen, which diffuses through the thin walls of the capillaries and the lymph into the tissues and cells. The blood, having given up its oxygen to the tissues, again contains uncombined, or reduced, hemoglobin and therefore is ready to take up carbon dioxide. The carbon dioxide now being under higher pressure in the tissues than in the blood, diffuses from the tissue cells through the lymph and the capillary walls into the blood, where it is taken up as was explained previously. The waste-carrying blood is pumped to the lungs where the oxygen pressure in the alveoli is higher, and the carbon dioxide pressure lower than in the blood. Therefore, in the lungs the carbon dioxide which was changed into sodium bicarbonate changes back to carbon dioxide on reaching the capillaries in the alveoli. The lower pressure of the carbon dioxide in the alveoli permits the carbon dioxide in the blood to diffuse through the thin walls of the capillaries and of the alveoli until an equilibrium in pressure between the carbon dioxide in the blood and the alveoli is reached. At the same time, the higher pressure of oxygen in the alveoli causes it to diffuse through the walls of the alveoli and the capillaries and enter the blood, where it combines with the reduced hemoglobin, and oxyhemoglobin is once again formed in the blood. In the lungs, the blood does not ordinarily give up all its carbon dioxide. Some carbon dioxide is required for the maintenance of respiration. It acts as a stimulant to the respiratory center in the medulla. The chemical change attendant upon the formation of sodium bicarbonate from carbon dioxide plays an important part in maintaining the slightly alkaline reaction of the blood.

The ordinary automatic rhythmic movements of respiration are controlled by the respiratory center in the medulla oblongata which originates the impulses causing them. These impulses pass down the spinal cord to the nerves which supply the respiratory muscles. Probably, the most important of these nerves is the phrenic, which supplies the diaphragm; others are the vagus, supplying the larynx; and the intercostal, supplying the muscles of the thorax and abdomen. The respiratory center is affected by various conditions; thus the respiration is also affected. An increase in the amount of carbon dioxide, which has acid properties, increases the acidity of the blood, and is immediately followed by increased respiratory movement. A decrease in the amount of carbon dioxide in the blood can cause all respiration to cease until the normal amount of carbon dioxide is once again present in the blood. The carbon dioxide then stimulates the respiratory center and breathing is resumed. External sensations may affect the respiratory center. For example, if one were running along the side of a mountain stream and suddenly plunged into the cold water, he would experience a deep, gasping respiration. Also, in excitement, the respirations may increase, while in shock they are usually shallow and sighing. As has been stated in the previous chapter, the respiratory muscles ordinarily act automatically without conscious effort of the will. Activity of these muscles produces alternate inspirations and expirations of air in and out of the lungs which, with a period of rest between movements, constitutes what is called the cycle of respiration. This cycle is divided into three phases: the first phase, inspiration or the flow of air into the lungs; the second phase, expiration or the flow of air out of the lungs; the third phase, a period of rest. The cycle is completed about fourteen to eighteen times per minute in the normal adult while at rest. During inspiration, the diaphragm contracts and the ribs are elevated by the accessory muscles of respiration, thus enlarging the thoracic cavity and creating a negative pressure in the cavity. This forces the lungs to expand and causes the outside air to rush in and equalize pressure. In expiration, the diaphragm relaxes and the elasticity of the lungs, together with the weight and pressure of the relaxed chest walls, allows the chest to return to its original size, thus expelling a certain amount of air from the lungs. The lungs, when filled to their utmost capacity, hold about 4,500 cc. of air. Practically 500 cc. of air is breathed out at a normal, quiet expiration. This air which is changed at each expiration is called the TIDAL AIR. The amount of air breathed out or in may be increased by forceful expiration and inspiration. The amount of air left in the lungs after the most forceful expiration is about 1,000 cc. and is known as the RESIDUAL AIR. Under normal conditions the reserve supply of air in the lungs is about 2,600 cc. Certain abnormal types of breathing may be noted. Dyspnea is labored or difficult breathing. Apnea is a condition in which there is a cessation of breathing. Hyperpnea is an abnormal exaggeration of, or extremely deep, respiration. Prolonged interference with the aeration of the blood may produce a condition called ASPHYXIA. This may or may not be a temporary state of oxygen starvation.

THE DIGESTIVE SYSTEM AND DIGESTION

The digestive system consists of the alimentary canal and its accessory organs. The alimentary canal is a continuous tube, extending from the mouth to the anus, 28 to 30 feet long. It is composed of the mouth, the pharynx, the esophagus, the stomach, and the small and large intestines. The accessory organs of digestion are the teeth, the tongue, the salivary glands, the liver, gallbladder and the pancreas. The mouth is nearly oval in shape, and is formed in front by the lips, above by the hard palate in front and the soft palate behind, laterally by the cheeks and below by the floor of the mouth and the tongue. This cavity opens posteriorly into the pharynx, from which it is partially separated by the uvula, a small flap of mucous membrane which hangs from the soft palate. The anterior pillars of the fauces are two curved folds of mucous membrane running from the uvula to the sides of the base of the tongue. In the small depression between the anterior and posterior pillars of the fauces on either side, is a small mass of lymphoid tissue called the tonsil. The tongue is a muscular organ occupying the floor of the mouth. It is covered with mucous membrane, contains the special organs of taste, is an important organ of speech and assists in the mixing and swallowing of food. The salivary glands consist of three pairs which

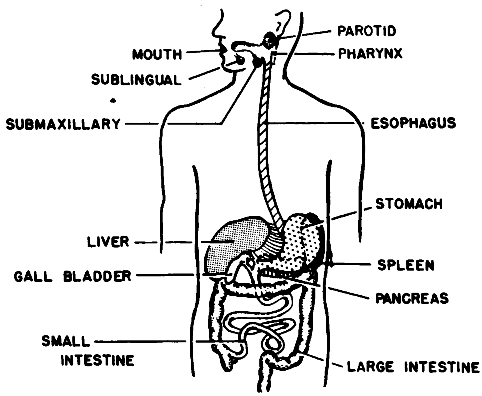

Figure 55.—Digestive tract. (Diagrammatic.)

discharge their secretion, saliva, into the mouth. The parotid glands, situated in front of and below the ears, discharge their secretion by way of Stensen's ducts, which enter the mouth opposite the upper second molar teeth. The submaxillary glands lie beneath the lower jaw and the sublingual glands, which lie beneath the tongue, discharge their secretion by way of ducts opening into the floor of the mouth. The pharynx is the expanded upper portion of the alimentary canal; it lies behind and communicates directly with the mouth, the nasal chambers and the larynx. By means of the eustachian or auditory tubes, it also communicates with the tympanic cavity, or the middle ear. That part of the pharynx which is above the level of the soft palate is used only for respiration; the lower part is used primarily for passage of food. This muscular structure extends from the base of the skull above, to the level of the sixth cervical vertebra below, where it joins and is continuous with the esophagus. This organ is somewhat funnel shaped with the widest portion at the top. The esophagus, or gullet, is a muscular tube about ten inches long extending from the pharynx above to the stomach below. Situated near the median line of the body it is inclined slightly to the left. The upper part lies directly behind the trachea and in front of the vertebral column. Passing downward in front of the vertebral column through the thoracic cavity, the esophagus pierces the diaphragm about one-half inch above its termination at the cardiac opening of the stomach. The walls of the esophagus contain an inner lining of mucous membrane, a middle layer of connective tissue, and an outer coat of both voluntary and involuntary muscle tissue. The remaining parts of the digestive system are located in the abdomen, which will be described briefly before continuing with the digestive system.

The Abdominal Cavity

The ABDOMEN is that portion of the trunk lying below the diaphragm. It consists of a wall made up in part of bone, muscles and tendons; it is the largest cavity in the body. The stomach, liver, gallbladder, intestines, pancreas, spleen, kidneys, bladder, some of the generative organs, blood vessels and nerves are located in the abdominal cavity. The cavity, for descriptive purposes, is considered in two parts: an upper, larger part called the abdomen proper, and a lower, smaller portion called the pelvis. The abdominal cavity in the adult male is shaped much like a barrel; the upper end is bounded by the diaphragm and is somewhat wider than the lower end. A continuous smooth membrane known as the peritoneum lines the wall of the abdominal cavity and the surfaces of the organs within it. The peritoneum itself is a thin, glistening, serous membrane which secretes a small quantity of serous fluid known as peritoneal fluid. This fluid, secreted from the flattened endothelium, lubricates the inner surface of the peritoneum and thus permits movement of the structures inside the cavity with the least degree of friction. The serous fluid which lubricates the pleura was discussed in the preceding chapter on respiration. In the male, the peritoneum is a completely closed sac, but in the female it is indirectly open to the surface. The portion of the peritoneum lining the walls of the abdominal cavity is known as the parietal peritoneum; that which covers the organs or viscera is known as the visceral peritoneum. Parts of the duodenum, colon, bladder and kidneys are not covered with peritoneum; however, the remaining principal abdominal organs are completely enveloped by it. Numerous folds of the peritoneum extend between the various organs and serve to connect them with the posterior wall of the abdomen and with one another. The various ligaments of the liver, and the mesentery, which holds the intestine in place and contains the vessels which supply it, are examples of these folds. The omentum is an apron-like structure composed of four layers of peritoneum. It is freely movable and is of service in walling off inflammations or infections within the abdomnal cavity.

The stomach

The STOMACH is a hollow, muscular organ which is situated in the abdomen between the esophagus above and the small intestine below. In shape, it is much like a gourd; the wide upper end, the fundus, lies in the hollow of the diaphragm and is directed upward and backward to the left. The fully distended stomach of an adult is about 10 to 11 inches in length with its greatest diameter 4 to 4½ inches. Its average capacity is about 2 to 2½ pints. The size and shape of the stomach depend considerably upon its contents. The stomach has two openings: one at the upper end called the cardiac orifice and one at the lower intestinal end, the pyloris or pyloric orifice. The portion of the stomach about the cardiac orifice is naturally termed the cardiac part and the portion of the stomach about the pyloric orifice is termed the pyloric part. The remaining portion is termed the body of the stomach. It is a rounded chamber, capable of great distension and will contract to a narrow, tubelike structure when the stomach is empty. The walls of the stomach consist of four layers of tissue. From within outward they are: a thick lining of mucous membrane, a layer of strong connective tissue, a muscular layer, and an outer coat of serous membrane which consists of the peritoneum. When the stomach is empty, the three outer coats contract and the inner coat is thrown into many folds. When the stomach is full and distended, these folds disappear. Within the inner lining are numerous glands which secrete the gastric juice.

The intestines

The INTESTINE is a muscular, membranous tube about 28 feet long. It begins at the pyloric orifice of the stomach and ends at the anal orifice which opens on the surface. It consists of the small and the large intestine which together occupy a large portion of the abdominal and pelvic cavities. The small intestine is about 23 feet long, and is divided into three parts: the first, the duodenum, is about 1 foot long; the second part, the jejunum, is about 9 feet long; the third part, the ileum, is about 13 feet long. The duodenum presents a horseshoe-shaped curve and is closely fixed to the posterior abdominal wall. The jejunum and the ileum form a series of irregular loops which are movable.

Like the stomach, the SMALL INTESTINE is made up of four layers of tissue. These layers have the same names as those found in the stomach. The mucous membrane of the small intestine lies in folds, some of which disappear when the intestine is distended, while others are permanent. This membrane presents a soft, velvety appearance imparted to it by a large number of very tiny, finger-like projections called villi. The villi contain small blood capillaries and lymph vessels, called lacteals, which play an important part in the process of digestion by collecting digested food products. Many simple glands which secrete a digestive fluid known as the intestinal juice are located in the mucous lining. The small intestine opens into the large intestine through the ileocecal orifice at the junction of the cecum with the ascending colon. This opening is guarded by a valve called the ileocecal valve which prevents the regurgitation of contents of the large intestine into the small intestine.

The LARGE INTESTINE begins on the right side, about two and a half inches below the ileocecal junction, and extends to the anus. It is approximately 5 feet long, larger in diameter than the small intestine, and is divided into the following parts: The cecum, the ascending colon which curves at the lower border of the liver; the transverse colon, which crosses the abdominal cavity from right to left to the splenic region where it curves downward forming the splenic flexure; the descending colon, which descends to the brim of the pelvis over which it curves to form the sigmoid flexure; and the rectum, the terminal dilated portion of the intestine that communicates with the outside through the anal orifice. The walls of the large intestine are of the same structure and arrangement as those of the small intestine, except that the longitudinal muscle fibers in the large intestine are arranged in three bands which extend the entire length of the colon; they are a little shorter than the colon, thus causing the walls to pucker. The mucous membrane of the large intestine is smooth and contains no villi, but secretes a mucus which lubricates the tube. At the blind end of the cecum is a small, wormlike projection called the vermiform appendix, often the seat of the pathologic condition known as appendicitis.

The liver

The LIVER is the largest gland in the body, and weighs from 50 to 60 ounces in the normal adult. Shaped like a wedge, it is located in the upper part of the abdomen, directly beneath the diaphragm on the right side. The liver is divided into five lobes by five fissures, the largest of which is the transverse fissure through which the vessels, ducts and nerves enter and leave the organ. The liver is made up of many minute lobules of liver cells arranged concentrically about a central vein. Bile is both an excretion, which carries off certain waste products, and a secretion, which plays an important part in the emulsification and absorption of fat. Bile aids in preventing putrefaction and helps produce an alkaline reaction in the liver and intestine. It is secreted from the liver and stored in the gallbladder which is located on the lower surface of the liver in the gallbladder fissure. This fluid varies in color from thin, greenish yellow to golden brown and has a specific gravity varying from 1.05 to 1.10. It contains a pigment, bilirubin, which is derived almost entirely from the breakdown of hemoglobin in the liver. The many important functions of the liver include: (1) Bile-secreting; (2) glycogenic—the glycogen is manufactured from monosaccharides brought to the liver from the digestive tract by the portal vein. Glycogen is stored in the liver and is reconverted into dextrose by the action of a special enzyme whenever the body activities require it; (3) fat-storing; (4) urea-producing—it takes up nitrogenous waste products from the blood and converts them into urea which is discharged back into the blood stream for elimination by the kidneys; (5) waste-removing—by means of the bile, certain other waste products are produced such as broken-down red corpuscles, disintegrated liver cells and bile pigments; (6) source of fibrinogen and prothrombin.

The pancreas

The PANCREAS is a compound gland which is situated in the abdomen behind the stomach at about the level of the second lumbar vertebra. It secretes pancreatic juice, a digestive fluid which contains some of the chief agents concerned with digestion, and is carried to the duodenum by the pancreatic duct. In the connective tissue between the lobules of the gland are small areas of modified glandular tissue cells which have no ducts. They are known as the islands of Langerhans, are thought to secrete a substance called insulin which is discharged directly into the blood stream and is concerned with the metabolism of carbohydrates.

The Process of Digestion

Before describing the process of digestion, the substances used as foods must be briefly considered. FOODS are those substances necessary to maintain the normal composition of the body by nourishing and building up tissues or, by oxidation, supplying heat or energy. Foods include:

1. Water.
2. Inorganic salts, such as those of sodium, calcium, potassium, magnesium and iron.
3. Vitamins, which are organic chemical compounds essential to normal life and growth.

4. Proteins, which are nitrogen-containing substances, examples of which are lean meats and leguminous vegetables.
5. Carbohydrates (starches and sugars).
6. Fats (animal oils and vegetable oils).

Water, inorganic salts and vitamins are very essential to life, but in themselves have no energy-producing properties and therefore are not foods in the strict sense of the word. They are necessary to maintain the normal composition of the tissues. Complete withdrawal of either water or organic salts would cause the death of the organism. The body's energy is derived from proteins, carbohydrates and fats. After ingestion, these substances must undergo various chemical changes, METABOLISM, before they can be utilized by the body. These chemical changes take place during the process known as digestion. In digestion the complex molecules are broken into smaller forms and heat is evolved. The tissue cells are able to utilize the smaller forms only. The process of digestion begins in the mouth and ends in the small intestine. This process is both mechanical and chemical. The mechanical features include the chewing and grinding of the food, the passage of the food along the alimentary canal by muscular action and the mixing of the food by dilution and solution in aqueous secretions. The chemical changes that take place are brought about by the action of enzymes or digestive ferments. These substances effect the transformation of other compounds by catalytic action. Such an action is one in which a change is produced in a substance by contact with another substance called a CATALYST. When the action is completed, the catalyst appears to remain unchanged, although it has produced reactions in the other substance. Enzymes produced in the living body cells could well be termed organic catalysts because they bring about necessary changes in foods to be used by the body.

In the process of digestion, food is first taken into the mouth where mastication is accomplished by the teeth of the maxillae and the mandible. Following this mechanical dividing and grinding, the food presents a larger surface area for the action of the saliva. During the mastication period, the saliva pours into the mouth from the salivary glands and is mixed with the food through the movements of the tongue and the muscles of the cheeks. This serves to moisten and soften the food. Starches are converted into sugar through the action of the salivary enzymes—PTYALIN and MALTASE. The SALIVA is a colorless, turbid and viscid liquid with a specific gravity of about 1.003, and a neutral or slightly acid reaction. The enzyme, ptyalin, converts starch to maltose. Maltase breaks up the maltose into dextrose. The presence of food in the mouth and the sight and smell of appetizing food act as nerve stimuli to increase the amount of saliva necessary for digestion. A person who has had the experience of passing by a bakery will recall that the flow of saliva had increased as a result of seeing the food and smelling it. When food has been reduced to a consistency suitable for swallowing, it is formed into what is known as a BOLUS. By deglutition, or swallowing, the bolus passes from the mouth to the pharynx, and then into the esophagus through which it is carried to the stomach. The act of swallowing is largely voluntary, but the final stage in the passage of the bolus through the pharynx and esophagus is the result of involuntary muscular action. The musculature of the esophagus causes a contraction of the tube immediately after the passage of the bolus, which follows the bolus downward like a wave, finally forcing it through the cardiac opening of the stomach. This wavelike contraction that forces the bolus of food along its path is called PERISTALSIS. In the stomach, the food which has been swallowed is thoroughly mixed with the gastric juice by the muscular movements of the stomach walls. As digestion proceeds in the stomach, the food becomes a thin, liquid mass known as CHYME, portions of which periodically pass through the pyloris into the duodenum. Within the mucous membrane of the stomach lie a great many simple gastric glands. Their function is to secrete the gastric juice which has the specific gravity of about 1.002 to 1.003. It is strongly acid in reaction due to the presence of hydrochloric acid. There are three enzymes which may be found in gastric juice: pepsin, rennin and lipase. The flow of gastric juice occurs partly in response to nerve impulses sent to the stomach as a result of the sensory impression of taste and smell received in the brain, and partly by the presence of chemical substances in the stomach itself. The food on mixing with the gastric juices becomes acid in reaction. The hydrochloric acid in the gastric juice stops the action of ptyalin, aids in coagulating proteins and activates PEPSIN. This enzyme prepares protein for complete digestion by breaking it down into simpler chemical compounds known as peptones and proteoses. The enzyme RENNIN, which is present in many persons only during early life, precipitates casein from the caseinogen in milk and causes the milk to clot or curdle. LIPASE, also called steapsin, is a fat-splitting enzyme which has very little activity in the stomach, but probably serves to split up the emulsified fat found in milk. The chyme, on passing into the duodenum from the stomach, consists of water, inorganic salts, partially digested food and the indigestible portions of meats, cereals and fruits. The acid character of the chyme causes the secretion of intestinal fluids by glands and mucous membrane of the duodenum and the small intestine. The chyme also accelerates the secretion of the pancreatic juice and the bile. The intestinal fluids, which are alkaline in reaction, exert a neutralizing and precipitating influence on the various constituents of the chyme, and as soon as this occurs, gastric digestion stops and intestinal digestion begins.

Intestinal digestion is largely completed by the time the food reaches the ileocecal valve. Necessary changes are produced in the food to allow for absorption. In the intestine, the food is subjected to the action of the pancreatic juice, the intestinal juice and the bile; all act at the same time. The pancreatic juice in man is a thin liquid with a specific gravity of about 1.0075 and is alkaline in reaction. It contains four enzymes: TRYPSIN, EREPSIN, AMYLASE and LIPASE. Human bile plays an important part in the digestion and absorption of fats, because it accelerates the action of lipase and perhaps amylase, and helps in the neutralization of the hydrochloric acid. It is also considered an aid in lubricating the intestine to facilitate the passage of indigestible and waste material. Peristaltic movement forces the foodstuff along the small intestine until finally it enters the large intestine, at which time digestion is virtually complete. When the content of the small intestine enters the large intestine, it contains some unabsorbed food materials; it can also contain digestive enzymes received in the small intestine, and it is probable that digestion and absorption continue for a time in the large intestine.

The indigestible waste material, combined with certain waste substances from the bile and intestinal secretion, passes slowly along the large intestine by peristaltic movement and rapidly loses its water content by absorption. By the time it reaches the descending colon, it has acquired the consistency of feces. By digestion, the carbohydrates, proteins and fats contained in the various foods that have been ingested have been changed into substances of simpler chemical composition. Starches and compound sugars have been changed into simple sugars, proteins have been broken down into amino acids and their derivatives, fats have been finally emulsified and split into fatty acids and glycerin, all of which are suitable for absorption and assimilation. The absorption of digested food takes place principally from the small intestine and is the process by which fluid or other substances from the alimentary canal are taken up by the blood or lymph vessels. Absorption from the small intestine takes place in two ways: by the capillaries of the villi to the blood stream and by the lymphatics to the thoracic duct and the superior vena cava. The products of fat digestion are taken up chiefly by the lymph capillaries in the villi and carried by the lymph vessels via the thoracic duct into the blood stream at the junction of the left internal jugular and the left subclavian veins. A small amount of fat is absorbed by the blood capillaries and a portion of it is appropriated by the liver for its own use and for storage. The products of protein and carbohydrate digestion are taken up by the blood capillaries of the villi and carried through the portal circulation to the liver. In the liver, the excessive dextrose is withdrawn and changed to glycogen by the action of the liver cells, thereby maintaining a constant amount of sugar in the blood. Some of the amino acids are also converted to glycogen by the action of the liver cells. This liberates urea which is carried in the blood to be excreted by the kidneys. The glycogen is stored in the liver to be liberated again as dextrose when needed by the body.

THE NERVOUS SYSTEM

The ability of the human organism to adapt itself to its surroundings or environment, to coordinate and regulate the activities of its various parts so that they work harmoniously together, and to reason, is due solely to the presence in it of nerve tissue. This is the most highly specialized tissue in the body. It is present in every part of the body in the form of nerve cells, small masses containing nerve cells called nerve centers, or ganglia, and conducting or connecting elements called nerve fibers, bundles of which are termed NERVES. These forms, collectively constitute the complex apparatus known as the nervous system, frequently spoken of as the "ruler of the body."

Primitive System

The lowest form of animal life, the unicellular animal organism such as the Amoeba, possesses no distinctive nervous system but adapts itself to its surroundings by the property of irritability which is inherent in the protoplasm of which it is composed. The single cell animal moves about and carries out its processes of metabolism and reproduction entirely within and by itself and always reacts in the same way to any specific stimulus.

A little higher form of animal life, the Metazoon, has a soft, semifluid body of protoplasm consisting of groups of cells which stick together. Most of these cells, originally derived from a single parent cell, have lost their characteristics as individual cells and have become specialized for certain functions. Some are specialized so that they link the different parts of the body of this water-dwelling animal together with a primitive nervous system which deals with outside impressions, brings about necessary movements and controls various living activities. Other cells are specialized to form a supporting substance (primitive skeleton) and others are specialized to provide for movement (primitive muscles). In all parts of the outer supporting substance are cells which are specialized to receive external stimuli and are known as sensory or receptor cells. From the receptor cells extend two elongated portions called processes. One, the peripheral process, passes toward the surface and may even pass beyond it. The other, called the central process, passes inward into the body and connects with a network of cells of the nervous system called connector cells. The connector cells communicate with each other by processes and have other processes reaching still deeper into the body, connecting with motor or effector cells, which have processes distributed to the primitive muscles of the animal. Thus a means is provided by which a sensation or impression of danger received by a receptor cell can be carried to a connector cell and thence, through the network of connector cells, to a number of motor cells. As a result of stimulation of the motor cells there occurs a general response of the primitive muscles and the animal moves away from the point of danger. Such a general muscular response to a local stimulus is always the same if conditions of stimulation are the same.

Nerve elements

In producing the movement just described three basic nerve elements have been shown to exist: (1) The receptor or sensory cells, (2) the network of connector cells, and (3) the motor or effector cells. These basic elements are found in the nervous systems of all forms of animal life higher than the Metazoon, with such modifications as are necessary to permit a particular type of animal to carry out its purpose in life.

Nerve cord system

When the higher stage in animal life represented by the earthworm, or Lumbricus, has been reached, there has evolved from the primitive nervous system one in which there is a central, controlling part, quite distinct from a peripheral portion of nerve fibers carrying impulses to or from the central part. In the earthworm this central part consists of a nerve cord running longitudinally through the entire length of the body, in each segment of which the nerve cord is slightly swollen or enlarged on each side. These enlargements are collections of nerve cells called ganglia from each of which, nerves pass off to each side. Some of these nerves are motor and are connected with muscles; others are sensory and end in receptor or sensory cells in the covering of the body. Close to the front end of the worm is located a single pair of ganglia called the cerebral ganglia which are connected with each other by a bridge of nerve fibers. From the side of each cerebral ganglion a strand of nerve fibers curves around the side of the worm's alimentary canal and connects with the first ganglion of the nerve cord. In the more highly developed animals the brain may be said to be represented by the cerebral ganglia, the spinal cord by the nerve cord, the pairs of spinal nerves, and the ganglia on the nerve cord.

In the higher animals modification and evolution of the primitive nervous system of the Metazoon has proceeded to the point where a central nervous system consisting of the spinal nerves has been developed. The primitive connector cells and their processes, and the primitive motor cells without their processes, have collected to form the central nervous system and ganglia of sensory nerves. In the evolution of nerves, the processes of the primitive receptor or sensory cells have formed sensory or afferent nerves which pass into the central nervous system while the processes of the primitive motor or effector cells have formed motor or efferent nerves which pass out of the central nervous system. If, for convenience, both sensory and motor fibers are carried in the same nerve trunk, that nerve trunk is known as a mixed nerve. The cranial nerves arising from the brain and the spinal nerves arising from the spinal cord are typical examples of mixed nerves. With this evolution of the nervous system there have been developed special receptors for the functions of sight, smell and hearing; in the highest forms of animal life certain parts of the brain have enlarged to enable it to control the many complex functions and movements of the body.

For the purposes of study and description in this book, the nervous system will be considered as divided into three parts, the CEREBROSPINAL or central nervous system, the PERIPHERAL nervous system and the SYMPATHETIC nervous system. For the same purposes, the impulses carried by the afferent or sensory nerves will be termed IMPRESSIONS while those carried by the efferent or motor nerves will be termed IMPULSES.

The central nervous system consists of the brain, or encephalon, contained within the cranial cavity, and the spinal cord, or medulla spinalis, which occupies the upper two-thirds of the spinal canal. The brain and the spinal cord dominate the entire nervous system.

The peripheral nervous system consists of 12 pairs of cranial nerves attached to the brain and 31 pairs of spinal nerves attached to the spinal cord. These nerves are associated with the functions of the special and general senses and with the voluntary movements of the body.

The sympathetic nervous system is often considered as part of the peripheral nervous system with which it is intimately connected and closely intermingled. It is also known as the autonomic, vegetative, and ganglionic nervous system. This system controls the automatic or involuntary muscles of the body.

Histology

Nerve tissue is made up of nerve cells, or neurons, and their processes, held together in the brain and spinal cord, by a special supporting tissue called the neuroglia and by ingrowths of the membrane covering the brain and spinal cord, the pia mater. The nerve cell, or NEURON, is the unit of structure and of function in the nervous system; it varies in size, shape and structure, and consists of the cell body, or cyton, and one or more processes extending out from the body. Nerve cells having but one process are called unipolar cells; those having more than one, multipolar cells. The cell body, consisting of nucleated protoplasm, is the origin of the changes which give rise to nerve impulses and presides over the nutrition of the cell. The processes of nerve cells are outgrowths of the cell body and provide the pathways along which nerve impulses are carried. They are of two kinds: the axon, or axis-cylinder process, a single, unbranched process which lengthens out to become the axis-cylinder or conducting part of a nerve; and the dendrite, or protoplasmic process, a short process that divides into smaller and smaller branches which terminate in free ends in the nervous tissue. The axons vary in length, some extending only a very short distance beyond the cell while others continue to more distant parts of the body. The longer processes, which usually acquire protective sheaths, are known as nerve fibers, and these, arranged in bundles, form the nerves, or nerve trunks, which pass to every part of the body.

Nerve fibers are the conducting elements of the nervous system and bring the nerve cells into relation with each other and with the various tissues of the body. They constitute the greater part of the brain and the spinal cord, make up the nerves, and are known as medullated or white fibers and nonmedullated or gray fibers; the difference is due to the presence or absence of the white medullary sheath. The central and essential part of a nerve fiber is the axis-cylinder which, in medullated fibers, is surrounded by the medullary sheath or white substance of Schwann,

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and the whole enclosed in a delicate membrane called the primitive sheath or neurolemma. The axis-cylinder, in nonmedullated fibers, is surrounded by a delicate nucleated sheath corresponding with the neurolemma of the medullated fibers. Medullated nerve fibers form the white part of the brain and the spinal cord and the greater part of every cranial and spinal nerve; nonmedullated fibers compose most of the sympathetic nervous system and some of the central system. The medullated fibers constitute the white matter of the nervous system; the nonmedullated fibers, the gray matter.

Physiology

Nerves usually are classed according to the impressions or impulses they conduct and the direction in which the impression or impulse is carried. Afferent nerves conduct impressions of pain, hunger or feeling from all parts of the body into the central nervous system, and since these impressions are spoken of as sensations, afferent nerves are also known as sensory nerves. Efferent nerves conduct impulses from the brain and spinal cord to the parts to which nerves are distributed. Most efferent nerves go to muscles and are commonly termed motor nerves; those that go to secreting glands are called secretory nerves; while those that restrain or check movement or secretions are called inhibitory nerves. As stated before, some nerves have both afferent and efferent fibers and are known as mixed nerves.

The Cerebrospinal Nervous System

The brain, the largest and most complex mass of nerve tissue in the body, weighs about 3 pounds and fills the cranial cavity of the skull. It is continuous with the spinal cord at the foramen magnum, is very vascular, and when observed in life is seen to pulsate. The outer layer of the brain, the cortex cerebri, is made up of gray matter and the deeper parts of white matter. The gray matter, composed largely of nerve cells, receives and stores afferent impressions and transforms them into efferent impulses; the white matter, consisting principally of nerve fibers, conducts the efferent impulses. The brain is covered by three membranous coats, the meninges, which named from without inward, are: the DURA MATER, the ARACHNOID and the PIA MATER.

The dura mater

The dura mater, a dense membrane of fibrous connective tissue, contains many blood vessels and is arranged in two layers, except in a few places. The outer layer of the dura mater is adherent to the inner surfaces of the bones of the skull and forms bone periosteum. The inner layer covers the brain and sends numerous prolongations inward for the support and protection of the lobes of the brain. These projections form the venous sinuses through which the blood is returned from the brain to the large veins of the neck. They also form the sheath for the nerves leaving the cranial cavity. The inner layer continues through the foramen magnum into the spinal canal where the spinal cord is invested.

The arachnoid

The arachnoid, a delicate serous membrane, lies between the dura mater and the pia mater. Except in the longitudinal fissure of the brain this membrane does not dip down into the crevices and depressions of the brain. Between the arachnoid and the pia mater is a space called the subarachnoid space, in which is found

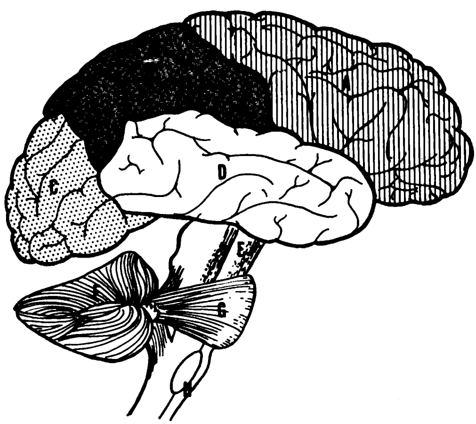


Figure 56.—Schema showing the connection of the several parts of the brain. (Gray.)

A. Frontal lobe	**E. Cerebral peduncle**
B. Parietal lobe	**F. Cerebellum**
C. Occipital lobe	**G. Pons**
D. Temporal lobe	**H. Medulla oblongata**

a certain amount of cerebrospinal fluid. It also continues into the spinal canal.

The pia mater

The pia mater, a delicate membrane of connective tissue containing a network of blood and lymph vessels, lies under the arachnoid and extends to all crevices and depressions of the brain. The membrane contains the blood vessels of the brain and supplies blood to all parts of the brain. It is frequently called the nutritive membrane, and likewise continues into the spinal canal.

The brain

The brain itself is divided into three main parts: the FOREBRAIN, containing the cerebral hemispheres and other bodies; the MIDBRAIN, a short constricted portion connecting the pons and cerebellum with the forebrain; and the HINDBRAIN, consisting of the medulla oblongata, pons and cerebellum.

The cerebrum, or forebrain, is the largest part of the brain and fills the whole of the upper part of the cavity of the skull. It is composed of gray matter externally, which is the active part of the brain, and white matter internally, in which are embedded masses of gray matter. The outer portion of the cerebrum is made up of alternate elevations, called convolutions; and depressions, called fissures. The fissures divide the cerebrum into hemispheres and the hemispheres into lobes, the latter bearing names corresponding to the cranial bones near which they lie. The hemispheres are known as right and left.

Brain fissures

The great longitudinal fissure extends from the front to the back of the cerebrum and completely divides it into two hemispheres except in the middle portion where a broad transverse band of white fibers called the corpus callosum connects the hemispheres. The transverse fissure separates the cerebrum from the cerebellum. The fissures of the brain divide each hemisphere into sections called lobes, designated as the frontal, parietal, temporal, occipital and central, or Island of Reil. Among the important fissures are: the FISSURE OF ROLANDO, called the central sulcus, running from the top and near the middle of each hemisphere downward and forward for two-thirds of its vertical measurement and separating the frontal lobe from the parietal lobe; the lateral cerebral fissure FISSURE OF SYLVIUS, separating the frontal and parietal lobes from the temporal lobe; and the parieto-occipital fissure separating the parietal from the occipital lobe.

The cerebrum

The function of the cerebrum is to govern all of the mental activities and coordinate body movements. This section of the brain contains the centers of reason, intelligence, will, memory and all of the higher emotions and feelings. Certain areas of the brain have a preponderance of control over certain functions, although all areas are more or less closely connected by association fibers; the frontal lobe is primarily the seat of reasoning or higher psychic thought; that portion just anterior to the central fissure is the motor area; the temporal lobe is the seat of hearing and the occipital lobe is the seat of vision.

The white matter consists of fibers which run in three directions: from above downward, from the front backward and from side to side. They form a connection between the different parts of the brain and connect the brain with the spinal cord.

The ventricles

Within the brain there are four communicating cavities called ventricles. There are two lateral ventricles, one situated within each cerebral hemisphere; the third ventricle, lying in the lower middle portion of the brain and communicating on each side with a lateral ventricle. The fourth ventricle is situated between the pons and the cerebellum, connecting above with the third ventricle and continuing through the medulla into the minute central canal of the spinal cord. The ventricles contain a clear lymphlike fluid, the cerebrospinal fluid. There are openings between the fourth ventricle and the space between the inner and middle layers of the meninges of the brain. This space is continuous with a similar space between the meninges of the spinal cord. Both contain cerebrospinal fluid.

The cerebellum

The cerebellum, sometimes called the "little brain," lies in the lower posterior part of the skull, between the occipital lobes of the cerebrum above, and behind the pons and medulla oblongata, and is connected to these structures. It is somewhat oval in form and consists of two lateral hemispheres and a central portion called the vermis, or middle lobe. A large, deep fissure called the horizontal fissure incompletely divides the cerebellum into an upper and a lower portion. Other deep fissures separate the hemispheres into lobes; and numerous, curved fissures, varying in depth and roughly parallel with each other, separate the lobes into layers, or leaves, the edges of which appear as fine ridges. The surface of the cerebellum therefore presents a slightly ridged and laminated appearance, instead of a convoluted one like that of the cerebrum. The substance of the cerebellum is composed of a solid, compact central mass of white matter over which is a layer of gray matter, and its principal function is believed to be the regulation and coordination of ordinary movements and the maintenance of equilibrium.

The pons

The pons, or pons varioli, is a roughly rounded, white mass, situated in the midline of the cranial cavity at the base of the brain, in front of the cerebellum, beneath the cerebrum, and continuous with the medulla oblongata below. It is composed of a ventral or anterior portion, and a dorsal portion, and consists chiefly of ropelike bundles of nerve fibers connecting with the midbrain above, the medulla oblongata below and areas of gray matter. From its surfaces emerge the narrow white bands of nerve fibers that connect the medulla oblongata with the cerebrum and the cerebellum; the pons thus serves as a bridge, as its name signifies. In the gray matter of the pons are located the nuclei from which arise some of the cranial nerves.

The medulla oblongata

The medulla oblongata, or spinal bulb, extends in an almost vertical direction from the lower margin of the pons, above, through the foramen magnum to the level of the upper border of the first cervical vertebra, or atlas, below, and it is continuous with the spinal cord. Shaped somewhat like a flattened pyramid or cone, it rests in and is supported by a shallow groove in the basilar portion of the occipital bone. It is divided into two lateral halves by two fissures derived from the spinal cord, the anterior one extending the entire length of the medulla and ending at the upper end, the posterior one ending in the lower half. The lateral halves are further divided longitudinally by grooves and the surface of the medulla consequently appears convoluted. The upper portion of the posterior surface forms the lower part of the floor of the fourth ventricle of the brain, and the minute central canal of the spinal column passes through the lower half of the medulla and there opens out into the lower, tapered end of the fourth ventricle. The medulla is made up largely of a continuation of bundles of nerve fibers from the spinal cord, some of which end in the medulla while others pass on into the cerebellum. Much gray matter also is present in which are located numerous nerve nuclei and the reflex centers for regulating respiration, accelerating heart action and maintaining vascular tone. In the lower part of the medulla a large part of the nerve fibers decussate (cross to the opposite side) which is the reason why one side of the brain controls nerve activity in the opposite side of the body. The functions of the medulla are largely conduction, reflex action, and automatic action. Its function of conduction is especially important as it conducts all impressions passing between the brain and the spinal cord.

The spinal cord

The spinal cord, or medulla spinalis, is that part of the central nervous system which occupies the upper two-thirds of the vertebral or spinal canal. It is nearly cylindrical in shape, being slightly flattened in front and behind, and extends from the level of the upper border of the atlas to the level of the lower border of the first lumbar vertebra, a distance of about 18 inches in the adult male. Above, it is continuous with the medulla oblongata, and below it ends in a cone-shaped extremity, the conus medullaris. From this point a slender filament consisting mainly of fibrous tissue and called the filum terminale, extends downward about 8 inches where it is attached to the periosteum of the coccyx and so anchors the spinal cord. The nerve roots which spring from the lumbar and sacral portions of the spinal cord descend for a considerable distance in the spinal canal as an aggregation of long nerve fibers which, from its resemblance to a horse's tail, is called the cauda equina. The three coats or membranes which cover the brain extend down and cover the spinal cord, and the subarachnoid space between the arachnoid and pia mater is likewise continued as is the cerebrospinal fluid. Between the dura mater and the vertebral column is a protective covering of fatty tissue which also serves as a protection to the spinal cord. Two fissures, the ventromedian fissure anteriorly and the dorsomedian groove posteriorly, almost completely divide the spinal cord, leaving only a narrow bridge of connecting substance. The bridge is called the isthmus of the spinal cord and it contains the minute cavity called the central canal which traverses the entire cord and communicates with the fourth ventricle of the brain. The spinal cord is made up of white matter surrounding an H-shaped section of gray matter. The anterior parts of horns of this H-shaped substance are short and bulky while the posterior ones are long and slender. The white matter is composed of bundles of nerve fibers which run lengthwise through the cord. The gray matter of cell bodies, dendrites, axons, and collateral branches are held together by NEUROGLIA. The function of the bundles of nerve fibers is to conduct sensory impressions to, and motor impulses from, the brain.

The Peripheral Nervous System

The cerebral or cranial nerves, consisting of 12 pairs, originate in the brain and supply certain definite areas of the body. They are of three varieties, sensory, motor and mixed nerves. These nerves, after leaving the cranium through definite anatomical exits, split up into branches and are widely distributed. They are numbered from before backward in the order in which they arise from the brain, and are named in accordance with their nature, function, or distribution.

Spinal nerves

The spinal nerves, 31 pairs in number, named in accordance with the location of their exit from the spinal canal, are: 8 cervical; 12 thoracic; 5 lumbar; 5 sacral and 1 coccygeal. Each nerve arises from the spinal cord by two roots, an anterior motor root and a posterior sensory root. The latter contains a ganglion of cell bodies which make up the sensory neuron. The two roots

CRANIAL NERVES

Nerve No.	Nerve Name	Type	Distribution	Function
1	Olfactory	Sensory	Upper third of the nasal cavity	Sense of smell.
2	Optic	do	Retina of eye	Sight.
3	Oculomotor	Motor	All eye muscles except superior oblique external rectus.	Movements of eye.
4	Trochlear	do	Superior oblique muscle of eye	Do.
5	Trigeminal	Mixed	Skin of face, eyeball, lacrimal glands, mucous lining of mouth and pharynx; teeth and tongue; muscles of mastication.	Taste, mastication, secretion, and touch.
6	Abducens	Motor	External rectus muscle of eye	Movements of eye.
7	Facial	do	All muscles of expression of face; also supplies ear and part of neck.	Facial expression.
8	Acoustic	Sensory	Internal ear	Hearing and equilibrium.
9	Glossopharyngeal	Mixed	Tongue and pharynx	Taste, movement of pharyngeal muscles and sensation to mucous membrane of pharynx.
10	Vagus	do	Larynx, trachea, lungs, heart, pharynx, esophagus and stomach.	Both motor and sensory to lungs and larynx. Cardio-inhibitory. Motor to esophagus and stomach.
11	Accessory	Motor	Certain neck muscles	Movements of head.
12	Hypoglossal	do	Tongue	Movements of tongue.

unite to form a single trunk which emerges from the spinal canal through an intervertebral foramen and immediately divides into an anterior and a posterior branch. Each branch contains fibers from both the motor and sensory roots. Thus all of the spinal nerves are mixed nerves, for they carry sensory impressions and motor impulses. The posterior branches of these nerves are distributed to the skin and muscles of the back and the trunk; the anterior branches unite to form the three great plexuses known as the cervical, the brachial and the lumbosacral from which the nerve supply to the extremities and other parts of the body is derived. The cervical plexus provides nerves whose branches supply the skin and muscles of the head, face, neck, upper back, parts of the shoulders and thorax, and certain organs within the thoracic cavity. The brachial plexus gives off nerves that supply the upper extremity among which are the median, ulnar and radial nerves. The lumbosacral plexus supplies the nerves of the lower extremities, the chief ones being the sciatic (the largest nerve in the body), the femoral and the obturator nerves.

The Sympathetic Nervous System

This system, also called the autonomic and vegetative, innervates all the involuntary muscles, the various glands of the body and the striated muscles of the heart. The skeletal muscles may receive some sympathetic fibers. The system consists of two rows of central ganglia situated one on each side of the median line, partly in front and partly at the sides of the vertebral column and extends from the base of the skull to the coccyx. It also includes other ganglia situated in different parts of the body, and a network of small nerve trunks connecting the ganglia and ramifying to various organs. The central ganglia are joined with each other by cords of nerve fibers and each ganglion is connected with the spinal nerve of that region and with the spinal cord. A group or collection of ganglia and nerves supplying organs and structures in the body with nerve influence is called a plexus. Among the many plexuses in the body are: the cardiac plexus supplying the heart; the epigastric or solar plexus supplying the stomach; the pulmonary plexus supplying the lungs and the hypogastric plexus supplying the organs in that region of the body. Through the sympathetic system the movements of the viscera are regulated, the caliber of the blood vessels determined, the phenomena of secretion controlled and the metabolic processes of life maintained. The activity of this system does not excite the consciousness and is almost entirely involuntary.

Nerve Action

The outstanding physiologic property of nerve fiber is its conductivity or the capacity of nerve fiber to conduct impulses. For description and study purposes, the impulses carried by the afferent nerves have been termed impressions throughout this section, while those carried by the efferent nerves have been termed impulses. A nerve impression may then be said to be the influence

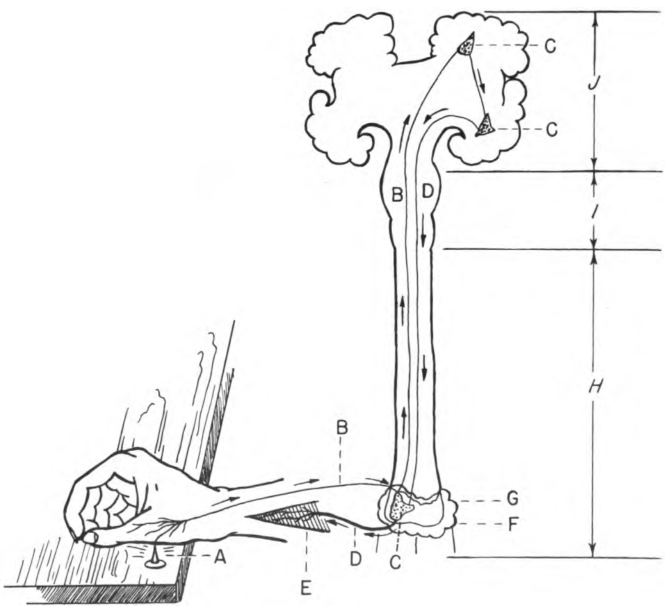


Figure 57.—Diagram of reflex action.

A. Tack pricking hand
B. Afferent nerves
C. Nerve cells
D. Efferent nerves
E. Muscle moving hand
F. White matter
G. Gray matter
H. Spinal cord
I. Medulla oblongata
J. Brain

or effect on feeling, sense or consciousness resulting from stimulation or excitation; and a nerve impulse is the influence or effect on muscle or other tissue that incites it to action. Under normal conditions, afferent nerve fibers are stimulated or excited only at their endings, called receptors, in the skin, mucous membranes and sense organs. Efferent nerve fibers are stimulated only through the nerve cells from which they arise. Sensory impressions are converted into motor impulses in the nerve cells or nerve centers. This conversion may be totally unconscious as well as involuntary (example—the emptying of the gallbladder during digestion); or, there may be consciousness of the act (example—the winking of the eyelid when the eye is touched). Upon reaching the central nervous system, sensory impressions may be carried to the brain. They may then give rise to a specific sensation in the consciousness, or they may be conducted by a direct or devious pathway within the central nervous system to a nerve cell or nerve center which converts them into motor impulses and conducts them away to incite response in some distant muscle or gland cell. When such a response occurs without intervening consciousness it is called reflex action; the nerve activity involved is a REFLEX and the pathway over which the impression and impulse travelled is a REFLEX ARC. The reflex is the basis of all functional activity of the nervous system, and the nerve function necessary for the control of the most intricate movements and activities is probably only a compounding of reflexes. In reflex action it is essential that there be: (1) A receptor which receives the stimulant or excitant; (2) a path to the central nervous system by which the sensory impression is carried and (3) a path from the central nervous system by which the motor impulse is supplied. Although the sensory impressions may be sent to, and the motor impulse received from, the brain in reflex action, it is believed that in most cases the impressions are received in the spinal cord and the motor impulses originated therein. Thus, in response to impressions received over the afferent or sensory nerves, the nerve cells in the spinal cord send out impulses without waiting for the impression to be carried to the brain or central nervous system. As an example, the hand is pricked by a tack. The receptor nerve ending receives the sensation and the afferent or sensory nerves carry it to the spinal cord and brain. Before the sensation has reached the brain, however, an order to lift the hand has been originated by the nerve cells in the cord and sent out by the efferent or motor nerves. The hand is moved and the brain made conscious of the stimulus at about the same time.

Reflexes are classed as simple reflexes, in which a single muscle or gland is involved, as in the corneal reflex; complex reflexes, in which several muscles or glands are involved and the action remaining coordinated, as in the patellar reflexes; spreading reflexes, in which a large number of muscles are involved; tonic reflexes or continuous reflexes, in which a reaction is repeated a number of times as in swallowing, coughing or hiccoughing and association or perception reflexes, in which a mental picture produces reaction as in the flow of saliva or gastric juice when well cooked food is seen or smelled.

The Special Senses

Various kinds of external stimuli produce nerve impressions which give rise to the phenomenon in consciousness known as sensation. Stimuli within the body give rise to such sensations as thirst, hunger, fatigue and many other less well defined sensations. The body is equipped with various mechanisms especially adapted to receive specific forms of stimuli from external surroundings. These mechanisms are called the organs of the special senses. The skin contains various forms of sensory nerve endings, which when acted upon by specific stimuli, give rise, through the nerve impulses generated, to such sensations as heat, cold, pressure and pain. Other more elaborate mechanisms similarly provide for the senses of sight, hearing, smell and taste.

Visual sense

The visual apparatus consists of the eyeballs, the optic nerves, and the visual centers in the brain, together with certain associated organs, as the eyelids, eyebrows, muscles of the eyeball and the lacrimal apparatus.

The eyelids are two thin movable folds projecting from above and below, placed in front of the eye. They are covered externally by skin, and internally by a mucous membrane, the conjunctiva.

The conjunctiva is reflected over the front of the eyeball. The interior of the eyelid is composed chiefly of connective tissue, part of which is dense fibrous tissue which forms the tarsal cartilage. Several small glands, the meibomian glands, are situated in this connective tissue. The upper eyelid contains a small muscle which acts to elevate or lower it. On the margin of each lid are double or triple rows of short hairs or cilia called the eyelashes. The function of the eyelids is to afford protection to the eyes. They are movable shades which may exclude light, dust, and other injurious substances.

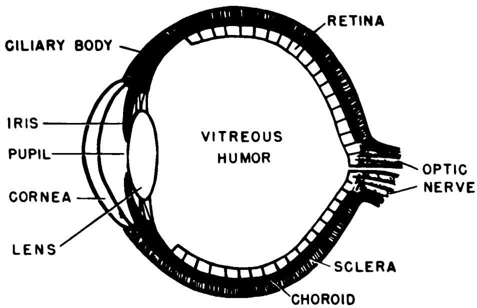


Figure 58.—Horizontal section of the eyeball.

The lacrimal apparatus consists of the lacrimal glands, the canaliculi, the lacrimal sac and the nasal duct. The lacrimal gland is situated at the upper and outer angle of the orbit and secretes tears which flow to the surface of the conjunctiva via several small ducts. This secretion passes over the eyeball and is collected by the canaliculi at the inner angle of the conjunctiva. These canaliculi communicate with the lacrimal sac from which the tears are discharged into the nose through the nasal ducts.

The orbit is a bony cavity in which the eyeball and its muscles are contained. It is shaped like a four-sided pyramid and is made up of seven bones: zygoma, maxilla, palatine, ethmoid, frontal, sphenoid and lacrimal. The orbit contains two openings posteriorly: the optic foramen for the passage of the optic nerve and the ophthalmic artery, and the sphenoidal fissure for passage of the ophthalmic veins and of nerves to the muscles of the eye.

There are six extrinsic muscles of the eye which serve to move the eyeball. These are the internal, external, superior and inferior rectus muscles, and the inferior and superior oblique muscles. The innervation of these muscles has been given under the cranial nerves.

The general shape of the eyeball is spherical, or, more exactly, it is "composed of the segments of two spheres of different sizes, the anterior being the segment of a small sphere forming about one-sixth of the eyeball, and the posterior being the segment of a much larger sphere and forming about five-sixths of the globe." The surface of the eyeball is made up of three distinct coats or layers. The outer layer consists of the sclera and the cornea. The sclera or "the white of the eye" is a dense, tough, fibrous membrane covering the posterior five-sixths of the eyeball and pierced posteriorly by the optic nerve. In front, where the light enters the eye, the sclera changes to a transparent membrane having no blood vessels, which covers the remaining sixth of the eyeball and is known as the cornea.

The middle layer is composed of the choroid and the iris. The choroid is a thin, vascular, chocolate-colored membrane lining the sclera and containing a network of blood vessels. It is pierced in the back by the optic nerve and is folded inward and arranged in radiating folds about the lens of the eye. These folds form the ciliary processes, contain the ciliary muscle and are well supplied with nerves and blood vessels. The iris is a thin, circular, contractile disk which is located directly behind the cornea and suspended in front of the lens but not in contact with it. It is perforated near its center by a circular opening called the pupil. The iris divides the space between the cornea and the lens into anterior and posterior chambers which contain a watery substance called the aqueous humor. The iris is composed of connective tissue, pigment cells, blood vessels and two sets of muscles. One set of muscle fibers contracts the pupil; the other dilates it. The function of the iris is to regulate the amount of light entering the eye. By contracting, it decreases the amount of light entering the eye; by dilating, it increases it. This is the part that gives the eye its characteristic color.

The inner layer of the eye is the retina, which is essentially the expanded fibers of the optic nerve. It is the screen on which the images fall and is most essential to vision. The retina is a transparent, purplish-colored membrane situated between the inner surface of the choroid and the outer surface of the vitreous body. The vitreous body is a transparent jelly-like substance which nearly fills the cavity of the eyeball and is separated from the retina by the hyaloid membrane. The retina consists of eight layers of cells, the most important of which is the first or external layer, called the "layer of rods and cones." The cells of this layer act as end organs to the optic nerve.

The crystalline lens is a solid transparent body enclosed in a transparent capsule or membrane and held in place by a ligament. It is situated between the iris in front and the vitreous body behind. The lens is an elastic body which tends to harden and lose its elasticity with age. It is kept normally tense by the pull of the suspensory ligament on its capsule. When the eye is adjusted for near vision, the ciliary muscle contracts, drawing the choroid forward, relaxing the suspensory ligament and allowing the lens to change its shape. This is called accommodation.

Common defects of accommodation are:

1. Hypermetropia, or farsightedness, a condition in which the focal point for near objects is behind the retina.
2. Myopia, or nearsightedness, a condition in which the rays are brought to a focal point in front of the retina.
3. Presbyopia, a condition similar to hypermetropia, found in old age and due to loss of elasticity of the lens.
4. Astigmatism, a condition in which the curvature of the cornea or lens is defective, causing a dispersion of rays and a blurring of the image.

Sense of hearing

The ear, or the organ of hearing, is composed of three parts: the external, the middle and the internal ear. The external ear consists of the auricle and the external auditory canal, which extends from the outside to the eardrum, or tympanic membrane. This membrane separates the external from the middle ear. The middle ear (tympanic cavity) is a small, irregular air-filled cavity located in the temporal bone. It communicates with the pharynx through the eustachian or auditory tube, and also with the mastoid air cells. It is separated from the internal ear by a thin bony plate containing two small openings, one of which is closed by a thin membrane. The other opening, the fenestra ovalis, is the connection between the middle and the internal ear, and is occupied by the base of the stapes, one of the ear ossicles or bones located within the middle ear. These bones form a chain extending from the tympanic membrane to the fenestra ovalis. The internal ear contains the perceptive organ of hearing and consists of a labyrinth hollowed out of the petrous portion of the temporal bone. This labyrinth is lined with a membrane, contains a fluid called endolymph and is divided into the vestibule, the semicircular canals and the cochlea. The semicircular canals and vestibule receive nerve endings from the vestibular branch of the auditory nerve and are concerned with the sensation of equilibrium.

The end organs of hearing are located in the cochlea. Hearing

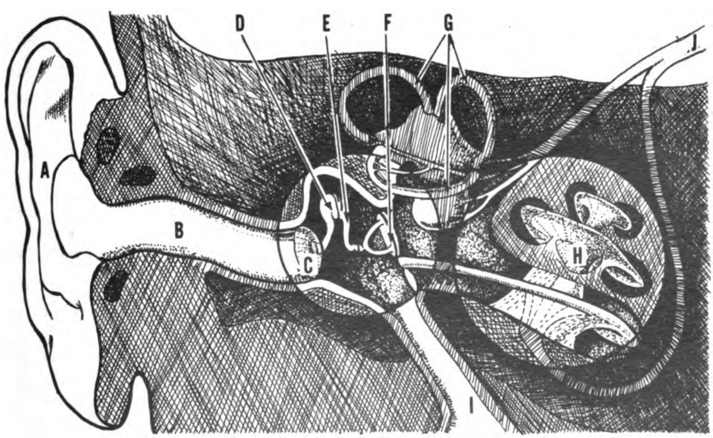


Figure 59.—Semi-diagrammatic section through the ear.

A. Concha	F. Stapes (stirrup)
B. External auditory canal	G. Semi-circular canal
C. Tympanic membrane	H. Cochlea
D. Malleus (hammer)	I. Eustachian tube
E. Incus (anvil)	J. Auditory nerve

is accomplished by sound waves which strike against the eardrum and are transmitted by the ear ossicles to the endolymph of the internal ear, the movement of which stimulates the end organs of hearing. The center of hearing is in the temporal lobes of the brain.

Olfactory sense

The sense of smell is accomplished when emanations from certain substances come in contact with special nerve endings of the olfactory nerve which are distributed in the mucous membrane of the upper part of the nasal chambers.

Sense of taste

Taste is accomplished by certain end organs known as taste buds which are groups of modified epithelial cells of the tongue around which terminate nerve fibers. They are located at the tip, the lateral borders and the posterior portion of the dorsum. The nerves concerned with the sense of taste are the chorda tympani branch of the facial, the lingual branch of the trigeminal and the glossopharyngeal. There are four fundamental tastes: salt, sweet, acid, and bitter. The pleasing variations which commonly are called taste are usually combinations of taste and smell. It is necessary for a substance to be in solution to stimulate the nerve endings concerned with taste.

Certain Special Functions and Activities

Speech

Speech, or the expression of coherent thought, is brought about by a combination of several acts under control of a certain brain center. The center of speech is considered to be located deep in the left temporal lobe of the brain. The larynx contains folds of mucous membrane called vocal cords, which are controlled by muscles that separate or bring these folds together according to the pitch of tone desired. When air is forced from the lungs past these folds certain sounds are produced, and in conjunction with the movements of the pharynx, tongue, lips, and cheeks, articulate speech results.

Sleep

Sleep is a period of more or less unconsciousness, during which most of the higher psychic powers are quiescent, but during which physiologic activities continue. It usually is considered a period of rest in which the constructive processes exceed the disassimilative or catabolic changes. Certain changes take place during sleep: respiration is slowed, the pulse is retarded and less blood is sent to the brain while greater amounts are sent to the extremities. The cause and necessity for definite periods of sleep are not thoroughly understood.

Body temperature

Heat regulation, or maintenance of constant body temperature, is a two-sided process and consists of controlling the loss of heat as well as the production of heat. Heat is lost through the excreta, through expired air, by evaporation of sweat and by radiation and conduction from the skin. Heat is produced by physiologic oxidations within the body. This is effected by muscular exercises and partly by the variety and quantity of food.

The preservation or elimination of heat is controlled chiefly by the sympathetic nervous system, by nerves to sweat glands and by vasomotor nerves. An increase of blood to the skin increases the loss of heat by radiation. The opposite effect may be produced by vasoconstriction or decrease of blood flow to the skin.

Fever is an abnormal condition of increased body temperature, the exact cause of which is unknown. Generally it is considered to be a metabolic disturbance caused by certain toxic substances which act upon a possible heat center in the brain and influence the sympathetic nervous system.

THE SPLEEN AND OTHER DUCTLESS GLANDS

The term ductless glands is applied to those organs whose function is to produce special secretions containing hormones, which are discharged into the blood or the lymph. These organs are also called endocrine glands or glands of internal secretion. They are of glandular structure and have no ducts. The glands generally spoken of as endocrine glands are the thyroid, the parathyroid, the thymus, the suprarenals, the pituitary body or hypophysis, and the pineal body or epiphysis. The spleen, though it has no ducts, has not been found to have an internal secretion and therefore, while anatomically a ductless gland, physiologically it is not a gland of internal secretion.

The SPLEEN is situated in the upper left part of the abdomen directly beneath the diaphragm and behind the stomach. Its border is roughly circular in outline, its size varies greatly, and its average weight is from 5 to 8 ounces. A soft, highly elastic, contractile organ, the spleen is known to be active in the destruction of old or defective blood cells, both red and white, as well as in the formation of some of the lymphocytes of the blood stream.

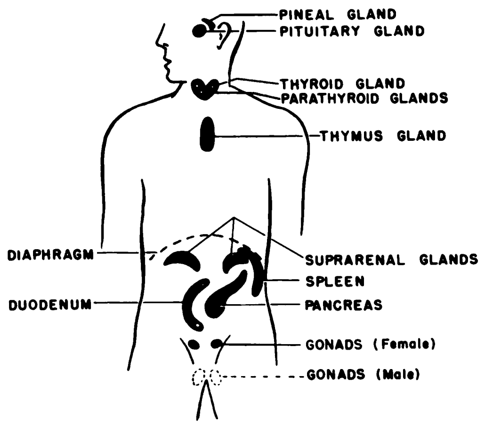


Figure 60.—Ductless glands. (Diagrammatic.)

The THYROID gland is a highly vascular body situated anteriorly in the neck at the junction of the trachea with the larynx. The gland secretes a substance called thyroxin which contains a large percentage of iodine and has a marked influence on body growth and on nervous stability. CRETINISM is the result of a congenital defect or atrophy of the thyroid gland, which causes the arrest of skeletal and mental development.

The PARATHYROIDS, usually four in number, are small grainlike bodies located on or near the posterior surface of the lobes of the thyroid, two on each side. The internal secretion which they furnish regulates calcium metabolism which is so essential in bones, blood and other tissues, and is believed to aid in neutralizing certain toxic substances.

The THYMUS is located in the thorax posterior to the sternum. Its function is obscure but it is believed to exert an influence on body growth and the development of the reproductive organs. The thymus gland usually disappears by the age of 6 years.

The SUPRARENALS, or ADRENAL GLANDS, are two flattened bodies which lie like caps over the upper pole of each kidney. These glands each consist of two portions: an inner, highly vascular mass of tissue called the MEDULLA which is enclosed within an outer portion, or capsule, called the CORTEX. Each portion has a separate secretion and function. The secretion of the medulla, adrenalin, or epinephrine, has a marked effect on the rate of the heart and the blood pressure. It increases blood pressure by constricting the blood vessels, slowing the pulse rate, and increasing the force of the heart beat. It also increases the output of sugar in the urine. CORTIN, the secretion of the cortex, regulates important phases of the mineral and water metabolism of the body. From the cortex was first isolated the substance known as ascorbic acid, which is the antiscorbutic vitamin called vitamin C.

The PITUITARY BODY, or HYPOPHYSIS, is a small, oval-shaped gland attached to the base of the brain and situated in a depression (sella turcica) in the sphenoid bone. The pituitary appears to influence or control the secretions of the other ductless glands. It produces numerous important hormones, some of which are far from being definitely identified. In the anterior lobe, hormones influencing sex, growth, thyroid metabolism and carbohydrate metabolism are known to be present. In the posterior lobe there are hormones which stimulate contractions of nonstriated muscles, constrict arteries, raise blood pressure, and cause antidiuresis (decrease in urine secretion). Overproduction or underproduction results in pituitary giants or dwarfs, respectively.

The PINEAL BODY, or EPIPHYSIS, is a small, flattened, cone-shaped gland situated near the pituitary body. Although rudimentary it is said to produce an internal secretion which counteracts at least some of the functions of the pituitary, particularly the stimulation of the gonads, and is also considered necessary for the development of the eyeball.

The PANCREAS, mentioned elsewhere as producing digestive enzymes, also produces, from areas of specialized tissue called the islands of Langerhans, a hormone called insulin. Like other products of the glands of internal secretion, insulin is poured directly into the blood. It is essential in the regulation of carbohydrate metabolism. An insufficiency, relative or absolute, results in the condition called diabetes.

The GONADS, or sex glands (male—testes, and female—ovaries), each produce internal secretions which are responsible for the development of appropriate secondary sex characteristics such as the beard and the mammary glands.

THE EXCRETIONS

The waste products resulting from the activities of the body are called excretions. They are discharged to the exterior by organs known as the excretory organs, some of which are arranged in systems. The discharge of the waste products of the body takes place by means of: (1) The urinary system, which eliminates water, and certain organic and inorganic waste products; (2) the skin, which eliminates water, organic and inorganic waste materials by means of perspiration; (3) the lungs (see Respiration), which eliminate certain gaseous waste products, such as carbon dioxide, water vapor, and small amounts of nitrogen; and (4) the alimentary canal (see Digestion), which eliminates the residue remaining after digestion.

Urinary System

The urinary system consists of the kidneys, the ureters, the bladder and the urethra.

The kidneys are two large, glandular organs situated in the posterior part of the abdominal cavity, one on each side of the lower movable portion of the spinal column. These organs are bean shaped and each is about 4½ inches long, 2 inches wide, and 1¼ inches thick. On the concave side of each organ is a deep, notchlike depression called the hilus, through which the blood vessels and nerves enter and leave the kidney. The hilus extends inward into the kidney to form the narrow space known as the sinus of the kidney. The parenchyma, or specialized glandular tissue of the kidney, consists of an inner portion called the medullary substance, or medulla, and an outer portion called the cortical substance, or cortex. The medullary substance surrounds the sinus of the kidney and appears largely in the form of conical masses known as renal pyramids, whose apices project into the sinus to form small conical elevations called renal papillae. In the cortical substance is an immense number of tubules called uriniferous (urine-carrying) tubules and thousands of small structures known as malpighian bodies or renal corpuscles. These bodies are located in the cortical substance of the kidney and consist of an outer, spherical-shaped, membranous sac called Bowman's capsule, and an inner, minute, convoluted coil of blood capillaries called the glomerulus. Bowman's capsule is an expansion of the uriniferous tubule, and its membranous wall folds in so that its outer surface becomes an inner surface, as when one part of a hollow rubber ball is pushed inward. From Bowman's capsule the uriniferous tubule continues through the cortical and medullary substances until it terminates in the opening in the papilla with which it communicates. The collecting part of the tubule in the pyramids empties into the kidney pelvis, there discharging the accumulated urine.

The main function of the kidneys is to secrete urine. By doing so, certain waste materials are removed from the blood and prevented from accumulating, thereby keeping blood composition constant. They also play an important part in maintaining the normal, slightly alkaline reaction of the blood by excreting enough substances to reduce their quantity to the normal level. For example, should the reaction of the blood tend to become too alkaline, the kidneys will excrete more alkali salts in the urine. Also, when the presence of more acid substances in the blood tends to make its reaction less alkaline, they excrete more acid salts. Likewise, although the removal of sugar is not concerned with the reaction of the blood, the kidneys will remove all excess sugar present in the blood.

Urine

Normal urine of man varies in color from a pale yellow to a brownish hue, is acid in reaction, and has a specific gravity ranging from 1.015 to 1.025. Various food and medicinal substances affect the color of the urine. The degree of acidity varies at different periods of the day and is affected by the character of the individual's food or by the ingestion of medicinal substances. Ordinarily, urine is composed of about 95 percent water, the remainder being nitrogenous waste products, solids, and salts. The chief nitrogenous constituent of urine is urea. The inorganic salts are those of sodium, calcium, ammonium, potassium, and magnesium; the organic salts are lactates and acetates. Certain abnormal constituents as albumin, sugar, indican, acetone, casts and blood may be found in pathologic conditions. In blood plasma there is normally about 0.03 percent urea present while in urine there is nearly 67 times as much, or about 2.0 percent. This great increase is largely due to concentrating the urea contained in a very large amount of filtrate in a relatively small amount of urine.

Besides removing the waste products of normal body metabolism from the blood, the kidneys also are able to remove exceptionally large amounts of most foreign poisons that could find their way into the blood stream. Outstanding examples of poisons so removed are mercury, various barbituric acid derivatives, and alcohol. Most medicinal substances given in treatment are ultimately eliminated from the body through the kidneys.

The functions of the kidneys show them to be organs extremely vital to the well-being of the body. If they fail to perform their vital functions, the composition of the urine changes, substances that should be removed remain in the blood, and those substances rapidly build up to a concentration that results in toxic conditions.

The ureters are two musculomembranous tubes which connect the kidney and the bladder. Each ureter leaves the kidney at the hilus and enters the bladder at the lower and back portion of the organ, where it delivers the excretion of the kidney to the bladder.

The urinary bladder acts as a reservoir for urine until some such time as micturition is convenient or necessary.

Skin

The skin is a tough elastic membrane forming the outer covering of the body and contains certain appendages such as the hair and nails. Sweat glands and sebaceous glands discharge their secretions upon the surface of the skin.

The two principal layers of the skin are the epidermis, or cuticle, and the derma, or true skin (cutis vera). The epidermis consists of stratified squamous epithelium and may be divided into two layers, the superficial layer being horny and hard, and the inner layer, known as the germinative layer, consisting of soft protoplasmic cells.

The derma is a highly sensitive and vascular layer of connective tissue containing blood vessels, hair follicles, sweat and sebaceous glands and nerve endings.

The sweat glands are coiled tubular glands, the coils of which lie embedded in the derma and surround a small tuft of capillaries. These glands are located in the subcutaneous tissue and open by a duct upon the surface of the skin. The sweat glands serve as excretory organs, excreting the sweat or perspiration.

Sebaceous glands

The perspiration, or sweat, excreted by the sweat glands of the skin, is a clear, colorless, watery liquid with a specific gravity of about 1.004 and a slightly acid reaction. It consists chiefly of water with small quantities of salts, fatty acids, urea and carbon dioxide.

The sebaceous glands are compound sacular glands, the ducts of which open near the hair shaft. These glands secrete an oily substance, sebum, which keeps the skin soft and pliable. The true skin is well supplied with specialized nerve endings which carry impressions of touch, heat, cold and pain. The true skin also contains motor nerves to blood vessels, and secretory nerve fibers to the glands.

The skin serves as a protective covering, to aid in the preservation of body temperature, and as an excretory organ. It contains the nerve endings previously mentioned.

CHAPTER 2
CHEMISTRY

Chemistry is the branch of the physical sciences which deals with the composition of matter, and with the changes which matter undergoes. More and more of man's necessities, as well as his conveniences, are produced by the tremendous chemical industry in this country. Many advances in dentistry and medicine are a direct result of chemical research in the fields of plastics, metallurgy and drugs.

A dental technician should know how chemical relationships are used in pharmacy and materia medica, and in dental laboratory work where dentures and restorations depend, to some extent, on chemical processes.

INORGANIC CHEMISTRY

INORGANIC chemistry deals with substances arising from, or occurring principally in, the mineral world. Rocks, soils, air, water and metals are included under this heading. Another branch of chemistry, dealing with substances concerned with living organisms, is called ORGANIC chemistry. Organic chemistry will be discussed later.

Matter

Matter is anything which occupies space; it is everywhere, and only a complete vacuum does not contain matter. It must be in the form of a gas, liquid or solid; these conditions are called the physical states of matter.

In addition to being in one or another physical state, matter may also be composed in different ways: first, it may be composed of one element; second, of one compound; or third, of a mixture.

Elements, Compounds, and Mixtures

Elements are the building stones of matter. By definition an ELEMENT is a substance which can not be broken into other simpler substances, nor be made from other substances by ordinary means. A COMPOUND, on the other hand, is defined as a substance made up of two or more elements always in the same weight ratio.

Elements are of two kinds: metals and nonmetals. Metals are solids, except mercury; they have luster when cut and have strength to permit forging and drawing. Nonmetals may be solid, but lack the other properties of metals.

Elements and compounds have fixed physical and chemical properties. PROPERTIES are those differences by which substances are distinguished. For example, gold and brass have different physical properties which enable a jeweler to tell them apart. Gold is denser, softer, and has less spring than brass. The physical properties usually are: color, physical state, freezing point or melting point, taste and odor.

Chemical properties are the changes that a substance undergoes when put in contact with certain other substances. The meaning of this will become more apparent later.

In order to clarify some of the definitions above, common table salt will serve as an example. When pure, it always has the same color, taste and lack of odor. The same amount will always dissolve in a given quantity of water at room temperature. It always melts at the same temperature and resolidifies (freezes) at the same temperature. In short, pure table salt always has the same physical properties. Its chemical properties also exhibit constant characteristics.

Experimentation in the laboratory will show that the compound, table salt, may be split into two products or elements: one a greenish yellow gas, the other a silvery, soft metal. No other products may be obtained from table salt. The breakdown of a substance to determine composition is called ANALYSIS. The gas and the metal are always produced in the same proportion from table salt; they always have the same properties and neither of them may be further broken into simpler substances. Further, when the gas and metal are allowed to come in contact, heat is generated and a white product results. This product has all the properties of the original salt, and is identical with it.

Chemically speaking, the preparation of a substance from components is called SYNTHESIS. What has been done in the laboratory

CHART OF COMMON ELEMENTS

Atomic No.	Element	Symbol	Atomic weight	Valence	Metal or nonmetal	
1	Hydrogen	H	1.0078	+1		Gas.
2	Helium	He	4.003	0	Nonmetal	Do.
6	Carbon	C	12.01	±4	do	Solid.
7	Nitrogren	N	14.008	−3,+1,2,3,4,5	do	Gas.
8	Oxygen	O	16.000	−2	do	Do.
9	Fluorine	F	19.00	−1	do	Do.
10	Neon	Ne	20.183	0	do	Do.
11	Sodium	Na	22.997	+1	Metal	Solid.
12	Magnesium	Mg	24.32	+2	do	Do.
13	Aluminum	Al	26.97	+3	do	Do.
14	Silicon	Si	28.06	±4	Nonmetal	Do.
15	Phosphorus	P	30.98	−3,+1,3,5	do	Do.
16	Sulfur	S	32.06	−2,+2,4,6	do	Do.
17	Chlorine	Cl	35.457	−1,+1,3,5,7	do	Gas.
19	Potassium	K	39.096	+1	Metal	Solid.
20	Calcium	Ca	40.08	+2	do	Do.
23	Vanadium	V	50.95	+2,3,4,5	do	Do.
24	Chromium	Cr	52.01	+2,3,6	do	Do.
25	Manganese	Mn	54.93	+2,3,4,6,7	do	Do.
26	Iron	Fe	55.84	+2,+3,+6	do	Do.
28	Nickel	Ni	58.69	+2,3	do	Do.
29	Copper	Cu	63.57	+1,2	do	Do.
30	Zinc	Zn	65.38	+2	do	Do.
33	Arsenic	As	74.91	−3,+2,3,5	Nonmetal	Do.
35	Bromine	Br	79.916	−1,+1,3,5,7	do	Liquid.
47	Silver	Ag	107.880	+1	Metal	Solid.
50	Tin	Sn	118.70	+2,+4	do	Do.
53	Iodine	I	126.92	−1,+1,3,5,7	Nonmetal	Do.
73	Tantalum	Ta	180.88	+3,4,5	Metal	Do.
78	Platinum	Pt	195.23	+2,3,4	do	Do.
79	Gold	Au	197.2	+1,+3	do	Do.
80	Mercury	Hg	200.61	+1,+2	do	Liquid.
82	Lead	Pb	207.21	+2,+4	do	Solid.
88	Radium	Ra	226.05	+2	do	Do.
92	Uranium	U	238.07	+1,2,3,4,6	do	Do.

is this: table salt has been demonstrated as a compound, and the gas and metal from which it is made, as elements. A rereading of the definitions will prove that these substances fit the required conditions of elements when analyzed, and a compound when synthesized.

MIXTURES are more difficult to understand completely. There are two kinds of mixtures: HOMOGENEOUS, in which the composition is the same throughout; and HETEROGENEOUS in which the components of the mixture are distinguishable visually. For example, salt in solution is a homogeneous mixture; the salt is evenly spaced throughout the water, it is not apparent, and the same properties are present throughout the mixture. Concrete, on the other hand, is heterogeneous; close examination reveals sand, stone and a cement binder. It should be understood that mixtures do not have constant composition; compounds do. The components of a mixture may vary in amount. Ordinarily, when separated, mixtures yield different compounds and not elements, although an element may be one of the components of a mixture.

There is another real distinction between a mixture and a compound. Each component in a mixture behaves as if it were separate and distinct. Each of the components in concrete, for example, may be separated mechanically from the others. Salt may be separated from salt solution by a mechanical process; the water will evaporate leaving salt. If salt water were a compound, it would all evaporate and the evaporating material would have the same composition as the part waiting to be evaporated.

Atoms

Dalton, nearly 150 years ago, decided that each element must have some limiting particle size into which it can be divided, and that when this limiting size is reached one will have the atom. The ATOM is defined as the smallest division of an element which will still have all the properties of the element, but which are different from atoms of any other element. When one element reacts with another, the individual atoms of each element are reacting. In making table salt from sodium metal and chlorine gas, each single atom of sodium reacts with a single atom of chlorine. In some chemical combinations, an atom of one element may unite with more than one atom of another.

Molecules

When, a single sodium atom joins a single chlorine atom, these now-combined elements form a molecule of sodium chloride. A MOLECULE is the smallest part of a substance that is capable of independent existence and that still has all the properties of the substance. Thus, one can not break down a molecule of sodium chloride any further without getting sodium, a metal, and chlorine, a gas, each with properties quite different from sodium chloride, the original compound.

The sodium atom alone, with its own individual characteristics, is also correctly called a molecule by definition. It is the smallest part of the substance (element in this case) capable of independent existence, and it still has all the properties of the substance.

While a compound may be as small as a single molecule, ordinarily the term "compound" is used for a large number of identical molecules. This is done in the same way that the word "element" may be used to represent a large number of identical atoms of an element.

Sometimes two or more atoms of the same element combine to make a molecule. Free oxygen, for example, usually occurs as a molecule made up of two atoms. Sometimes ozone is encountered around electric motors. This is a sharp-smelling gas made up of three atoms of oxygen per molecule.

The sodium chloride molecules consist of atoms from two different elements. Many other molecules are made up of atoms of three, four or more elements. For example, sulfuric acid contains hydrogen, sulfur and oxygen atoms; sulfadiazine has carbon, hydrogen, oxygen, nitrogen and sulfur atoms.

Symbols and Formulas

Every science, business and occupation uses abbreviations in writing—"Corp." for corporation, "U. S." for United States, "C. O. D." for cash on delivery. Chemistry has its own set of symbols and formulas, or abbreviations.

Atoms and molecules are not indicated by their full names, but are referred to by their commonly known abbreviations. H_2O, for example, is one common chemical formula with which everyone is familiar. Two atoms of hydrogen are combined with one atom of oxygen to form the compound water. It is easy to see that H stands for hydrogen, and O for oxygen.

However, chemical symbols are not always the first letters of the English words for the elements. Symbols for certain elements are taken from their Latin names to allow for better international understanding. For example, Au (aurum) is the symbol for gold, Ag (argentum) for silver and Fe (ferrum) for iron.

When the atom does not occur alone but is doubled up as in free oxygen, a small numeral (in this case a "2") is placed below and after the symbol. Thus, the element's symbol O becomes the molecular symbol O_2.

Whenever the molecule is that of a compound, the atoms must be represented in the exact ratio in which they occur. For example, in the compound, sulfuric acid, the formula H_2SO_4, shows that each molecule is made up of two hydrogen atoms, one sulfur atom and four oxygen atoms.

Atomic Size

In the metric system, one millimeter is 1/1000 of a meter. The MICRON, a smaller unit, is 1/1000 of a millimeter. This dash (—) is 1 millimeter; divided into 1000 equal parts, each part would be 1 micron. A micron is the unit of size used to measure bacteria. If a micron is divided into 1,000 parts, each part will be a MILLIMICRON. Atoms may be thought of as small spheres; their diameter is approximately 1/10 of a millimicron.

Electrons, Protons and Neutrons

This simplified atom is much like the solar system. The distances should be on the same scale, too, but the parts would be so small they could not be seen on the page.

The revolving ELECTRONS are electrically negative, —, and weigh 1/1835 as much as the parts in the nucleus. The parts of the nucleus are protons, positively charged, +, and neutrons, electrically neutral, N.

The number of negative charges, (—), outside the nucleus is the same as the number of positive charges, (+), inside. Thus each atom is electrically neutral.

All atoms get their weight from the nucleus. Their size is determined by the distance outward to the farthest revolving electron. Atoms are not flat as shown on a piece of paper. The electrons revolve about the center in all planes, as if free to run anywhere on the surface of a ball.

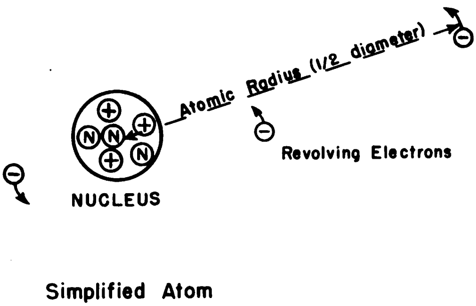


Figure 61.—Simplified atom. (Diagrammatic.)

The atoms of each individual element have a specific number of (+) in the nucleus and this is called the ATOMIC NUMBER of the particular element. There are atomic numbers at present from 1 to 96.

To summarize: Atoms are infinitely small. Their weight depends on the number of (+) (protons) and (n) (neutrons) in the nucleus. Their atomic number depends on the number of (+) in the nucleus and is different for each element. Each atom contains positive and negative electrical particles but these are equal in number, and the atom is neutral.

Atomic Weight

The atoms of each individual element have a definite average weight, as they occur in nature. It would be impossible to weigh individual atoms, but by weighing the same number of atoms, of gold and of silver for example, it could be said that a gold atom is heavier than a silver atom. In order to compare atoms by weight, it is necessary to count a large number. The number counted is

6.02×10^{23} or 602000000000000000000000 of each element. The weight of this number of atoms is called the ATOMIC WEIGHT. When given in grams, it is the GRAM-ATOMIC WEIGHT. Therefore, the atomic weight of an element is the comparative weight of a large number of atoms of that element. In order to compare things there must be a standard, and the oxygen atom is used as this standard. The weight of 6.02×10^{23} atoms of oxygen is exactly 16 grams, and the weight of the same number of atoms of gold is 197.2 grams. It is apparent that each gold atom is more than 10 times heavier than each oxygen atom, whether weighed in grams, pounds or any other unit.

Formation of Molecules

Compounds are made up of molecules, each of which has two or more atoms. Common table salt would be a compound of molecules made up of atoms of sodium and chlorine. If 1 gram atomic weight of sodium and 1 gram atomic weight of chlorine are mixed, there is a reaction and all of the sodium and chlorine is used up. If 1 gram atomic weight of sodium is mixed with ½ gram atomic weight of chlorine, then only half the sodium is used.

Since each gram atomic weight has an equal number of atoms, it is clear that 1 atom of sodium will react with 1 atom of chlorine to form 1 molecule of sodium chloride. If there is an excessive number of atoms of either sodium or chlorine, the excess will not react but will remain uncombined.

Molecular Weight

In the case of elements whose molecules are made up of one atom, the molecular weight is the same as the atomic weight. The same number, 6.02×10^{23}, is used for comparing molecules or atoms.

In some elemental gases—for example, the elements oxygen and nitrogen—the common molecule contains two instead of one atom. In these cases the molecular weight is twice the atomic.

The sodium chloride molecule also has a relative or molecular weight. This molecular weight is the sum of the atomic weights of sodium and chlorine. It follows that by using 1 atomic weight of sodium and 1 atomic weight of chlorine, the product is 1 mole-

955512 O—52——9

cular weight of sodium chloride. For example:

23 gm. sodium + 35.5 gm. chlorine = 58.5 gm. sodium chloride

6.02×10^{23} atoms + 6.02×10^{23} atoms = 6.02×10^{23} molecules

The above information is written by a chemist as:

$$Na + Cl \longrightarrow NaCl$$

Reactions, Physical and Chemical

PHYSICAL CHANGE is best demonstrated by considering water. Everyone is familiar with water in its three physical states and has a good idea of how to change it from one state to another. Liquid water becomes solid when cooled below 0° C.; warming melts the ice and, on heating to about 100° C., the ice becomes gaseous water. At 100° C., if heat is furnished, all the liquid will disappear and only steam will remain. If the vapor is cooled at 100° C., the steam will again condense to water. All the chemical properties will remain the same. This is an example of physical change, a change without alteration in composition.

CHEMICAL CHANGE is change in which new substances are formed which have different composition and chemical properties from the original substance. Sodium metal and water react violently to produce a gas and a white solid. These products are different in composition from the original materials and have different chemical properties.

The striking of a match produces a series of chemical changes. The heat of friction is enough to cause the head of the match to begin combination with the oxygen of the air. The heat produced by this combination is sufficient to bring the wood or paper to a temperature so high that it will also react with the oxygen of the air, and will burn. The composition and properties change as these reactions progress.

Valence

Valence is the property of elements which causes them to combine with other elements and form compounds. Valence is measured in whole numbers since atoms react in whole numbers. The strength with which compounds are held together is independent of valence; therefore, a high valence does not mean strong binding.

Referring to the chart of elements, one will find calcium and chlorine. Calcium has a valence of $+2$ and chlorine has $+1$, $+3$, $+5$, $+7$ and also -1. Just as atoms are electrically neutral, so are molecules. The only manner in which Ca and Cl may join is as follows: 1 atom of Ca^{+2} + 2 atoms of Cl^{-1}. The compound is then made up of molecules of $Ca\frac{Cl}{Cl}$ or in chemical symbols, $Ca^{+2}\ Cl_2^{-1}$, normally written $CaCl_2$.

The normal standards of valence are oxygen, which has a value of -2, and hydrogen with the value of $+1$. Baking soda has the formula $NaHCO_3$. Valence of each of the elements appears complicated, but it is clear when oxygen is assigned a value of -2. There are 3 oxygen atoms with 2 negative charges each, or a total of 6 negative charges. Hydrogen and sodium are always $+1$. $Na^{+1}\ H^{+1}\ CO_3^{-2x3} = -6$ represents what is known so far. In order for the molecule to be neutral, it is necessary that carbon, which has a valence of $+4$ or -4, be given the + valence in this case.

Some gases, which are rare in nature, do not have any valence. Helium and neon have 0 valence meaning, that they do not react chemically. The atom and the molecule are identical. All gases, except these and a few others that do not appear in the chart, have doubled atoms in the molecule and normally exist in doubled form. The oxygen and nitrogen one breathes are not atomic. They are molecular and have the symbols O_2 and N_2.

When one element combines with a second element in different atomic ratios, different compounds are produced. Mercury forms two compounds with chlorine, mercurous chloride ($HgCl$) and mercuric chloride ($HgCl_2$). The first of these, used in internal medicine, has the common name "calomel." In small doses calomel is fairly nontoxic. The second, which is commonly called corrosive sublimate, or bichloride of mercury, is a deadly poison.

Ions

It must be recalled that atoms of pure elements are neutral—that is, they have no electrical charge. When certain elements react with others to form compounds, their atoms gain or lose electrical charges according to their valences (combining power). The valence of an ion is equal to the number of charges it bears. Thus, when the neutral atoms of sodium (a solid) react with those of chlorine (a gas) to yield white, crystalline sodium chloride, the now-combined atoms acquire electric charges. The sodium has acquired a positive electric charge, and the chlorine has acquired a negative electric charge. These charge atoms are now called ions. An ION is defined as any electrically charged particle. These changes from atom to ion are shown by the following:

$$Na + Cl \rightarrow Na^{+1}\,Cl^{-1}$$

The plus and minus signs are inserted to show that it is the sodium atom that becomes a positive ion and the chlorine atom that becomes the negative ion. This is the reason the chart of elements specified + and — valences.

The terms atom and ion cannot be used interchangeably. When an atom becomes an ion by taking on an electrical charge, it has properties that differ from those of the pure element. It will be recalled that when the metal, sodium (Na), combined with the nonmetal, chlorine (Cl), the sodium lost its metallic characteristics.

Ionization

One peculiarity about compounds such as $Na^+\,Cl^-$ is the fact that the two kinds of ions do not stay together in solution. If a solution of salt is electrolyzed, that is, made part of a direct electric current, the Na^+ will go toward the negative pole of the battery and the Cl^- will go toward the positive pole.

Inorganic chemicals in solution break up into ions (ionize) and these ions travel about in the solution. Thus $H^+\,Cl^-$ in solution will provide H^+ ions and Cl^- ions. These ions have properties different from those of the uncharged atoms from which they originally were made. Another phenomenon is that they behave almost as if their partners were not there. Whether Na^+Cl^- or H^+Cl^- or $Ca^{+2}\,Cl_2^{-1}$ is put into solution, the Cl^- ion has a definite set of properties and these properties are always the same.

Radicals

Inorganic chemicals made up of three or more atoms usually produce but two kinds of ions in solution. Ionization in such compounds is not according to valence alone but produces radicals.

RADICALS are groups of atoms bound into an ion. Nitric acid, HNO_3, has valences as indicated: H^{+1} N^{+5} O_3^{-2}. The ionization, however, does not follow such a complex pattern. H^{+1} and $(NO_3)^{-1}$ are the only ions formed. NO_3^{-1} is called a radical and is a group of atoms. Radicals do not occur independently. They are found only in compounds.

Nomenclature

The naming of inorganic compounds is not complicated. Definite rules are applied which prevent confusion. These rules can be demonstrated by example. The names of the more common radicals are:

H_2SO_4 = sulfuric acid	SO_4^{-2} = sulfate radical	Na_2SO_4 = sodium sulfate.
	HSO_4^{-1} = bisulfate radical.	$NaHSO_4$ = sodium bisulfate.
H_2SO_3 = sulfurous acid	SO_3^{-2} = sulfite radical	NA_2SO_3 = sodium sulfite.
	HSO_3^{-1} = bisulfite radical.	$NaHSO_3$ = sodium bisulfite.
HNO_3 = nitric acid	NO_3^{-1} = nitrate radical	$NaNO_3$ = sodium nitrate.
		KH_2PO_4 = monopotassium phosphate.[1]
H_3PO_4 = phosphoric acid.	PO_4^{-3} = phosphate radical.	K_2HPO_4 = dipotassium phosphate[1] and
		K_3PO_4 = potassium phosphate.[1]
H_2CO_3 = carbonic acid	CO_3^{-2} = carbonate	Na_2CO_3 = sodium carbonate.
	HCO_3^{-1} = bicarbonate	$KHCO_3$ = potassium bicarbonate.
HCl = hydrochloric acid	Cl^{-1} = chloride ion	$CaCl_2$ = calcium chloride.

[1] Other names are available and used for the derivatives of phosphoric acid, but these are the easiest to understand.

Chemical Reactions and Equations

Chemical changes all obey one of the fundamental laws of nature and all chemical equations are written to conform to the same law.

The law of conservation of mass and energy states that by chemical means no one may create or destroy matter or energy For example, if 100 pounds of material are chemically changed, the products will still weigh 100 pounds. Applications of this law are not always obvious. When a candle burns in air, it disappears and the products of the reaction appear to weigh nothing. However, if the candle is burned in a closed space, and the gases which result from the burning are collected, it is found that the products weigh more than the candle by exactly the amount of oxygen required to burn the candle.

Everyone realizes that the law of conservation of mass and energy must hold as far as energy is concerned. If man were able to create energy, perpetual motion would be possible. Some machines appear to run by perpetual motion, but actually depend on the sun for energy. On the earth on which we live, all energy comes from the sun. Energy may be changed from one form to another, but not created or destroyed. It may, however, be wasted. Chemical reactions are of four kinds:

1. Combination

   Sodium + chlorine (gas) yield sodium chloride

   $$2Na + Cl_2\uparrow \longrightarrow 2NaCl$$

   Two elements combine to yield a compound.

2. Decomposition

   Heat + mercuric oxide yield mercury and oxygen (gas)

   $$\triangle + 2HgO \longrightarrow 2Hg + O_2\uparrow$$

   A compound breaks down into its element.

3. Double Decomposition

   Sodium chloride + silver nitrate yield sodium nitrate and silver chloride (precipitate)

   $$NaCl + AgNO_3 \longrightarrow NaNO_3 + AgCl\downarrow$$

   Two compounds exchange position or negative ions.

4. Substitution

   Water + sodium yield sodium hydroxide and hydrogen (gas)

   $$2H_2O + 2NA \longrightarrow 2NaOH + H_2\uparrow$$

   One element substitutes for all or part of another element, freeing it from combination.

The kinds of reactions are fairly clear with the exception of double decomposition. Double decomposition depends on the formation of a compound which does not stay in solution or does not ionize. In the equation given, the silver chloride is insoluble and precipitates. For that reason alone, the reaction takes place. If a gas had resulted, it would have been liberated and the reaction would also have proceeded. Mixing solutions of two compounds does not mean that a reaction will occur. If NaCl and KNO_3 are mixed, the resulting solution will contain Na^+, K^+, Cl^- and NO^-_3 ions. The same solution could be made by mixing $NaNO_3$ and KCl. This is not a reaction.

Four examples of chemical reaction or equation have been given. Chemical equations are written in terms of molecules and contain much information. The symbols for atoms and molecules represent single units, but to have a quantity large enough to work with, the units normally represented are the atomic and molecular weights.

Equation 1 shows molecules in use. Since the sodium atom and molecule are the same Na must be used; but when chlorine is used with it, Cl_2, the molecule must be written. In order to balance the equation, 2Na must be used to react with Cl_2 and 2NaCl must result. Balancing an equation is simply making it obey the law of conservation of matter. The arrow ($\uparrow$) pointing up indicates that the substance is a gas.

Equation 2 shows the symbol $\triangle$ to indicate heat.

Equation 3 shows the arrow ($\downarrow$) pointing down to indicate an insoluble precipitate.

Equation 4 may be used to show weight balance between reactant side and product side, when approximate atomic weight is used.

Weight balance may be shown by the following example:

Reactants   *Products*

$$2H_2O + 2Na \longrightarrow 2NaH + H_2$$

$$(2 \times 18)\ \text{gm.} + (2 \times 23)\ \text{gm.} = (2 \times 40)\ \text{gm.} + 2\ \text{gm.}$$

$$36\ \text{gm.} + 46\ \text{gm.} = 80\ \text{gm.} + 2\ \text{gm.}$$

$$82\ \text{gm.} = 82\ \text{gm.}$$

Oxygen

Oxygen, one of the most important elements is a tasteless, colorless, odorless, nonmetallic gas. The earth and everything in it totals about 49 percent oxygen. Air is over 23 percent oxygen by weight; water is about 89 percent oxygen by weight; and all rock and soil contain a high percentage of combined oxygen.

Oxidation

The combination or reaction of oxygen with other elements is called OXIDATION, and the products of this reaction, which contain oxygen, are called OXIDES. Some common oxides are:

Formula	*Name*	*Alternate name*
ZnO	Zinc oxide	Zinc white
H_2O	Water	Hydrogen oxide
H_2O_2	Hydrogen peroxide	(Per—meaning more or excess)
SO_2	Sulfur dioxide	Phosphoric anhydride
P_2O_5	Phosphorous pentoxide	Laughing gas
N_2O	Nitrous oxide	
Al_2O_3	Aluminum oxide	(chief constituent of clay)

The reaction of oxygen with iron does not usually occur rapidly enough to produce flame and is called slow oxidation or rusting. Oxidation, rapid enough to produce a flame, is called COMBUSTION. Such materials as gasoline, wood and coal undergo combustion when raised to a high enough temperature to initiate a reaction.

Water

Water occurs almost universally on the earth: as a liquid in lakes, rivers, oceans and rain; as a solid in snow and ice; and as a gas in steam or vapor. About 70 percent of the earth's surface is covered with water. It is found in many minerals and forms a large part of living animals and plants.

Water has some interesting and peculiar properties: one of the few liquids that expands upon freezing; it is quite stable, does not break down readily into its constituents, hydrogen and oxygen.

Another peculiar thing about water is the fact that it ionizes to form H^+ and OH^-, not $2H^+$ and O^-. H^+ is the hydrogen ion and OH^- is called the hydroxyl ion. The importance of these properties in acids and bases will become apparent later.

Pure water is NEUTRAL. That is, it possesses equal numbers of hydrogen ions (H^+) and HYDROXYL ions (OH^-). Also, any aqueous (watery) SOLUTION in which equal numbers of hydrogen ions and hydroxyl ions exist is neutral. The process of adding a base to an acid, or vice versa, until the hydrogen (positive) ions and the hydroxyl (negative) ions are equal in number is called NEUTRALIZATION.

The word "neutral" has two different meanings. In the statement "compounds and neutral," ELECTRICAL neutrality requires that the number of positive electric charges and negative electric charges be equal. The term "neutral" used in this section indicates a balance or cancellation of acid and basic properties, so that the solution itself exhibits neither acid nor basic characteristics.

Water is an excellent CATALYST or CATALYTIC AGENT. A catalyst is an agent which modifies the speed of a reaction without being changed by the reaction.

Water is an excellent solvent. More compounds will dissolve in water than in any other solvent.

Acids, Bases and Salts

Water combines readily with many other types of molecules to form new compounds. While water itself is neutral, it combines with other oxides to form important new compounds which are not neutral, and which are classified into two groups—acids and bases.

When water molecules unite with metallic oxides, such as the oxides of iron or of sodium, the resulting compound is a base. Basic solutions are said to be ALKALINE. When a nonmetalic oxide (such as an oxide of carbon, phosphorus or silicon) combines with water, the compound formed is an ACID.

Acids

Acids are characterized by the presence of excess hydrogen ions. In the equation

$$CO_2 + H_2O \longrightarrow H_2CO_3 \text{ (carbonic acid)},$$

the hydrogen is present as two hydrogen ions (H^+).

An acid is sour to the taste because the hydrogen ion is present.

Bases

Bases are characterized by the presence of the radical, OH^- (hydroxyl). The appearance of this negative ion can be seen in the equation which demonstrates how the metallic oxide (Na_2O) combines with water to form sodium hydroxide.

$$Na_2O + H_2O \longrightarrow 2(Na^+OH^-)$$

A basic solution will feel slippery like soap, because of the presence of this hydroxyl ion.

It is necessary in dentistry and medicine to indicate acidic strength or basic strength of solutions. This is done by means of pH. A neutral solution is assigned the value of pH = 7.0.

A dental technician should know that a pH scale exists and that acidic and basic strength of solutions is indicated as follows:

pH 0 1	2 3 4	5 6	7
strongly acidic	moderately acidic	weakly acidic	neutral

8 9	10 11 12	13 14
weakly basic	moderately basic	strongly basic

Thus, a solution of pH = 3 is moderately acidic, while one of pH = 6 is very weakly acidic. A solution of pH = 9 is weakly basic, while a solution of pH = 13 is strongly basic.

Salts

A base will destroy the characteristic properties of an acid, usually to form water and a salt. The following equation shows an acid, hydrochloric acid (HCl), and a base, potassium hydroxide (KOH), combining to produce water and a salt, potassium chloride (KCl).

$$HCl + KOH \longrightarrow H_2O + KCl$$

When salt is mentioned, most people think of sodium chloride (NaCl). But since the products of neutralization (interaction of an acid with a base) are water and a salt, it is apparent that there are many kinds of salts.

Combination of an acid and a base to form a salt does not necessarily destroy all of the acid or alkaline characteristics of the two compounds that formed the salt. Most salts when in solution are either acidic or basic, and not neutral.

An acidic solution results when a strong acid (an acid that is quite strong in producing hydrogen ions) is combined with a weaker base. In a similar manner, a basic solution will be produced by combining a weak acid and a strong base (a base that is stronger in producing hydroxyl (OH^-) ions in water.

Some of the more common salts that may be encountered are:

Formula	*Name*	*Alternate name*
NaCl	Sodium chloride	Salt, or table salt
KI	Potassium iodide	
$MgSO_4$	Magnesium sulfate	Epsom salts
Na_2SO_4	Sodium sulfate	Glauber's salt
$KMn0_4$	Potassium permanganate	
Na_2CO_3	Sodium carbonate	Soda ash
$NaHCO_3$	Sodium bicarbonate	Baking soda, bicarbonate of soda
Na_2SiO_3	Sodium silicate	Solution—water glass
$AgNO_3$	Silver nitrate	Fused-lunar caustic
$K_2Cr_2O_7$	Potassium dichlorate	
$NaBO_3$	Sodium perborate	
$KClO_4$	Potassium perchlorate	
$KClO_3$	Potassium chlorate	

Indicators

Indicators are substances which, by change of color or other visible change, indicate whether a solution is acid, alkali or neutral. They are used to indicate pH, to tell whether sufficient acid or base has been added to a solution to neutralize it, or to indicate other characteristics of a solution.

The most commonly used indicator is LITMUS PAPER. This is filter paper impregnated with a dye made from lichens, and allowed to dry. Litmus paper remains purple when neutral, turns blue when moistened with a basic solution and red when moistened with an acid solution.

Molar and Normal Solutions

A 1 molar solution (1 M solution) is one in which the concentration of solute is 1 gram-molecular weight per liter of solution. A 1 molar solution of sodium chloride contains 58.5 gm. (molecular weight of NaCl) in enough water to make 1 liter of solution.

A 0.5 molar solution contains ½ gram-molecular weight of solute per liter, and a 2 molar solution contains 2 gram-molecular weights per liter.

The normal solution is related to the molar solution, but applies mainly to acids and bases. A 1 normal solution (1 N solution) contains (or will react with) 1.0078 grams of hydrogen ions per liter. This amount of hydrogen is 1 gram-atomic weight of hydrogen. The weight of a compound which will furnish or react with 1 gram-atomic weight of hydrogen ions is called the GRAM-EQUIVALENT WEIGHT of that compound.

H_2SO_4 (sulfuric acid) has a gram-molecular weight of (2 x 1) + 32 + (4 x 16) = 98 grams, approximately. A 1 M solution of H_2SO_4 will have 98 grams of the acid in each liter. This solution contains 2 atomic weights of hydrogen, and therefore the 1 M solution must be 2 N. A 1 N solution of H_2SO_4 would contain

only $\frac{98}{2} = 49$ grams of H_2SO_4.

The following table is presented to show relationship of gram-molecular and gram-equivalent weights, as well as molar and normal solutions.

Compound	Gram-molecular weight (grams in 1 liter of molar solution)	Number of H+ ions or (OH)− ions	Gram-equivalent weight (grams in 1 liter of normal solution)
	Gm.		*Gm.*
HCl	36.5	1	36.5
H_2SO_4	98	2	$49 = \left(\frac{98}{2}\right)$
H_3PO_4	98	3	$32.67 = \left(\frac{98}{3}\right)$
NaOH	40	1	40
$Ca(OH)_2$	74	2	$37 = \left(\frac{74}{2}\right)$
$Al(OH)_3$	78	3	$26 = \left(\frac{78}{3}\right)$

It can be seen that gram-equivalent weight is simply gram-molecular weight divided by the number of H^+ or $(OH)^-$ ions in the compound. And since equivalent weight is the same or smaller than molecular weight, it also can be seen that the NORMALITY of a solution is simply molarity MULTIPLIED by the number of H^+ or OH^- ions per molecule. Restated, normality is the number of gram-equivalent weights per liter of solution.

Relationship of pH and normality

A solution of 1 N hydrochloric acid as a pH=0; 0.1 N has a pH=1; and, 0.01 N has a pH=2.

A 1 N solution of sodium hydroxide has a pH=14; 0.1 has a pH=13; and, 0.01 N has a pH=12.

This shows the relation between pH and normality.

ORGANIC CHEMISTRY

Organic chemistry is the name given to that field of chemistry which deals with compounds of carbon. These include organic acids, bases, salts, alcohols and many other classes of compounds, all of which contain carbon.

Many of these compounds originally came from living organisms (plants and animals), hence the term organic. Today there are thousands of carbon compounds which are not found associated with living matter (except indirectly), but are synthesized by the chemist from coal, petroleum or some other source of carbon.

All of the compounds of carbon are essentially different from the compounds studied in the previous section. The parts of these compounds that contain carbon do not ionize, or break down, when mixed with water. In fact, most organic compounds are only slightly soluble in water, with the exception of the carbonates and small molecular weight compounds. The carbonates are considered inorganic and are rarely included in the subject of organic chemistry.

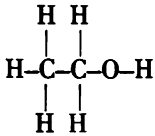
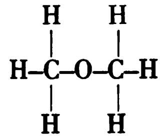
Inorganic reactions take place either between ions or between elements. Organic reactions are reactions of molecules made up of different elements—molecules which can react only as a unit because they do not ionize.

Structure of Organic Molecules

The manner in which molecules of an organic compound are put together has a good deal to do with their reactions.

The same set of wooden boards might be assembled in one way to make a ladder, in another way to make a chair, and in another way to form a box—each with its own characteristics. Similarly, the way in which an organic molecule is assembled—its structure—determines its characteristics or properties.

The formula C_2H_6O, for instance, represents equally well two entirely different compounds: ethyl alcohol and methyl ether. Since carbon always has a valence of 4, oxygen 2 and hydrogen 1, in organic compounds, there are two, and only two, ways of assembling these atoms into a molecule. Examples are:

(A)  (B) 

(A) represents ethyl alcohol, usually represented by the formula C_2H_5OH. (B) is methyl ether, ordinarily identified as $(CH_3)_2O$.

These compounds (of identical molecular composition) have different properties because they are different STRUCTURALLY. A few of these properties are listed for comparison:

Property	*Ethyl alcohol*	*Methyl ether*
Physical state	Liquid at room temperature	Gas at room temperature
Boiling point	+78° C.	—23.7° C.
Reaction with sodium	Reacts	Does not react

Organic compounds that will be encountered in the work of a dental technician include:

Phenol (carbolic acid)
Eugenol (oil of cloves)
Guaiacol (beechwood creosote)
Methyl alcohol (wood alcohol)
Ethyl alcohol (grain alcohol)
Acetone
Methyl methacrylate (both monomer and polymer)
Waxes
Procaine hydrochloride (novocaine)
Acetylsalicylic acid (aspirin)
Epinephrine and adrenalin

WEIGHTS AND MEASURES

Before any laboratory work or study is undertaken, it is necessary to have some idea of measurements. Accuracy in measuring is of utmost importance in the laboratory. Incorrectly measured quantities of alloy and mercury, or acrylic powder and liquid, can cause the failure of a restoration or denture. An incorrect dosage of a drug can be the cause of serious illness or even death.

Several Systems of Measurement

Several systems of weights and measures are in use throughout the world today. Universal use of the metric system has been proposed, but until this change is in effect, a knowledge of the various other systems remains necessary. This knowledge will enable one to convert measurements from one system to another, often a requirement in laboratory or pharmaceutical work.

In the United States, the English system of length and the avoirdupois system of weights are commonly used. The weighing of precious metals such as gold and platinum is an exception; these metals are weighed by the troy system. A majority of pharmacists use the apothecaries' system of weights and measures, atlhough the United States Pharmacopeia (USP) adopted the metric system in 1890. As early as 1875, the Secretary of the Navy directed that the metric system be used in the Medical Department of the Navy. The metric system is also official in the other armed forces of the United States. Nevertheless, the change from the apothecaries' to the metric system has been slow, and both systems prevail to this date.

The conversion of one set of weights and measures to any other system requires no memorization. Relations between systems are to be found in many reference books, such as the USP, chemical handbooks, and other scientific texts. Conversions are not difficult; they require only simple mathematics and methods demonstrated in the following paragraphs of this chapter.

LENGTH CONVERSION

English system	*Metric system*
5,280 feet = 1 mile (mi.)	1,000 meters = 1 kilometer (km.)
3 feet = 1 yard (yd.)	100 meters = 1 hectometer
1 foot = 12 inches (in.)	10 meters = 1 dekameter
The FOOT (ft.) is the unit.	1 meter = 10 decimeters
	1 meter = 100 centimeters (cm.)
	1 meter = 1,000 millimeters (mm.)
	The METER (m.) is the unit.

Conversion Table

1 meter = 39.37 inches = 1.09 yards = 100 centimeters.
1 inch = 2.54 centimeters = 25.4 millimeters.

The metric system is a decimal system, a system of tens. Each unit in the system is related to the other units by multiplying or dividing, by 10, the correct number of times. Thus to change meters to millimeters it is necessary to first divide the number of meters into 10 points, each of these tenths is the number of decimeters; then divide each decimeter into 10 parts to get the number of centimeters; finally, dividing each centimeter into 10 parts will yield the answer in millimeters. Naturally it is simpler to divide a meter one time into 1,000 equal parts, the usual manner of changing meters into millimeters.

To illustrate the conversion of length units from one system to another, two examples are presented.

I. Suppose a patient is 5 ft. 10 in. tall and it is required that his height be given in centimeters.

(1) Before actual conversion, it is easier if only one English unit is used, so 5 ft. 10 in. is converted to inches. 5 feet x 12=60 inches + 10 inches=70 inches.

(2) From the conversion table it is seen that each inch is equal to 2.54 centimeters or, there are 2.54 cm. per inch. 70 inches x 2.54 cm/in=177.8 cm., the desired answer.

The underlined term is a factor which consists of two parts, the numerator (top) of the fraction is in the desired unit, while the denominator (bottom) of the fraction is in the unit being converted.

II. To further show the use of a factor, as well as length conversion, another example is given: convert 13.7 centimeters to inches.

(1) The factor desired will be a fraction, giving a true relation of inches to centimeters, with inches on top (numerator), and centimeters on the bottom (denominator). In the conversion tables, two equalities are found: 39.37 inches=100 centimeters, and 1 inch=2.54 centimeters. Either of these may be used:

$$\frac{39.37 \text{ in.}}{100 \text{ cm.}} \text{ or } \frac{1 \text{ in.}}{2.54 \text{ cm.}}$$

By this time it should be clear that the factor is simply a method of canceling out the unit which is not desired and putting in its place the unit sought.

(2) Having selected a factor, the conversion follows: 13.7 cm. x $\frac{39.37 \text{ in.}}{100 \text{ cm.}}$=5.39 in. Exactly the same result would be found if the other conversion factor were used.

Problems

The following problems are to be converted by the student:

1. Convert 1 ft. 5¼ in. to millimeters.
2. Convert 4.39 cm. to inches.
3. Convert 1.87 meters to feet and inches.

Answers

1. 438 mm. 2. 1.73 in. 3. 6 ft. 1.6 inches.

Conversions in length between the metric and English systems have been discussed to illustrate the principles used. The same method of conversion will be applied to the measurements of volume, weight and temperature in the following paragraphs.

VOLUME CONVERSION

Apothecaries' Liquid Measure

1 quart (qt.)	= 2 pints (pt.)
1 pint	= 16 fluid ounces (fl. oz.)
1 fluid ounce	= 8 fluid drama (fl. dr.)
1 fluid dram	= 60 minims (min.)

Metric Liquid Measure

1 liter (1) = 1,000 milliliters (ml. sometimes mil.)

There are other metric liquid measures, but these are the only ones commonly encountered. The cubic centimeter is the same as the milliliter for all practical purposes, thus it is used interchangeably with milliliter; ml. and cc. stand for the same amount.

Conversion Table

1 liter = 1.056 quarts	1 min. = 0.06 ml. (cc.)
1 ml. (cc.) = 16.23 minims	1 fl. dr. = 3.7 ml. (cc.)
1 pint = 473.12 ml.	1 fl. oz. = 29.57 ml. (cc.)

The same kind of conversion is made for volume as for length. Two examples are given:

1. Convert 12 fluid ounces to cc.

$$12 \text{ fl. oz. x } \frac{29.57 \text{ cc.}}{1 \text{ fl. oz.}} = 33.48 \text{ cc.}$$

2. Convert 10 fluid ounces to minims.

$$10 \text{ fl. oz. x } \frac{60 \text{ min.}}{1 \text{ fl. dr.}} \text{ x } \frac{8 \text{ fl. dr.}}{1 \text{ fl. oz.}} = 4{,}800 \text{ min.}$$

It is clearly seen in both examples that factors are chosen which allow the units to cancel, leaving only the desired unit.

The student should make the following conversions:

1. 1 qt. 1 pt. 1 fl. oz. = ? ml. (or cc.) Ans. 1,488.93 ml.
2. 32 min. = ? ml. Ans. 1.92 ml.
3. 365 ml. = ? fl. dr. Ans. 98.65 fl. dr.

WEIGHT CONVERSION

The common system of weighing groceries and commodities in general is the AVOIRDUPOIS SYSTEM. Since most of the units in this system bear the same names as different sized units in other systems, only the pound and ounce will be given here. The pound is the unit, and it contains 16 ounces, avoirdupois. Whenever ounces and pounds avoirdupois are referred to hereafter, the abbreviation (av.) will designate the avoirdupois system.

Apothecaries' Weights

1 pound = 12 ounces
1 ounce = 8 drams
1 dram = 3 scruples
1 scruple = 20 grains (gr.)

Troy Weights

1 pound = 12 ounces
1 ounce = 20 pennyweights (dwt.)
1 pennyweight = 24 grains (gr.)

Metric Weights (kg)

1 kilogram = 1,000 grams (gm.) Pharmacy uses (Gm.)
1 gram = 1,000 milligrams (mg.)

As in length units there are many metric units, but these are the only ones commonly used. The chemical abbreviation for the gram is (g.); this is sometimes encountered.

Conversion Table

1 pound (av.) = 453.592 gm. (for practical purposes 454 gm.)
1 ounce (av.) = 28.35 gm.
1 pound (apoth. or troy) = 373.236 gm.
1 ounce (apoth. or troy) = 31.103 gm.
1 gram = 15.432 grains (apoth. or troy)
1 grain (apoth. or troy) = 0.0648 gm. = 64.8 mg.
1 pennyweight = 1.555 gm.
1 kilogram = 2.2 pounds (av.)
1 kilogram = 2.68 pounds (apoth. or troy)

Weight conversions appear complicated by the many systems and units involved. Actually they are no more difficult than length conversions if one takes the time to read the units properly and obtain the proper conversion factor. These three examples should be studied and the problems solved:

Examples:

1. Convert 76 grains to grams.
   76 grains x 0.0648 gm./grain=4.9248 gm.
2. How many grams in a 1 pound 3 ounce (apoth.) sample?
   An apothecaries' pound = 12 ounces, so there are 15 ounces.
   15 ounces x 31.103 gm./apoth. ounce = 466.545 gm.
3. What is the kilogram body weight of a man who weighs 186 pounds?
   186 pounds (av.) x 1 kg./2.2 pounds = 84.54 kg.

Problems:

1. Convert 11 pennyweights to grams. Ans. 17.105 gm.
2. Convert 17 grams to grains. Ans. 262.3 gr.
3. Convert 11.370 grams to milligrams; to kilograms. Ans. 11,370 mg.; 0.01137 kg.

Limits of accuracy

In making calculations and taking measurements there is a limit to the extent to which they need be carried. For example, it is useless to carry calculation as far as 1.0759732 grams, or 6.30472 centimeters. The measuring devices in use in normal pharmaceutical and laboratory work are not designed to measure with such a high degree of accuracy. Even if they were, there would be no difference in the healing action of dosages of the same drug, one weighing 1.074 grams and the other 1.076 grams.

The limit of accuracy — the point at which a calculation is stopped — varies with the type of measurement and the amount being measured. The limits of accuracy which usually need to be observed for the different types of measurement are as follows:

For length measurements: Calculate to the nearest millimeter. Thus, in the problem

$$4.257 \div 3.1$$

do not stop with the answer at 1.3 meters, but calculate as far as 1.373 meters, to include millimeters.

For weight measurements: For weights up to 10 grams, calculate to the nearest .001 gram.

For weights between 10 and 100 grams, calculate to the nearest .01 gram.

For weights between 100 grams and 1 kilogram, calculate to the nearest .1 gram.

For weights of 1 kilogram and over, calculate to the nearest 1.0 gram.

For volume measurements: Calculate to the nearest 0.1 cc.

NOTE—At times, more accurate measuring devices are available, and the amount and type of materials to be measured will require greater accuracy of measurement. In such cases more exacting limits of accuracy than those just prescribed will be observed.

Rounding off

The process of eliminating the fraction at the end of a calculation is called rounding off. Suppose two friends decide to share equally the cost of the gasoline for an automobile trip. It is found at the gas station that they owe $4.17. The calculated half share of $2.085 involves one-half cent. One person will have to pay the next higher amount, $2.09; the other, $2.08. The point in any calculation beyond which there is no meaning, is called the last significant figure. The last significant figure in the above example is the cent unit.

Raising the last significant figure by one unit, or leaving it unchanged, is the next point to be considered.

If 16.3 cc., is multiplied by 2.01, the answer is 32.763 cc. Since no attempt is made to measure beyond the nearest 0.1 cc., the number 7 is the last significant figure, and it is rounded off by changing the result to 32.8, the measurement closest to 32.763. The rule for rounding off is as follows:

Calculate one place beyond the last significant figure.

If this figure is 5 or higher, the last significant figure is rounded off to the next higher number. If the extra place figure is less than 5, the last significant figure is not changed.

Problems:

Round off: (a) 4.70125 mm.; (b) 5.76125 mm.; (c) 4.055000 mm.
Answers: (a) 4.7 mm.; (b) 5.8 mm.; (c) 4.1 mm.

The relation of volume and weight

It is easy to weigh solids, but inconvenient to weigh liquids. Fortunately it is not necessary to weigh liquids often; SPECIFIC GRAVITY is used to calculate the volume more easily and the amount is then measured.

Specific gravity (sp. gr.) is the weight of a liquid or solid compared with that of an equal volume of standard substance (usually water, which has a specific gravity of 1).

For example: Wood (sp. gr. 0.8) is 8/10 as heavy as water, and floats on the water. (Mercury sp. gr. 13.59) is 13.59 times as heavy as water, and sinks in water.

Density is the weight per unit of volume of any substance. Liquid water weighs very nearly one gram for each cubic centimeter. Therefore, it is correct for general purposes to say that water has a density of one gram per cubic centimeter (written 1 gm./cc.).

Thus: (1) Water is assigned the value of 1 because it is a standard of specific gravity.

(2) Water has a density of 1 in grams per cubic centimeter.

Therefore, in terms of grams and cubic centimeters (that is, in the metric system), specific gravity and density are represented by the same number and are interchangeable.

How to use specific gravity or density

Supposing 17 grams of alcohol (95%) which has a density (sp. gr.) of 0.8, are desired? Instead of weighing it, a volume is poured out and measured.

How much volume? The formula is:

$$\text{Density} = \frac{\text{weight}}{\text{volume}} = \frac{\text{gm.}}{\text{cc.}}$$

so:

$$\text{Volume} = \frac{\text{density}}{\text{weight}}$$

The volume to be measured, then is $\frac{17 \text{ gm.}}{0.8 \text{ cc.}} = 21.25$ cc.

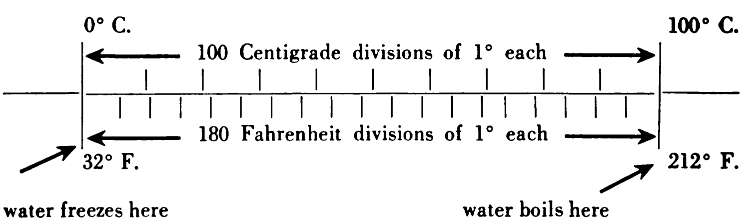
The answer is rounded off to read 21.3 cc.

TEMPERATURE CONVERSION

Fahrenheit—The scale of temperature measurement commonly used is called Fahrenheit (F.). On this scale the freezing point (f.p.) of water is 32°, and the boiling point (b.p.) is 212° at sea level pressure. One degree equals 1/180 of the distance between the boiling point and the freezing point. The base of the Fahrenheit scale is 32° above zero.

Centigrade—The centigrade scale of temperature measurement is used in scientific work for a number of reasons. The main reason is because there are 100 equal divisions between the boiling point and freezing point of water, thus making it an easier scale to use. The boiling point of water is set at 100° and the freezing point at 0°.

Either of these two scales can be used to designate a certain degree of heat in a solution, gas or solid. A graphic representation of what has just been explained is shown below.



To convert from one reading to another, there are four things to be remembered:

(1) The base of centigrade is zero degrees (0°).

(2) The base of Fahrenheit is 32°.

(3) 1 degree centigrade is equal to $\frac{180° \text{ F.}}{100° \text{ C.}} = \frac{9° \text{ F.}}{5° \text{ C.}}$

(4) 1 degree Fahrenheit is equal to $\frac{100° \text{ C.}}{180° \text{ F.}} = \frac{5° \text{ C.}}{9° \text{ F.}}$

Except for these different bases, conversions are made exactly as in the case of centimeters to inches. For example:

(a) Convert 37° C. (normal body temperature) to Fahrenheit temperature.

$$37° \text{ C. x } \frac{9° \text{ F.}}{5° \text{ C.}} = 66.6° \text{ of Fahrenheit measure.}$$

But this first answer is still based on zero, and therefore it must be changed to the Fahrenheit base by adding 32°.
Thus: 66.6° plus 32° = 98.6° F., the final answer.

Percentage

Percent (%) is a term meaning PARTS IN ONE HUNDRED. It is used in stating the strength of certain solutions, the composition of mixtures or compounds, and in many other ways.

Example:

(a) One man wants to give another man an immediate idea of how many white horses there are in a mixture of white and black horses. If there are 100 horses, 17 white and 83 black, he will say 17 percent of the horses are white. That is, 17 parts out of 100 parts are white.

If there are only 36 horses, 10 white and 26 black, what percentage of white horses has he? This is not complicated, but it involves an actual calculation—not just adding the parts in 100.

A decimal fraction is parts per one $\frac{\text{10 white horses}}{\text{36 horses}}$; this must be converted to percent or parts per hundred. To change the decimal fraction it is multiplied by 100 to get percent. This gives 27.8 percent white horses. Note that percent is seldom a whole number; usually it is a number with a decimal fraction.

(b) In Washington it was cloudy 286 days in 1949. What percentage of the year was it cloudy?

$$\frac{\text{286 days cloudy}}{\text{365 days in year}} \times 100 = 78.4\% \text{ of the total days was cloudy.}$$

(c) A man is paid $189.73 a month and his rent is $46.50. What percent of his pay goes for rent?

$$\frac{\$46.50 \text{ rent}}{\$189.73 \text{ pay}} \times 100 = 24.5\% \text{ of his pay goes for rent.}$$

Solutions

A solution is a mixture of two or more materials. It is a special kind of mixture; the particles must be in their smallest size (molecular), and the mixing so complete that any part of the mixture has exactly the same composition and properties as the whole.

Solutions may be liquid, solid or gas. If they are solid, they must have gone through the mixing as a liquid for in no other form could the mixing be complete enough to make a true solution. A gaseous solution results if two gases are allowed to mix.

If a pinch of salt is stirred into a cup of water, the salt goes away, apparently; actually it goes into solution in the water (dissolves). Now, if the solution is heated on a stove and the water boiled off, so that only the salt is left, where is the water? It is in solution in the other gases which go to make up air.

Solvent and solute

A SOLVENT is that part of the solution which is the major part of the mixture, or the liquid in which a gas or solid is dissolved. The SOLUTE is the minor part, or the dissolved gas or solid.

Concentration

Naturally, there is some interest in just how much solute is present in a given amount of solvent. For instance, if there is a small amount of hydrochloric acid in a large quantity of water, the solution is harmless; but if there is very much hydrochloric acid in a small amount of water, this solution is dangerous under some conditions. This strength of solution, or amount of solute in a given amount of solvent, is called CONCENTRATION.

It must be understood that the total amount of solution has nothing to do with its concentration; for example: concentration is described in terms of percent. It does not mean that 100 units of solution are required to tell what the degree (%) of concentration is.

Dilute and concentrated solutions

These are relative terms—a concentrated solution is one which contains much solute, and a dilute solution is one which contains little solute. These are not exact and there is no dividing line between the two unless applied to the same solvent and solute.

Saturated solutions

A given amount of solvent will dissolve a definite amount of solute at a given temperature. Warm water will dissolve more sugar than cold water. Although the speed of solution is not important, it is true that warm water will not only dissolve more sugar, but it will dissolve it faster.

A SATURATED SOLUTION is one which has dissolved all the solute it can at a specific temperature. In preparing a saturated solution, an excess of solute must be present. Without excess solute, is it possible to know there is actually enough solute to saturate the solvent?

TEMPERATURE affects solution differently; usually the higher the temperature, the more solute will be taken up—but not always. For example, in the case of lead sulfate dissolved in water, twice as much dissolves at 90° C. as at 25°. For common salt, there is practically no temperature effect.

Solubility

The SOLUBILITY of a material is the fixed amount in grams of that material found in a saturated solution, with 100 grams of water as the solvent, at a specific temperature. Thus, the solubility of sodium chloride at 0° C. is 35.7 gm. (written: Sol sodium chloride (0°C.) = 35.7). Where a solvent other than water is used, it must be named.

Percentage Solutions

Terms used in the chemistry of solutions have been defined; concentration from the standpoint of percentages will be discussed. Percentage may be a very exact way of stating concentration, but in many cases it is not used accurately.

There are three ways of expressing parts per hundred (percent) when talking about solutions:

(1) Percent by weight (weight in weight).

(2) Percent by volume (volume in volume).

(3) Percent by weight-volume, or weight-in-volume percent.

These three systems can be used for preparing solutions with equal accuracy, but the third type of solution (weight-in-volume percent solution) is the one most frequently prepared. It is used whenever percent is called for, and one of the other methods is not specified. NOTES: Solutions prepared by these three methods differ from each other in concentration.

The principles involved in each of the three systems are illustrated in the following:

1. A 10 percent SOLUTION BY WEIGHT of sugar in water means that each 100 gm. of solution contains 90 gm. of water and 10 gm. of sugar. Making up a percent-by-weight solution is simple. For example, to prepare 15 gm. of a 10%-by-weight, silver nitrate solution (NOTE: a WEIGHT of solution, not a VOLUME), 10% x 15 gm. of silver nitrate is needed, or 1.5 gm. The rest of the 15 gm. must be water, so 13.5 gm. of water is needed. The density of water being practically one gram per cubic centimeter (written 1 gm./cc.), 13.5 cc. of water is measured and 1.5 gm. of silver nitrate is added.

The final volume is usually a little more than the volume of water used, but change in volume is not a point here.

2. A 10 percent solution, VOLUME IN VOLUME, of sugar in water means that exactly enough sugar has been dissolved in water to have expanded it so that the sugar takes up 10 percent of the total volume. This is quite complex and will not be discussed further. In pharmacy, however, a volume-in-volume solution means volume of liquid ingredient in 100 cc. of solution.

3. A 10 percent WEIGHT-VOLUME SOLUTION of sugar means that 10 gm. of sugar has been put into solution in enough water to make 100 cc. Exactly how much water it will take is unknown but this knowledge is not necessary.

Following are two examples of the procedure for preparing weight-volume percent solutions:

(a) To make 120 cc. of a 2 percent sodium chloride solution (by weight-volume percent): first, the required weight of sodium chloride is determined:

$$\frac{2 \text{ gm.}}{100 \text{ cc.}} \times 120 \text{ cc.} = 2.4 \text{ gm.}$$

It should be recognized that the factor, $\frac{2 \text{ gm.}}{100 \text{ cc.}}$, comes directly from the percentage specified. To the 2.4 gm. of sodium chloride should be added sufficient water to make 120 cc.

(b) To make 50 cc. of a solution which is 1 percent sodium carbonate and 5 percent glucose:

Sodium carbonate........................1% x 50 cc. = 0.5 gm.
Glucose ....5% x 50 cc. = 2.5 gm.

The proper amounts of the two solids are weighed out and dissolved in enough water to make a total volume of 50 cc.

NOTE: One should not start with a volume of water equal to the total required volume — this usually gives too much solution and hence a solution weaker than the one called for. It is clear that the weight-in-volume system is the one which a technician will encounter most frequently.

Dilution of alcohol

As issued, ethyl alcohol is 95 percent (by weight) alcohol and 5 percent (by weight) water. This solution is diluted by rule-of-thumb methods which are approximate, not accurate. The usual rule is to take the volume in cc. of the 95 percent solution which equals the percent solution desired, and then dilute to 95 cc. with water.

Example:

To make 50 percent alcohol from stock issue:
Take 50 cc. of the 95 percent alcohol and dilute it to 95 cc. with distilled water.

NOTE: The lower the percentage of alcohol required, the more error there is in this method, because the density of the solution required becomes greater.

Dilution of acids

Occasionally an advanced technician may be instructed to prepare a percent dilution of acid. When so instructed, he will commonly make up a weight-volume percent solution.

Acids and ammonia are issued in so-called CONCENTRATED solutions. The label of the original bottle shows the percent acid by weight and the specific gravity of the concentrated solution. With this information one is able to make up percent solutions.

Example:

> Given a stock bottle of CONCENTRATED hydrocloric acid (36% acid by weight, specific gravity = 1.42), make up 500 cc. of a 10% solution (wt.-vol. %) of hydrochloric acid.

The solution required will have 10 percent of 500 cc. of hydrochloric acid (that is, 50 gm.) made up to 500 cc. with distilled water.

Now, just how much of the stock (concentrated solution) contains exactly 50 gm. of hydrochloric acid?

The specific gravity of 1.42 means that each cc. of the stock weighs 1.42 gm. The percent by weight means that there are 0.36 gm. of acid in each gm. of stock. Therefore each cc. of stock contains 36 percent of 1.42 gm. of acid = 0.511 gm. hydrochloric acid in each cc.

All that is left to determine is: How many cc. of stock, containing 0.511 gm. acid per cc., contain 50 gm. of acid.

$$50 \text{ gm.} \times \frac{1 \text{ cc.}}{0.511 \text{ gm.}} = 97.8 \text{ cc.}$$

A factor is used here just as it was used in earlier calculations. Therefore, to make 500 cc. of 10 percent hydrochloric acid it is only necessary to measure out 97.8 cc. of this particular concentrated stock and dilute it to 500 cc. with distilled water.

Caution: DO NOT pour water into concentrated acids; they react vigorously. Pour the acid into twice its own volume of water first, with stirring; cool this dilution to room temperature; then add sufficient water to make up the required volume.

Making up solutions

Some types of solutions may be ordered (a) in a way that will give a definite volume, or (b) another way, where the volume to be made up is not definite.

An example of each is given:

(a) Make up 30 cc. of the following:

Zinc iodide	8 gm.
Iodine	10 gm.
Glycerine	50 cc.
Distilled water to make	100 cc.

This case is actually a wt.-vol. %, since no definite volume of water is added; it is sufficient to make the final volume 100 cc., and have the other components in the proper ratio. The 30 ml. are made using the following quantities:

Weigh: $\frac{30 \text{ cc.}}{100 \text{ cc.}} \times 8 \text{ gm.} = 2.4 \text{ gm.}$ zinc iodide, and

$\frac{30 \text{ cc.}}{100 \text{ cc.}} \times 10 \text{ gm.} = 3.0 \text{ gm.}$ iodide, then measure

$\frac{30 \text{ cc.}}{100 \text{ cc.}} \times 50 \text{ cc.} = 15 \text{ cc.}$ glycerine

(b) Make up 50 cc. of the following:

Sodium carbonate	10 gm.
Sodium chlorite	30 gm.
Distilled water	100 cc.

In this type of solution no definite volume results. The best procedure is to use the volume asked for as the volume of the solvent, work the rest of the components in ratio to this, and throw away the excess which results.

50 cc. is desired, so work on the basis of

$\frac{50 \text{ cc.}}{100 \text{ cc.}} \times 10 \text{ gm.} = 5 \text{ gm.}$ sodium carbonate,

$\frac{50 \text{ cc.}}{100 \text{ cc.}} \times 30 \text{ gm.} = 15 \text{ gm.}$ sodium chlorite and 50 cc. water

and 50 cc. water.

Mix the 50 cc. water, 15 gm. sodium chlorite, and 5 gm. sodium carbonate. This will give more than a total volume of 50 cc., but not so much as to be wasteful if the excess is discarded.

CHAPTER 3

MATERIA MEDICA

Many of the substances used in the treatment of disease are obtained from the animal, vegetable and mineral kingdoms. These substances generally are spoken of as medicines, commonly termed drugs, and in studying them it is necessary to consider their source, composition, physical characteristics, chemical properties, preparation and administration, physiologic and toxicologic action. The science which treats of the substances used as medicines is MATERIA MEDICA.

That particular science which relates to the properties of medicinal substances and the application of remedial agents in the treatment of disease is known as THERAPEUTICS. In addition to the use of drugs as remedial agents, electricity, water, serums, heat, and light rays are among the other agents employed for curative purposes. Therapeutics is divided into three classes known as RATIONAL, which is based upon the known laws of the remedies and diseases; EMPIRICAL, based entirely on the results of clinical observation and experience; and GENERAL, when remedial agents other than drugs or medicines are used.

To the technician approaching materia medica for the first time, it must seem to include a mass of detailed information to be memorized; but only certain essentials are included in this handbook. Memorization is not required or advised. Learning will be made easier to those who understand the following principles:

First: All drugs are grouped into classes.

Second: All drugs in the same class generally produce about the same effect.

Third: Drugs in the same class producing the same effect differ from one another only in:

1. The amount required to produce the effect.
2. The time required to produce the effect.

3. The length of time the effect lasts.
4. The method of administration (for example, one drug can be given orally, while another must be injected).

Fourth: General methods of treatment of poisoning are the same for drugs of the same class.

Branches of Materia Medica

Materia medica has been divided into separate fields—all of them related to therapeutics, the treatment of disease:

PHARMACOGNOSY—the source and the properties or characteristics of drugs.

PHARMACY—preparation and dispensing of drugs.

PHARMACODYNAMICS—the effect of drugs on living tissues.

TOXICOLOGY—the study of poisons.

Of these four fields, this section will elaborate on only one—pharmacodynamics.

Action of drugs (pharmacodynamics)

Drugs are administered to help the body overcome disease and the effects of disease. They provide this help only by acting quantitatively—by increasing, decreasing, or otherwise aiding one or more of the body's physiologic functions. No drug can affect cellular activity qualitatively. For example, no drug can cause the parotid gland to secrete anything other than its normal secretion, saliva.

Irritation

A drug irritates a tissue, organ or gland, causing its activity to increase, decrease or stop altogether.

Stimulation and depression

The effect of irritation is either stimulation or depression. For example, pilocarpine stimulates (increases) the flow of saliva; atropine depresses (decreases) the flow of saliva. These, like most drugs, also produce a number of effects on other organs or tissues of the body. But only those types of drug actions are named that are necessary to explain specific principles.

The same drug may stimulate cells to greater activity when it is given in small quantities, and may depress cell activity when administered in larger doses. For example, small quantities of atropine stimulate the respiratory center, and breathing becomes rapid; but, excessive amounts of atropine paralyze the respiratory center, and breathing stops. This action is something like that which follows the application of heat. Mild heat can stimulate and increase circulation in an area, while too high a temperature will burn and destroy the tissues.

Irritation (stimulation or depression) may be caused by a drug acting in any one of four ways: locally, generally, indirectly, and selectively.

1. Local Drug Action:

Local drug action is the action of a drug at the site of application. It is not limited to external application, but may be brought about whenever the drug is applied—skin, alimentary tract, or elsewhere.

2. General Drug Action:

General action is the action of a drug in which cellular activity in general is affected. Only a few drugs exert this general effect, alcohol and quinine being two that do.

3. Indirect Drug Action:

Indirect drug action produces an effect in a tissue or organ as a result of the drug acting upon some other tissue or organ. It is a secondary change that follows a drug-induced, primary change in another organ. For example, a cardiac poison acts directly on the heart and injures it, indirectly depressing the respiration. Respiration is depressed because the injured heart can no longer pump sufficient blood to the respiratory center in the medulla.

4. Selective Drug Action:

Selective drug action limits the effects of a drug to one particular organ or tissue. The selective action of certain drugs is a potent weapon in the fight against disease. Because of such action, a disease involving a particular organ may be treated without the drug affecting another organ.

Reversibility

If the tissues return to normal after an irritating drug is eliminated, the action is said to be REVERSIBLE; if they do not, the action is IRREVERSIBLE.

Types of Drugs

Drugs may be classified according to any of several systems, such as whether they occur naturally or are synthetic. Or, drugs may be grouped on a basis of their chemistry and identified as alkaloids, acids, fats or resins.

In this chapter drugs will be grouped according to their principal uses. Wherever possible, they have been selected because there may be occasion to use these drugs or to observe their effects.

Administration of Drugs

Different routes of administration

In dentistry, drugs usually are applied locally, given orally or injected intra-orally. Occasionally, it is necessary to use some other method when a patient is unable to swallow or to take the drug by the other methods mentioned, or when more rapid or less rapid action may be desired.

There are ten methods or routes of drug administration in current use. The following list is limited to seven routes the dental technician may encounter during his naval career:

1. Oral.
2. Skin and mucous membrane (topical application or inunction).
3. Subcutaneous.
4. Intramuscular.
5. Intravenous.
6. Inhalation.
7. Intradermal or Inoculation (vaccination).

Selection of method

The route or channel for drug administration is determined by the following factors:

1. The effect desired (stimulation or depression).
2. The urgency for producing it—whether the patient is in shock, or in spasm. (Morphine, usually administered intramuscularly, can be administered intravenously if more rapid action is desired.)
3. The channel suitable and available for administering the drug. (The unconscious patient, for example, can not swallow.)

4. The drug itself—the usual and advisable ways of administering it.
5. The rate of absorption. Before a drug can produce an effect (other than local), it must reach the blood stream. The time required to reach the circulation will vary according to the route of administration.

The rate of drug absorption often is the most important factor in determining the method of administering the drug selected. The preceding list of methods of administration, if arranged according to rate of absorption, would appear in the following order:

1. Intravenous
2. Inhalation
3. Intramuscular
4. Subcutaneous
5. Intradermal or Inoculation
6. Oral
7. Inunction

Oral administration

Oral administration is the most convenient and most common method of drug administration. It is the method usually employed in dental practice in administering drugs for general effect. This method is not suitable for drugs such as penicillin, antitoxins or hormones, which are destroyed by the gastric secretions or eliminated too rapidly.

Some drugs are absorbed from the gastro-intestinal (G.I.) tract and carried to the liver. From the liver, they pass to the circulation. For this reason, drugs which the liver destroys, or the action of which the liver modifies, should not be given orally.

Skin and mucous membrane

Drugs usually are applied to the skin or mucous membranes to produce a local effect, but this method also may be used to produce systemic (general) effects.

The vascularity (richness in blood vessels) of the absorbing surface has much to do with its usefulness as a surface for drug administration. The mucous membrane is a more efficient absorbing surface than the skin because of its greater vascularity and the relative thinness of the tissue which the drug must penetrate to reach the blood vessels.

Practically all available mucous membranes are used—the mouth, nose, pharynx, rectum and vagina. Each has a certain desirable feature.

It is well to remember that a soluble drug, placed under the tongue, will be dissolved and absorbed, and will produce its effect almost as rapidly as when given hypodermically. Morphine sulfate may be given in this way very effectively.

Subcutaneous administration

Subcutaneous administration of a drug is the hypodermic introduction of the drug beneath the skin.

A drug administered subcutaneously produces its effect more rapidly than when given orally. Also, this method prevents the fluids of the gastro-intestinal tract from acting on the drug.

The two principal disadvantages of subcutaneous administration are:

a. An aseptic technic is always necessary.
b. The injection is usually painful.

Intramuscular

In this method the solution of the drug is injected into one of the skeletal muscles—usually the deltoid (shoulder) or gluteal (buttock) muscle. Absorption is faster than in subcutaneous administration and infection is less apt to occur.

Intravenous

Intravenous drug administration is the administration of a solution of a drug directly into a vein. Since there is no delay in absorption, action is immediate. Because the drug is introduced directly into the circulation without having to be absorbed by it, a certain amount will produce the same effect as a larger amount given orally. Thus, the intravenous dose usually is smaller than the oral dose. The toxicity of a drug given by intravenous injection often is greatly reduced if it is well diluted and is injected slowly.

Advantages of intravenous administration are:

a. Immediate action.
b. Complete control of the dosage.

Disadvantages are:

a. Aseptic technic required.

b. Only a limited number of drugs can be administered by this method.

c. Unfavorable reactions are more likely to occur with this method.

d. Once the drug is injected, absorption can not be stopped or delayed.

NEVER GIVE DRUGS INTRAVENOUSLY UNLESS SPECIFICALLY INDICATED.

Inhalation

Inhalation is used in administering highly volatile drugs such as ether, chloroform, nitrous oxide and certain medicated vapors. The rich capillary areas of the alveoli of the lungs absorb these agents rapidly.

Intradermal

Intradermal means "within the skin." Vaccination for smallpox is an intradermal administration of a virus. Some drugs also are administered intradermally.

Conditions Modifying Drug Action and Effect

A number of special conditions or factors modify the action of a drug and, as a consequence, its effect upon the patient.

Many of these special conditions vary from patient to patient. Others apply to the drug itself, such as deterioration or weakness of the drug from age.

The dental technician must be concerned with these factors. During battle, he often will be required to care for the sick and to treat the injured. Certain conditions require that the size of the dose and frequency of administration be modified to compensate for their influence.

Specific patient conditions

Specific patient conditions which influence drug action and effect are:

1. Age of patient
2. Size and weight

3. Sex
4. Individual idiosyncrasy
5. Tolerance
6. Habituation
7. Severity and type of disease or injury
8. Subject

Age of patient

Children and the very old are more susceptible to drug action and, as a rule, should receive smaller doses. The method of converting the adult dose to a child's dose is given in the section dealing with dosage.

Size and weight

The dosage is in direct ratio to size and weight of a typical 150 pound patient. A very large individual requires a larger dose; a smaller individual, a smaller dose.

Sex

Women generally require smaller doses than men, because, as a rule, they weigh less, and have a different physical and mental makeup. Pregnancy may necessitate a change in the dosage of a drug. Purgatives, diuretics and other active drugs must be given with a great deal of caution during pregnancy and lactation.

Idiosyncrasy to drugs (drug allergy)

By idosyncrasy is meant an unusual personal reaction to a drug. A person demonstrating an unusual allergic reaction to one drug is very likely to be allergic to others.

Drugs most likely to produce allergic reactions include aspirin, quinine, arsphenamines, the sulfa drugs, the barbiturates, iodine and others.

Tolerance

Tolerance is the capacity to resist the action of a drug. There are two types of tolerance—congenital and acquired.

a. Congenital tolerance, as the name indicates, is present from birth and may be due to racial or other special factors.

b. Acquired tolerance is a tolerance brought about by use of the drug. As tolerance increases, the dosage may have to be increased. The most familiar example of tolerance is that acquired for tobacco (nicotine).

Habituation

Continued and regular use of certain drugs results in a craving for the drug when it is withdrawn. Habituation usually decreases the effects of drugs, as seen in persons addicted to heroin or to cocaine.

Cumulative drug action

Eventually, repeated small doses of a drug may show more marked symptoms than earlier doses. Lead is an example of a drug that accumulates in the tissues until additional doses increase its strength to a poisonous degree. Through continued contact with white lead, painters often develop a form of lead poisoning called "painters' colic."

Disease and pathologic conditions

Disease often is an important factor in determining dosage. Response to drug action in the presence of disease is variable. Much more quinine can be given to an individual who actually has malaria than to one who does not have the disease.

There are also miscellaneous factors, which are not patient conditions, that modify drug action and effect, such as:

1. Route and speed of administration
2. Temperature of drug solution
3. Age of drug
4. Synergism

Route and speed of administration

The influence of different routes and speeds of administration on drug action and effect was discussed previously.

Temperature of drug solution

Normally, drug solutions are administered at body temperature. A solution designed to prevent or overcome shock might itself contribute to shock if it were taken from the refrigerator and injected into a vein without first being warmed.

Age of drug

A drug may become weak with age, so that a larger quantity must be given; or the strength or concentration of a drug may increase through evaporation of some of the solvent.

Synergism

The action of a drug may be intensified by the presence of another drug or drugs having the same or similar effects in the body. The Navy's A.P.C. (aspirin, phenacetin and caffeine) combines drugs (aspirin and phenacetin) whose combined effects are greater than that of an equal amount of either one of the drugs administered alone.

Antibiotics

Antibiotic literally means "against life" (ANTI, against, BIOS, life), and fortunately enough, the forms of life that antibiotics act against are bacteria. ANTIBIOTICS are those therapeutic, bacteriostatic agents produced by molds, fungi and bacteria. Bacteriostatic means preventing or arresting the growth of bacteria.)

Alexander Fleming, the English bacteriologist, first saw the significance of the bacteriostatic action of penicillin. It is highly improbable that Fleming actually was the first to observe this action, but there is no doubt that he was the first to see it successfully—that is, to recognize the significance of what he saw.

After this initial observation, Fleming concentrated upon identifying the specific factor in the mold, Penicillium, which was responsible for the bacteriostatic action. Eventually this factor was isolated, and because it was produced by Penicillium, Fleming named it penicillin.

Penicillin first was used clinically in 1941. Its high therapeutic value, plus the great need for such agents, has stimulated further work in this field. Other valuable antibiotics have been discovered, and the search continues for more. A few representative antibiotics will be discussed in this section.

As a class, the antibiotics have a number of common characteristics:

1. Antibiotics are highly SELECTIVE—are effective only against certain diseases. For this reason the specific organism causing the infection should be identified whenever possible, before an antibiotic is prescribed.

2. Antibiotics, in less than adequate dosages, result in the development of resistant strains of bacteria.
3. Certain antibiotics are particularly liable to develop resistant bacterial strains.
4. Antibiotics arrest the growth of bacteria against which the sulfa drugs are not effective.
5. One antibiotic may be effective against some bacteria which are resistant to another antibiotic.

   It will be seen that the antibiotics share several characteristics of a general nature with the sulfonamides or sulfa drugs. Both can develop resistant bacteria, and both are selective in their action. There is another common characteristic of the antibiotics which, to some extent, is shared by the sulfonamides.

6. Antibiotics (unless a special preparation is used) are rapidly excreted (mostly through the kidneys), and this must be compensated for by frequent doses.

Methods of administration

Unlike the sulfonamides, not all of the antibiotics may be administered by the same channels. They are administered as follows:

PENICILLIN: Intramuscularly, orally, and topically (as an ointment).

STREPTOMYCIN: Intramuscularly, subcutaneously, by inhalation, and topically.

TYROTHRICIN: Topically only.

BACITRACIN: Topically only.

Bacteria affected by specific antibiotics

Following are the general groups of bacteria most affected by each of the antibiotics:

PENICILLIN: Most gram-positive bacteria.

STREPTOMYCIN: Gram-negative bacteria and certain gram-positive strains that have developed resistance to penicillin.

TYROTHRICIN: Both gram-positive and gram-negative bacteria.

BACITRACIN: Same organisms that are susceptible to penicillin.

Toxic symptoms

Streptomycin seems to be the principal offender. Reactions to penicillin are rare and transient (of brief duration).

PENICILLIN: Chills, fever, flushing, urticaria (itching), rash.

STREPTOMYCIN: Fever, muscle aches, dizziness, urticaria.

Sensitization of the patient may follow the topical administration of penicillin. That is, he may be so conditioned by the topical application of penicillin that he will react unfavorably to later administration of the drug by any method. One should be aware of this possibility and should avoid sensitizing a patient to this valuable therapeutic drug when some other agent might serve equally or nearly as well.

Anesthetics

Anesthetics are drugs that diminish or eliminate sensation or feeling—particularly the sensation of pain. The discovery literally marked the beginning of modern surgery, for the surgeon through the use of anesthesia can pay full attention to the fine details of his technic. He never could do this if his patient were feeling pain or struggling during the surgery.

Over a century ago an American dentist, Horace Wells, demonstrated the anesthetic properties of nitrous oxide ("laughing gas"). He had one of his own teeth extracted under the influence of this gas—the first instance of painless surgery through use of anesthesia.

There are two kinds of anesthetics—LOCAL anesthetics and GENERAL anesthetics.

Local anesthetics act on the peripheral nervous system. They act on the nerve itself, blocking the nerve impulse coming from that area.

Since the local anesthetic drug solution must be made to come in contact with the nerve, it is injected on the nerve, or close to it.

General anesthetics act on the central nervous system (the brain and spinal cord). Most general anesthetics put the patient to sleep.

Local Anesthetics Used in Dentistry

The local anesthetics most used in dentistry are:

1. Procaine hydrochloride (novocain)
2. Benzocaine (ethylaminobenzoate)
3. Butyn
4. Ethyl chloride
5. Cocaine hydrochloride

PROCAINE HYDROCHLORIDE, the local anesthetic most used in dentistry, is injected hypodermically and applied topically. It has many attributes to recommend its use: is easily prepared in solution, is relatively nontoxic itself, and its effects are certain.

Procaine hydrochloride is prepared for use in the dental office in two forms:

a. The AMPULE (carpule), a loaded glass cartridge that is inserted in a specially designed syringe. The ampule contains slightly over 2 cc. of 1 percent or 2 percent solution of procaine hydrochloride, with epinephrine in a strength of one part in 30,000 or one part in 50,000 (written 1 : 30,000 and 1 : 50,000). When such preparations are used, reliance for sterility, correct dosage, and pH of the solution is placed upon the manufacturer.

b. The TABLET, like the ampule, is manufactured with epinephrine included. In preparing tablets the following essentials are important:

(1) Always use sterile, distilled water. (Distilling water does not automatically render it sterile; it must be sterilized after distillation.)

(2) One 20 mg. tablet dissolved in 1 cc. of sterile, distilled water gives a 2 percent solution.

(3) A special boiling cup is provided for dissolving procaine hydrochloride tablets in water. If one is not available, any sterile container may be used, if it can be heated.

Epinephrine is a VASOCONSTRICTOR (from VAS, vessel and CONSTRINGERE, draw together). By constricting or contracting the blood vessels of the injected area, it retards the rate at which the blood stream carries away the procaine hydrochloride, thus prolonging the anesthetic effect of the solution.

Although procaine hydrochloride is relatively nontoxic, epinephrine is highly toxic, and fatalities have followed the injection of 1 cc. of a 1 : 1000 solution. Some anesthetic solution ampules are prepared without epinephrine for cardiac patients, who should not be given epinephrine.

BENZOCAINE is used locally, usually in the form of an ointment. In dentistry it is used in the treatment of "dry socket," painful ulcers and postextraction wounds. Benzocaine is a surface anesthetic when used in the manner described for butyn in the following paragraph.

BUTYN is used to anesthetize the mucous membrance to make insertion of a needle less painful. A wisp of cotton, moistened with butyn or benzocaine, is held for a few moments against the intended site of injection.

ETHYL CHLORIDE is a highly volatile liquid (evaporates rapidly). It is sprayed on the surface of the skin or mucous membrane to be anesthetized. The anesthesia produced is superficial (shallow), is limited to the area sprayed, and is adequate for lancing superficial abscesses and for other procedures which do not involve more than a quick, shallow incision. Anesthesia is produced by the refrigeration and frosting of the tissue surface.

Ethyl chloride is furnished in a glass container provided with a stopcock. When the stopcock is released, the liquid is sprayed as a vapor.

COCAINE is the most potent of the local anesthetics used for surface anesthesia. Because it is also the most toxic, its use has been greatly restricted in recent years, and is now rare in dental practice.

General anesthetics used in dentistry

The general anesthetics used most in dentistry are:

1. Nitrous oxide
2. Ether
3. Pentothal sodium

Nitrous oxide and ether are administered by inhalation. Pentothal sodium is a powder which is dissolved in water and administered intravenously.

The administration of general anesthetics is a complicated procedure, and is quite properly a practice specialty in itself. No one who is not properly trained should administer a general anesthetic, except under conditions of dire necessity, or under the direction of someone who is qualified.

Hypnotics and Sedatives

Hypnotics are drugs which produce sleep. Sedatives are drugs which allay apprenhension and nervousness. Both act on the central nervous system.

Classifying these drugs as either hypnotics or sedatives is done on the basis of the effect produced by a single dose of average size. For the most part, drugs of either group—depending upon the size of the dose—are capable of producing either effect. A hypnotic, in half the usual dose, produces a sedative effect, while two or three times the usual dose of a sedative, given in a single dose, will produce sleep—will act as a hypnotic.

Both hypnotics and sedatives usually are administered by mouth.

They are used in dentistry for two purposes:

1. To secure a night's sleep for a patient who otherwise might be kept awake by postoperative pain and nervousness or by preoperative fear and apprehension.

It should be mentioned here that hypnotic drugs will not relieve pain. Hypnotics should be administered in conjunction with pain-relieving drugs if pain is present. Otherwise, the effect of the hypnotic is wasted, or sleep is produced only by an excessive dosage.

2. To quiet the nervous patient preoperatively. Much can be done for this type of patient by the administration of a hypnotic—in half the hypnotic dose—30 or 40 minutes before treatment. Thanks to long established (if not generally used) methods of pain control, patients need neither dread dental treatment nor arrive for their dental treatment in a highly nervous state.

The following hypnotics and sedatives are used widely in dentistry. Either the proprietary (trade) name or the pharmaceutical name, or both, will be given.

Hypnotics

1. Pentobarbital (nembutal)
2. Phenobarbital (luminal)
3. Barbital (veronal)
4. Dial
5. Amytal

Sedatives

1. Bromides. The bromides—sodium, potassium and calcium—are the most commonly used sedatives. Because they may be bought without a prescription, occasionally one sees the results of overdosage—mental depression, thick speech, mental sluggishness, skin rash, and perhaps even delirium. These conditions may appear only after long-continued, habitual use.

2. Dilantin Sodium. Dilantin sodium has a sedative action, but its important use is to suppress epileptic convulsions.

Fifteen percent of the users of this drug develop reactions of various kinds. As a matter of dental professional interest, the most important reaction is hypertrophy (overgrowth) of the gums.

Other hypnotic or sedative agents

Among other agents which may be used as hypnotics, sedatives, or both are the following:

1. Chloral hydrate
2. Paraldehyde
3. Avertin
4. Scopolamine ("twilight sleep")
5. Papaverine

Analgesics

Analgesics are drugs which primarily relieve pain. There is no "pure" analgesic—that is, a drug which limits its effect to ameliorating pain. All analgesics have secondary effects, some of which may be desirable or not, depending upon the patient and his condition.

Analgesics are of two kinds:

1. Opium and its derivatives (narcotics)
2. Antipyretic (fever-reducing) analgesics

Narcotic analgesics (opium, morphine and their derivatives)

Opium is derived from the juice of the poppy plant. From it is derived morphine, and from morphine—codeine, apocodeine and apomorphine. All drugs in this group are habit forming. Their secondary effects generally are the same, differing mainly in degree.

Whether opium is smoked in a pipe—the Asiatics' way—or is swallowed in the form of LAUDANUM (tincture of opium) or paregoric (the camphorated tincture), the analgesic effect is due to the morphine content.

Morphine

There is no drug superior to morphine for the relief of pain. This includes pain from any cause—burns, gallstones, migraine and other severe pain. It acts swiftly and furnishes complete relief. Morphine is sometimes used to calm a highly nervous patient before an operation of some magnitude.

Unfortunately, the secondary effects of morphine limit its use. When morphine is given, three secondary effects should be kept in mind:

1. MORPHINE IS HABIT FORMING. This limits the number of doses that can be administered without the patient developing a craving (addiction) for the drug. Morphine should be used only as a stopgap, to control extreme pain (as in a severe burn) until specific treatment can be carried out. A few doses will carry the patient through the critical stage, after which he will no longer require the drug.

In certain incurable diseases, associated with great pain, habituation is of no consequence. The patient is given morphine as often as he may require it.

2. MORPHINE DEPRESSES RESPIRATION. Another secondary effect limits the use of morphine—it is never given to a patient who has respiratory difficulty. Morphine will further depress his breathing, which is already difficult, and will put the patient in danger of actual respiratory failure. Fewer than twelve breaths per minute, particularly in a patient who already has received morphine, indicates that immediate respiratory failure is impending.

3. MORPHINE CONTRACTS THE PUPILS OF THE EYE. In cases of head injury, whether accompanied by pain or not, the patient is never given morphine until the neurologic examination has been completed.

Most head injuries cause the pupil on the side opposite the injury to be either larger or smaller than the other one. By constricting the pupils, morphine makes them of equal size. It can be seen that this would disguise the characteristic evidence shown by contraction or enlargement of one pupil.

As a rule, morphine is injected intramuscularly, but it may also be given intravenously, orally or sublingually. The action commences almost as soon after sublingual administration as after intramuscular injection.

Codeine

Codeine is derived from morphine and, in comparison with morphine, has three advantages:

1. Is less habit forming.

2. Depresses respiration less than morphine.
3. Increases the effectiveness of other analgesics when administered with them (synergistic).

Codeine is not as powerful an analgesic as morphine—its main disadvantage. More codeine is required to produce the same effect. In some cases, after pain reaches a certain intensity, codeine will not be effective. However, codeine may be used to prevent the pain from ever reaching that intensity. The drug is given as soon as pain begins—or before, if possible. Then further doses are given, usually at 3- or 4-hour intervals. This early or advance treatment (premedication) with codeine is often successful in suppressing pain that, once fully established, would have required morphine.

Codeine usually is administered by mouth, but it may be injected intramuscularly in suitable form if the patient can not swallow.

Antipyretic analgesics

Antipyretic analgesics are coal tar derivatives. They differ from opium and its derivatives in three ways:

1. Like opium, they relieve pain, but in addition, they reduce fever.
2. Generally, they are not habit forming.
3. Their secondary effects are not potentially as dangerous as those of the opium group. Therefore, the range between the therapeutic and the toxic dose is considerably larger than it is for the opium and morphine group.

Anodynes

The drugs used in dentistry as local anodynes (pain relievers) are a varied group. They include:

1. Eugenol
2. Beechwood creosote
3. Compound tincture of benzoin
4. Phenol
5. Iodine tincture (2%)
6. Iodine-aconite combination

Eugenol

Eugenol is a volatile oil derived from oil of cloves. Like other essential oils, it penetrates tissue readily.

Eugenol is used in dentistry for toothache. For this purpose it is usually applied as a dressing. A cotton pellet is moistened with eugenol, squeezed dry and placed in the cavity. It may be sealed in with either gutta percha or a cement. Excessive amounts and long-continued use may lead to irritation of the pulpal tissue.

Eugenol mixed with zinc oxide is used to treat hypersensitive dentin of a freshly prepared cavity and as a base in deep cavities. The eugenol and zinc oxide are mixed on a glass slab to the consistency required by the operator.

Beechwood creosote

Beechwood creosote is the principal constituent of the "toothache drops" so widely dispensed. It has an obtundent (soothing, partially anesthetic) action. It is an old remedy in root canal therapy and is not widely used today as a pulp canal antiseptic.

Compound tincture of benzoin

Compound tincture of benzoin is used to soothe the pain resulting from inflammation of the oral mucous membrane. Its effect is due to the protective film it forms over the tender tissue. Such a film has been used to retain medicaments (chromium trioxide solution, for example) in the gingival crevices in the treatment of infection.

Phenol

Phenol is occasionally used as an anodyne, especially in treating pulpitis. Since phenol is an organic acid with a powerful caustic action, it relieves pain by cauterizing and paralyzing the nerve endings. If it is employed for this purpose, it should be used most carefully, and in minute quantities. Phenol is used by many dentists in an attempt to sterilize, and for cleansing cavities prior to placing restorations. It is applied sparingly with a cotton pellet and may be partly removed by wiping the cavity with a cotton pellet moistened with alcohol.

Iodine tincture (2% iodine, 2-2½% sodium iodide)

Iodine has been used to treat pain by applying a small quantity to the dried mucous membrane directly over the apex of the suspected tooth. Used in this way, iodine is a counterirritant, and owes its effect to this action.

Antiseptics and Disinfectants

Bacteriostatics and bactericides

An antiseptic or BACTERIOSTATIC drug is one that stops the growth of bacteria. A disinfectant, or BACTERICIDAL drug, is one which kills bacteria. The newer terms "bacteriostatic" and "bactericide" are replacing the older ones, "antiseptic," and "disinfectant." The newer terms are preferred because they indicate more accurately the effect produced on bacteria by drugs of each class. (STATIC means stop; CIDE means kill.)

The difference between bacteriostatic and bactericidal action is largely one of degree. Bacteriostatics generally become bactericidal in strong concentrations, and bactericides become bacteriostatic if sufficiently diluted.

Mode of action

Bacteriostatics and bactericides produce their effects on bacteria by one or more of these actions:

1. Coagulation (thickening, curdling) of the bacterial protoplasm.
2. Combination with the bacterial protoplasm.
3. Interference with bacterial metabolism, either nutritional or respiratory.

Classification

In any classification of the bacteriostatics, overlapping can not be avoided. For example, mercurochrome is a mercury derivative and also a dye.

Following are a few representative bacteriostatics. It is difficult to group them satisfactorily, but a chemical classification is the least objectionable even though it is not applied strictly.

1. ACIDS
   - Sulfuric
   - Boric
   - Acetic
   - Carbolic (phenol) and creosols
2. OXIDIZING AGENTS
   - Hydrogen peroxide
   - Sodium perborate
   - Zinc peroxide

3. Metals and Derivatives
   - Mercury
   - Mercurochrome
   - Metaphen
   - Merthiolate
   - Silver nitrate
   - Silver protein
   - Zinc chloride
4. Dyes
   - Gentian violet
   - Methylene blue
   - Acriflavine
   - Scarlet red
   - Brilliant green
   - Mercurochrome

Acids

Practically all acids have bacterial and disinfectant effects. For that matter, so has a flame. Undiluted acids and flame produce practically the same effects on tissues; both char and burn.

Undiluted acids act as caustics and are used undiluted only when a caustic effect is desired, as in the emergency treatment of snake bite or, in dentistry, in the removal of surplus gingival tissue. Otherwise, acids always are used in diluted form. This usually reduces their caustic effect to an astringent one.

Even when diluted, solutions of acids are not suitable for intra-oral use. The surfaces of the teeth are attacked and, if contact is long continued, the enamel will be destroyed.

Following are most of the acids that a dental technician will use or handle:

Sulfuric acid formerly was used in dentistry for the removal of necrotic debris from putrescent root canals. Its use has been superseded largely by other drugs, but it is still used occasionally. When a dental officer uses this drug, his assistant can anticipate instructions to have a saturated solution of sodium bicarbonate ready for neutralizing the acid.

Boric acid is a mild inorganic acid that may be used as a mouth-wash without damage to the teeth. However, since it is but weakly bacteriostatic, there is little occasion for its use. Because it is relatively nonirritating and somewhat bacteriostatic, it has come to be widely used as an eyewash.

TRICHLORACETIC ACID occurs as colorless crystals. In high concentrations it is caustic but, when diluted, its action is reduced to an astringent one.

Since the crystals readily take up atmospheric moisture (deliquesence), an escharotic (corrosive, caustic) solution is made by leaving the bottle uncovered or by putting the crystals in a dappen dish. Concentrated solutions are used in the mouth for painless removal of hypertrophied tissue.

By using trichloracetic acid, a small tissue tag that sometimes covers the distocclusal surface of a third molar may be removed quite simply. A small wisp of cotton is spun around a barbed broach, dipped in water, squeezed almost dry, and the tip lightly touched to the crystals of the acid. Usually one or two crystals will adhere. After these have gone into solution with the water remaining in the cotton, the shank of the broach is carefully dried to remove any excess solution that might touch the patient's lip or fall on his tongue.

The tip of the broach is passed around the periphery of the tissue tag, and slightly under it. It will burn the tissue painlessly, forming a white covering. The surface of the tooth should be washed with water. When the patient returns three days later, the thin surface layer of burnt tissue will have sloughed away. This treatment can be repeated until the desired amount of excess gingival tissue has been removed.

PHENOL (carbolic acid) is furnished to the dental clinic either as crystals or as liquefied phenol—a solution of 90 percent phenol in water.

Phenol was the first antiseptic to be used, Lord Lister's use of phenol spray in 1867 marking the beginning of the era of antiseptic surgery.

Phenol in a very dilute concentration acts as a local anesthetic by paralyzing the nerve endings. It is effective in treating aphthous ulcers, being applied very sparingly on a wisp of cotton and diluted immediately with alcohol. Sometimes it is used in ointments (0.5%) to relieve the pain of earache.

The phenol coefficient (p/c) of a bacteriostatic or disinfectant is its germicidal power compared to that of phenol. If a bacteriostatic has a phenol coefficient of 2, it has twice the germicidal efficiency of phenol when both are tested on the same organism (usually Bacillus typhosus), under the same conditions.

Very dilute solutions of phenol (½% to 1%) sometimes are used as a bacteriostatic for the skin, but more desirable agents are available for this purpose.

Solutions of 5 percent phenol are used for the disinfection of instruments or clothing.

ANESTHETIC GANGRENE is that form of gangrene which follows the prolonged application of weak solutions of phenol (some dressings are soaked in phenol). Here the anesthetic effect of phenol becomes its greatest danger and indicates the truth of the familiar phrase, "too much of a good thing," for, in the absence of pain, gangrene may develop unnoticed.

CREOSOTES AND GUAIACOL are derived from tars distilled from various woods. They are closely related to phenol and are used only as disinfectants. CREOSOTE is made up chiefly of cresol and guaiacol.

In dental practice, guaiacol is of some importance. The combination of iodine, guaiacol and eugenol—equal parts of each—may be used in the treatment of "dry socket."

Oxidizing agents

The oxidizing agents accomplish their antiseptic action by the release of oxygen. This nascent (just released) oxygen oxidizes the bacteria that it reaches. Organisms vary in resistance and susceptibility to the bacteriostatic action of nascent oxygen, but on the whole, gram-positive organisms are more susceptible.

There is another action of the oxidizing agents which, like the anesthetic effect of phenol, usually is beneficial but can become harmful. This second action is the mechanical action which takes place with the decomposition of hydrogen peroxide into water and nascent oxygen. Usually the decomposition takes place rapidly, and the oxygen is liberated with a bubbling and foaming of the solution, which mechanically lifts organisms and tissue debris from the wound. When this takes place in a contaminated surface wound, the action is both antiseptic and mechanical. But in a confined space, infectious material very likely will be forced deeper into the tissues. For this reason, hydrogen peroxide, or other agents having a similar action, never are used in root canals. Should a canal become blocked by debris, the continuing production of gas may carry infection deep into the facial tissues. A description of the most common oxidizing agents and their dental uses follow:

Hydrogen peroxide ordinarily used is the 3 percent U.S.P. solution. However, solutions with concentrations as great as 25 percent and 30 percent are available. These stronger solutions are extremely caustic and never should be be used by anyone unfamiliar with them. Whenever hydrogen peroxide is received from the storeroom, before it is used, the label on each bottle should be carefully checked to make sure the concentration is proper for the intended use.

In stomatitis (inflammation of the mouth), particularly where there is slough (a mass of dead tissue), hydrogen peroxide has considerable merit. It is nontoxic and may be used by the patient as a part of home care. In concentration, one part hydrogen peroxide is used with three parts water.

Sodium perborate is a white powder that gives off oxygen as it decomposes. Sodium perborate is said to be less irritating to tissue than hydrogen peroxide, because of its greater alkalinity.

Sodium perborate may be used to treat the same conditions for which hydrogen peroxide is used—acute ulcerative gingivitis and general oral conditions which require the use of an antiseptic and deodorant.

The concentration used, 2 percent to 4 percent, is prepared by dissolving a teaspoonful in approximately half a glass of warm water and using as a mouthwash. It also can be mixed with water and used in paste form. It should be removed from the tongue and other parts by thorough rinsing, to avoid the development of a characteristic soreness known as "perborism."

Zinc peroxide is an insoluble yellow powder. Unlike either hydrogen peroxide or sodium perborate, it releases oxygen very slowly—its principal advantage. This drug is useful in the treatment of chronic ulcers, osteomyelitis, and other suppurative (pus-forming) and draining, mouth conditions in which long-continued antiseptic deodorizing action is useful.

POTASSIUM PERMANGANATE formerly was used in the treatment of snake bite, but newer antivenoms have replaced it. It still may be used in emergency. The crystals are applied directly to the site after it has been incised.

Although potassium permanganate is an oxidizing agent, better ones are available for dental use. It can be used in weak solution over long periods, as a mouth irrigator, to control sepsis during jaw fixation. While quite satisfactory in preventing constitutional symptoms in such cases, the teeth and soft tissues become badly stained and are cleansed with some difficulty.

IODINE is one of a group of related elements, all of which are protoplasmic poisons and owe their bacteriostatic effect to this action. Protoplasmic poisons exert their action on ALL protoplasm, not on bacterial protoplasm alone. This means that the concentration used must be one that will produce the maximum bacteriostatic effect, with a minimum of injury to the protoplasm of the host. Often there is but slight difference between the concentration that will strike this fine balance, and the one that will injure the host. Strict attention to this detail will prevent unnecessary reactions, such as tissue burns.

IODINE TINCTURE probably is the most familiar bactericide used today. It is bacteriostatic and often used as a counterirritant.

Iodine tincture formerly a 7 percent alcoholic solution and not indicated for use within the mouth, is now a mild tincture (about 3%) and is acceptable for oral use. Weaker solutions are effective also— as low as 1.25 percent.

The principal dental use of iodine is by local application, usually prior to needle insertion, to disinfect the site of injection. When used within the concentration range previously given, it is capable of accomplishing this result as well as any agent.

IODOFORM is an iodine compound which is most commonly seen incorporated in gauze called "iodoform gauze." It is used chiefly as a pack for infected wounds within the mouth, the real benefit to the patient coming from the mechanical action the gauze exerts—not from any long-continued bacteriostatic effect. The mechanical effect is that of keeping the wound open, permitting healing to take place from the floor of the wound.

Iodoform has a disagreeable odor and taste. This may be overcome without interfering with the efficacy of the drug by dipping the iodoform gauze in eugenol. The gauze is squeezed dry before it is placed in the wound.

CHLORINATED LIME is used for disinfection of water. *Chloramine-T*, another chlorine compound, is used in concentrations of from 0.5 percent to 4.0 percent as a tissue bacteriostatic.

In general, the action of the chlorine compounds is similar to that of the oxidizing agents in that both decompose to accomplish their action. Like hydrogen peroxide the chlorine compounds in strong solution become injurious. If these agents are used, the concentration should be checked and the directions on the label carefully followed.

Metals and metal derivatives

The salts of the heavy metals such as mercury, silver and zinc, are soluble protoplasmic poisons. Whether the effect is bacteriostatic, astringent or caustic depends upon the concentration of the solution. Following are descriptions of some compounds of these metals:

BICHLORIDE OF MERCURY is extensively used for the disinfection of utensils and bracket tables that are not made of steel. Steel is corroded by its action. Furnished to the dental clinic in the form of tablets, one tablet dissolved in a liter of water makes a 1 : 20,000 solution.

Bichloride of mercury is extremely toxic. It should be stored so that there will be no possibility of its being administered to a patient, either locally or systemically.

METAPHEN and MERTHIOLATE, both mercury compounds, are relatively nontoxic when compared with bichloride of mercury. Each is used for instrument disinfection, skin disinfection and for irrigations.

METAPHEN, also a disinfectant, does not corrode steel instruments. A concentration of 1 : 5000 alcoholic solution is used for this sterilizing purpose. For *skin* application, solutions of from

1 : 5000 to 1 : 10,000 are used. For disinfection of the skin, aqueous (water) solutions also may be used: however, they are not suitable for instrument disinfection.

MERTHIOLATE is used for skin and instrument disinfection. For skin, the tincture (a 1 : 1000 alcoholic solution) is used; for wounds and instruments, a 1 : 1000 aqueous solution.

SILVER NITRATE is furnished in glass ampules. In the usual concentration furnished, silver nitrate is extremely caustic, and care should be taken that none of the solution falls anywhere on the patient. In more dilute solutions, silver nitrate becomes astringent and bacteriostatic in its action, but it is not used to any great extent in dentistry for either of these purposes.

Silver nitrate is used in an attempt to sterilize a cavity after the cavity has been prepared. It is believed by some authorities that the silver nitrate sets up a barrier of silver, which slows or halts the progress of caries. Usually, after silver nitrate has been allowed to remain in the cavity from a few seconds to two minutes, it is precipitated with eugenol. Upon precipitation the solution turns black and permanently stains the tooth structure—its chief disadvantage.

Silver nitrate is used to desensitize hypersensitive gingival areas of the cementum. The objectionable black stain limits this use. More recently, the fluoride pastes have been used for this purpose, but it is still too early for them to be evaluated accurately.

SILVER PROTEIN, a special colloidal solution of silver which is only mildly irritating, has been used for gingivitis. It is used in concentrations of from 15 percent to 20 percent to irrigate the gingival tissues.

ZINC CHLORIDE in strong solution (50%) is intensely caustic whereas in a weaker solution (½% to 1%) it can be used as an astringent. When used in concentrated form the solution will reduce sensitivity in cementum and dentin. Often it is incorporated in pleasing and therapeutic mouthwashes.

The dyes

The dyes primarily are used in dentistry as bacteriostatics. They are applied locally, for selective action against certain bacteria and for special tissue effects. In recent years, particularly since the sulfonamides and penicillin have been available, the dyes have been used less frequently. However, in certain oral conditions they are still valuable therapeutic agents. Their value lies not so much in their equal or greater effectiveness as in their economy and the fact that their use allows the sulfonamides and antibiotics to be reserved for more severe infections.

In dentistry the dyes are used only locally. The amounts used in treating the average dental condition, need cause no concern over possible toxic reactions.

Dyes used in dentistry

The following dyes are commonly used in dentistry:

1. Gentian violet and crystal violet
2. Brilliant green
3. Methylene blue
4. Acriflavine and proflavine
5. Scarlet red

GENTIAN VIOLET and CRYSTAL VIOLET are closely related dyes with similar reactions and uses. The therapeutic effects herein described for gentian violet apply also to crystal violet.

Gentian violet exerts a selective bactericidal action against gram-negative bacteria. Also, it is an effective bacteriostatic (checks the growth) against gram-positive organisms. Because of this action, gentian violet is particularly useful in treating, locally, mixed oral infections — that is, oral infections not preponderantly caused by one organism.

Gentian violet is used in gingival infections and in infected tooth sockets. It seems to be the drug of choice (1% solution) in the treatment of thrush, a disease chiefly affecting infants but seen occasionally in adults.

The solution is applied with a cotton applicator, or on cotton held in pliers. The area is swabbed with the solution; if allowed to dry before the patient closes his mouth, greater effectiveness results.

BRILLIANT GREEN belongs to the same group of dyes as gentian violet, and is employed for the same purposes. In dentistry it is combined with crystal violet in a 1 percent solution.

METHYLENE BLUE is a weak bacteriostatic, at best. When used, the concentration is 1 percent aqueous solution.

Methylene blue is used in gingival infections, practically as gentian violet is used, but with less justification.

ACRIFLAVINE and PROFLAVINE are both reddish brown powders soluble in water and in alcohol. Aqueous solutions of from 1 : 1000 to 1 : 5000 are applied locally.

The bacteriostatic action is marked and is increased in the presence of blood serum. These dyes are used in infections of the oral mucosa, particularly ulcers.

SCARLET RED is classified as a wound stimulant in some pharmacology texts. In dentistry it is used in the form of a 4 percent to 8 percent ointment and as a dusting powder in the treatment of chronic ulcers. It is said to have the power of stimulating epithelial proliferation.

MERCUROCHROME is a mercury compound, although it is often classed as one of the fluorescein dyes. It is used as a skin disinfectant prior to surgery and as a germicide for the genito- urninary tract.

A 1 to 2 percent aqueous solution is used. The principal dental condition in which mercurochrome is employed is suppurative gingivitis. Some authors recommend its use in gingivitis caused by a streptococcus. It has been recommended as a surface bacteriostatic for mucous membranes prior to needle insertion.

It is the custom of pharmacies in the service to tint certain solutions for identification purposes. Paragraph 12B22.3, Manual of the Medical Department, states that "Poisons which are frequently used shall be safeguarded by proper labels, containers, DISTINCTIVE COLORING,* * *" Dyes are used for coloring these solutions. For example, fuchsin is used to tint solutions of phenol pink, and methylene blue is used to tint solutions of bichloride of mercury blue (para 21B22.6 MMD).

Soap.—Generally overlooked as an antiseptic is soap. A thorough scrubbing with soap and warm water will reduce the number of bacteria. The liquid soaps are superior to the soft soaps, due perhaps to the alcoholic content.

Essential oils.—The essential, or volatile oils are distilled from plants. Since earliest times, they have been used as preservatives, which indicates their bacteriostatic effect.

However, the essential oils are not used in dentistry for antiseptic effect, but for the relief of pain which follows their local application.

Therefore, these drugs are not classified as bacteriostatics, but as obtundents, or anodynes, because they are used locally for the relief of pain.

Essential oils used in dentistry include:

Oil of clove (eugenol is its active constituent)
Oil of eucalyptus (eucalyptol)
Oil of thyme (thymol)

Oil of clove and its active constituent, eugenol, are applied locally for the relief of toothache due to caries.

Oil of eucalyptus is used in root canal therapy, with gutta percha points.

Thymol is combined with other drugs in mouthwashes.

Protein Hydrolysates and Amino Acids

Protein hydrolysates and amino acids are substances prepared from milk, beef, wheat, and bean proteins. They furnish, in a form readily assimilated by the body, substances required for building of tissue and blood protein. Protein hydrolysates are administered orally or intravenously to patients in conditions where additional protein is required.

Vitamins

Vitamins are accessory food factors—substances which must be supplied in small quantities to maintain normal health.

While vitamins are a necessary part of the normal diet, there are special conditions under which they are administered as medicines. These include diseases caused by deficiency of vitamins in the diet, and certain other diseases and conditions. Sometimes extra vitamins are given before and after operations or treatments that make extra demands upon the patient's system.

Vitamin A

Sources: Principally from butter, carrots, green vegetables, fresh liver.

Necessary for night vision and healthy skin; for dentin formation during development of the teeth.

Vitamin D

Sources: Principally from fish oils, eggs, and exposure to sunlight.

Necessary for the control of calcium and phosphate metabolism. A deficiency produces rickets in children.

Vitamin E

Sources: Principally from corn and wheat germ oil.

Main function is to prevent oxidation of necessary vitamins and unsaturated fatty acids. Necessary for normal reproduction in many animals.

Vitamin K

Sources: Green vegetables.

Necessary for the normal clotting of blood.

Vitamin B_1 (thiamine)

Sources: Mainly from pork, beans and peas, and fortified flour.

Main function is to prevent beriberi and degeneration of the peripheral nervous system.

Vitamin B_2 (riboflavin)

Sources: Milk, liver, wheat germ.

Main function is to prevent types of dermatitis or anemia due to slow formation of red cells.

Vitamin C

Sources: Fresh green vegetables, citrus juices, tomatoes.

Main function is to prevent scurvy, characterized by spongy gums, loose teeth, resorbed dentin or cementum.

Nicotinic Acid

Sources: Meat, fish, bread.

Necessary to prevent pellagra (diarrhea, dematitis, dementia).

HANDLING OF DRUGS IN THE OPERATING ROOM

Paragraph 1398 of the Manual of the Medical Department of the U. S. Navy: "*Custody of Narcotics, Alkaloidal Poisons, etc.* All narcotics, alkaloidal poisons, alcoholic beverages, and poisonous chemicals for use in the dental department of a ship or station, except small quantities for immediate use, shall be kept in a separate locker or safe and the key or combination shall remain in the possession of an officer of the dental department except at naval hospitals and at naval dispensaries commanded by officers of the Medical Corps. If a safe is used, a copy of the combination shall be enclosed in a properly sealed envelope and given to such an officer as may be designated by the commanding officer."

Paragraph 1399: "*Dispensing of Spirits or Drugs.* The dental officer of a ship or station shall not permit any spirits or drugs, the property of the Government under his charge, to be placed in the possession of any person except in small quantities for legitimate use in the treatment of patients."

Bottles used for the dispensing of drugs are generally kept in the medicine compartment of the instrument cabinet. Three types of small bottles are in common usage; the first has a medicine dropper which serves as a stopper and dispenser; the second is a one-half ounce, wide-mouthed bottle, provided with a ground glass stopper; the third is a glass bottle, with a grooved stopper which aids in dispensing drugs in drop form.

All dispensing and stock bottles are to be kept clean, tightly stoppered, and plainly labeled as to their contents. Medicament applicators and cotton pellets should never be dipped into a dispensing bottle. The medicine is placed in a dappen dish on the bracket table for use by the operator. When dappen dishes have been used for the application of medicines they should be emptied upon completion of use, cleaned and returned to their proper places in the cabinet. When more than two medicines are being used, it is necessary to have a means of positive identification for the drug in each dappen dish. For this purpose, various colored dappen dishes are employed. Another means of distinguishing between two medicines is by placing one of the drugs in the deep cup of one dappen dish and the second drug in the shallow cup of another.

The following publications contain additional or complete information on all drugs:

A.D.R.—Accepted Dental Remedies

N.F.—The National Formulary

N.N.R.—New and Nonofficial Remedies

U.S.P.—The Pharmacopoeia of the United States

The following drugs are among those commonly found in the dental operating room:

Acetylsalicylic acid (aspirin), U.S.P.

The acetyl derivative of salicylic acid.

PROPERTIES: It occurs as a white crystalline powder or colorless crystal, odorless, and stable in dry air. Slightly soluble in water and freely soluble in alcohol. In moist air it gradually hydrolyzes into acetic and salicylic acids.

ACTION AND USES: It is an analgesic and antipyretic. Frequently used to allay pain after dental procedures; given dry in tablet form.

AVERAGE DOSE: 0.3 gm. or 5 grains.

Alcohol—ethyl alcohol, U.S.P.

A mixture of alcohol and water containing not less than 92.3 percent by weight or 94.9 percent by volume at 15.56°C. of C_2H_5OH.

PROPERTIES: A transparent, colorless, mobile and volatile liquid. It has a slight, characteristic odor and a burning taste. It is inflammable.

ACTION AND USES: Large doses cause intoxication by depression and finally paralysis of the central nervous system. Alcohol is used externally as a refrigerant and rubefacient in giving baths and alcohol rubs.

AVERAGE DOSE: 10 cc. or 2.5 fluidrams.

Aromatic spirit of ammonia, U.S.P.

PROPERTIES: A nearly colorless liquid when freshly prepared but gradually acquiring a yellow color on standing. It has the taste of ammonia, an aromatic and pungent odor, and is affected by light. It is stored in glass-stoppered bottles, in a cool place and protected from light.

ACTION AND USES: It is used as a reflex stimulant to prevent fainting and to relieve nausea or sick headache caused by hyperacidity of the gastric juice. It should be well diluted with water.

AVERAGE DOSE: 2 cc. or 30 minims.

Amyl nitrite, U.S.P.

PROPERTIES: A clear, yellowish liquid of a peculiar ethereal fruity odor and a pungent aromatic taste. It is inflammable.

ACTION AND USES: A vasodilator (dilates the blood vessels), given by inhalation to relax spasms of blood vessels in angina pectoris. It is supplied to the Navy in the form of glass pearls (ampules) containing 5 minims each. When it is to be administered the pearl is crushed in a handkerchief and the volatile amyl nitrite inhaled. Action is almost instantaneous.

AVERAGE DOSE: 0.2 cc. or 3 minims by inhalation.

Atropine sulfate, U.S.P.

The sulfate of the alkaloid, atropine.

PROPERTIES: A white, crystalline powder or colorless crystals.

ACTION AND USES: Used to check salivary secretions.

AVERAGE DOSE: 0.005 gm. or 1/120 grain. However, due to the frequent occurrence of unpleasant and toxic symptoms, one half the average dose is advised. (0.025 gm. or 1/250 grain).

Benzoic acid, U.S.P.

Found naturally in benzoin and balsam of Peru.

PROPERTIES: White crystals resembling scales or needles; usually odorless.

ACTION AND USES: It is a stimulant, an expectorant, a diuretic and is soothing to the mucous membrane. Sometimes used in mouthwashes.

AVERAGE DOSE: 1 gm. or 15 grains administered in syrup.

Benzoin, compound tincture of, U.S.P.

Solution of the balsamic resin in alcohol.

ACTION AND USES: Used as a protective and soothing agent. It is used in the treatment of chronic gingival inflammation and for sealing or fixing drugs in cavities and gingival crevices.

Boric acid (boracic acid), U.S.P.

PROPERTIES: Occurs as colorless, odorless scales of pearly luster, as crystals or as white powder, slightly oily to the touch.

ACTION AND USES: A mild bacteriostatic, used externally in lotions and ointments. An aqueous solution containing from 2 to

4 percent is used as an eye lotion.

AVERAGE DOSE: 0.5 gm. or 8 grains.

Butacaine sulfate (butyn sulfate), U.S.P.

PROPERTIES: A white, odorless crystalline powder slowly soluble in water.

ACTION AND USES: It is a local anesthetic often used to produce topical anesthesia by surface application.

Calcium carbonate, (precipitated chalk), U.S.P.

PROPERTIES: A fine white powder without odor or taste.

ACTION AND USES: Used chiefly as an antacid and polishing agent in dentifrices.

Calcium hydroxide, (slaked lime), U.S.P.

PROPERTIES: Soft, white crystalline powder, possessing an alkaline, slightly bitter taste. Soluble in water.

ACTION AND USES: Currently in use for capping exposed but vital pulps.

Chloroform, U.S.P.

PROPERTIES: A clear, colorless, mobile liquid, of characteristic ethereal odor and a burning, sweet taste.

ACTION AND USES: Used as a general anesthetic. Gutta percha dissolved in chloroform produces a solution of chloropercha. Found useful in the dental laboratory as a solvent for waxes.

Chromium trioxide, U.S.P.

PROPERTIES: Small needle-shaped crystals or prisms of dark, purplish red.

ACTION AND USES: It is used alone in solutions up to 7 percent, or in connection with a solution of hydrogen peroxide in the treatment of Vincent's infection. It should not be brought in contact with alcohol or other oxidizable substances lest an explosion result.

Codeine sulfate, U.S.P.

An alkaloid obtained from opium.

PROPERTIES: White crystals usually needle-like or a white crystalline powder.

ACTION AND USES: It is sedative, analgesic and hypnotic, usually given in tablet form.

AVERAGE DOSE: 0.03 gm. or ½ grain.

Epinephrine, U.S.P.

PROPERTIES: The active principle of the suprarenal gland. A white or light brownish, odorless powder which gradually darkens on exposure to air.

ACTION AND USES: It is used locally for its vasoconstrictor action in hemorrhage. It prolongs the effect of local anesthetics by slowing the circulation in the injected area, thus retarding the removal of the anesthetic agent by too rapid absorption into the blood stream. In this way it also lessens the general toxic effect of the anesthetic. By constricting the blood vessels it causes a rise in blood pressure.

AVERAGE DOSE: For local anesthesia in dentistry, 1 to 5 minims of 1 : 1000 solution per cubic centimeter.

Ethyl aminobenzoate, (benzocaine) U.S.P.

PROPERTIES: Small white crystals or as a white crystalline, odorless powder.

ACTION AND USES: It is used in the form of an ointment, solution and dusting powder. Useful for application to a painful wound after oral surgery has been performed. In alcoholic solution it is used as a topical anesthetic prior to the insertion of the needle.

AVERAGE DOSE: Generally applied in ointment form.

Ethyl chloride, U.S.P.

PROPERTIES: Colorless, mobile, very volatile liquid with an agreeable odor and a burning taste. It is preserved in a hermetically sealed container and should be kept in a cool place protected from fire and light.

ACTION AND USES: When inhaled it produces general anesthesia promptly and may be used for short operations. Sprayed on the skin or mucous membrane, it produces local anesthesia by refrigeration and is sometimes used in minor operations.

Eugenol, U.S.P.

PROPERTIES: A colorless or pale yellow liquid obtained from

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clove oil and from other sources. Has a strongly aromatic odor of clove and a pungent, spicy taste. It becomes darker and thicker on exposure to air. It is soluble in two parts of 70 percent alcohol; miscible with alcohol, chloroform, ether or fixed oils.

ACTION AND USES: Mixed with zinc oxide to form a paste, it is used as a temporary and sedative filling material in deep-seated cavities.

Ferric subsulfate solution (Monsel's solution) N.F.

PROPERTIES: A dark, reddish brown liquid, odorless or nearly so, of an acid, strongly styptic taste, and miscible with water and alcohol without decomposition.

ACTION AND USES: It is used in dentistry for the control of hemorrhage after the extraction of teeth.

Formaldehyde solution (formalin), U.S.P.

PROPERTIES: A clear, colorless or nearly colorless liquid, having a pungent odor. The vapor acts as an irritant on mucous membranes.

ACTION AND USES: It is a strong bacteriostatic and disinfectant, having powerful reducing properties and readily combining with protein and other types of organic matter. In combination with beechwood creosote, formaldehyde has been employed in the treatment of infected root canals. It is also used in the reduction of ammoniacal silver nitrate.

Glycerin, U.S.P.

PROPERTIES: A clear, colorless, syrupy liquid having a slight characteristic odor and a sweet taste. It is miscible with alcohol and water.

ACTION AND USES: Used as a constituent of toothpastes, as a solvent in the preparation of glycerites, and is frequently mixed with pumice to make a paste for use in prophylactic procedures.

Gutta percha

PROPERTIES: Consists of the dried purified latex obtained from certain trees. It is partly soluble in benzene, oil of turpentine and almost entirely soluble in chloroform.

ACTION AND USES: It is used in a prepared form as a temporary dental filling material; also for root canal fillings.

Hydrochloric acid, U.S.P.

PROPERTIES: It is a colorless, fuming liquid having a pungent odor.

ACTION AND USES: It is used as a flux and in pickling solutions for gold work. In its diluted form it is sometimes used for the enlarging of root canals.

Hydrogen peroxide solution, U.S.P.

PROPERTIES: Colorless, usually odorless liquid having a slightly acid taste, and produces a froth in the mouth.

ACTION AND USES: It is sometimes used in the bleaching of teeth. Diluted 50 percent with water it is often employed in the treatment of ulcerated areas in the gingival tissues of the mouth. It deteriorates on standing and should be stored in dark, tightly stoppered bottles and in a cool place.

Iodine, U.S.P.

PROPERTIES: Heavy, grayish black plates or granules, having a metallic luster, characteristic odor and acid taste.

ACTION AND USES: It is used in the form of an alcoholic solution for the disinfection of skin and mucous membranes. As a constituent of disclosing solutions, iodine aids in detecting the presence of plaques and foreign matter on tooth surfaces.

Magnesium sulfate (Epsom salt), U.S.P.

PROPERTIES: Small colorless needles or prisms, odorless with a cooling, saline and bitter taste; freely soluble in water.

ACTION AND USES: It is frequently used to moisten compresses and dressings for application to wounds. It relieves pain and congestion in swollen areas by the extraction of fluid from these parts.

Merthiolate

PROPERTIES: A light cream-colored crystalline powder having a slight odor. By weight 1 part of merthiolate dissolves in approximately 1 part of water or in approximately 8 parts of alcohol.

ACTION AND USES: Under suitable conditions of testing, merthiolate is bactericidal for nonsporulating bacteria, except Mycobacterium tuberculosis and is more or less bacteriostatic for all.

It may be used for disinfecting tissue surfaces when spores of pathogenic bacteria are not to be considered.

AVERAGE DOSE: The concentration recommended for general application is 1 : 1000 isotonic solution. For hypersensitive mucous membranes, dilutions of from 1 : 2000 to 1 : 5000 may be used.

Morphine sulfate, U.S.P.

PROPERTIES: White, feathery, silky crystals, or cubical masses of crystals, or as a white crystalline powder; it is odorless.

ACTION AND USES: A powerful narcotic, which is depressant to the central nervous system, relieves pain and produces sleep.

AVERAGE DOSE: 0.008 gm. or 1/8 grain.

Nitric acid, U.S.P.

PROPERTIES: A fuming, colorless, caustic liquid, with a somewhat suffocating odor.

ACTION AND USES: Used to remove facings from crowns and to clean porcelain before fusing and staining.

Nitrous oxide, (nitrogen monoxide), U.S.P.

PROPERTIES: A colorless gas, having a slight, characteristic odor and, in aqueous solution, a somewhat sweetish taste.

ACTION AND USES: A quick acting anesthetic, requiring only a few inhalations to produce unconsciousness. It is usually mixed with oxygen.

Penicillin

Penicillin is bacteriostatic systemically and locally for microorganisms. It is an antibiotic substance produced by the growth of Penicillium notatum. Penicillium chrysogenum or by other means. This drug may be used as an adjunct either topically or systemically in the treatment of Vincent's stomatitis. For Vincent's gingivitis the topical application of penicillin in normal saline, 5,000 to 10,000 units per cc., may be effective in relieving subjective and objective symptoms. The penicillin salts may be incorporated in chewing troches or lozenges which permit more prolonged topical medication.

Phenobarbital, U.S.P.

PROPERTIES: White, glistening small crystals or crystalline powder, odorless and stable in air.

Action and Uses: Used as a sedative and hypnotic, usually given in tablet form.

Average Dose: 0.03 gm. or ½ grain.

Phenol (carbolic acid), U.S.P.

Properties: Colorless to light pink, interlaced or separate needle-shaped crystals or crystalline mass. It has a characteristic, somewhat aromatic color; is liquefied by the addition of 10 per cent water.

Action and Uses: It is used in a 5 percent solution for disinfection of the hands. Concentrated phenol coagulates albumin, but its weaker aqueous solutions do not. Concentrated liquefied phenol is used for the disinfection of cutting-edged instruments, which are damaged by boiling water sterilization. After taking the instruments out of the phenol they are rinsed in ALCOHOL to remove all phenol. If phenol is spilled on the skin or in the mouth, it should be washed off immediately with alcohol.

Potassium arsenite solution (Fowler's solution), U.S.P.

Properties: A clear, colorless liquid.

Action and Uses: It is used in the treatment of Vincent's infection. Care must be observed in the continued use of arsenicals because of the possibility of arsenical poisoning.

Potassium permanganate, U.S.P.

Properties: Dark purple and bronzelike crystals, odorless and having a disagreeable astringent taste.

Action and Uses: It is a powerful oxidizing agent when in contact with organic matter and great care should be observed to prevent explosions. It is decomposed with the liberation of oxygen. In solutions of from 1 : 1000 to 1 : 5000, it is sometimes used to treat infections of the mucous membrane.

Procaine hydrochloride (novocain), U.S.P.

Properties: Small white crystals, or as white crystalline powder. It is odorless, stable in the air, and soluble in water.

Action and Uses: A local anesthetic similar in action to cocaine but less toxic. Is nonirritant and has very little anesthetic effect when applied externally to mucous membranes. When injected subcutaneously, it exerts a prompt and powerful anesthetic action which is sustained by the addition of epinephrine.

AVERAGE DOSE: In solution of from 0.5 to 6 percent. A 2 percent solution with epinephrine is most commonly used for conduction (block) anesthesia.

Pumice, N.F.

PROPERTIES: A substance of volcanic origin, consisting chiefly of complex silicates of aluminum, potassium and sodium. It occurs as a very light, porous gray mass or as a gritty powder.

ACTION AND USES: Used for cleaning and polishing teeth, and the finishing of restorations.

Rosin, U.S.P.

PROPERTIES: Occurs as sharply angular, translucent, amber-colored fragments after distillation of the volatile oil from turpentine.

ACTION AND USES: Rosin applied in chloroform solution (40% rosin and 60% chloroform) is used as a varnish for pulp protection in deep cavities, and as an ingredient of many mixtures for the sealing of pulp canals. When mixed with zinc oxide in approximately equal parts, it is the basis of and serves as a binder for many so-called surgical packs and many impression pastes for temporary rebasing of dentures.

Silver nitrate, U.S.P.

PROPERTIES: Colorless or white crystals, becoming gray or grayish black on exposure to light, in the presence of organic matter.

ACTION AND USES: It is a caustic bactericide, bacteriostatic or astringent depending on its concentration. It is applied as a mild caustic to wounds, ulcers and granulations. As ammoniacal silver nitrate, it is used to treat hypersensitive dentin and gangrenous root canals. Reducing agents for silver nitrate are formalin, eugenol or strong light.

Sodium perborate, U.S.P.

PROPERTIES: White crystalline granules or a white powder. It is odorless, has a saline taste, is stable in cool dry air, but is decomposed with the evolution of oxygen in warm or in moist air. In aqueous solution, sodium perborate is decomposed into sodium metaborate and hydrogen peroxide, the solution gradually evolving oxygen.

ACTION AND USES: It is used as a cleansing mouth bacteriostatic and is found in some toothpastes, powders and mouthwashes.

Streptomycin

Streptomycin is produced by several strains of Streptomyces griseus. As a dental therapeutic agent, streptomycin is to be regarded as in the experimental stage; its bacteriostatic efficacy, usefulness and value under clinical conditions remain to be determined. Streptomycin has been used successfully with penicillin in the treatment of infected root canals.

Sulfuric acid, U.S.P.

PROPERTIES: A colorless, odorless liquid of oily consistency, very caustic and corrosive.

ACTION AND USES: Used in a diluted form for enlarging root canals and in "pickling" solutions for gold work.

Tannic acid (tannin), U.S.P.

PROPERTIES: A yellowish white to light brown spongy powder, for the most part odorless, and with a strong astringent taste.

ACTION AND USES: An astringent, moderately bacteriostatic and hemostatic. It is sometimes used as a constituent of mouthwashes. It is chemically incompatible with a wide range of substances and hence is a useful antidote in poisoning.

Thrombin, topical, A.D.R.

PROPERTIES: A water-soluble, white or buff-colored powder, derived from bovine or human plasma.

ACTION AND USES: It can be applied to the bleeding surface as a powder or dissolved in isotonic sodium chloride solution. In certain types of bleeding, absorbable pledgets are soaked in thrombin solution and placed on the bleeding tissue. It must never be injected.

Thymol, U.S.P.

PROPERTIES: Large colorless crystals or white crystalline powder, having an aromatic, thymelike odor, and a pungent taste.

ACTION AND USES: As a bacteriostatic, it is employed in mouthwashes, gargles and sprays. The crystals are often melted and applied to dentin where they recrystallize and afford pulp protection under restorations.

Thymol iodide, N.F.

PROPERTIES: A reddish brown or reddish yellow powder with a very slight aromatic odor.

ACTION AND USES: It is sometimes used in pulp-capping preparations and as a constituent of root-filling materials. Also widely used under restorations for pulp protection.

Trichloracetic acid, U.S.P.

PROPERTIES: Colorless, deliquescent crystals, having a slight, characteristic odor.

ACTION AND USES: It is used as a caustic to destroy tissue and as a cauterizing agent for aphthous ulcers (canker sores).

Zinc chloride, N.F.

PROPERTIES: Occurs as a nearly white granular powder or in porcelain-like irregular masses.

ACTION AND USES: It is used as a bacteriostatic, astringent and escharotic. It is used for reducing the sensitivity of exposed cementum in anterior teeth, and is a constituent of some astringent mouthwashes.

Zinc oxide, U.S.P.

PROPERTIES: A very fine amorphous white or yellowish white powder, without odor or taste, insoluble in water.

ACTION AND USES: It is slightly bacteriostatic and astringent. It is used as a constituent of dental cements; as a paste with eugenol it serves temporarily to fill cavities in teeth.

TOXICOLOGY

Any substance applied to the body, ingested, inhaled, or developed within the body, which causes or may cause damage or disturbance of function is a POISON. Many substances are capable of producing death but are not classed as poisons. Powdered glass, needles or other similar foreign bodies may cause death, but their action is mechanical. All drugs listed as poisons are also used in medicine in the treatment of disease. A drug is a medicine when the dose given produces a therapeutic effect. It is a poison when the dose given, or the amount taken, causes sickness, disease or death. A drug, therefore, has a therapeutic or poisonous action according to the amount taken.

Before poisoning can be treated, it must be diagnosed, and before it can be diagnosed, it must be suspected. It should be suspected whenever a person is found unconscious with no readily discernible evidence of disease or injury.

Other conditions such as coma, basal skull fracture and epilepsy may simulate poisoning. But, if the symptoms of poisoning are well known, confusing these conditions with poisoning generally can be avoided.

On the basis of symptoms produced, poisons are divided into three classes. Each class produces typical symptoms.

Class I. IRRITANTS

Irritants produce nausea, vomiting, purging, delirium, and coma.

Class II. NERVE POISONS

These produce convulsions, spasms.

Class III. BLOOD POISONING

Blood poisoning causes redness, swelling and heat.

There are other symptoms of a general nature. Not all symptoms of a class will be found in each case, but one or more are usually seen.

In the treatment of poisoning, before the arrival of the medical officer, two important steps to be taken are the dilution and washing out of the poison. In the section on digestion, it was suggested that absorption of drugs by the tissues is much slower when the drug is present in a diluted form rather than the concentrated state. Repeatedly induced vomiting will aid in the removal of the drug from the stomach. The following chart issued by the Ninth Naval District lists the common poisons and their antidotes.

Commonly used emetics are powdered ipecac, 30 grains; ground mustard, 2½ drams; tartar emetic, ½ to 1 grain; apomorphine hydrochloride (hypodermically) 1/15 to ⅛ grain; tepid water, large quantity.

COMMON POISONS AND THEIR ANTIDOTES

Poison	*Symptoms*	*Antidote*
Acids, mineral and organic (hydrochloric, muriatic, nitric, sulfuric, acetic, oxalic).	Lips, mouth, tongue and throat burned dark brown, black, yellow-green, or yellow-orange. Burning pain in mouth and throat. Vomiting. Difficult speaking and swallowing. Cold, clammy skin. Shock and collapse. Possible yellow, brown or red acid stains on clothing.	Give solutions of sodium carbonate, milk of magnesia, magnesium oxide, lime water, chalk, plaster from the wall mixed with water, starch, piece of soap in water, milk, white of egg, or oil. Do not use a stomach pump or emetic.
Acid, carbolic (corrosive) (phenol, lysol, cresol, creosote).	Pupils contracted. Mouth, throat and tongue white.	Stomach tube or emetic, alkaline liquids, soap, white of egg, epsom salt, sodium sulphate or other soluble sulphates to hasten elimination from circulation; warmth and stimulation.
Alcohol, ethyl (whiskey, brandy, other intoxicating beverages, paraldehyde).	Exhilaration, staggering gait, deep snoring sleep. Often delirium tremens.	Stomach tube or emetic, strong coffee, solution of tannic acid, keep body warm, head low. Aromatic spirits of ammonia and ammonia to nose for respiration. Artificial respiration. Oxygen.
Alcohol, methyl (wood alcohol).	Dizziness. Headache. Nausea. Vomiting. Dimness of vision with ultimate blindness. Unconsciousness. Delirium. Convulsion. Cold, clammy skin.	Follow for alcohol, ethyl. Also give pilocarpine hydrochloride, ⅛ to ½ grain, solution of baking soda, drink water freely, hot coffee, aromatic ammonia.
Alkalies, caustic (corrosive) (lye, caustic soda or potash).	Collapse. Cold, clammy skin. Mouth, throat and tongue white. Burning pain in mouth, throat, esophagus and stomach. (Similar to mineral acids.)	Dilute acids, vinegar one glass to quart of water, dilute acetic or citric acid, 2 to 3 percent, lemon or orange juice, soothing fluid, oils, melted fat, milk, cream. Do not use emetics or stomach tube. Keep warm and lying down.

Poison	*Symptoms*	*Antidote*
Arsenic. (Fowler's solution, paris green, rat poisons, Scheele's green, Schweinfurt green, arsenical dyes in papers and candies.)	Faintness and depression after about 30 minutes. Intense stomach pain. Nausea and vomiting increase with every swallow. Cold, clammy skin.	Emetics; wash out stomach repeatedly with warm water or water and milk. Milk of magnesia, baking soda. Follow with Epsom salt. Then use oil, gruel, starch, mucilages, eggs. Relieve pain with morphine. Keep warm.
Belladonna (atropine, homatropine, hyoscyamus).	Redness or rash on skin. Dry nose, mouth and throat. Hoarse voice. Difficult swallowing. Dilated pupils with confused vision. Loud talk and laughter. May be wild delirium and convulsions.	Emetic, potassium permanganate solution, tannic acid, 20 grains, solution of iodine—6 to 12 drops to glass of water, strong tea. Relieve pain, give stimulants. Coffee, Epsom salt.
Carbon monoxide (illuminating gas, automobile exhaust, furnace gas).	Skin cherry red or bluish. Collapse and unconsciousness.	Artificial respiration in fresh air. Warmth. Oxygen.
Chloral hydrate ("knockout drops," and "Mickey Finn").	Stupor. Characteristic odor on breath.	Empty stomach at once unless victim is unconscious. Keep awake, artificial respiration. Oxygen. Keep warm. Coffee, aromatic ammonia.
Cocaine.	Dilated pupils. Talkativeness, restlessness, excitement and delirium. Hallucinations and mania followed by depression. Nausea, vomiting, numbness and tingling in hands. Headache and dizziness. Later, convulsions, collapse, bluish clammy skin, shock and possibly death.	Wash out stomach with solution of potassium permanganate or tannic acid or tea. Keep warm. Artificial respiration, if necessary.
Iodine.	Bitter taste in mouth. Severe pain in throat, esophagus, stomach and abdomen. Violent vomiting, possibly showing traces of iodine. Severe thirst. Pale face, convulsions and collapse.	Abundance of starch; flour in water, bread, potatoes or other starchy food. Sodium thiosulphate, 20 grains, follow with emetic or wash out stomach. Relieve pain. Keep warm.

Poison	*Symptoms*	*Antidote*
Lead and Barium compounds (sugar of lead, lead acetate, barium sulphide, etc.)	Metallic taste in mouth. Sense of tightening in throat. Stiffness in abdominal muscles. Blue line around gums. Paralysis of arms. Vomiting of white, flaky matter.	Epsom salt or Glauber's salt (sodium sulfate) at once. Emetics or stomach tube. Follow with milk and other soothing drinks; morphine for pain. Keep warm. Stimulants and artificial respiration if necessary.
Mercury compounds (corrosive,) (corrosive sublimate or bichloride of mercury, blue ointment, oxide of mercury, black wash, yellow wash, cinnabar vermilion.) Copper compounds (copper sulphate, bluestone).	Metallic taste. Thirst. Burning pain in mouth, throat and abdomen. Nausea. Bloody vomiting. Flushed face. Cold extremities. Lips, mouth, tongue and throat may look shriveled and white. Shock and collapse.	Empty stomach quickly, white of eggs, raw eggs or milk, charcoal in water, soap, chopped raw meats. Plenty of water. Again empty stomach. Keep warm. Stimulants. Vomiting absolutely necessary after antidote (or before if antidote is not quickly available). Wash stomach repeatedly. Follow with milk, water, coffee. External heat.
Mushrooms.	Pain in abdomen. Nausea and vomiting.	Stomach tube or emetics. Castor oil and copious enemas, stimulate, keep warm.
Opium and its derivatives (morphine, codeine, laudanum, paregoric, etc.).	Mental exhilaration and physical ease followed by dizziness, drowsiness and nausea. Slow, snoring breathing. Deep sleep. Cold, clammy skin. Cold extremities. Muscles relax. Bluish skin. Pupils contract, but may dilate just before death. No reaction to outside impressions.	Wash stomach with potassium permanganate solution, tannic acid. Lots of strong coffee. Caffeine and atropine. Keep awake by slapping with cold towels, etc. Do not walk. Artificial respiration if breathing stops.
Strychnine. Nux Vomica (dog buttons).	Sense of suffocation and inability to breathe. Shuddering. Jerking of muscles. Twitching and jerking of lower limbs. Convulsions. Body gets rigid and bends forward, backward or to one side. Features assume a stiff grin. Victim is fully aware of what goes on about him.	Control convulsions at once with chloroform or ether, followed by chloral hydrate, 20 grains, morphine, sodium amytal, 5 grains, sodium pentobarbital, 5 grains. Give tannic acid or solution of potassium permanganate by mouth at once as chemical antidote.

Poison	*Symptoms*	*Antidote*
Veronal or barbital (amytal, allonal, luminal, phenobarbital, peralga, etc.).	**Unconsciousness.**	**Wash stomach if awake. Use tannic acid solution if possible. Castor oil, Epsom salt, enemas, stimulants. Large amounts of water.**

CHAPTER 4

ODONTOGRAPHY

Odontography is a subject which deals with the description of the material and external configuration, position, structure, attachment and interrelation of the human teeth, and the correlation of the dental arches.

In man and in animal the shape and size of teeth differ according to their special uses. Animals may be classified by their eating habits as CARNIVOROUS or HERBIVOROUS. Man is OMNIVOROUS because his food is comprised of foods which are consumed by both carnivorous and herbivorous groups. His teeth are formed for cutting, tearing, and grinding many kinds of foods. The incisors, situated anteriorly, have edges for cutting; the cuspids and bicuspids, at the angles of the mouth, have fairly sharp points or cusps, suited for grasping and tearing; while the molars, situated in the posterior part of the mouth, have broad, tuberculated surfaces which serve well to grind more solid masses of food.

Man has two sets of natural teeth in his lifetime, DECIDUOUS and PERMANENT. The deciduous teeth are those which erupt in childhood. There are only 20 teeth in the deciduous set. The permanent set has 32 teeth. This set is the one that will be studied.

ERUPTION TABLE—DECIDUOUS TEETH

Teeth	Age of eruption	Age of calcification	Age of absorption
	Months	*Years*	*Years*
Central incisor	5–7	2	4
Lateral incisor	9–11	2	5
First molar	12–14	3	7
Cuspid	14–18	3	9
Second molar	18–25	3	8

ERUPTION TABLE—PERMANENT TEETH

Teetb	Calcification begins	Eruption	Calcification completed
	Year	*Years*	*Years*
Central incisor	1st	7–8	10–11
Lateral incisor	1st	7½–8½	10–11
Cuspid	3rd	12–13	12–13
First bicuspid	4th	10–11	11–12
Second bicuspid	5th	11–12	11–12
First molar	[1]8th	6½	9–10
Second molar	5th	12–14	16–18
Third molar	9th	17–20	18–24

[1] Fetal month.

Tooth Surfaces and Landmarks

Before proceeding with the study of tooth anatomy it is necessary to become familiar with the terms which will be heard and used daily during the career of a dental technician. There are definite names or terms for the several parts of the teeth. Learning these names and terms is most important in order that the technician understand and assist the dental officer in an intelligent manner.

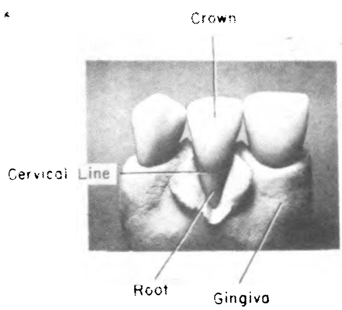

Figure 62.—Tooth.

As noted from figure 62 a tooth consists of a crown portion which can be seen and a root portion which is hidden beneath the gum tissue (gingiva). A tooth that is widest at the incisal edge is said to narrow GINGIVALLY.

Human teeth are embedded in bone in two opposing arches. The bones forming the upper arch are the MAXILLAE; the upper teeth are the MAXILLARY teeth.

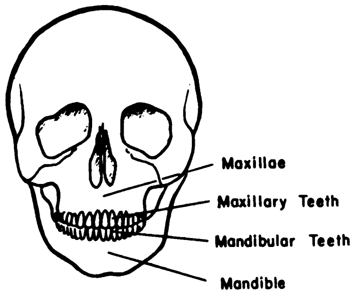

Figure 63.—Skull, frontal view.

The lower arch is formed by the MANDIBLE. Instead of being called "teeth of the lower jaw," these are known as MANDIBULAR teeth.

Anterior means "toward the front." Incisors and cuspids are anterior teeth which are used to bite.

Posterior means "behind." Posterior teeth are bicuspids and molars and are used to chew.

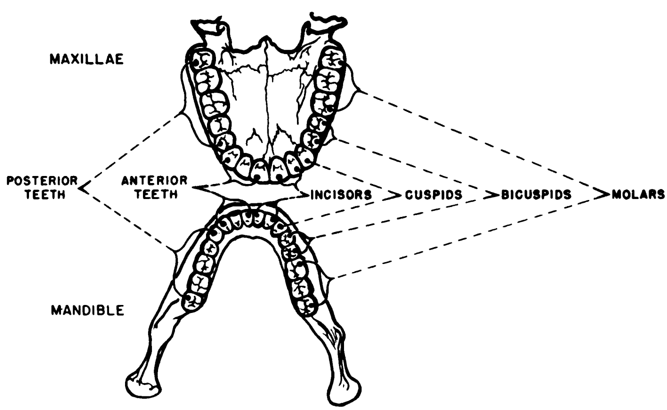

Figure 64.—Maxillary and mandibular arches.

An imaginary line that passes between the two front central teeth (central incisors) is called the MEDIAN line. The surfaces that face this line are called MESIAL, while those facing away from it are known as DISTAL surfaces.

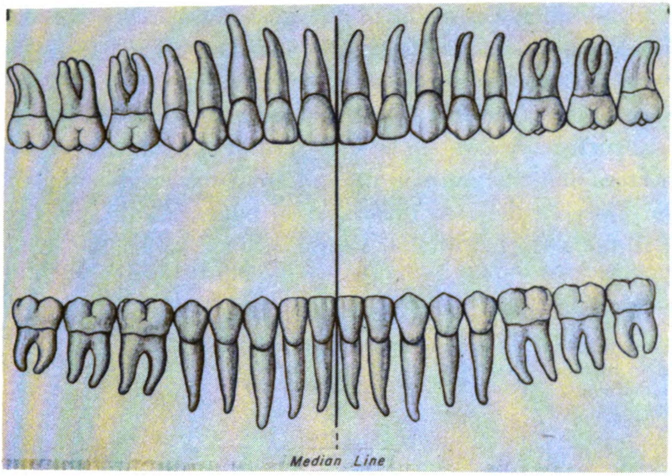

Figure 65.—Median line.

LABIAL surfaces are the surfaces of the anterior teeth which face toward the lips. When a person smiles, the labial surfaces of the anterior teeth are usually seen.

BUCCAL surfaces are the surfaces of posterior teeth which face toward the cheeks.

LINGUAL surfaces are the surfaces of the teeth which face toward the tongue. With jaws closed, one can move the tip of the tongue along the lingual surfaces of the upper and lower teeth. When a person looks into a mirror with the mouth open and the head bent slightly forward, he can see the lingual surfaces of the lower anterior teeth.

OCCLUSAL surfaces are the horizontal or chewing surfaces of the posterior teeth. When observing the lingual surfaces of the lower anterior teeth in a mirror, the occlusal surfaces of all the lower posterior teeth can be seen. During mastication (chewing)

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these are the surfaces upon which most of the food rests and is ground into smaller sections.

INCISAL edges are the cutting edges of the anterior teeth and can be felt with the tip of the tongue.

The preceding definitions have been given as a building block in the study of tooth structure. Further characteristics and landmarks are shown in figure 66. MARGINS are the borders of boundary lines of any surface of a tooth. They are named from the surfaces which they border.

The distal margin of the labial surface is the distal border of the labial surface. A LINE ANGLE is formed by the junction of any two surfaces and the name is derived from the combination of the two. Thus, in the case illustrated in figure 66, the junction of the distal surface with the incisal surface forms the disto-incisal angle.

The MARGINAL RIDGE is an elevation along the margin of the surface of a tooth. This is illustrated in figure 67.

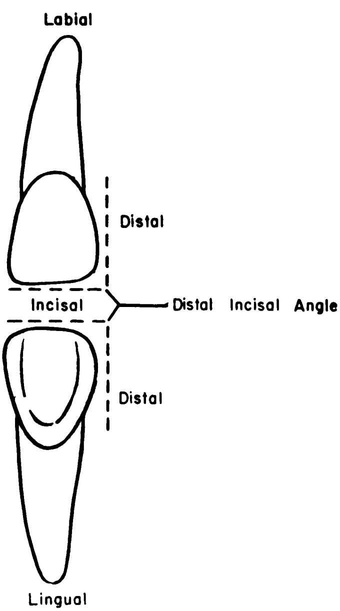


Figure 66.—Distal-incisal angle.

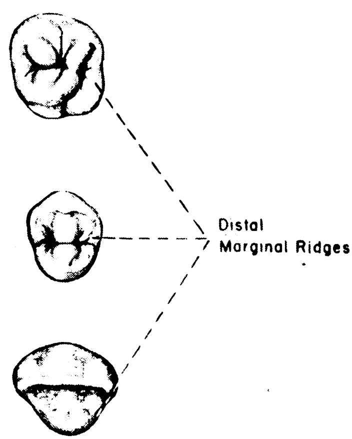


Figure 67.—Distal-marginal ridges.

The CERVICAL or gingival line is the slight indentation which encircles the tooth at the junction of the crown and root portions. In adults well along in years, this line may be quite noticeable, and close examination will reveal the gum attachment to be well away from its normal position at the cervical line.

Teeth show considerable variations in size, shape and other characteristics from one person to another. Certain teeth in the dental arches show a greater tendency than others to deviate from the normal. The descriptions that follow are of normal, average teeth.

Anterior Teeth

Maxillary or upper central incisors

There are two maxillary or upper central incisors, situated in the front part of the mouth, one on either side of the median line. The mesial surfaces of the two teeth contact each other at a CONTACT POINT.

The central incisor, viewed from the mesial or distal, has the

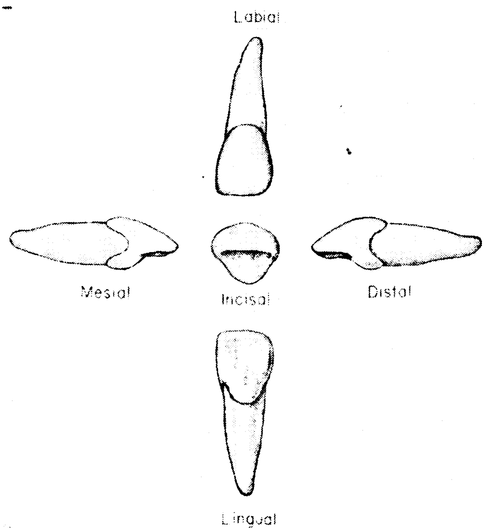


Figure 68.—Maxillary central incisor.

Figure 69.—Contact points.

appearance of a wedge, with the point of the wedge at the incisal edge.

The LABIAL surface, which is the most prominent surface of anterior teeth, resembles a thumbnail in outline. As can be seen from the illustration, it is bounded by the mesial, distal, incisal and gingival margins. The mesial margin is nearly straight and meets the incisal edge at almost right angles whereas, on the other side, the distal surface meets the incisal edge in a well rounded angle. The incisal margin is a straight line, and the gingival margin is curved in a half-moon form. There are two small furrows on the labial surface, known as developmental

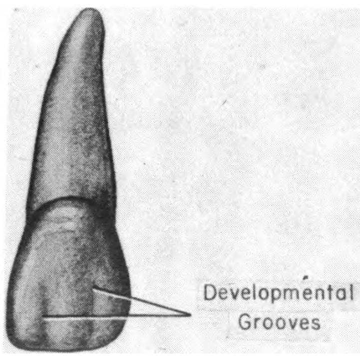


Figure 70.—Developmental grooves.

grooves. They mark the union of the three labial lobes of the crown. These, and the fourth or lingual lobe will be discussed further in a later chapter on the subject of histology.

Figure 71 shows the LINGUAL surface of the upper central incisor. In general, it is quite similar to the labial surface except that the outline is slightly smaller in all directions. While the labial surface is convex and bellies out like the front or forward surface of the sail on a catboat under way, the lingual surface is concave or depressed like the after-surface of the sail. On the mesial and distal edges are two raised portions, the mesial and distal marginal ridges. At the junction of the lingual surface with

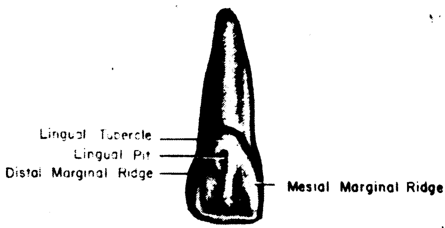
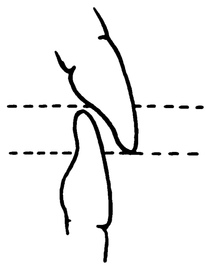


Figure 71.—Maxillary central incisor lingual surface.



Overbite

Figure 72.—Overbite.

the gingival margin, occasionally there is a raised point which is termed the lingual tubercle. In conjunction with the tubercle, sometimes a deep pit is found, the lingual pit. When assisting the dental officer in a root canal operation (removing the pulp tissue and refilling the hollow length of the tooth), the technician may see him make an external opening through this pit and drill into the canal. At the incisal margin a pronounced bevel can be noted which is made at the expense of the lingual surface. This is quite natural and is due to the fact that the upper anterior teeth "overbite" the lower anterior teeth and wear against them.

The boundaries of the MESIAL surface are the labial, lingual and gingival margins. The contact point is in the incisal third. The DISTAL surface of the crown resembles the mesial surface in outline, although it is more convex. The contact point is still in the incisal third, but farther gingivally than the mesial contact point. When teeth adjoin each other in the same arch, the spots where they touch each other are the CONTACT POINTS—a term that the technician will hear daily when he starts working in the laboratory or assisting at the chair.

Like all anterior teeth, the maxillary central incisor is single rooted. The ROOT of this tooth is from 1¼ to 1½ times the length of the crown. Usually the apex of the root is inclined slightly in the distal direction. The line angles of this tooth are well rounded.

Maxillary lateral incisors

There are two upper lateral incisors, each of which is on the distal side of the two central incisors which were described in the preceding paragraph. From the illustration on page 199, the lateral incisor appears to be quite like the central incisor, except that it is smaller in length and width and the developmental grooves of the LABIAL surface are not as evident as those of the central incisor. Of more significance, however, is the distal margin, which is well rounded away from the incisal edge, continuing this curvature to the gingival or cervical line. The mesial edge is nearly straight and the mesio-incisal angle is rather constant in all persons. The LINGUAL surface does not present a uniform appearance. In some instances it is markedly concave — almost spoonlike in appearance — and in others it is flat. Referring to the description of the central incisor, it can be seen that the lingual surface is narrower in a mesiodistal direction than is the labial surface. In the case of the lateral incisor this is not true. The labial and lingual surfaces are almost the same width. The MESIAL surface has the same shape as that of the central incisor, with the contact point in the incisal third. (The correct placing of contact points is of utmost importance in restorative dentistry.)

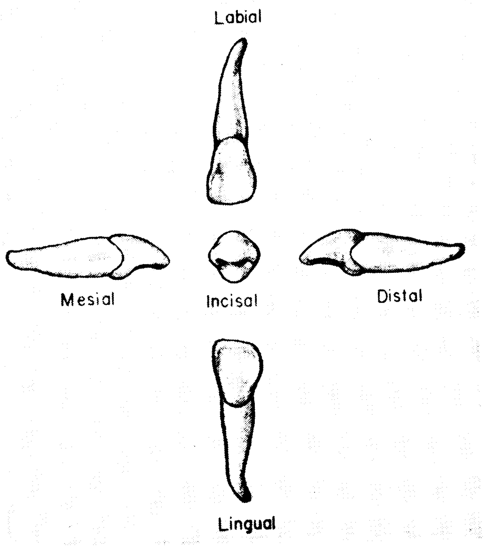


Figure 73.—Maxillary lateral incisor.

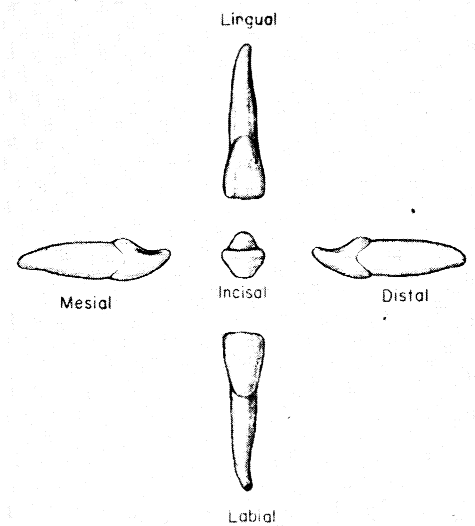


Figure 74.—Mandibular central incisor.

The DISTAL surface is well rounded, with its contact point in a position similar to that of the central incisor—that is, in the incisal third of the surface, but somewhat nearer the cervical or gingival margin. The ROOT is conical, but somewhat flattened mesiodistally.

Mandibular or lower central incisors

The mandibular or lower central incisors are the first teeth on either side of the median line. In general appearance, they are similar to the upper front teeth, but are more slender and smaller in every respect. The LABIAL surface is widest at the incisal edge, and tapers as it nears the gingival portion of the crown, making the tooth almost one-third narrower at the gingival than at the incisal margin. A second marked point of difference between this tooth and its counterpart in the upper arch is that both the mesial and distal margins meet the incisal edge at a sharp or acute angle. The developmental grooves may or may not be present; when present, they show as very faint furrows on this surface. The LINGUAL surface is concave from the incisal to the gingival edge. Calculus or tartar will form more readily on this surface, and the removal of such deposit will be demonstrated to the student at a later date in his course of training as a dental technician. The MESIAL and DISTAL surfaces are similar to those of the upper central incisors except that they are smaller in area. The distal surface, as in the upper incisors, is more rounded than the mesial. The ROOT is slender and much flattened on its mesial and distal surfaces. The contact points are at or near the mesio-incisal and disto-incisal angles.

Mandibular lateral incisors

The mandibular or lower lateral incisor, as can be noted in figure 65, is a little wider mesiodistally than the central incisor, and the crown is slightly longer from the biting edge to the gum line. The incisal edge is not at right angles to the mesial and distal edges as in the case of the central incisor. So far as the MESIAL and DISTAL surfaces are concerned, there is but a slight change in the measured width when compared with those of the lower central incisor. The ROOT is single and much flattened on its mesial and distal surfaces.

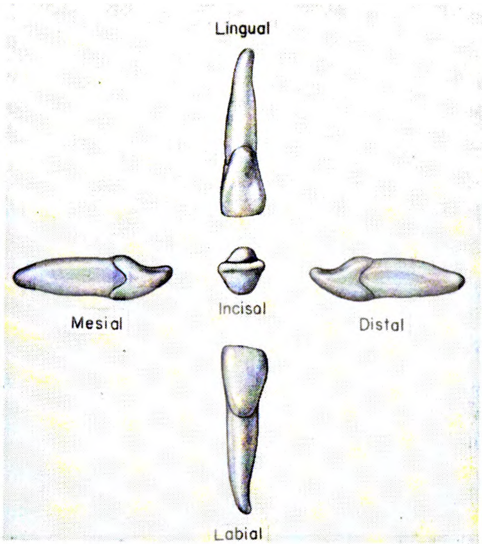


Figure 75.—Mandibular lateral incisor.

Cuspids

The incisors have been described — eight in number, four belonging to the upper arch and four to the lower. The next teeth to be considered will be the CUSPID or canine group. They appear as the third teeth from the median line in both the upper and lower arches, as noted in figure 65. The cuspids are four in number and the only teeth with a single cusp. Because of their shape, and the position they occupy in the dental arches, it may be said that cuspids play a leading role in characterizing smiles and facial features of individuals.

Maxillary cuspids

The LABIAL surface of the crown of the upper cuspid differs considerably from that of the upper central or lateral incisors. The incisal edges of the central and lateral incisors are nearly straight, whereas the cuspid has a definite point or cusp. The incisal margin presents two edges, mesial and distal. The disto-incisal cutting edge is the longer.

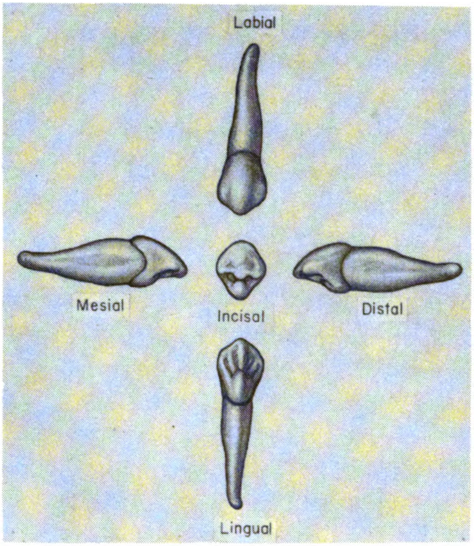


Figure 76.—Maxillary cuspid.

Figure 77 shows the curvature of the labial surface, which is made more prominent by the labial ridge extending down from the tip or peak of the cusp to the gingival line. The developmental grooves which were so prominent on the labial surface of the

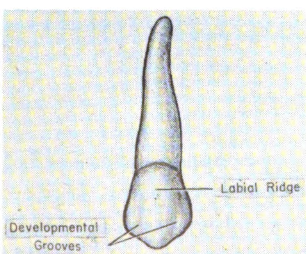


Figure 77.—Maxillary cuspid labial surface.

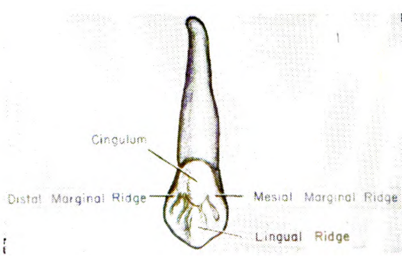


Figure 78.—Maxillary cuspid lingual surface.

central incisor are present here, extending two thirds of the distance from the tip of the cusp to the gingival line.

The LINGUAL SURFACE has the same general outline as the labial but is somewhat smaller, as the mesial and distal surfaces of the crown seem to converge toward the lingual. The lingual surface is concave, with very prominent mesial and distal marginal ridges, and a lingual ridge which like the labial ridge extends from the tip of the cusp toward the cervical line. There often is a small, raised area in the gingival portion of the lingual surface of the crown, to which is applied the name CINGULUM. It is similar to, but more prominent than, the lingual tubercle found in incisors. The MESIAL surface is almost flat from the incisal toward the gingival margin, while the DISTAL surface is convex in all directions with the exception of the gingival portion which is slightly concave. This is the first instance where such concavity has occurred on a PROXIMAL surface (a surface of a tooth that is adjacent to or in contact with another tooth of the same arch). The ROOT is single and the longest in the arch, usually being twice the length of the crown. This is but natural when it is recalled that the canine tooth is designed for seizing and holding. As the dental technician makes progress in his career he will note the frequent use of cuspids as abutment teeth for anchoring bridges.

Mandibular cuspids

The mandibular cuspids—like the incisors—are smaller and more slender than the opposing teeth in the maxillary arch. The LABIAL surface is much the same as that of the upper cuspids, except that the disto-incisal cutting edge is almost twice the length of the mesial edge. This characteristic should be remembered when selecting a lower right cuspid from an assortment of teeth for the denture that is to be fabricated in the laboratory. The LINGUAL surface as a rule is very smooth, and the presence of a cingulum is rare. The MESIAL surface is almost flat or straight for the entire length of the tooth while the DISTAL surface, as in most teeth, is convex from the incisal to the gingival as well as from the labial to the ligual. The ROOT is not so long as that of the upper, and is flatter mesiodistally.

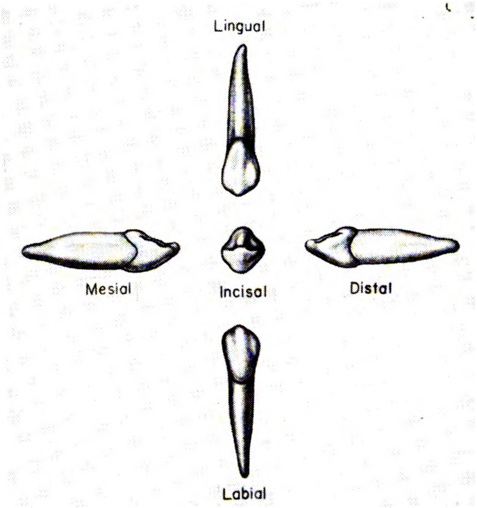


Figure 79.—Mandibular cuspid.

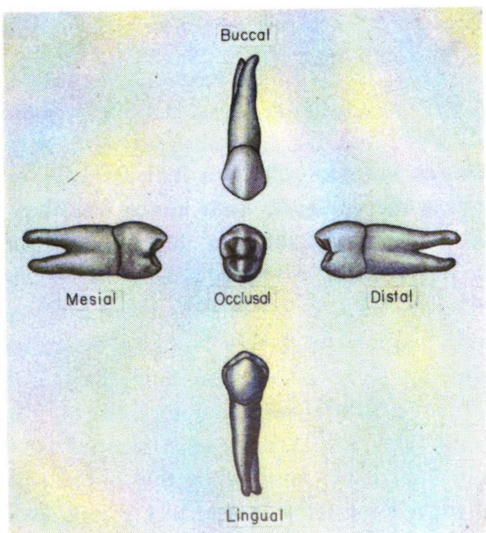


Figure 80.—Maxillary first bicuspid.

Bicuspids

The word BICUSPID means two cusps. The term PREMOLAR is used sometimes in place of bicuspid, but throughout this text the term bicuspid will be employed. The bicuspid teeth, as illustrated in figure 65, are eight in number. There are two bicuspids on each side of both the upper and lower arches located between the cuspid and molar teeth.

The cuspid is the third tooth from the median line and the first bicuspid is the fourth tooth from the median line. A labial surface for each of the anterior teeth has been described. As previously stated, the term LABIAL is used for those surfaces which are adjacent to the lips. The term BUCCAL is used to indicate the surfaces of the posterior teeth adjacent to the cheeks.

Maxillary first bicuspid

The maxillary first bicuspid is considered the typical bicuspid.

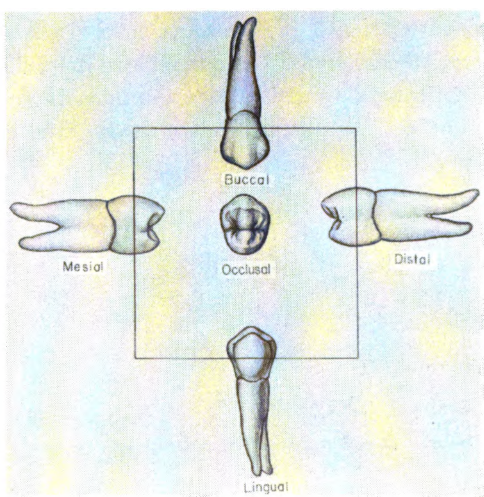


Figure 81.—Height of contour, maxillary first bicuspid. "The line encircling a tooth in the horizontal plane and passing through the surface points of greatest radius. On the proximal surface, this line passes through the points of contact."

The BUCCAL surface is somewhat similar to the labial surface of the cuspid. However, the tips of the cusps (both buccal and lingual) are located in the centers of the biting edges, which from here on will be called the OCCLUSAL EDGES or margins. With the location of the tip of the cusp as seen in figure 80, the mesiocclusal and distocclusal cutting edges appear to be of almost equal length. The height of contour is located at the junction of the middle and gingival thirds of the buccal surface. This is true of all buccal surfaces of the posterior teeth. From the cusp tip to the gingival margin, the buccal surface presents a slight ridge called the BUCCAL RIDGE which is similar to the labial ridge found in cuspid teeth.

The LINGUAL surface is narrower and shorter than the buccal surface, and is smoothly convex in all directions. Once again, attention is brought to the height of contour. This is located at the junction of the middle and occlusal thirds. The MESIAL surface is convex in the occlusal two-thirds, and flat or concave at the gingival third. The DISTAL surface is much the same as the mesial surface although the gingival third is generally flattened without the concavity which often occurs in the mesial surface. The contact point is located in the occlusal third or at the junction of the occlusal and middle thirds. As in the incisors and cuspids, the contact point on the distal surface is slightly nearer the gingival margin.

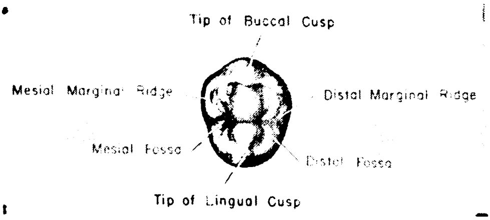


Figure 82.—Maxillary first bicuspid occlusal surface.

Close study of the occlusal or biting surfaces of the teeth will enable the technician to chart dental conditions accurately. The OCCLUSAL surface of the maxillary first bicuspid as shown in figure 82 presents a buccal and a lingual cusp. The mesial and distal marginal ridges which were observed on the lingual surfaces of anterior teeth correspond to the marginal ridges on the occlusal surfaces of posterior teeth. There are two pits or depressions (FOSSAE) in the occlusal surface, one near the mesial marginal ridge and the other near the distal marginal ridge. The pit near the mesial surface is named the MESIAL PIT, and the fossa or pit near the distal surface is the DISTAL PIT. In figure 82 and figure 83, five grooves can be seen on the occlusal surface. First, there is the mesial marginal groove, arising in the mesial pit and crossing over the mesial marginal ridge to terminate in the occlusal third of the mesial surface.

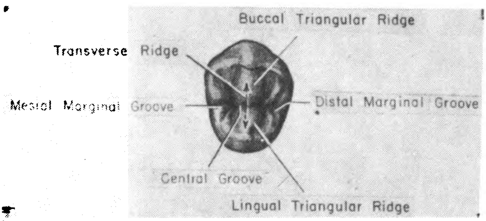


Figure 83.—Maxillary first bicuspid occlusal grooves.

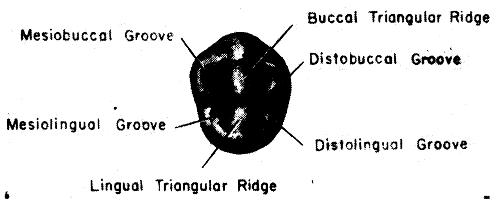


Figure 84.—Maxillary first bicuspid triangular ridges and grooves.

The mesial marginal groove and its counterpart, the distal marginal groove, are connected by the central groove. The next two grooves form triangular areas and are called triangular grooves. One is the mesial triangular groove. Like the mesial marginal groove, it starts in the mesial pit, but, instead of running almost straight across the ridge, this groove runs buccally and somewhat mesially toward the mesiobucco-occlusal POINT ANGLE (point made by the junction of three surfaces). It must be remembered that the occlusal surfaces of bicuspids have two cusps. These cusps are separated by a groove, known as the central groove, and a ridge extends from the tip of each of the cusps toward this central groove. This ridge is called a TRIANGULAR RIDGE. Thus, there are two triangular ridges present—namely, the buccal and the lingual. On the other side of the buccal triangular ridge there is another triangular groove, the distal triangular groove. Like the mesial triangular groove, it often separates the marginal ridge from the buccal cusp.

The ROOT is quite flat on the mesial and distal surfaces. In assisting the dental officer in oral surgery, the technician will observe that in about 50 percent of these bicuspids, the roots are divided in the apical third, and that when so divided the tips are slender and finely tapered.

Maxillary second bicuspid

The second bicuspid is the fifth tooth from the median line, figure 65, and resembles the first bicuspid very closely, but is smaller in all dimensions.

Mandibular first bicuspid

The features of the upper bicuspids have been described and they should be firmly in mind. In figure 65, the MANDIBULAR FIRST or the LOWER FIRST bicuspid is seen from its buccal aspect. The general outline shows a marked constriction at the gingival line. To this characteristic appearance the dental profession has given the name "bell crowned." Odontography textbooks agree that this tooth—the mandibular first bicuspid—which is next to be studied is the smallest of the four bicuspids. It differs greatly from the upper first in that, although there are two cusps—a buccal and a lingual—the latter is rudimentary in most instances, and might be compared to the cingulum on the lingual surface of the upper cuspid. The buccal cusp is long and sharp, and closely resembles the cusp of the lower cuspid, which proximates it mesially. The BUCCAL surface is very convex in all directions. The buccocclusal margin is divided into two parts by the buccal cusp. From this cusp a buccal ridge extends gingivally to the point of greatest convexity or bulging, located in the gingival third, which

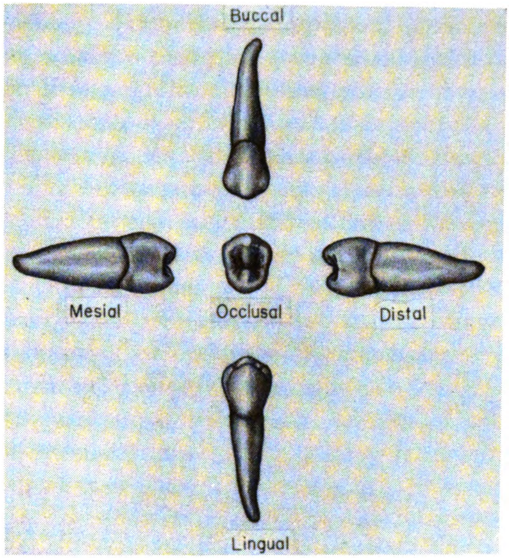


Figure 85.—Maxillary second bicuspid.

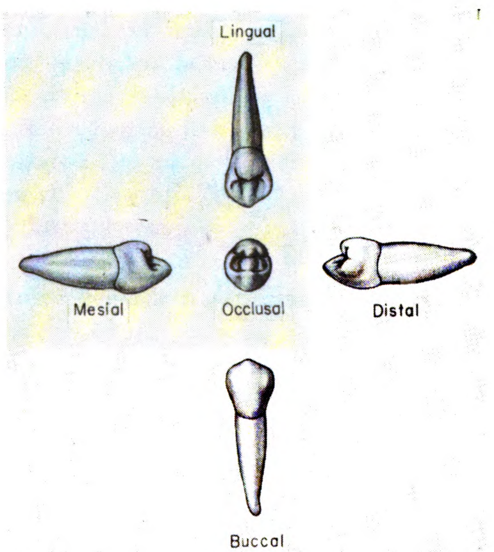


Figure 86.—Mandibular first bicuspid.

is spoken of as "the height of contour." The MESIAL surface shows a distinct convexity at the occlusal third, and then, for the remaining two thirds of its surface, is concave. The DISTAL surface is similar in shape to the mesial. It is this marked concavity of both surfaces which aids in making the lower bicuspid appear like an inverted bell. On both surfaces the contact points are in the occlusal third, with the distal contact point being located more gingivally than its mesial counterpart. The area of mesial contact is smaller because of the smaller distal surface of the adjacent cuspid. The LINGUAL surface is very convex and small in area, giving the appearance of overhanging the lingual surface of the root. When an amalgam restoration is placed, care must be taken in the contouring of a steel band which serves as a matrix, because of the extreme constriction of the neck or cervical portion of the tooth. The OCCLUSAL surface presents an outline which is almost circular, with the tip of the buccal cusp well away from the buccal surface. The mesial and distal marginal ridges are well defined and seem to blend with well rounded corners into the occlusal margin. The triangular grooves which were defined in the description of the upper bicuspids are quite well outlined, and there is a strong transverse ridge running from the buccal cusp to the lingual cusp. In these teeth the mesial and distal pits terminate in a fine line which is almost obliterated at the tip of the cusps while in the other teeth, it is a deep well defined groove. The ROOT is single, but in a few exceptions is found to be divided or bifurcated (from "*bi*"—two, and "*furca*"—fork) in its apical third.

Mandibular second bicuspid

The mandibular second bicuspid is the fifth tooth from the median line in the lower arch, figure 65. It has the same BUCCAL surface characteristics as the first bicuspid, with a prominent buccal ridge. The MESIAL and DISTAL surfaces usually are convex. In about one half of all lower second bicuspids a concavity exists in the gingival area. The LINGUAL surface is similar to that of the lower first bicuspid, with the exception that there may be two lingual cusps. The OCCLUSAL surface of this tooth offers three different patterns, two of which will be described in this paragraph. The first is the three cusp type, in which the lingual groove divides the lingual marginal ridge into two distinct parts. The authors of some texts refer to this type of occlusal surface as the Y form. The mesial and distal triangular grooves are quite distinct as they join a short central groove; whereas, when the mesial and distal grooves occur, they have a faint appearance. As a result of the Y form, the following cusps are evident—the buccal, the mesiolingual and the distolingual. In the less common two cusp type, the central groove meets the triangular grooves to form a half circle.

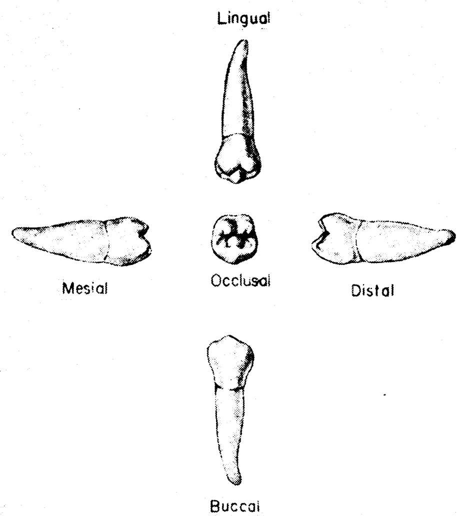


Figure 87.—Mandibular second bicuspid.

Since there is no lingual groove, there are two prominent cusps—namely, the buccal and the lingual. The particular type of occlusal surface that the technician may carve in the laboratory will be up to the discretion of the dental officer, who determines this from the occlusion of the opposing tooth in the upper arch. (OCCLUSION is the natural closure and fitting together of upper and lower teeth.) The root of the tooth is single, and in a great many instances the apical region is found to be quite crooked and bent.

Molars

The molar teeth are 12 in number and appear 6 in the maxillary arch and 6 in the mandibular arch. As shown in figure 64, the molars are quite different in their occlusal patterns from the bicuspids. There are many obvious differences. The cusps are large and prominent, with the broad surfaces of the occlusal or

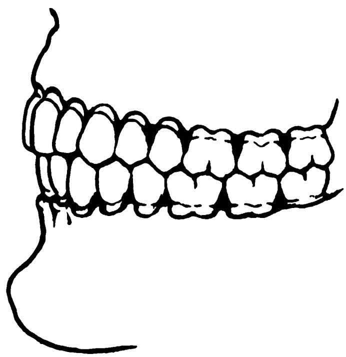


Figure 88.—Cusp relationship.

grinding surfaces broken up into rugged appearing ridges and well defined grooves. It can be seen why most eating is done on the molar teeth where, by nature of the physical characteristics of the occlusal surfaces, most of the grinding and chewing can be done. All of the cusps of the lower teeth bear a definite relationship to those of the upper.

Maxillary first molar

The maxillary first molar is the sixth tooth from the median line. The BUCCAL surface is convex in all directions, with the greatest convexity, or height of contour, located at the junction of the middle and gingival thirds.

The buccal groove, which is continued over from the occlusal surface, is quite prominent and terminates in the middle third. The LINGUAL surface resembles the buccal but is somewhat smaller in outline. The area of greatest convexity is at the junction of the middle and occlusal thirds. In the discussion of the lingual sur-

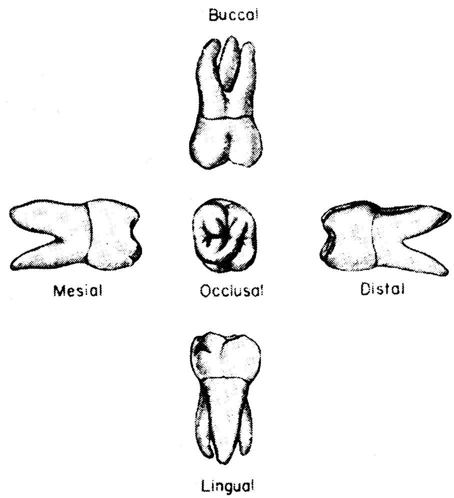


Figure 89.—Maxillary first molar.

faces of upper bicuspids—it was shown that the height of contour on these surfaces also is at the junction of the middle and occlusal thirds. It will be recalled that the buccal surface has a buccal groove. In the case of the lingual surface, there is no groove dividing the center of the lingual ridge, but the distolingual groove of the occlusal surface continues over onto the lingual surface and fades out in the middle third. In a great many cases there is an extra cusp on the lingual surface of the mesiolingual cusp. Such a cusp is often called the CUSP OF CARABELLI. Highly skilled pros-

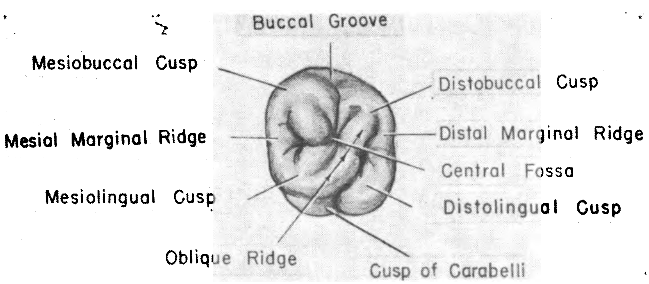


Figure 90.—Maxillary first molar occlusal surface.

thetic technicians generally reproduce this cusp when they are restoring a full crown. The MESIAL surface, which is flat, has its contact point in the occlusal third, near the buccal surface. The DISTAL surface is slightly more convex. Its contact point is nearer to the lingual and, in common with all the other distal contacts that have been described, it is located closer gingivally than that of the mesial surface. The OCCLUSAL surface presents four cusps, all of them prominent. The mesiolingual cusp is the highest. The names of the four cusps are, by virtue of their location, the mesiobuccal, the mesiolingual, the distobuccal and the distolingual. The mesial and distal marginal ridges differ from those studied in the bicuspids in that they are broader and thus appear stronger. A ridge, the OBLIQUE RIDGE, which has not been previously studied makes its appearance here. (Its presence is also common to the remaining two upper molar teeth.) It divides the occlusal surface into two valleys or depressions (fossae). The larger of these is the central fossa, and the smaller is the distal fossa. The oblique ridge runs from the mesiolingual cusp to the distobuccal cusp, and is marked in its midsection by the passage of the distal groove. From the central fossa arise many grooves. Chief among them

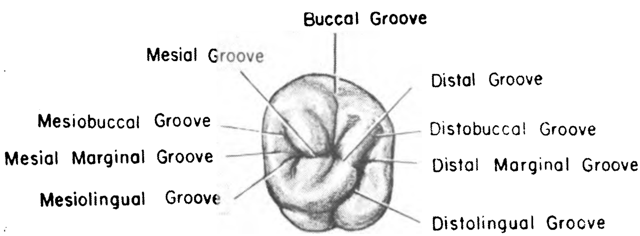


Figure 91.—Maxillary first molar occlusal grooves.

are: the mesial, which runs to the mesial marginal ridge; the distal, which crosses the oblique ridge to terminate in the distal fossa; the buccal, which runs over the buccal margin onto the buccal surface; the mesiobuccal triangular groove which, like its counterpart in the upper bicuspid, runs from the fossa toward the mesiobuccal angle. In the distal fossa the most prominent feature is the distolingual groove which parallels the course of the oblique ridge. A distobuccal triangular groove, and the ending of the distal groove as it appears over the oblique ridge, are also present. There are numerous other supplemental grooves and fissures, but a knowledge of the above will enable the technician to assist his dental officer skillfully. The ROOTS of the upper first molar are three in number and are named according to location as the mesiobuccal, the distobuccal and the lingual roots. The latter is the largest.

Maxillary second molar

The maxillary second molar is the seventh tooth from the median line.

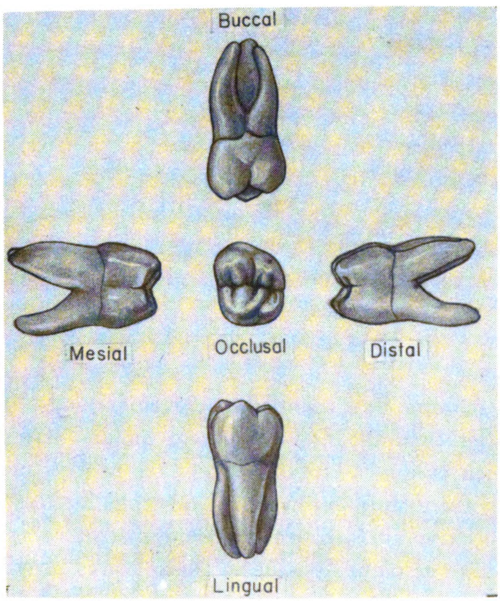


Figure 92.—Maxillary second molar.

Because of having the same function as that of the first molar, its physical characteristics are the same except that it is smaller, the occasional fifth cusp of Carabelli does not appear, and there is a marked reduction in the size of the distolingual cusp.

Maxillary third molar

The maxillary third molar is the eighth tooth from the median line, and was called by the ancients, Dens Sapientiae or "wisdom tooth" because of its appearance in the mouth when the young

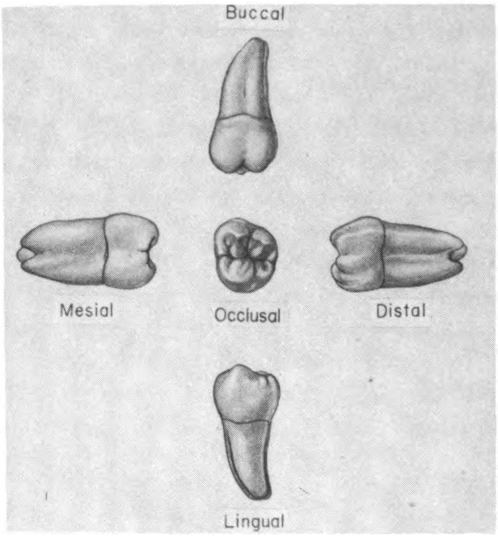


Figure 93.—Maxillary third molar.

adult was passing into manhood or womanhood. The tooth is much smaller than the first or second molars, with an occlusal outline which is almost circular due to the nearly complete disappearance of the distolingual cusp. Numerous fissures and grooves cover the occlusal surface, while the number of roots varies from one to as high as eight divisions. These ROOTS usually are fused together and are quite often curved distally.

Mandibular first molar

Numerous references are made to this tooth, as one of the "6-year molars" (the maxillary first molars also are thus known) because of the time of its appearance in the mouth. Other authors refer to it as the "key to occlusion." The mandibular first molar has a more convex BUCCAL surface than its counterpart in the upper arch but, like it, has the height of contour at the junction of the middle and gingival thirds. For the first time in this study of the teeth, two grooves can be seen on the buccal surface. They are the BUCCAL GROOVE, which is an extension of the buccal groove from the occlusal surface, and the DISTOBUCCAL GROOVE, an extension of the groove of the same name from the occlusal surface.

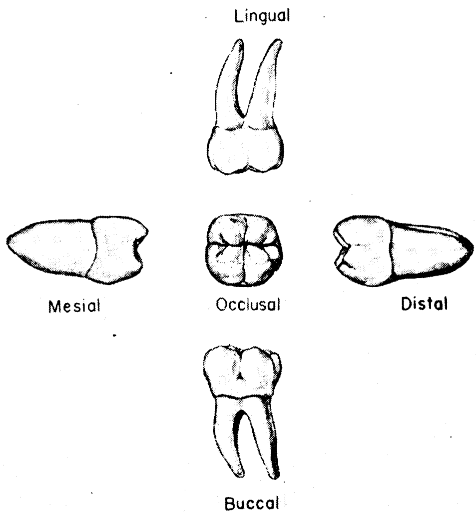


Figure 94.—Mandibular first molar.

The buccal groove ends in a buccal pit. This pit is often found in a decayed condition. The distobuccal groove generally fades out in the middle third of the buccal surface. The occlusal margin of the buccal surface is irregular, due to the appearance of three cusps. The LINGUAL surface is smaller than the buccal in area and is marked by an occlusal margin that shows two distinct cusps, created by a sharply defined lingual groove that ends in the middle third of this surface. The MESIAL and DISTAL surfaces are both convex in the upper two thirds, with a concavity existing at the gingival portion. The contact points are located in the occlusal thirds of the surfaces. The OCCLUSAL surface presents an interesting study, with all five cusps present on the occlusal; this differs from the upper first molar in which the fifth cusp, when it appears, is on the lingual surface of the mesiolingual cusp. Four of the five cusps will afford the student no difficulty in naming them, but the fifth cusp bears a name which has not yet appeared—the DISTAL CUSP. The cusps on the BUCCAL outline appear in the following order: the mesiobuccal, the distobuccal, and the distal. On the LINGUAL surface appear the mesiolingual (the highest cusp) and the distolingual cusps. Three main grooves on the OCCLUSAL surface have already been mentioned: the buccal groove, which helps

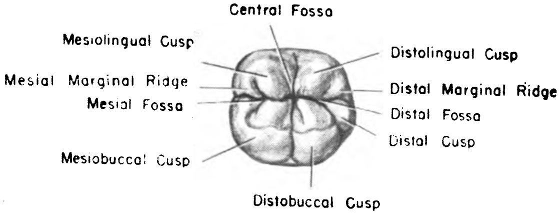


Figure 95.—Mandibular first molar occlusal surface.

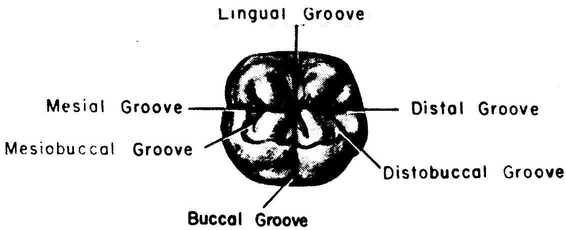


Figure 96.—Mandibular first molar occlusal grooves.

to distinguish the buccal cusps; the distobuccal groove, which likewise extends over the buccal margin and, as can be seen in figure 96, separates the distobuccal cusp from the distal cusp; the lingual groove, which divides the lingual margin into two portions and thus creates the distolingual cusp and the mesiolingual cusp. The remaining two grooves which should be noted are the mesial, which runs from the central fossa over the mesial marginal ridge, and the distal, which also arises in the central fossa and runs over the distal marginal ridge, there separating the distal cusp from the distolingual cusp. The distinguishing characteristic of the occlusal surface is the presence of a fifth cusp, namely the distal cusp. This tooth has two ROOTS, a mesial and a distal.

Mandibular second molar

The mandibular second molar like the maxillary second molar is known also as the "12-year molar," due to its time of eruption

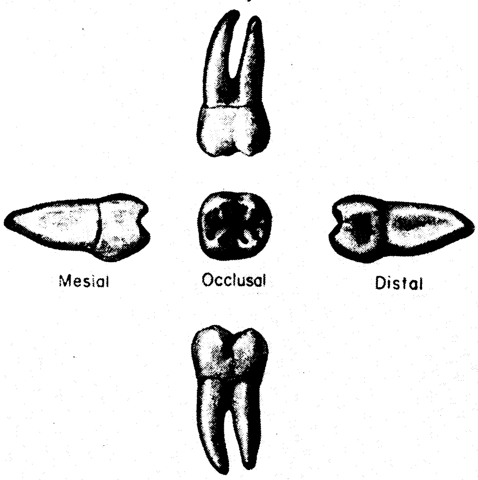


Figure 97.—Mandibular second molar.

in the mouth. The BUCCAL surface presents only one groove, the buccal, which arises in the OCCLUSAL surface, extends over the buccal margin onto the buccal surface, and usually ends in a deep pit, the buccal pit. The lingual surface resembles that of the lower first molar, with a lingual groove; however, the area of this surface is almost as great as that of the buccal surface. The MESIAL and DISTAL surfaces are more convex than those of the first molar. In the OCCLUSAL surface, the greatest difference between the lower first and second molars is the absence of a fifth cusp. Four cusps are outlined by the buccal, lingual, mesial and distal grooves: the mesiobuccal, the mesiolingual, the distobuccal and the distolingual. A central fossa is present and appears to be located, as its name implies, in tne geometric center of this surface. Prominent transverse ridges often occur, and when they appear, they tend to create a mesial and a distal fossa. The ROOTS are two in number and are smaller than those of the first molar. The student should be able to name the triangular grooves of this tooth.

Mandibular third molar

In the study of the general appearance of the teeth, the last tooth approached is one with which the student will become very familiar because of the many people who complain of trouble they experience from its eruption. The mandibular third molar or "wisdom tooth" as it is most commonly called, is the eighth tooth from the median line in the lower or mandibular arch. It appears in many forms, sizes and shapes. As its function is similar to

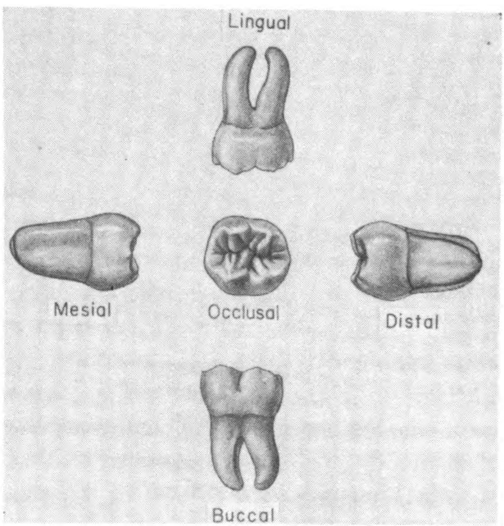


Figure 98.—Mandibular third molar.

that of the other two lower molars, its general appearance is the same, with smaller surfaces, more supplemental grooves, and four or five cusps which are not so sharply differentiated as in the case of the first two molars. The ROOTS, generally two in number, in many cases will show a distinct distal curvature and often will be found difficult to remove. Third molars often show wide and frequent variations. Characteristics of all other teeth, as given in this chapter, are rarely different in different individuals. Wisdom teeth, however, seldom have normal shapes and sizes.

CHAPTER 5

ORAL HISTOLOGY

Oral histology is the science which deals with the minute details of the dental pulp, of the hard tissues of the teeth, and of their supporting structures.

In the last chapter, the morphology or general appearance of the teeth was studied; now the structure of the teeth and their supporting foundation will be studied. In the section on biology such terms became familiar to the technician as protoplasm, cell membrane, nucleus and the like.

The drawing of the crown, figure 99, shows the enamel, the dentin, and the pulp. Covering the enamel is the enamel cuticle, which will be considered first.

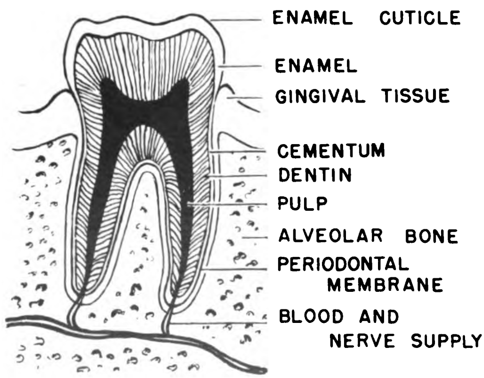


Figure 99.—Mesio-distal section through a lower molar.

Enamel Cuticle

The enamel cuticle is a protective membrane of epithelial origin, also known as NASMYTH'S MEMBRANE after one of its first observers. One concept of a possible function of the cuticle is, that the membrane protects the developing tooth when it is lying in its crypt before it erupts, shielding it from the acid formed by the dissolving of the root portion of the deciduous or "milk" tooth.

Children frequently have green stain on their teeth. This stain, quite common in children up to the age of 12 or 13, collects in the enamel cuticle, which has a crib-like or cobweb-like arrangement wherein CHROMOGENIC (color-producing) bacteria may take action. This will be discussed in a later chapter.

Ordinarily the enamel cuticle may be worn away in youth by mastication and brushing, but it has been recovered from extracted teeth of elderly adults. The cuticle, if it remains, is likely to be found where not exposed to abrasion, such as just below the contact points on the proximal surfaces of the teeth.

Enamel

Enamel is the hardest calcified tissue in the human body. Structurally, it is made up of small enamel rods or prisms and intercementing substance or interprismatic substance. (The terms

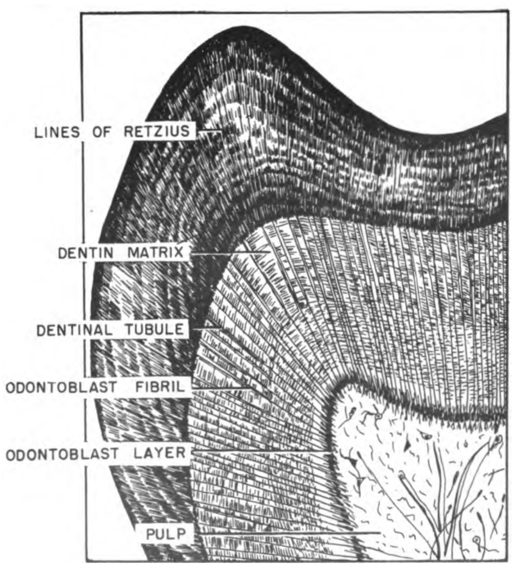


Figure 100.—Semi-diagrammatic sketch of enamel and dentin.

"enamel rods" and "intercementing substance" will be used in this chapter.) The rods are composed of calcium, phosphorus, magnesium, sodium, potassium, and traces of chlorine, fluorine and sulfur. Investigators say that enamel is from 96 to 98 percent inorganic substance, and from 2 to 4 percent organic substance. Dental researchers claim that there are as many as 12 million enamel rods in a tooth.

In looking at figure 100, one can see the continuous enamel rods. Although their course may appear a bit wavy and corkscrew-like, they are continuous from the dentino-enamel junction to the outer surface of the tooth.

The corkscrew-like growth pattern of the rods shows clearly under a microscope in longitudinal sections (slices taken in the long axis of the tooth). Because of the curled arrangement of the rods, alternate light and dark lines, named LINES OF SCHREGER, are observed.

In these microscopic sections, other lines running across the lines of Schreger, parallel with the outer surface of the enamel

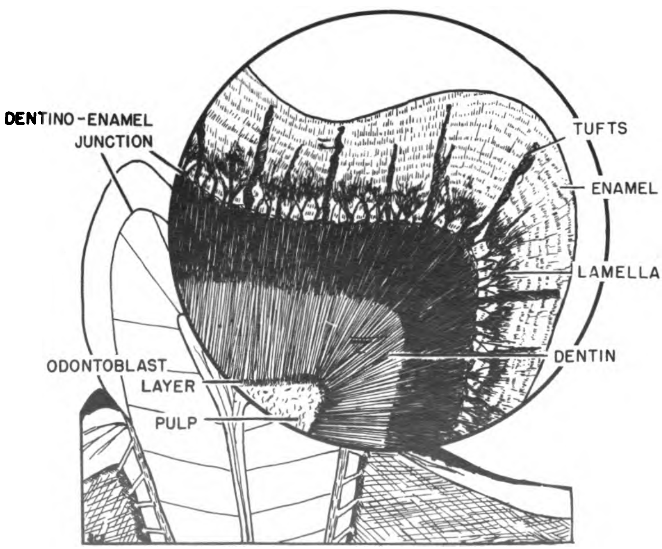


Figure 101.—Dentino-enamel junction. (Diagrammatic.)

also are seen. These bands, known as LINES OF RETZIUS, are caused by halts in the development of the enamel rods and indicate alternate periods of growth and rest. Childhood diseases, or deficiencies in the diet while the teeth are being formed, will change the even, rhythmic appearance of the lines of Retzius. Sometimes portions of the enamel fail to develop. If a childhood disease or deficiency in diet is serious enough, the bands may even be apparent at the surface of the enamel, in horizontal lines, as evidence of the earlier disease or nutritional disturbance.

Enamel spindles appear immediately over the dentin, and are found mainly in the cuspal portion of the crown. They are formed as a result of the odontoblastic (tooth-germ) processes which terminate in the enamel, and which will be discussed in the paragraph on dentin. These spindles can be seen only under the microscope.

The enamel also includes enamel tufts. These are composed of enamel rods and the intercementing substance, but are not quite so highly calcified as the enamel rods and intercementing substance found in the enamel portion of the crown. They, too, fan out from the dentino-enamel junction and extend in the enamel for a short distance.

Microscopic sections reveal that the dentino-enamel junction is not a straight line, but appears scalloped, wavy, or sharply arched, following the general contour of the crown. This uneven line is formed by the ameloblasts (enamel-forming cells) and the BASEMENT MEMBRANE of the DENTAL PAPILLA while the tooth is being formed, prior to the development of the hard structures. Nature provided this interlocking junction to give greater strength to the crown of the tooth and to bind the enamel and dentin together firmly.

Dentin

The dentin comprises the bulk of the tooth and consists of a calcified matrix (hardened by deposited lime salts), which is penetrated by tubules (small tubes). Dentin, as compared to enamel, is slightly compressible and is highly elastic. It is harder than bone, softer than enamel, and light yellow in color. Dentin is composed of 70 percent inorganic matter and 30 percent organic matter including water and carbon dioxide.

The dentin matrix consists of fine connective tissue FIBRILS (fibers or filaments) which are bound together by a calcified cementing substance.

Dentinal tubules

Throughout the matrix may be traced the dentinal tubules, which could be likened to hollow sticks of macaroni fanning out from the pulp. They are farther apart at the dentino-enamel junction than at the pulpal end of the dentin. The tubules are separated from each other by the dentin matrix. They contain the protoplasmic elongations of the odontoblasts, some of which end in the enamel as spindles, described earlier. The odontoblasts are the dentin-forming cells which lie along the pulpal surface of the dentin.

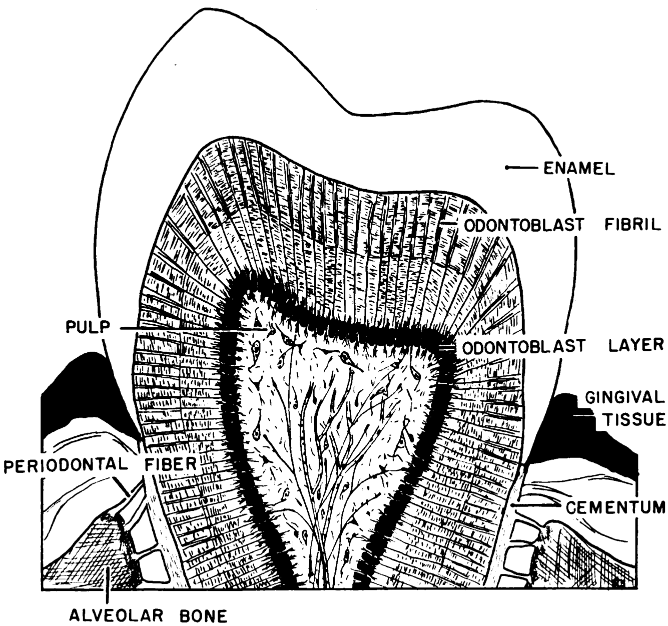


Figure 102.—Odontoblast layer. (Diagrammatic.)

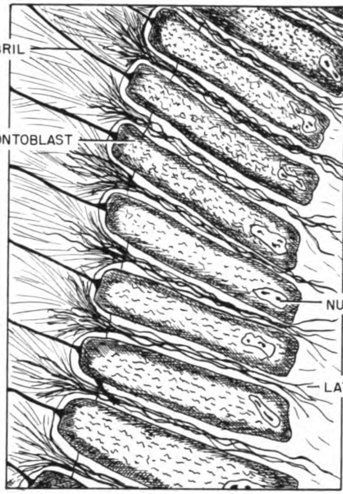


Figure 103.—Odontoblast layer. (Diagrammatic.)

Granular layer of Tomes

The root portion of a tooth is covered by a layer of bonelike material, the CEMENTUM. There is a thin layer of interglobular spaces on the surface of the dentin of the root portion of the tooth covered by cementum, known as the GRANULAR LAYER OF TOMES. In ground sections it shows a granular appearance. This layer is always present in the root portion of teeth, but ends at their cemento-enamel junction. It is composed of inadequately calcified dentin.

Dentinal nerves

The question of nerve supply in the dentin is still a controversial subject among oral histologists. Some histologists believe that nerve fibers within the dentin have actually been detected by using a silver staining method. The most commonly accepted theory today is one in which response to thermal, chemical or mechanical stimuli can be likened to the action which takes place in a thermometer. A thermometer has a small bore, and changes in temperature increase or decrease the height of the mercury in the thermometer. The bore of a tubule is microscopic in diameter and there are thousands of tubules in a very small area of dentin. Any slight change in temperature will cause the fluid in these minute tubes to react, and results in an increase or decrease in pressure. When the pressure in the dentinal tubules is increased or decreased, the pressure change is transmitted to the dentinal fibrils, and the cell fluid is forced into or pulled away from the odontoblasts, which expand or shrink. There are nerves present in the pulp chamber which form a network supplying the odontoblasts; each such expansion or shrinkage of these cells causes these nerves to transmit an impulse to the brain. When the dental officer places anesthetic solution near the nerves which supply the teeth, the ability of the nerves to transmit impulses is temporarily lessened. This explains why the patient feels little or no pain when the dental officer prepares the tooth structure for restorations. When candy or citrus fruit juices contact exposed dentin, a patient may experience pain due to a different kind of stimulation of the dentinal fibrils.

Secondary dentin

Dentin, unlike enamel, can be formed after the eruption of a tooth. It is not repaired at the site of damage, however, but rather new or SECONDARY DENTIN may be produced on the pulp surface underlying such damage (caries, trauma, irritation). More severe stimuli may cause the formation of IRREGULAR DENTIN which has fewer and frequently twisted tubules.

Cementum

The CEMENTUM is a thin layer of bonelike structure which covers the roots of the teeth. Normal cementum is thicker than the enamel cuticle but thinner than the enamel or dentin. In the scale of hardness of tooth structure, enamel is first, dentin second, and cementum third. The cementum contains about 55 percent inorganic substance and 45 percent organic material and water. The chief constituent of the organic material is COLLAGEN, which is a substance (also the main ingredient) making up the bulk of connective tissue. Cementum is lighter in color than dentin and is more homogeneous (uniform in quality throughout) than enamel or dentin.

The cementum usually joins with the enamel at the cervical line. The principal function of the cementum is to assist in the attachment of the tooth to its surrounding tissues. Normally the cementum contains the embedded ends of thousands of tough fibers. They are known as SHARPEY'S FIBERS. The other ends of these fibers are attached to the lamina dura.

Secondary cementum

Cementum can be laid down in response to either a physical, chemical or bacterial injury. This additional cementum is termed secondary cementum.

Dental Pulp

The DENTAL PULP is the soft tissue found in the pulp chamber and root canals of a tooth. Its primary function is the production of dentin.

The pulp contains many of the fibrous and cellular elements found in connective tissue. It is covered with a layer of columnar

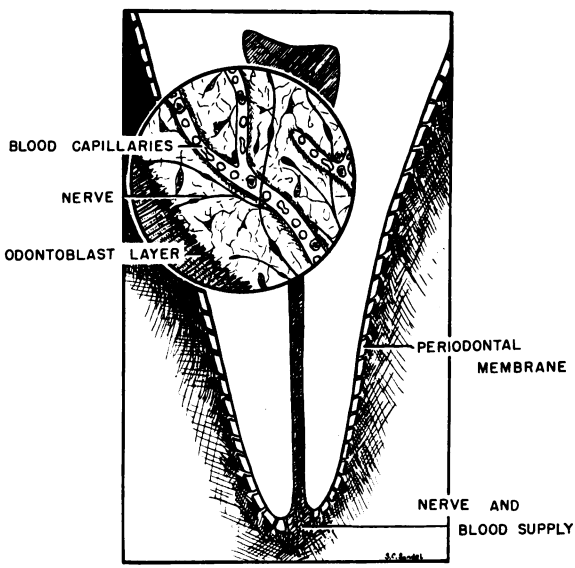


Figure. 104.—Pulp. (Diagrammatic.)

cells called odontoblasts. These form the dentinal fibers (Tomes' fibers) which, as previously described, enter the dentinal tubules. Blood and lymph vessels which are found in the dental pulp convey nutriment to the odontoblasts. Around the odontoblasts are arranged the endings of nerves which, together with the blood vessels, enter the pulp through the apical foramen (opening at the apex of the root). A unique characteristic of the pulp is that it is enclosed in hard walls. If there is any swelling due to inflammation of the pulp, injury (usually death) of the pulp results, because the unyielding walls of the pulp chamber prevent expansion of the pulp tissue. This condition may cause strangulation of the vessels at the apical foramen.

Periodontal Membrane

This tissue also is called the PERIDENTAL, the periodontium or the dental periosteum. It is by means of the fibers within this

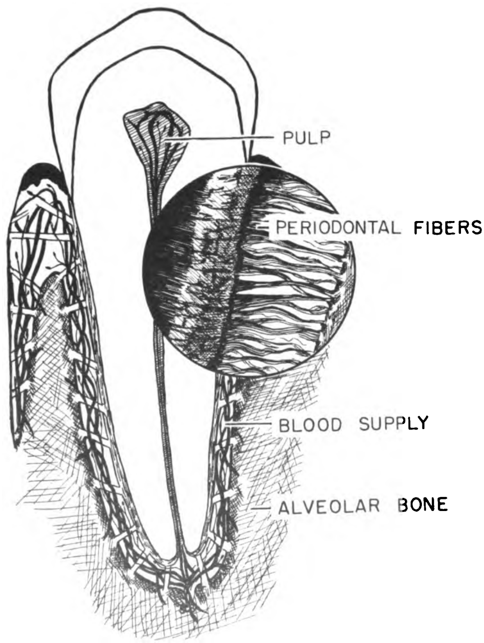


Figure 105.—Periodontal membrane. (Diagrammatic.)

tissue that the tooth is attached to the surrounding bony alveolus. The periodontal membrane helps to absorb the shock of blows, acting like a cushion for the tooth during mastication. In a roentgenogram, it appears as a dark line around the root of the tooth.

Near the cementum, the periodontal membrane contains a row of cells called CEMENTOBLASTS which can form additional cementum. This deposit is SECONDARY CEMENTUM. Secondary cementum may be deposited, after the cause of periodontitis (inflammation of the periodontal membrane) has been removed, and provides a freshened surface in which the fibers of the membrane can become reattached. The dental periosteum adjacent to the bone contains a layer of cells called OSTEOBLASTS, which can form additional bone. When orthodontic procedures (correction of irregularities of the teeth and malocclusion) are applied, the action of both the osteoblasts and the cementoblasts is of great importance to the maintenance of this membrane.

The periodontal membrane is made up of dense, fibrous tissue—the Sharpey's fibers named in the earlier section on cementum. These fibers are arranged in bundles, the ends of which extend into the cementum on one side and into the alveolar bone on the other. They are identified according to the way in which they are related to the cementum on one side and to the lamina dura on the other. (The lamina dura is the dense bone lining the alveolus or socket and appears as a white line in a roentgenogram.) These fibers of the periodontal membrane are: free gingival fibers, extending from the cementum to the gingivae; the alveolar crest fibers, stretching from the alveolar margin toward the cementum at the gingival portion of the tooth; transeptal (across the septum) fibers, extending from tooth to tooth across the interalveolar septa (bone between the teeth); horizontal fibers, running in a horizontal direction in the area between the crown and root; apical fibers, running radially around the end of the root; and oblique fibers, slanting midway between the horizontal and apical groups. One can see readily that the function of all these fibers is to prevent displacement of the tooth by securing it firmly in its alveolus. When a tooth is extracted the dental periosteum is permanently destroyed.

Alveolar Bone

The lamina dura, as previously stated, gives attachment to fibers of the periodontal membrane.

Under the microscope, differentiation between the lamina dura and the alveolar bone beyond it is difficult. However, LACUNAE (spaces) containing the osteoblasts (bone-forming cells), and canaliculi (channels) connecting the lacunae for nutritive purposes can be seen.

Alveolar Process

The bony structure supporting the teeth is less dense than typical bone and is known as the alveolar process. This bone is less calcified, is spongy in appearance, and has many "bone threads" or TRABECULAE making up its framework. The trabeculae are arranged to give the greatest support. Between the trabeculae run many blood vessels. The spongy, threadlike bone is protected by a dense, hard, cortical layer on the outer and inner surfaces—the external and the internal alveolar plate — which cover the whole alveolar process and are continuous with the lamina dura of each tooth socket.

The alveolar process does not remain in the same form throughout life. It is subject to many changes due to wear, senility and disease. The function of the alveolar process is to support the teeth. When teeth are removed, the alveolar process is partially resorbed. The extent and form of the remaining alveolar process are of prime importance to the prosthodontist because this bone must provide the foundation for dentures.

Tooth Development

About the fifth week of intra-uterine life (life within the uterus), the EPITHELIUM covering the whole embryo is continuous with and of the same quality as the mouth epithelium. The oral epithelium presents a thickening which divides into two ridges, the labial and the lingual ridge. From the lingual ridge, which is nearer the tongue, 10 little knobs of tissue appear which are to become the deciduous teeth. About the twelfth week, the knobs or TOOTH GERMS of the permanent set appear, to the lingual of the DECIDUOUS row.

Beneath the base of each tooth germ, there occurs a thickening or multiplication of the cells which comprise the dentinal PAPILLA. The papilla pushes its way into the base of the epithelial tooth germ, causing the latter to become bell shaped. This germ, as it matures, is known as the ENAMEL ORGAN, because it produces the enamel of the tooth. The papilla keeps on growing, pushing the enamel organ into the shape of the crown portion of the tooth.

The cells of the inner layer of epithelium (the layer closest to the papilla) are the ameloblasts. Each ameloblast forms one enamel rod from the dentino-enamel junction to the periphery of the crown. Once the ameloblasts have been formed, they do not divide into more cells.

About the twentieth week, the cells innermost from the ameloblasts are transformed into odontoblasts, which as previously explained, are the cells which produce the dentin. They gradually deposit dentin on the outer aspect of the papilla. As more and more dentin is deposited, the odontoblasts leave their thin, netlike processes (dentinal fibrils) within the dentinal tubules. The odontoblastic layer recedes more and more from the dentino-enamel junction as it forms dentin. Blood vessels make their appearance in the papilla, carrying nourishment to the ameloblasts and the odontoblasts. The continuations of the fibrils of the papilla form the matrix of the dentin when they change to collagen (main constituent of the organic substance of bone). These fibrils are known as KORFF'S FIBERS. At this point the student should grasp the thought that dentin is deposited from the dentino-enamel junction inward, while the enamel is deposited from that junction outward.

From the rim of the enamel organ, cells begin to multiply until a cylinder-like sheath extends farther and farther away from the enamel organ into the underlying connective tissue. This sheath guides the form of the root and is called the SHEATH OF HERTWIG. The odontoblastic layer of the dentinal papilla stretches out along the sheath of Hertwig and, as more of the sheath forms, additional dentin is formed. This process continues until the epithelial sheath has guided the formation of the entire root of the tooth. As the dentin of the root portion is formed, the odonto-

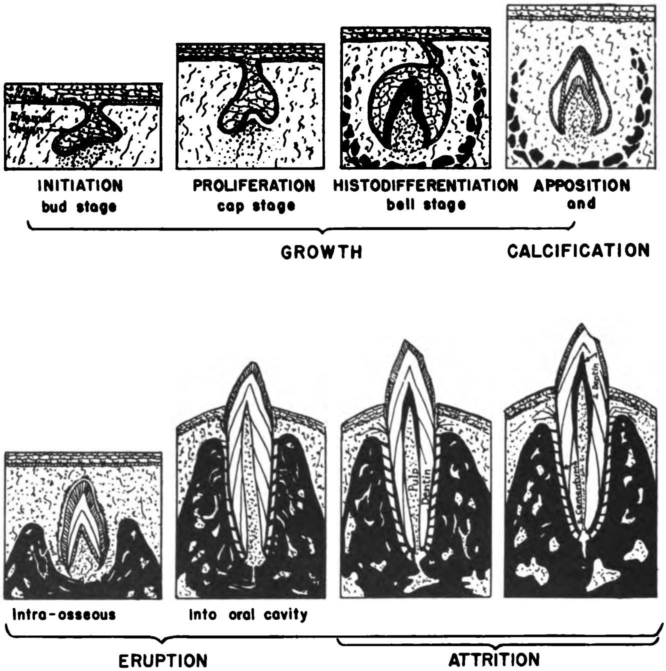


Figure 106.—Life cycle of a tooth. (Modified from Schour & Massler.)

blastic layer recedes inward toward the center from the periphery, until eventually the dental papilla becomes the dental pulp, and the pulp cavity is formed.

Theories on Cause of Tooth Eruption

Some of the factors that apparently combine to cause tooth eruption are: growth of the root, growth of dentin, pressure from muscular action, formation and resorption of bone, proliferation (cell multiplication) of dental tissues, and pressure resulting from the vascularity (richness in blood vessels) of the pulp and periapical tissues.

In brief, it can be said that as the tooth germ of the permanent tooth begins to grow, the pressure exerted by its development causes the destruction of the thin, bony septum (wall or partition)

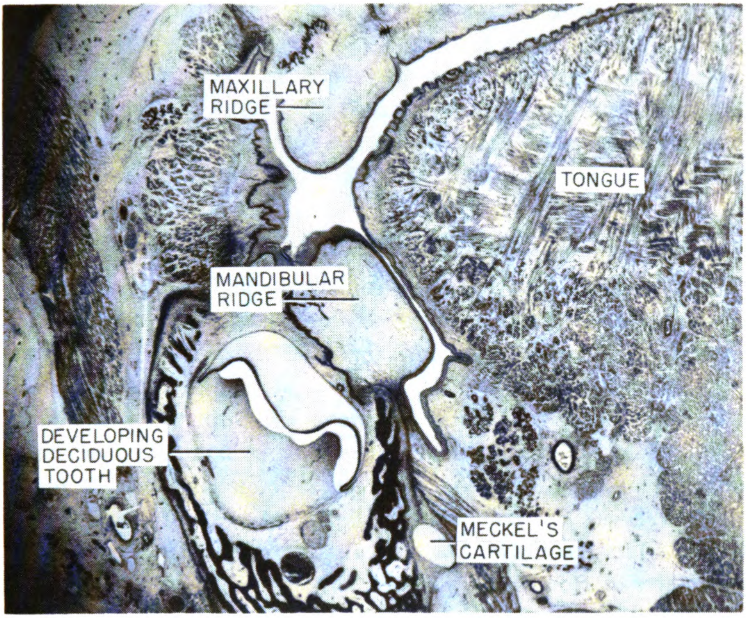


Figure 107.—Photomicrograph of cross section through jaws of a six month human fetus. (Enlarged.)

between its crown and the root of the deciduous tooth. OSTEOCLASTS, which are the bone-destroying cells, gradually eat the root away. All the time this action is taking place, the crown of the permanent tooth is gradually moving into the position occupied by the deciduous tooth, which prior to the eruption of the permanent tooth becomes loose and is shed.

CHAPTER 6

ORAL BACTERIOLOGY

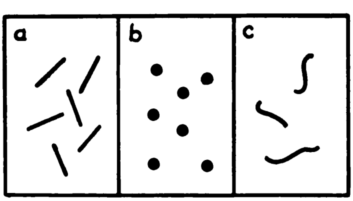
Oral bacteriology—sometimes called microbiology—is that part of the field of biologic sciences which deals with bacteria in general, and in particular with those which are concerned with the oral cavity.

Bacteria occupy a rather unique position in the scheme of living things. They exhibit characteristics of both the plant and animal kingdoms, and appear to be a connecting link between the two. Some bacteria are branched and sheathed, much like plants. Other forms of bacteria possess organs of locomotion, a property of animals.

Although they occupy this intermediary position, bacteria are usually assigned to the plant kingdom for classification purposes. Thus, bacteria are said to be minute, unicellular plantlike organisms, devoid of chlorophyll. They exist singly, or in aggregates or clumps called colonies.

Morphology

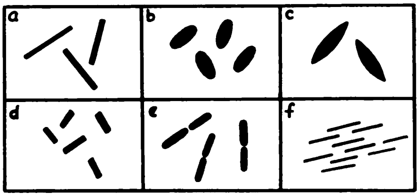
There are three general morphologic types of bacteria: bacilli, or pencil-shaped rods; cocci, or spherical globules; and spirilla, or wavy and coiled threads.



a. Bacilli — rod-shaped.
b. Cocci — spherical.
c. Spirilla — spiral or wavy.

Figure 108.—General morphology.

There are many variations of these basic forms. Some bacilli are slender with parallel sides, others are short and fat with rounded sides. Some have pointed or tapered ends while others are flat ended. There are distinctive arrangements of bacilli. Some occur haphazardly, others lie end to end in pairs or short chains, while others may be stacked like cordwood.



a. Pencil-shaped bacilli with square ends.
b. Short, fat "cocco-bacilli."
c. Bacilli with pointed ends.
d. Bacilli with no distinctive arrangement.
e. Bacilli in pairs, "diplo-bacilli."
f. Bacilli in bundles, or layers.

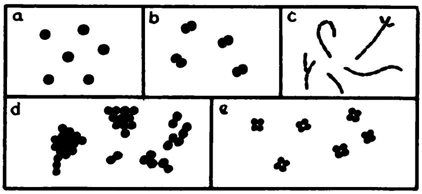
Figure 109.—Variations in basic forms.

Cocci vary in size and arrangement, rather than in shape. The variation in arrangement is a result of different types of cell division. Most bacteria multiply by means of simple binary fission occurring in one plane. Or, more simply, the cell enlarges until it reaches maximum growth, then constricts about its middle until it splits into two "daughter" cells. This division commonly occurs in either the vertical or horizontal plane.

Cocci dividing this way, with the daughter cells assuming no characteristic arrangement following division, are called MICROCOCCI. Another group of cocci divide and two daughter cells remain in such close apposition that they appear in pairs. These are called DIPLOCOCCI, or paired cocci. Still others cling together through many divisions, and result in the formation of chains of varying lengths. They are termed STREPTOCOCCI, or chain cocci.

Some cocci multiply in a two dimension plane, or both horizontally and vertically. Sheets or clusters of cocci are the products of this type of division. The organisms in clusters are called STAPHYLOCOCCI.

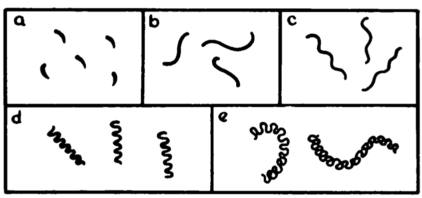
Still another type of cocci divides in three planes at right angles to each other, or horizontally and vertically plus depth. This formation produces cubes or packets of eight cocci, which are called SARCINAE. Figure 110 demonstrates the various arrangements of cocci.



a. Micrococci.
b. Diplococci.
c. Streptococci
d. Staphylococci.
e. Sarcinae.

Figure 110.—Cocci patterns.

Spirilla occur in many forms; simple ones contain but a single curve, others are coiled or corkscrew shaped. There is considerable variation in the length and width of these organisms and in the rigidity of the individual turns of the coil. In figure 111, some of the more common spiral forms are illustrated diagrammatically.



a. Comma — or Vibrio.
b. Curved — or Spirillum.
c. Wavy — or Borrelia.
d. Corkscrew — or Treponema.
e. Buttonhook — or Leptospira.

Figure 111.—Forms of spirilla.

Size

There is considerable variation in the size of bacteria as well as in the shape. Micro-organisms are measured in terms of microns (μ). A micron is one thousandth of a millimeter (0.001 mm) or roughly 1/25,000 of an inch. The average bacillus measures about 2 μ in length and 0.5 μ in width. Some may be as long as 40 μ while others are as short as 0.4 μ. Cocci average between 0.8 μ and 1.3 μ in diameter. Usually, spiral forms are considerably longer than bacilli.

Cell structure

From recent studies, made possible by the perfection of the electron microscope which gives many times the magnification of the usual microscope, it is evident that the bacterial cell is extremely complicated. Physical and chemical studies disclosed a definite cell wall surrounding the protoplasm of the bacterial cell, but the existence of a nucleus is still questionable. There is no discrete body like the one which exists in the cells of higher animals. However, from chemical studies, the protoplasm is known to contain large amounts of nuclear material, and concentrations of this material have been demonstrated on electron micrographs.

Capsule

In addition to the cell wall, all bacteria possess a slime layer. When the slime layer is enlarged or thickened, it is called a capsule, which is secreted by the cell wall. In pathogenic (disease-producing) organisms, this capsule is a defensive structure which is thought to protect the bacteria from the phagocytic action of the leukocytes. Encapsulated organisms which lose their capsules for one reason or another, usually are no longer pathogenic.

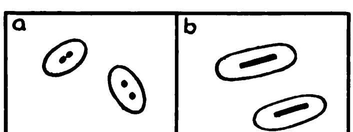


Figure 112.—Capsules.

Use is made of the capsule in the identification of certain organisms, notably the PNEUMOCOCCI. When mixed with their specific "typing sera," the capsules of these organisms will swell noticeably. They will give no reaction to sera that is not specific for them.

Figure 112 is greatly exaggerated for purposes of clarity. It shows cocci and bacilli surrounded by capsules.

Flagella

It was mentioned in the introduction to this chapter that some bacteria have organs of locomotion. These organs are called flagella. Bacteria are described as being either "motile" or "non-motile" depending on whether or not they are flagellated. Flagella usually are located in one of the four positions shown diagrammatically in figure 113. They can not be seen unless special staining technics are employed.

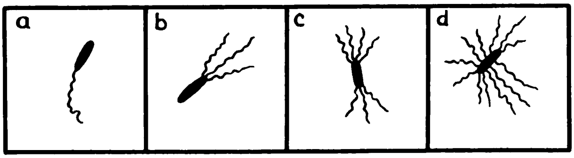


Figure 113.—Bacterial organs of locomotion.

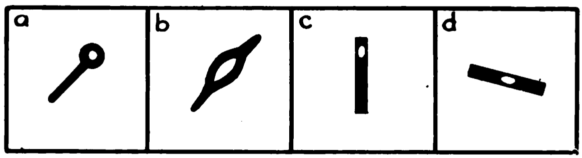
Many bacilli are flagellated, but very few cocci ever have been proved to be motile. Certain spiral forms are motile without possessing flagella. They are able to propel themselves by means of a coiling-uncoiling motion, or by wormlike movement.

Spores

Under certain conditions, some bacilli will form cystlike structures within their cellular protoplasm. These cysts are called spores.

Spores are not reproductive structures (one cell produces only one spore). Spore formation is not well understood but apparently condensations of cellular constituents become surrounded by very resistant walls. When the bacterial (vegetative) cell dies and disintegrates, the spore is liberated. Under adverse conditions spores may remain in this state indefinitely. Once conditions become favorable again they usually elongate and form another vegetative cell. The spore is considered a resting stage in the life of sporulating (spore-forming) bacteria.

The size and position of the spores cause the bacterial cells to have a distinctive morphologic appearance during the time they are sporulating Figure 114 illustrates the four basic types of spores.



a. "Terminal" spore producing a drumstick-shaped cell.
b. "Central" spore causing the cell to appear spindle shaped.
c. "Terminal" spore with no distortion.
d. "Central" spore with no distortion.

Figure 114.—Basic types of spores.

Spores are extremely resistant to the usual types of sterilization such as heat and disinfection. They will survive boiling for several hours and over 100 degrees of dry heat. This property of resistance makes them of especial importance wherever conditions of absolute sterility are necessary.

Nomenclature

The system of nomenclature in bacteriology is similar to that used in other biologic fields. Each organism is given two names. The first is called the generic name and is always capitalized; the second is known as the specific name and is not capitalized.

The generic name refers to a large group of organisms exhibiting many of the same morphologic, physiologic, pathogenic and immunologic characteristics. Thus, all cocci occurring in grapelike clusters or bunches are given the general name STAPHYLOCOCCI. Certain dissimilarities exist among organisms of the same genus, and they are further differentiated into species. Hence we have STAPHYLOCOCCUS AUREUS, STAPHYLOCOCCUS ALBUS and STAPHYLOCOCCUS CITREUS, to name a few.

The generic name may be either descriptive or it may refer to the scientists who originally discovered the organisms. For example, Staphylococcus is a Greek word for "a bunch of grapes;" Bacillus is a Latin word for a "little stick;" Pasteurella and Brucella honor two early bacteriologists, Pasteur and Bruce.

Usually, the specific name is only descriptive, either describing the organism or the disease it causes. Thus a lemon yellow staphylococcus is termed STAPHYLOCOCCUS CITREUS, and the organism producing diphtheria is known as CORYNEBACTERIUM DIPHTHERIAE.

Cultivation

Thus far, only individual cells or small groups of a few cells have been concerned in the discussion of morphology. It is not difficult to see these organisms in stained preparations made from specimens such as throat smears, sputum, urine and feces. However, little differentiation between species can be made on this basis. It is necessary to cultivate them in the laboratory in order to have enough living organisms (a culture) on which to perform the various tests for further identification.

Bacteria are either free living or parasitic. Among the free-living bacteria are the soil and water bacteria, none of which are of much importance from a disease-producing point of view. These organisms have relatively simple nutritional requirements which are met by assimilation of material from the soil and water in which they live.

The parasitic bacteria, or pathogenic (disease-producing) bacteria as they are more commonly called, are much more complex in their food requirements. They have become adapted to the environment of the host in which they live and from which they derive their food supply. To cultivate the organisms in the laboratory, the conditions to which they are normally accustomed must be partly simulated.

The simplest type of media, on which the more hardy forms of pathogens will grow, is nothing more than a beef broth made by mixing ground beef, salt and water. This is called NUTRIENT BROTH. However, most pathogenic organisms are more demanding in their nutritional requirements and some form of enrichment must be added to the nutrient broth to support their growth. Blood, serum, sugars, proteins and chemicals are some of the materials usually added for enrichment. The nutrient broth then takes the name of the enriching material, i. e., serum broth, lactose broth, nitrate broth and beef heart broth.

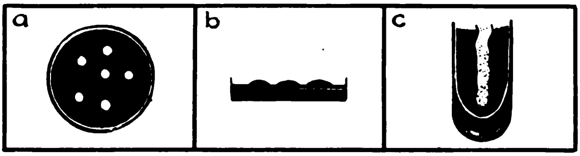
With a few exceptions, different genera and species of bacteria growing in one type of broth present much the same appearance. Within a few hours after adding bacteria to the test tube (inoculating), the broth will become turbid with small organisms, producing a granular cloudiness, and larger organisms, developing a milky or chalky type of growth. Differentiation into morphologic types can be made by microscopic examination of growth in broth cultures, but no distinction can be made between the various species.

As bacteria grow together in dense compact masses, called COLONIES, further identification can be made. Bacteria disperse as they divide and multiply in liquid media; thus it is necessary to provide a more solid medium in which they can form colonies. Adding a stiffening agent to the broth will produce a gelatin-like mass. The usual stiffening agent is a product of seaweed, called agar. When agar is added to nutrient broth the resulting media is called nutrient agar. As in the case of the enriched broths, the various types of agars are often named according to the enrichment added to them. Examples are: blood agar, serum agar, dextrose agar and ascitic fluid agar.

Broth media (liquid) is ordinarily dispensed in test tubes and flasks, the ends being stoppered with cotton plugs. Agar media (gel) is usually contained in test tubes and petri dishes.

Colony Morphology

The morphologic characteristics of the colonies produced on solid media differ as much between various genera and species as does the morphology of individual cells. Cell morphology influences colony morphology to a great extent. Encapsulated bacteria tend to produce glistening, sticky colonies due to the character of this slime layer. Nonencapsulated bacteria generally produce a dry, granular type of colony. Motile bacteria may form an irregular, spreading colony due to the movement of the bacteria. Nonmotile organisms often have discrete, regular shaped colonies. The colonies of large bacteria will be several millimeters in diameter, while those of small bacteria may be pinpoint in size. In addition to shape and size, color is often an identifying feature. Some organisms produce a definite pigment. Species often may be identified by their color alone.



a. Plate culture in petri dish as seen from above.
b. Side view of colonies in plate culture.
c. Tube of solid media showing bacterial growth.

Figure 115.—Plate and tube cultures.

"Pure" cultures of a single organism seldom are encountered in the specimens handled by a clinical laboratory. Sputum, urine, feces and other specimens taken from the body will contain many different types of bacteria. Cultivation on solid media is the only means of routinely separating these organisms for purposes of identification. The specimen is spread over the surface of the agar in a petri dish; wherever an individual organism is deposited, a colony will develop within 24-48 hours.

Selective media

The media discussed so far are concerned primarily with the propagation of bacteria. In routine clinical laboratory work many other types of media are used which serve the dual purpose of both propagation and identification. Identification is accomplished by means of some reaction by the bacteria on the media.

By adding certain chemicals to agar media the growth of some genera or species can be inhibited while the growth of others continues.

By introducing various dyes into the media, some bacteria will absorb the dye and may be identified by their characteristic color.

Blood is a necessary enrichment for many pathogenic organisms. Some pathogens destroy the red blood cells, and clear (hemolytic) areas will appear surrounding the colony in the otherwise red agar.

Media which contain these various chemicals and dyes are called SELECTIVE or DIFFERENTIAL MEDIA.

Physiologic Reactions

Often it is impossible to identify an organism on the basis of cell or colony morphology alone. Other properties must then be investigated. The most commonly employed property is the physiologic, or the action of bacteria on various substances. For example, most organisms will utilize sugars of one type or another in their metabolism. This results in fermentation or the breakdown of the sugars into acids. "Hardening" of apple juice into vinegar is an example of microbial action on the sugar contained in the cider. Thus, by inoculating a series of broth tubes containing different types of sugar, one can determine which of the sugars the organism will or will not ferment. The reactions of most species are well known and it is a relatively simple matter to identify unknown organisms in this way.

Other physiologic reactions are of a similar nature. Some bacteria reduce nitrates to nitrites (chemically distinguishable) while others do not; indole (fecal odor) is produced by some and not by others; hydrogen sulfide (odor of rotten eggs) is generated by some species, and many other reactions take place involving the same general principle.

The types of liquid and solid media that may be used for cultivation and identification of bacteria are practically unlimited. However, in the usual clinical laboratory the methods are so standardized that most technicians commonly employ the dozen or so basic types. Most of these are produced commercially and their preparation requires only the weighing out of a dry powder, suspending it in water, sterilizing it and pouring it into suitable sterile containers.

Inoculation

Introducing bacteria, or a specimen suspected of containing bacteria, into a tube or petri dish of culture media is called inoculation. The instrument used is called an inoculating loop or needle. This is made of either platinum or nichrome wire suitable for flame sterilization, held by a bakelite holder, or melted into the end of a piece of glass tubing. Cotton swabs are often used in obtaining specimens from the body orifices, and the inoculation may be made directly with the swab. In a like manner, dental instruments may be used in taking specimens from the mouth.

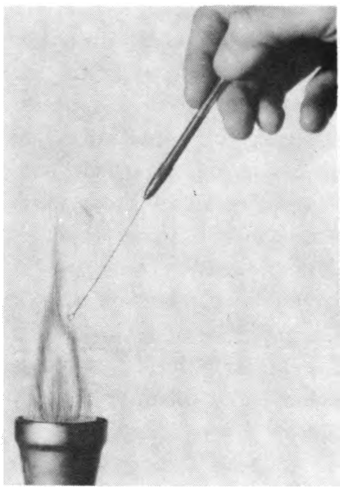


Figure 116.—Flaming the loop.

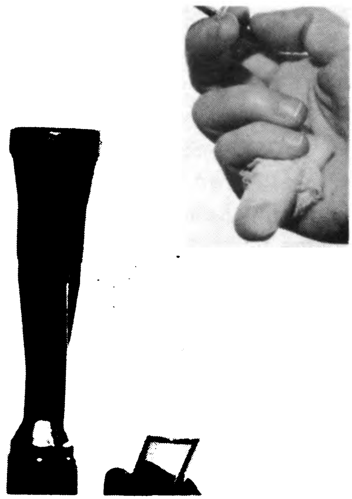


Figure 117.—Removal of plug.

To avoid contamination from the millions of bacteria in the air and dust of a room, certain precautions must be observed when inoculating culture media. When using media in tubes or flasks, the following procedure is recommended:

1. Hold inoculating instrument containing the specimen in the right hand as if it were a pencil.
2. Grasp the test tube or flask containing the media in the left hand.
3. With the little finger of the right hand, grasp the cotton plug in the tube or flask by pressing the plug against the

palm of the hand with the little finger. Pull the plug out and continue to hold with little finger and palm until inoculation is completed. If the plug is laid down, it will become contaminated.

4. Pass the open mouth of the tube or flask through the flame of a burner several times. This kills any bacteria that might be on the end of the tube and burns off cotton lint which may carry the bacteria.
5. Plunge the inoculating instrument down into the tube or flask. If the media is liquid, the needle should extend well into it. In the case of solid media, gently stroke the surface of the agar with the tip of the instrument, taking care not to break the surface of the media.

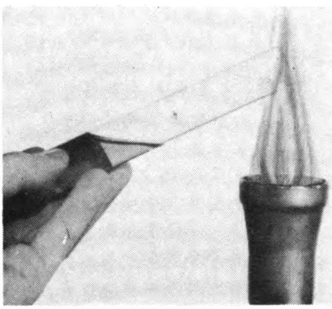


Figure 118.—Flaming the open end of test-tube.

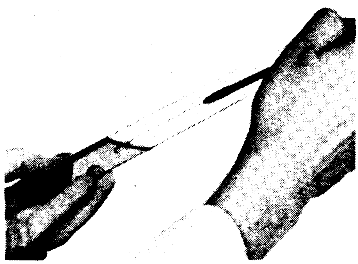


Figure 119.—Inoculating liquid media.

6. Remove the inoculating instrument.
7. Again pass the open mouth of the tube or flask through the flame several times.
8. Replace the cotton plug in the mouth of the tube or flask.

The procedure of inoculating media contained in petri dishes is called "streaking." The specimen is streaked over the surface with an inoculating loop or cotton swab. The recommended procedure is as follows:

1. Hold the inoculating instrument in the right hand.

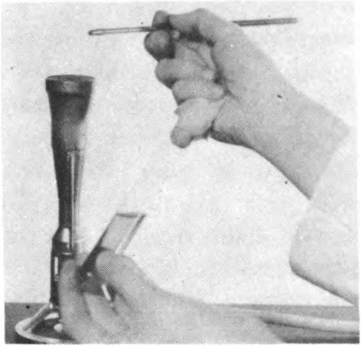


Figure 120.—Replacing the plug.

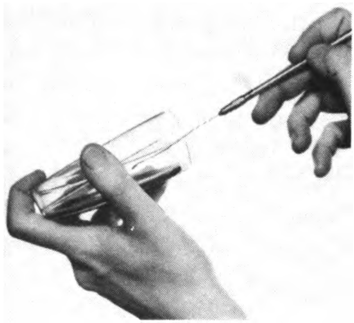


Figure 121.—Streaking the agar surface.

2. Place petri dish on a table with the media side down.
3. Grasp lid of petri dish with the left hand. Lift the lid just enough to allow the inoculating instrument to be inserted.
4. Gently streak the surface of the agar with the instrument tip. Care must be exercised or the surface will be "plowed."

   Several streaking technics are in general use. Two are diagrammed in figure 122.

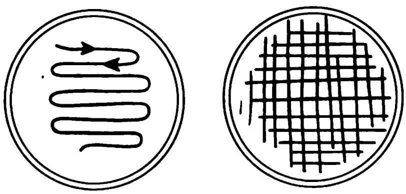


Figure 122.—Streaking technics.

The principle remains the same, no matter which technic is followed, of spreading the specimen as thinly as possible over the entire surface of the agar. The more streaks made on the surface, the more isolated will be the colonies that will develop from the individual bacterial cells.

5. Replace lid on petri dish and INVERT for incubation.

Incubation

After media has been inoculated it must be incubated in order to obtain maximum growth in the least possible time. Pathogenic organisms are accustomed to body temperature, consequently incubators are set at 37° C. (or 98° F.). Most bacteria will form recognizable colonies within 24 hours although some may require as long as 48-72 hours.

In addition to the correct incubation temperature, sufficient humidity must be maintained for maximum growth. Most incubators have either a water bottle or tray which must be kept filled.

All bacteria may be divided into two groups depending on whether they will or will not grow in the presence of oxygen. Those that will grow in the presence of oxygen (open air) are called AEROBES; those that grow only in the absence of oxygen are called ANAEROBES. The line of demarcation between the two is not sharp and there are many organisms that will grow either way; these are called FACULTATIVE ANAEROBES.

The majority of pathogenic organisms encountered in the clinical laboratory seem to grow best under a reduced amount of oxygen. This condition is produced by incubating them in a

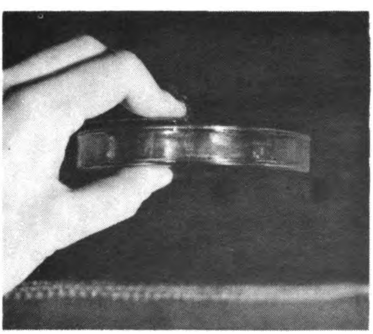


Figure 123.—Petri dish inverted for incubation.

Figure 124.—Candle jar.

"candle jar." Tubes or plates that have been inoculated are placed in a glass jar, as shown in figure 124, the candle lighted, and the top replaced. The flame exhausts the oxygen of the air in the jar, producing the desired state of reduced oxygen tension. The glass jar is then placed in the incubator.

Staining

As pointed out earlier in the section on morphology, many bacteria can be classified into their genera by examining the individual cells under the microscope. Thus, cocci occurring in chains are STREPTOCOCCI, and cocci in clusters are STAPHYLOCOCCI. It is possible to make a microscopic examination by placing a bit of culture or specimen in a drop of water on a glass slide. Such a preparation is called a "wet mount" or a "hanging drop." However, better results are obtained if the bacteria are stained with a dye, since they will be outlined more distinctly, and can be brought into focus more easily. In addition, bacteria react to various stains in different ways which is of great value in identification. Like cultivation methods, staining technics are practically unlimited. However, only three or four technics are used routinely. Directions for three commonly used stains follow. Composition of the various solutions used in these stains may be found in any laboratory manual on bacteriology.

Simple stain

1. Thoroughly clean a glass slide with soap and water, then dip in alcohol or acetone to dissolve any remaining grease, and wipe dry.
2. Pass slide through the flame of a burner or lamp several times.
3. Place a drop of saline (0.9% salt solution) on the slide.
4. Place the specimen or culture to be examined in the drop of saline, mix thoroughly and spread thinly.
5. Allow the slide to dry in the air. Heating to hasten drying is apt to distort the bacterial cells.
6. Pass the slide, with the smeared side up, through a flame several times to "fix" the smear onto the surface of the slide. Do not overheat slide or cells will become distorted.

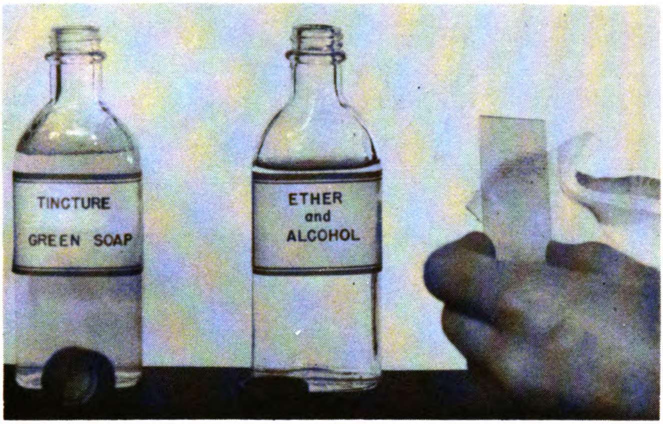


Figure 125.—Cleaning glass slide.

Figure 126.—Flaming the slide.

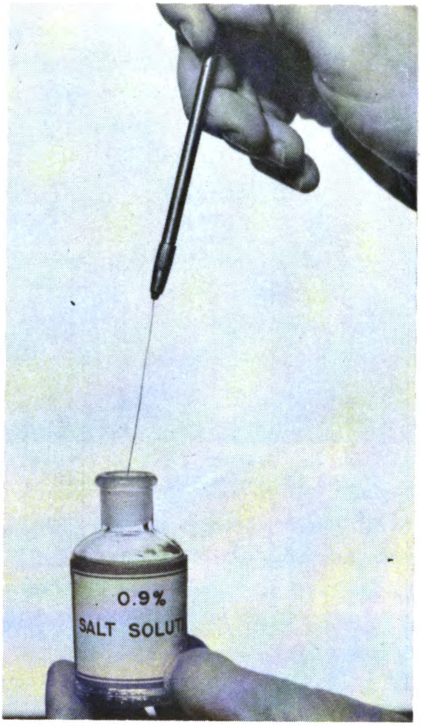


Figure 127.—Flamed loop being dipped into saline solution.

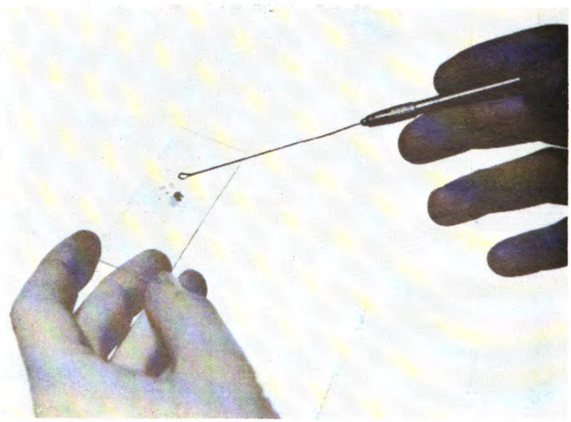


Figure 128.—Specimen being placed into drop of saline.

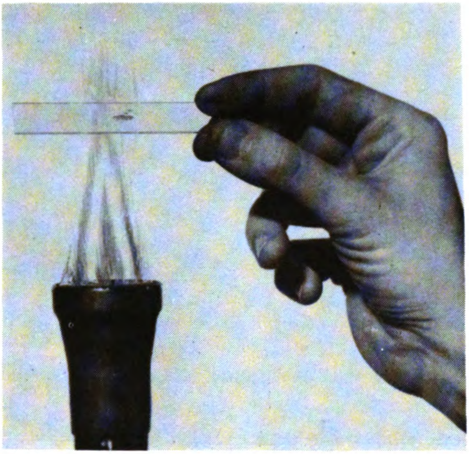


Figure 129.—Fixing the specimen on the slide.

7. Cover the fixed smear with one of the simple stains, such as methylene blue, basic fuchsin or safranine. Allow to stand for 2 minutes.
8. Wash the stain off with tap water.
9. Allow the stained slide to dry in air or blot dry.

Figure 130.—Staining slide for two minutes.

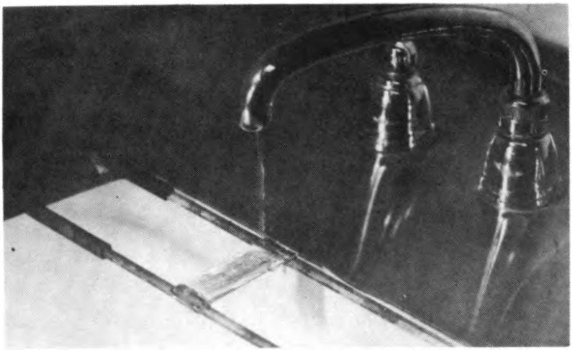


Figure 131.—Washing off excess stain.

The stained smear is now ready for examination. Simple smears are of value when only the morphology of the cells is to be determined.

Simple stains are used most often when working with known cultures or specimens, and no differentiation between genera or species is required. They are also useful for determining the sterility of solutions, when only the presence or absence of bacteria must be demonstrated.

With unknown specimens, however, additional information can be gained by using more complex methods of staining.

Gram stain

The most commonly used staining technic in bacteriology is the Gram stain. Much of the classification of bacteria is based on the reaction to this stain by micro-organisms.

The underlying principle is that some genera of bacteria will withstand decolorizing agents, such as alcohol and acetone, while other genera will not. This principle is easily demonstrated by first applying a purple stain, then decolorizing, and finally applying a red stain (counterstain). Those organisms that withstand the decolorizing will retain their purple color and are called gram-POSITIVE. Organisms that do not withstand decolorization will lose the purple dye when the alcohol is applied and will take on the red color of the counterstain when it is applied. They are called gram-NEGATIVE. Figure 132 illustrates both types.

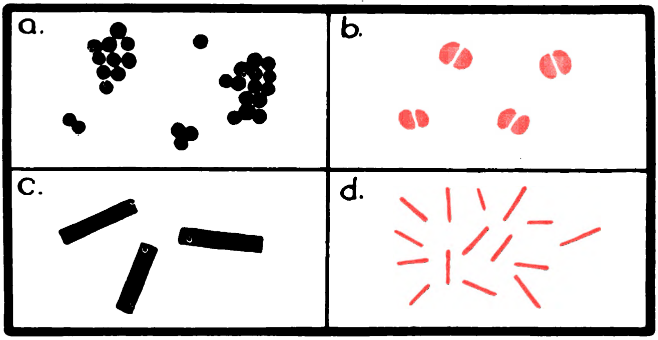


Figure 132. Gram-positive and gram-negative bacteria.

a. Gram-positive, Staphylococci.
b. Gram-negative, Diplococci.
c. Gram-positive, Bacilli.
d. Gram-negative, Bacilli.

It follows that all bacteria may be divided into two groups, gram-positive and gram-negative. This reaction is of inestimable value, since many organisms that are morphologically identical or similar are placed in different genera by their Gram reaction. The causative organisms of pneumonia and gonorrhea are both diplococci, but the former is gram-positive and the latter, gram-negative; consequently one belongs to the genus DIPLOCOCCUS and the other to the genus NEISSERIA.

A partial list of the Gram reactions of some of the common bacterial genera follows:

Gram-positive cocci	*Gram-negative cocci*
Staphylococcus	Neisseria
Streptococcus	
Diplococcus	
Micrococcus	
Sarcina	

Gram-positive bacilli	*Gram-negative bacilli*
Bacillus	Bacterium
Clostridium	Escherichia
Corynebacterium	Shigella
Listerella	Brucella
	Pasteurella

The technic for performing the Gram stain is as follows:

1. Prepare a smear as described for the simple stain, steps 1 through 6.
2. Flood the slide with crystal violet solution for 1 minute.

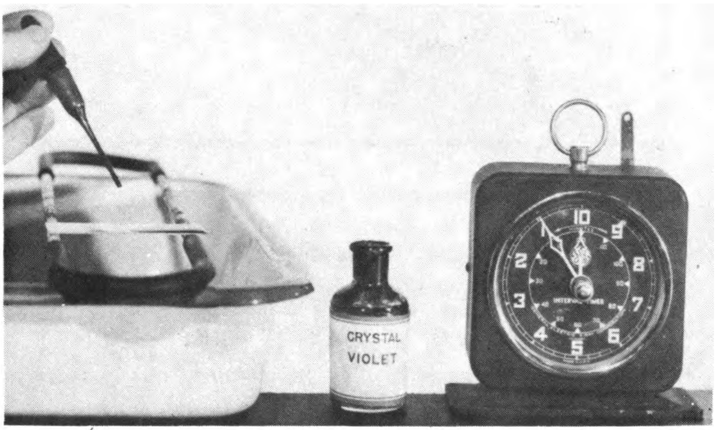


Figure 133.—Flooding slide with crystal violet for one minute.

3. Wash with water.
4. Cover the slide with Gram's iodine solution for 1 minute.

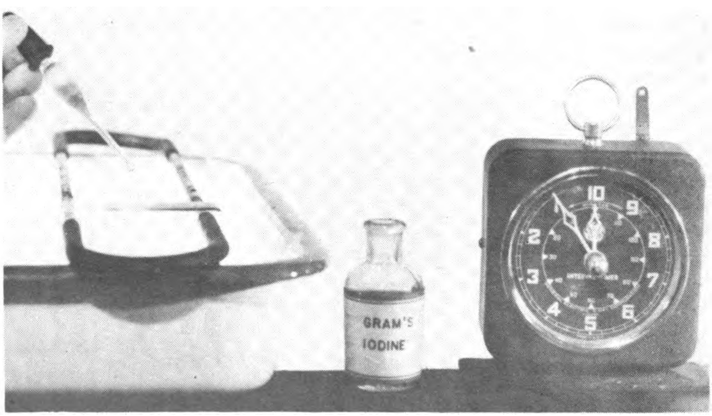


Figure 134.—Flooding slide with Gram's iodine for one minute.

5. Wash with water.
6. Decolorize by dropping alcohol or acetone-alcohol on the slide, holding the slide at an angle so that the alcohol will run off—NOT MORE THAN 20—30 SECONDS.

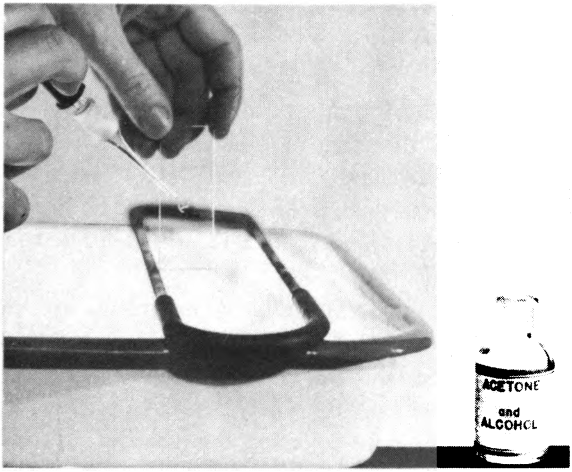


Figure 135.—Decolorizing with acetone-alcohol.

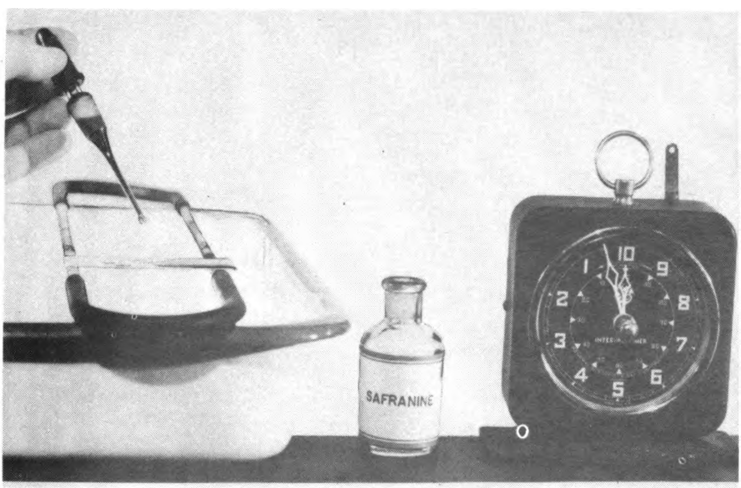


Figure 136.—Flooding slide with safranine for thirty seconds.

955512 O—52——18

7. Wash with water.
8. Flood the slide with safranine for 30 seconds.
9. Wash with water.
10. Allow to dry in air or blot dry.

The stained slide is now ready for microscopic examination. Gram stains may be kept almost indefinitely for reference purposes.

Acid-fast stain

Another differential staining technic, used routinely in clinical laboratories for the detection of tubercle bacilli, is the acid-fast stain or Ziehl-Neelsen stain. The principle involved in this stain is somewhat similar to that in the Gram stain. The tubercle bacillus is resistant to decolorization by acid, while all other organisms are not.

Since MYCOBACTERIUM TUBERCULOSIS organisms are most commonly found in the respiratory tract, sputum is the usual specimen submitted to the laboratory. Urine samples and gastric washings are also common. Routinely these specimens must be concentrated in order to enhance the chances of finding the organisms. The technic for concentration may be found in any laboratory manual or textbook on chemistry. Once the concentrate is made, smears are prepared as described for the simple stain. An acid-fast stain may be made from any unconcentrated specimen, but the possibility of finding "acid-fast" organisms is lessened. The technic is as follows:

1. Cover the fixed smear with carbolfuchsin and steam gently over a flame for 5 minutes. The simplest method for doing this is to place the slide on one side of a tripod and the burner on the other side. The heat can be regulated by the distance the burner is from the slide. The stain must be constantly renewed to make up for that lost by evaporation.
2. Wash with water.
3. Decolorize with acid alcohol until the color stops running. This usually requires about 5 minutes.
4. Counterstain with methylene blue for 1 minute.
5. Wash with water.
6. Allow to dry in air.

Since the Mycobacteria are resistant to decolorization, they will appear red against a blue background. They are called "acid-fast."

Collection and Treatment of Specimens

There are four phases involved in the detection and identification of pathogenic organisms: (1) Direct smear, (2) culture, (3) animal inoculation, and (4) immunologic methods.

In oral bacteriology the first two are used much more frequently than the latter two. Much the same technic is used for obtaining material for smears and cultures. It is essential that sterile conditions be maintained in both cases to prevent contamination by other organisms of the smears and cultures, and also of the patient's mouth.

Specimens are obtained by using either cotton swabs or inoculating loops. Swabs are sterilized in screw-capped jars, or wrapped individually in paper and sterilized. The platinum inoculating loop is sterilized by holding it in a flame until it is cherry red.

The technic for inoculating media and making smears, once

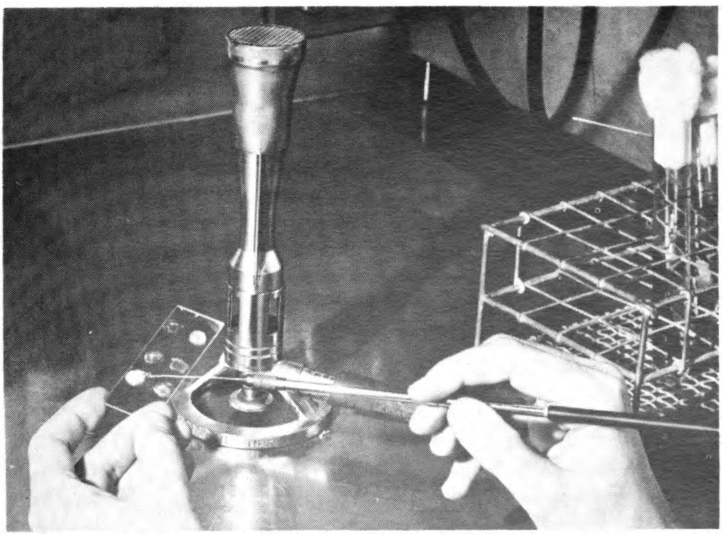


Figure 137.—Arrangement of smears.

the specimen has been obtained, has already been described. No time should be lost, since the specimen will dry out and will become contaminated.

Correct labeling is imperative. Gummed labels are much more satisfactory than wax pencils where the volume of work is not too large. Information on the label should include the patient's name, type of specimen, kind of media or type of stain, and the date.

It is routine practice in oral bacteriology to take smears from six areas: (1) The most irritated area of the right maxillary posterior gingivae, (2) a similar anterior maxillary area, (3) a similar left posterior area, and (4), (5) and (6) from corresponding areas of the mandible. All six may be placed on the same slide as in figure 137. The smears are arranged on the surface of the slide from left to right, with the maxillary smears above and the mandibular smears below. If specimens from all the areas are taken at once, 6 drops of saline may be put on the slide at the same time.

The smear should be fixed as soon as the six spots have dried. It is not necessary to stain immediately.

A common error made by inexperienced technicians is to pick up too much material from the gingivae. The resulting smears are much too thick for a satisfactory microscopic examination.

Stained smears that are to be saved for a permanent slide collection are protected by a coverglass. To "mount" a coverglass on a slide, a drop of Canada balsam is placed on the area to be covered. The coverglass (also called coverslip) is held between thumb and forefinger and is brought into contact with the drop of mounting fluid at a 45° angle. It is released gradually to allow the air bubbles caught under the coverslip to escape. The cover may be pressed into position with the eraser end of a pencil. Excess mounting fluid should be wiped off with lens tissue. Usually, two coverglasses are required to cover the six routine smears mentioned previously.

Use of the Microscope

Before using this delicate and expensive piece of equipment, the technician should be thoroughly familiar with one of the

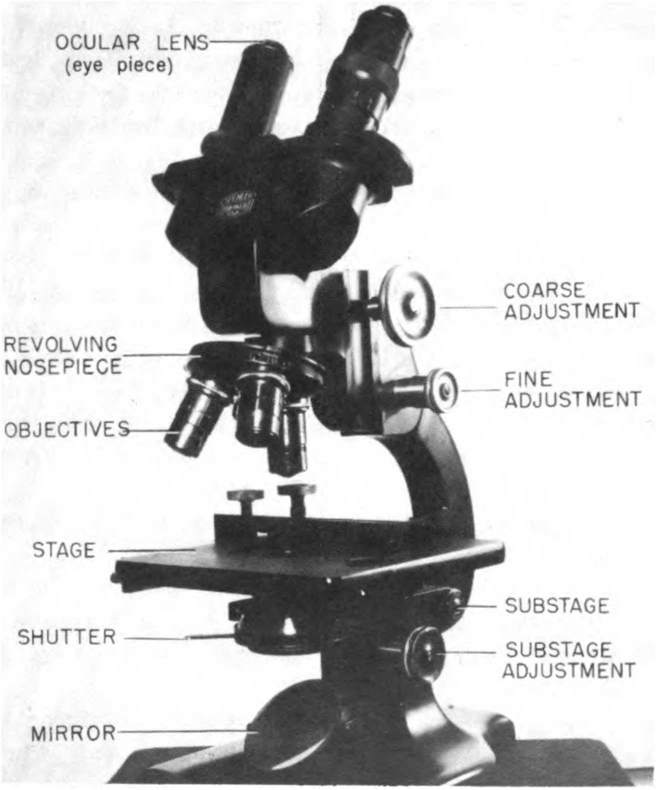


Figure 138.—Binocular microscope.

manuals supplied by the manufacturers on the care and use of the microscope.

The lenses are in the oculars (eyepieces) and in the objectives, consequently these parts must be handled with the greatest care. Two oculars are usually included with each microscope, one with a magnification of 6 X and the other 10 X. They are labeled accordingly.

There are three objectives mounted on the turret, or revolving nosepiece. These may be recognized by their markings or their appearance. (1) The shortest of the three is the "low power" objective, which will be marked "16mm." (2) The plain, long objective is the "high power" or "high dry." It will be marked "4mm." (3) The long objective with a black or a scored brass ring around it is the "oil immersion" objective. It will bear the marking "1.8mm" and is the objective used in the examination of bacteria, since the other objectives do not give sufficient magnification.

Use of a microscope requires instruction and practice. It is advisable to start with the low power lens and an easily seen object, such as a wax pencil mark on a glass slide.

Steps to be followed in focusing a microscope are as follows:

1. Place the slide to be examined on the stage. There are two devices used to hold slides in place, spring clips and a "mechanical stage." If the former is used, the slide is placed under the clips, and if the latter is used, the slide is placed within the jaws. Make sure that the part of the slide to be examined is over the hole in the stage.
2. Revolve the nosepiece until the low power objective is pointing down toward the hole in the stage.
3. Run the substage condenser up until the lens of the condenser almost touches the under side of the slide. The knob controlling the substage condenser is located under the stage.
4. Look into the ocular, and using the coarse adjustment knob, run the body tube up and down until you get the field in focus. This operation must be done carefully because running the objective into the slide will break it and perhaps scratch or break the lens of the objective.
5. The amount of light can be controlled by the mirror. If the field is too bright or too dark, vary the amount of light by adjusting the mirror toward the light source (microscope lamp, open window, light bulb).
6. To get the clearest field possible, use the fine adjustment knob.

Once the technic of focusing has been mastered, switch to the "high dry" objective and practice with it.

To use the "oil immersion" objective, a drop of immersion, or cedarwood oil is placed on the slide over the part to be examined. The body tube is run down by turning the coarse adjustment knob until the oil immersion objective lens makes contact with the drop of oil. Extreme care must be exercised in focusing, since the objective is very close to the slide.

To prevent the oil from drying on the lens, the objective should be wiped off with lens tissue each time it has been used. A towel or hem of a gown should not be used to wipe microscope lenses for these are likely to scratch the glass.

Normal Flora of the Mouth

In making bacteriologic studies of the oral cavity it must be remembered that in the mouth, as well as in many other parts of the body, large numbers of bacteria are living without causing any apparent harm to the host. These bacteria, of many different species, are called the normal flora. For an area or a part of the body to have a normal flora, it must have an opening to the outside. Thus, the skin, mouth, nasal passages, lower intestine and other regions all have groups of organisms that are commonly present.

In addition to the normal flora of the mouth, there will often be transitory organisms that have been inhaled or ingested. These bacteria usually disappear within a short period of time. The presence of pathogenic organisms is not always indicative of disease, since many of them require specific conditions, such as a break in the skin or mucous membrane, before they exert harmful effects. Conversely, the fact that an organism is part of the normal flora does not mean that the organism will never be pathogenic. Under certain conditions most organisms can become harmful to the body on which they are living.

The normal flora of the mouth includes a large number of different genera and species. Were it not for the washing action of the saliva there would be tremendous numbers of bacteria present in the mouth at all times. Saliva exerts a mild bactericidal action on some species, but mechanical washing is much more effective in ridding the mouth of organisms. Once swallowed, most bacteria are killed by the acids of the stomach. However, there are so many crevices, folds, and areas of lodged food particles that the normal flora has little difficulty in surviving the action of saliva.

Organisms which may be seen in microscopic examination of mouth specimens are discussed in the following paragraphs.

Staphylococci

Both STAPHYLOCOCCUS ALBUS and STAPHYLOCOCCUS AUREUS may be isolated from the mouth. These organisms rapidly become pathogenic if they are able to penetrate the mucous membranes through cuts or traumatic injury. They are known as PYOGENIC organisms because pus is formed wherever they gain a foothold.

Staphylococcus aureus

MORPHOLOGY: 0.8 to 1.0 microns in diameter. Occur singly, in pairs, short chains and irregular clumps. Nonmotile. Gram-positive.

CULTURAL: Abundant growth on nutrient agar. Colonies are opaque, smooth, flat, moist and yellowish.

PATHOGENESIS: Found on the mucous membrane and skin. The cause of boils, abscesses, furuncles and suppuration in wounds. Certain strains produce toxins which are a significant cause of food poisoning.

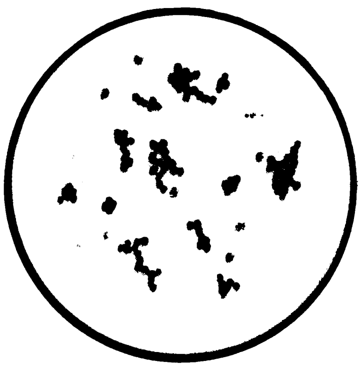


Figure 139. Staphylococci.

Streptococci

STREPTOCOCCUS VIRIDANS is almost always present. This is a pyogenic organism and acts much like the staphylococci. Other species of streptococci may be found in the mouth from time to time.

Streptococcus

MORPHOLOGY: Most species are 0.5 by 1.0 micron in diameter. The cells are oval, occur in pairs, and in short or long chains. They are gram-positive.

CULTURAL: Streptococci are usually grouped according to their effect on blood agar. The pinpoint colonies may be surrounded by clear areas (hemolytic group), by a green area (viridans group), or the media may not be affected (nonhemolytic group). Streptococci may be found growing either in the presence or absence of oxygen. They are usually found where organic matter containing sugar has accumulated.

PATHOGENESIS: Many species are harmless. Some of the diseases associated with the presence of Streptococci are tooth abscesses, sore throat, tonsilitis, blood stream infections, scarlet fever and rheumatic fever. Streptococci are also thought by some investigators to be a causative agent in dental caries.

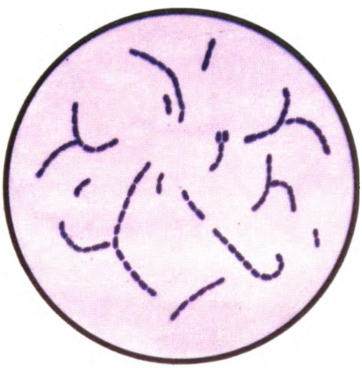


Figure 140. Streptococci.

Pneumococci

Many different types of Pneumococci are present, especially during those months when respiratory infections are most common.

Pneumococcus

MORPHOLOGY: Oval-shaped cocci arranged in pairs; each pair may be enclosed in a capsule. Gram-positive.

CULTURAL: Ordinary laboratory media.

PATHOGENESIS: Causative agent of lobar pneumonia; occasionally causes middle ear, pericardial and meningeal infections.

Micrococci and Sarcina

Other gram-positive cocci, such as Micrococci and Sarcina, are usually transitory in their appearance.

Sarcina lutea

MORPHOLOGY: Spheres, usually grouped in packets. Size, 1.0 to 1.5 microns. Easily stained. Gram-positive.

CULTURAL: Grows well on ordinary laboratory media.

PATHOGENESIS: Rarely pathogenic.

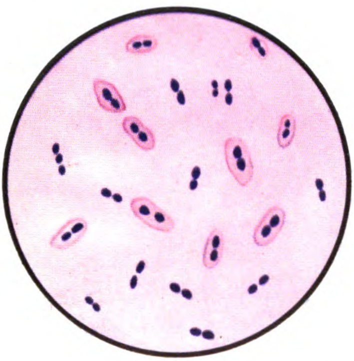


Figure 141. Pneumococci.

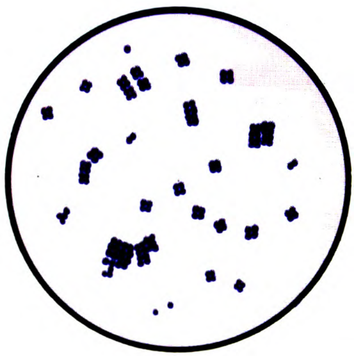


Figure 142. Micrococci.

Neisseria

Gram-negative cocci may be found in profusion. Neisseria catarrhalis, Neisseria flava and Neisseria sicca are the nonpathogenic members of this group.

Neisseria catarrhalis

MORPHOLOGY: Oval in shape. 0.6 to 0.8 micron in diameter.

Occur singly or in pairs with adjacent sides flattened. Gram-negative.

CULTURAL: Colonies are small, circular and grayish white when grown on agar. Grows in the presence of oxygen.

PATHOGENESIS: Found in the oral cavity. Often associated with other organisms in inflammations of the mucous membrane.

Diphtheroids

Members of the genus Corynebacterium, called Diphtheroids because they resemble the diphtheria bacillus, are always present and will increase tremendously in numbers when respiratory infections are prevalent.

Corynebacterium diphtheriae

MORPHOLOGY: Rods measuring 0.3 to 0.8 micron. Rods are straight or curved. Do not stain evenly. Show granules. Nonmotile. Gram-positive.

CULTURAL: Requires special media (tellurite) for growth. Three types may be distinguished: gravis, mitis and intermedius.

PATHOGENESIS: Causes diphtheria, may be found in the oral cavity and throat membranes of diseased patients. Found in seemingly healthy mouths of carriers of the disease.

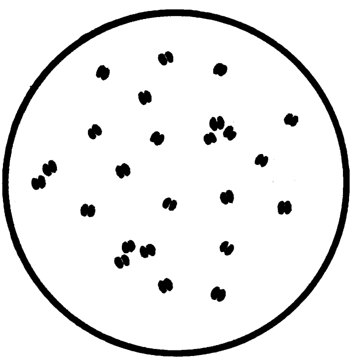


Figure 143. Neisseria.

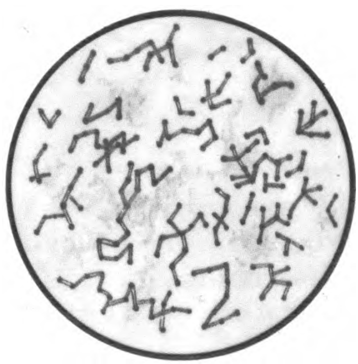


Figure 144. Diphtheroids.

Bacilli

Large gram-positive rods are often found in very dirty mouths.

Proteus and aerobacter aerogenes

Of the gram-negative rods, Proteus and Aerobacter aerogenes are the ones most commonly found in the mouth.

Proteus vulgaris (B. proteus)

MORPHOLOGY: Thin, small bacilli; occur singly and in pairs or chains.

CULTURAL: Ordinary laboratory media.

PATHOGENESIS: Generally nonpathogenic; "X" strain used in Weil-Felix reaction (for diagnosis of Typhus fever).

Figure 145. Bacilli.

Figure 146. Proteus.

Aerobacter aerogenes

MORPHOLOGY: Short, plump rods. Gram-negative.

CULTURAL: Grows well on most media that will support growth of ESCHERICHIA COLI.

PATHOGENESIS: Generally nonpathogenic

Fusiform bacilli

Fusiform (spindle-shaped) bacilli can be isolated from most mouths, especially along the gum lines and between the teeth.

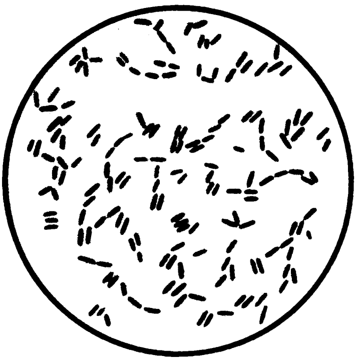


Figure 147. Aerogenes.

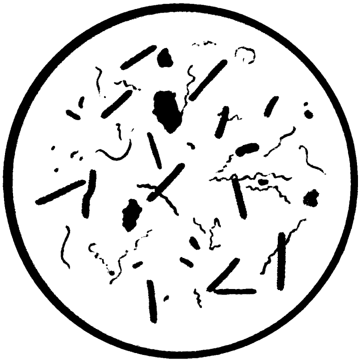


Figure 148. Fusiform bacilli and Borrelia vincentii.

Bacillus fusiformis

MORPHOLOGY: A cigar-shaped rod 10 to 14 microns in length by 0.75 micron in diameter. Usually slightly curved; occurs in pairs. Does not form spores. Stains easily with the usual dyes. Gram-negative.

CULTURAL: Grows in the absence of oxygen. Best media is ascitic fluid or blood serum.

PATHOGENESIS: Whether the organism actually causes disease has not been fully determined. Always found with BORRELIA VINCENTII in Vincent's infection.

Borrelia vincentii, Treponema microdentium

A variety of spiral forms may be found in dirty mouths in the areas between the teeth and along the gingival margins. See figure 148.

Smear from Vincent's infection

In conjunction with his clinical observations, the dental officer often will make a smear from the grayish lesions of the disease which are present along the gingival margins. Smears are made in routine fashion and may be stained either by Gram's method or with a simple stain. The latter will usually suffice since the morphology of the organisms is distinctive. Both Borrelia vincentii and fusiform organisms must be present for the smear to be called positive.

Smear from root canal culture

The sterile points which have been placed in the root canal are withdrawn and dropped into a test tube containing a suitable media such as beef infusion broth, thioglycolate, or glucose ascites. The technician will place the test tube in the incubator and leave it preferably for 72 hours. At the end of this period, the test tube is removed and observed for any turbidity or sedimentation. If there is any question as to the absence or presence of turbidity, a smear is made and the Gram stain is used. Often, to confirm whether there are staphylococci or streptococci, the technician will streak a plate of blood agar or nutrient agar.

Borrelia vincentii

MORPHOLOGY: 8 to 12 microns in length by 0.3 micron in diameter. Has 3 to 8 spirals. Stains easily with the usual dyes. Motile. Gram-negative.

CULTURAL: Grows in the absence of oxygen.

PATHOGENESIS: Always found with Bacillus fusiformis in Vincent's infection.

Lactobacillus

MORPHOLOGY: Rods. Variable in size, usually long and slender. Nonmotile. Gram-positive.

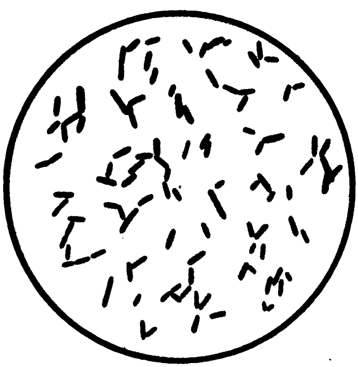


Figure 149. Lactobacillus.

CULTURAL: Poor surface growth. Appear as pinpoint colonies. Require small amounts of oxygen, or are anaerobic. Tomato juice agar is usually used for growth.

PATHOGENESIS: Believed to be associated with the production of dental caries. Lactobacillus colony counts of the saliva are used to determine the dental caries activity present in the oral cavity. Many different species can be cultured from the oral cavity.

Actinomyces israeli

MORPHOLOGY: Threads 0.5 micron in diameter, but may be any length. Angular branching and club-shaped forms may be seen. Nonmotile. Gram-positive.

CULTURAL: Old colonies are warty in appearance. Very difficult to remove from media. Cultivation is not difficult on ordinary agar.

PATHOGENESIS: Causes actinomycosis in humans. Strains can be isolated from periodontal pockets, pulps and root canals. Some species are thought to be associated with tooth decay.

Figure 150. Actinomyces.

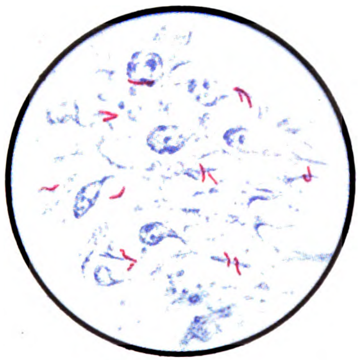


Figure 151. Mycobacterium.

Mycobacterium tuberculosis

MORPHOLOGY: Rods ranging in size from 0.3 to 0.6 by 0.5 to 4.0 microns. Straight or slightly curved. Occur singly or in occasional threads. Stain evenly or may show beaded forms. Nonmotile. Gram-positive.

CULTURAL: Growth requires several weeks and a special media is needed.

PATHOGENESIS: The cause of tuberculosis in humans. The bacilli can usually be found in the sputum of patients with active tuberculosis of the lung.

Treponema pallidum

MORPHOLOGY: Very fine spirals. Varies in size from 0.25 to 0.3 by 6 to 14 microns. Special stains are necessary. Microscope with dark field illumination is used to view the organism in the living state.

CULTURAL: Grown with difficulty Requires the absence of oxygen. Media containing ascitic fluid with the addition of fresh kidney is used to grow the organism.

PATHOGENESIS: The cause of syphilis in man.

Figure 152. Treponema.

Figure 153. Monilia.

Candida albicans (Monilia albicans)

MORPHOLOGY: Oval, budding yeastlike fungus.

CULTURAL: Common laboratory media, both at room temperature and at 37° C. On Sabouraud's glucose agar at room temperature, the colonies are cream colored, and have a distinct yeastlike odor.

PATHOGENESIS: Believed to be the causative factor in infections of the mucous membranes of the mouth (thrush).

Bacteriology of Dental Caries

There is considerable controversy over the role of bacteria in dental caries. It is almost impossible to discuss it from a single aspect, since so many other factors such as diet, systemic conditions and heredity cannot be ignored. It is an established fact, however, that certain bacteria, especially Lactobacilli, are usually in evidence when dental caries is present. Typical caries has not been reproduced experimentally by Lactobacilli, but the deductions reached from experimental work are suggestive. Many experiments have shown a close association between the numbers of Lactobacilli present and the degree of carious involvement. This is the basis of the "Caries Activity Test."

In dental caries, the role of micro-organisms seems to be that of breaking down various compounds to form acids. It is noted that areas under attack are protected from the cleansing action of chewing or of hygienic measures and include the bottoms of sulci, pits and interproximal surfaces. The attack is accomplished by the formation of a *plaque* on the enamel surface of the tooth. Plaques are thin, adherent, gelatin-like layers made up of several different species of bacteria. Among these are Leptotrichia, Actinomyces, Lactobacillus, Streptococcus and incidental organisms from the normal flora. The exact role of these various forms has not been agreed upon, up to this point, by investigators. However, it is known that most strains of Lactobacilli recovered from carious areas are usually very actively acidogenic. The presence of the other forms would indicate that they also play some form of secondary role.

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CHAPTER 7

ORAL PATHOLOGY

Oral Pathology is that science which treats of the essential nature of oral disease, both clinical and microscopic, with special reference to functional and structural changes caused by oral and other diseases.

This chapter will explain some of the problems in diagnosis and treatment that confront the dental officer. The dental technician, on occasion, might be the first one to observe these pathologic conditions in the patient's mouth. A few of the conditions to be described could become evident after the dental officer's examination of the patient, but before the appointment date set for an oral prophylaxis. In such a case the dental officer should be notified immediately, before the patient receives treatment.

Anomalies

Although there are many oral anomalies (deviations from normal), this chapter will be limited to those which are of prime interest to dental technicians.

DEVELOPMENTAL anomalies are those which occur during the formative period of the body. They are of two classes: CONGENITAL anomalies which occur before birth and ACQUIRED anomalies which occur after birth.

Dental Caries

Modern scientists differ in their concepts of the cause of dental caries. There are two main groups who describe the causes of caries as ACIDOGENIC and PROTEOLYTIC.

The acidogenic theory

The older, acidogenic school of thought explains that caries is the result of bacteria causing carbohydrates (principally sugars) to ferment and to form lactic acid which dissolves the lime salts or inorganic material of the enamel and dentin. Soon other bacteria and their products dissolve the remaining organic material.

The proteolytic theory

This school of thought holds that the organic pathways in the enamel (along the lamellae and the pseudolamellae), chiefly in the form of microscopic defects, provide passageway for the causative factors of caries to enter the dentin. In order to prevent this entrance, metallic salts are often employed to construct "blocks" or "plugs" from the organic material in the enamel.

Enamel cuticle

The enamel cuticle varies in appearance in teeth of the same patient. It appears deeply stained in carious teeth with large masses of bacteria clumped on it in the first phase of dental caries. This clumped bacterial mass is called the BACTERIAL PLAQUE, and supposedly it gives rise to acid concentrations which destroy the enamel. Caries of the enamel does not begin under all of these plaques. In fact, cuticle is very resistant to acids. Caries may not develop if the substance of the cuticle is well hornified and can act as a barrier.

The presence of enamel cuticle is not required for the formation of bacterial plaques. When the cuticle is absent, such plaques form directly on the surface of the enamel, and acid may be produced beneath them. Caries production depends upon the amount of acid present and the length of time it is in contact with tooth surface.

Enamel and dentin

The appearance of carious enamel and dentin depends upon how rapidly the carious process proceeds, and upon certain other factors. One is the presence of crevices between the enamel lamellae (organic pathways) which might provide an entry for bacterial products.

After caries has begun in the enamel, it may stop and become what some writers call "chronic caries." This is seen often in proximal surfaces in contact with carious tooth surfaces. The areas in which the caries has been arrested are dark colored, hard, and, in some cases, hollowed out. If the process does not stop, the enamel becomes chalky in appearance and can be scraped away. Such areas are called white spots and are areas of decalcification—a process which usually immediately precedes caries.

In caries of the dentin, a leathery mass — or sometimes a cheesy mass — is formed as a result of decalcification. This substance is easily removed with one of the spoon excavators. Often, secondary dentin formation takes place and the deeper zone of the involved area is hardened and usually dark.

Not all teeth decay. Enamel cuticle variations are thought to be partially responsible for immunity to dental caries. Recent work on fluorine content of water indicates that the fluorine acts as a favorable factor in the lessening of the incidence of dental caries. Recent U. S. Public Health Service studies report that fluorine in small amounts, deposited in enamel and dentin during development, is responsible for the lessening of the initial dental caries. This is due to the fact that enamel, which contains slightly more than the average amount of fluorine, seems to inhibit the formation of acid on its surface.

Dental caries according to its progress, falls into one of two classes: pit and fissure caries and smooth surface caries.

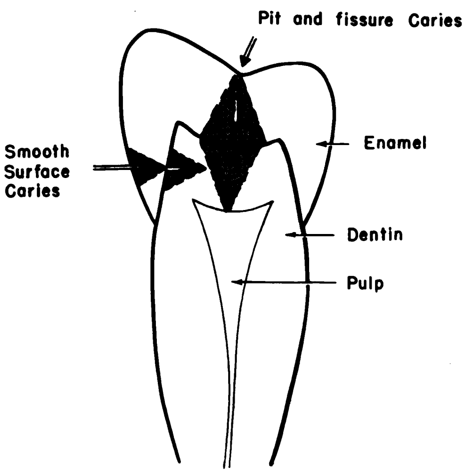

Figure 154.—Progress of caries. (Diagrammatic.)

In PIT and FISSURE caries, the apex of a triangular area of carious tooth structure is at the surface of the tooth, and the base is at the junction of the enamel and the dentin. The acid which initiates caries forms in the pits and fissures or in the enamel lamellae and penetrates to the junction of the enamel and the dentin, where it spreads laterally. This is possible because of the presence of less calcified material in the interglobular spaces, enamel spindles and enamel tufts. At this point, the form of the carious area changes; the base of a second triangle is located at the dentino-enamel junction with its apex pointed toward the pulp.

In SMOOTH SURFACE caries the triangle in the enamel has its base at the surface with the apex toward the dentino-enamel junction. It is presumed that the enamel has taken this form because the concentration of acid is greatest under the center of the bacterial plaque which initiates the caries. When this carious process reaches the dentino-enamel junction, it spreads laterally for the same structural reasons that it does in pit and fissure caries. Within the dentin the progress is the same — that is, the apex of the triangle is pointed toward the pulp, and the base remains at the dentino-enamel junction. In both of these types of caries there is an undermining or backward decay which spreads along the dentino-enamel junction, and weakens the enamel rods to such an extent that biting on very soft food could break down the crown of the tooth.

Dental caries is more rapid in dentin than in enamel, because the dentin contains a larger proportion of organic substance. As soon as bacteria enter the dentinal tubules, they begin to decay the dentin matrix; hollowed-out areas appear on the walls of the tubules and form the so-called areas of LIQUEFACTION FOCI. These foci become larger until they meet the walls of other foci; their union forms a larger mass of softened dentin called a COLLIQUATION FOCUS. It is in this manner that a leathery or cheesy mass of dentin is produced.

Pulp reaction to dental caries

The pulp tends to resist all types of irritation and does so by exhibiting certain inflammatory reactions to these stimuli.

In the first stage of resistance, the pulp cells become swollen and there is a greater collection of fluids in the area of greatest injury. With the increasing severity of caries of the dentin, a mild hyperemia (excess of blood) is present. White blood cells enter the area of injury in an attempt to wall off the irritant. Before any bacteria enter the pulp from the decayed dentin, their products may precede them and induce changes in the pulp such as edema (swelling), hyperemia and other mild inflammatory conditions.

Since the pulp is contained in hard, unyielding walls, swelling induced by inflammation results in pressure which may cause self strangulation and death of the pulp. The cells degenerate when the pulp dies. The first cells to degenerate are the odontoblasts which are located at the outer layer of the pulp and serve

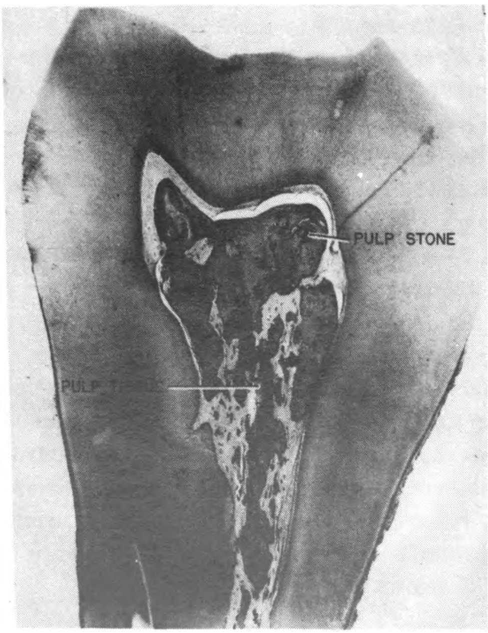

Figure 155.—Photomicrograph of cross-section of tooth, demonstrating pulp stones.

to produce secondary dentin. Then the connective tissue cells die and cease to form fibers. Next, the walls of the blood vessels stop functioning and finally the nerve tissue dies.

The type of reaction that the pulp undergoes will depend upon the severity of the injury and the resistance of the tissues. If the virulence of the attacking bacteria is great and the patient's resistance is low, the pulp quickly becomes inflamed. In as short a space as 24 hours the pulp may become hopelessly involved and die. On the other hand, if the type of injury is very mild and the resistance of the patient is high, irregular dentin formation or calcification of the dentinal tubuli may take place. Pulp stones (round or irregular calcified bodies) may be formed within the pulp. Their presence, however, does not necessarily indicate response to pulpal stimulation.

If irritation of this type keeps up over a period of time, degeneration of the pulp takes place until FIBROSIS occurs — in which the entire pulp seems to turn into a fibrous, strawlike mass.

A degenerative process may take place in the pulp without caries. As persons grow older, the apices of the teeth grow smaller; this change reduces the flow of nutritive material via the blood vessels into the pulp. In older people the pulp can become so FIBROTIC that there is a loss of sensation where no infection may be present.

In ACUTE PULPITIS (acute inflammatory involvement of the pulp), white cells, which take part in inflammatory processes wherever blood circulates in the body, attempt to clear the injured area. The bacteria and their products increase in the pulp cavity and the white cells become more numerous. Phagocytosis may also take place outside the apical foramen and there exhibit new inflammatory processes in the periapical tissues. This usually is the beginning of abscess formation unless successful healing and repair take place.

The patient may or may not experience pain in early abscess formation; the amount of damage which has been done and the severity of the condition influence the feeling of pain. If the virulence of the bacteria is low and the patient has a low grade body reaction, a chronic periapical lesion — a root end abscess — may develop. If the infection is highly virulent, with severe pain, it

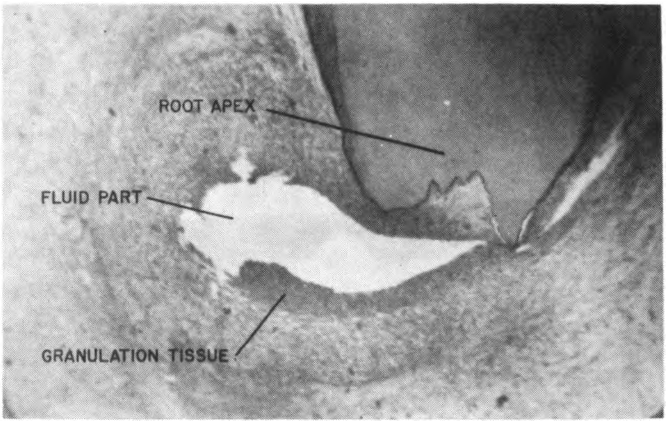

Figure 156.—Periapical abscess.

may be necessary to drain the abscess by opening into the pulp chamber thereby easing the pain, or to extract the tooth and eliminate the abscess. Between two extremes there are many combinations of cellular reactions. But, unless the infected areas are removed, they may act as foci of infection, causing constitutional reaction and symptoms elsewhere in the body.

Periodontal Disease

The oral cavity is lined with mucous membrane, part of which is attached to the alveolar process and comprises the gingivae and that portion of the gingivae which is attached to the cementum of the root — the EPITHELIAL ATTACHMENT. The normal appearance of the gingivae is somewhat stippled with a uniform pink color. The gingival surface is hornified according to the amount of brushing it may receive.

Gingivitis

Inflammation of the gingival tissue may result from the action of injurious agents such as toothbrush bristles, toothpicks, bacteria, acids and alkalis. As elsewhere in the body in response to injurious agents, the periodontal membrane and gingivae will exhibit the characteristic signs of swelling, redness, pain, increased heat and loss of function. Most authorities agree that the most frequent cause of gingivitis is a bacterial invasion through a break in the epithelium lining the gingival sulcus. The section on oral bacteriology lists the more common types of oral bacteria which may be present and it is known that the mouth affords the ideal requirements for the support of bacterial growth. Systemic factors play a role in the maintenance of tissue tone or condition in much the same manner that an athlete builds his body by adherence to a diet and studied exercise. Lack of vitamin C and vitamin B complex in the diet of an individual will cause a loss in tissue tone. Local factors such as overhanging margins of restorations will aid in food impaction which in turn will act as local irritants in the early destruction of the gingival tissue.

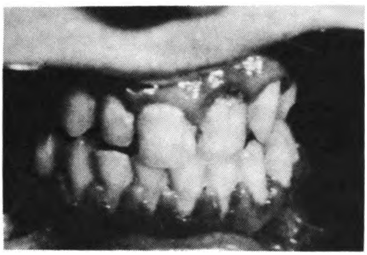

Figure 157.—Hypertrophic gingivitis.

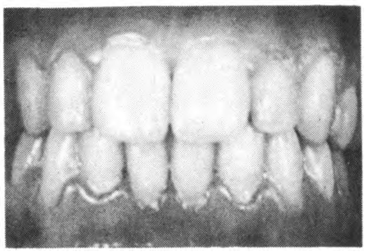

Figure 158.—Gingivitis due to nutritional upset.

Vincent's infection

Vincent's infection is generally found in mouths in which there is a definite lack of oral hygiene. It is a bacterial infection and requires tissue whose resistance has been lowered before the infecting organisms can successfully invade and grow in the tissues. The region of the partially erupted lower third molar affords a particular haven for bacterial growth. When Vincent's organisms invade the throat, the condition is termed VINCENT'S ANGINA. Clinically, this specific type of gingivitis is characterized by the early formation of a false, grayish white membrane which peels away to leave a bleeding surface. The interdental papillae which occupy the interproximal embrasures become necrotic and form crater-like depressions. This disease is associated with a characteristic fetid breath. Often the infection is so painful that the patient has trouble in eating. Authorities disagree on the communicability of the disease but care in washing the eating utensils of a person in the acute stages will generally suffice to curtail transmission. Generally, living conditions aboard ship are the same for all personnel. Diet, rest and exercise all tend to create good or mediocre body resistance. If personnel are tired and run down they are more susceptible to infections. Therefore, Vincent's infection, under such conditions, may affect personnel in sufficient numbers to constitute a serious epidemic. All patients must be carefully instructed in oral and personal hygiene and isolated when necessary.

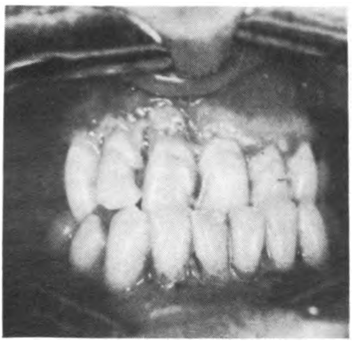

Figure 159.—Vincent's infection—Necrotic gingivae.

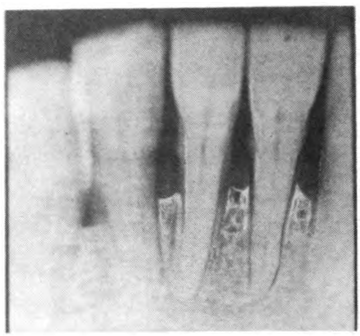

Figure 160.—Roentgenographic evidence of periodontitis.

Periodontitis

Periodontitis is an inflammatory condition of the tissue supporting the teeth. This inflammation is most often caused by neglected deposits of calculus.

When destruction of the gingival epithelium occurs in the gingival crevice, a portal of entry for bacteria is created. As more of the epithelial attachment is destroyed, the crevice epithelium grows toward the apex of the root in an effort to maintain the attachment to the cementum. As this growth takes place apically, the fibers of the periodontal membrane are destroyed by the pressure of the growing epithelium. Alveolar bone is resorbed to a point where the epithelial attachment is present. During the destruction of the attachment more bacteria can gain entrance to the underlying tissues through the broken attachments of the fibers. Eventually, if untreated, the tooth will be lost through destruction of the supporting tissues.

Clinically the color of the gingival tissues is intensified and as the disease progresses, they will take on a bluish appearance. The height of the interdental papillae is diminished and with pocket formation there may or may not be pus exudation from the gingival crevice.

Periodontosis

Periodontosis is a noninflammatory degenerative disease of the tissues supporting the teeth.

Clinically, in the early stages, the gingival tissue appears to be normal in color and the teeth are mobile without any accompanying signs of pus exudation. Roentgenographic examination will reveal wide destruction of bone. As the disease progresses, the clinical signs of periodontitis are superimposed. The term PYORRHEA, meaning a flow of pus, is commonly applied to either of the foregoing conditions. Since pus is found only in some cases, the term pyorrhea is not used to denote periodontosis.

Factors in periodontal disease

The etiologic factors considered in periodontal disease may be divided into systemic and local. Among the former are such conditions as blood dyscrasias, nutritional and endocrine disturbances, metallic poisoning and infectious diseases such as syphilis and tuberculosis. Local factors include lack of oral hygiene, chemical irritation, highly seasoned food, the loss of teeth, faulty restorations and improper use of the toothbrush.

Hypoplasia

The microscopic appearance of HYPOPLASIA (the defective or incomplete development of the enamel and dentin) has been described in the chapter on histology. This condition is generally an aftermath of a disturbance in the life of the embryo or during early childhood. Before birth syphilis may cause CONGENITAL HYPOPLASIA, and this may be evidenced in the so-called Hutchinson's teeth, in which the incisal edges of the anterior teeth may be noticeably notched and the molar biting surfaces may have a "mulberry" appearance. The appearance of this syndrome alone, however, should not lead one to a conclusive diagnosis of congenital syphilis.

Figure 161.—Hutchinson's teeth.

The degree of hypoplasia varies from a mild to a severe form. Small patches of less calcified enamel, with an increase of interglobular spaces and a widening of the dentino-genetic zones may be seen. Severe forms, where part or all of the enamel may not develop and the quality of the dentin is exceptionally poor, also occur. Between these two extremes is a wide variety of hypoplasias, depending upon the character and severity of the causative factors. Etiologic factors include the acute exanthematous fevers (smallpox, chickenpox, measles, scarlet fever); rickets (vitamin deficiencies—principally A, C, and D); mineral deficiencies (calcium and phosphorous) and excessive or inadequate endocrine gland function. Some local disturbances cause hypoplasia; these include traumatic injuries, infections and tumors. Fortunately, harmful effects from the acute exanthemata are less common today than in the past. They usually, however, occur during childhood when the teeth are being formed and may either affect the cells forming tooth structures or alter the body fluids in such a way that calcification of these structures may be impaired. Since these fevers attack epithelial tissue, and enamel is of epithelial derivation, enamel shows the most striking effects. The Striae of Retzius become broader, the less calcified spots in the enamel become more numerous and the Lines of Schreger are less pronounced. The cross striations of the enamel rods become more evident and the intercolumnar substances may be increased. In the dentin, the interglobular spaces and the granular layer of Tomes increase in number and size respectively. This increase in width of the Striae of Retzius makes these lines visible on the crown surfaces of the teeth. These horizontal lines, called linear defects, run across the external and internal surfaces and are particularly seen on the anterior teeth.

Rickets affects the development not only of teeth but of the bones of the body also. This condition is a nutritional one which is caused by a lack of vitamin D, as well as minerals such as calcium and phosphorous. The Striae of Retzius are even more pronounced than those caused by acute exanthematous fevers and parts of the enamel may not form at all. Row upon row of interglobular spaces may be seen in the dentin. If the deficiency is severe enough, none of the enamel may form, leaving a crown of dentin only. Generally, in this disease the ameloblasts degenerate and body fluids are so altered that the albuminous elements in the dentin fail to completely coalesce. Within the wide interglobular spaces the wider dentinal tubuli are evidence of this discrepancy.

Mineral Deficiencies

Where deficiencies of calcium and phosphorus exist, connective tissue cells in the dentinal papilla proliferate and grow between the ameloblasts. This results in a wider intercolumnar substance and may produce small areas of lesser calcification between enamel rods. The ameloblasts may also degenerate. In the dentin a wider dentino-genetic zone (dentin-forming zone) with an increased number of interglobular spaces may occur.

It is important that the processes of enamel development be understood in order to better study these developmental disturbances and observe the defects arising from them. If enamel matrix formation is disturbed, the result is an enamel hypoplasia. However, another phenomenon occurs which appears to be caused by incomplete or defective maturation of the matrix. This condition is called HYPOCALCIFICATION. It shows actual mineral deficiency and may appear only as one or more small whitish spots on the tooth surface.

The vitamin deficiencies affect both the ameloblasts and the chemical composition of the fluids which actively enter into calcification processes in the enamel and dentin. Enamel pits, varying in size, may be visible to the naked eye on the surface of the enamel. This condition may also be seen as a result of

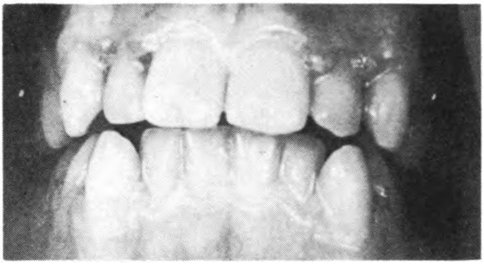

Figure 162.—Mild hypocalcification.

calcium and phosphorous deficiencies and in very mild forms of rickets. The Striae of Retzius may also be a trifle wider and dentin may exhibit pronounced contour lines of Owen.

Enamel Fluorosis or Mottled Enamel

When excessive amounts of fluorine are present in drinking water (two parts or more per million) there appears to be a disturbance in the processes of calcification. This may result in large areas of poorly formed enamel. White to brown opaque areas may be seen distributed throughout the enamel on most teeth, the anterior teeth being the most readily affected. This condition depends upon the amount of fluorine in the drinking water. It may range from a few small white spots here and there on one or more teeth to extensive involvement of nearly all tooth surfaces. Some enamel may be lost, particularly on the cusps. Teeth affected by fluorosis show a lesser tendency to decay. It has been demonstrated that a very small quantity of fluorine in drinking water (approximately 1 part per million) is coincidental with the finding that about 50 percent less dental caries of enamel and dentin appears in the mouths of those people who have been drinking this water since birth.

Disturbances of the Endocrine Glands

Malfunction of the thyroids, parathyroids and pituitary glands sometimes causes severe interference with dental developmental processes. The thymus, adrenals, pineal, male and female ductless reproductive glands (gonads) may influence such development to a lesser degree. Both the cellular elements and body fluids seem to be altered, producing such phenomena as retarded eruption, malposition of teeth, dwarfed teeth, malocclusion and defective attachment apparatus. In addition to being related to some disturbance of developmental forces, endocrine malfunction may also produce an alteration in calcium and phosphorous metabolism.

Local Disturbances

Local disturbances which may produce forms of hypoplasia are of a traumatic, infectious or neoplastic nature. Traumatic injury to the jaws or deciduous teeth, such as that occasioned by a blow or a fall, may kill or displace some of the ameloblasts or dentinoblasts. Absence or anomaly of part of the enamel and dentin may result. A microscopic change in the appearance of the dentin may follow, caused by an altered position and course of the dentinal tubuli or a change in the nature of the calcified matrix. When infectious, the bacteria may cause the death of a number of these cells and produce the above defects. Tumor masses and cysts in deciduous teeth may interfere with normal processes of calcification and parts of permanent teeth may not form at all.

Heredity

Heredity may also play an important role in dental anomalies. Though rare, there is a condition which evidently represents a generalized disturbance of ameloblasts. It affects all the teeth and appears to be a dominant mendelian characteristic. Teeth so affected are glossy, hard, have the appearance of jacket crown preparations and are said to be very resistant to caries. This condition has been called OPALESCENT DENTIN, and ENAMEL AGENESIS.

A condition of missing teeth, especially lateral incisors, is seen occasionally. This appears to be also familial in occurrence.

Erosion

Erosion is a loss of tooth structure usually found on the external surface of teeth at their necks. These defects are usually wedge shaped and cut rather deeply into the surface of the tooth. The enamel or dentin is usually hard and glistening. The area looks as if it had been cut by a stone or bur and then polished.

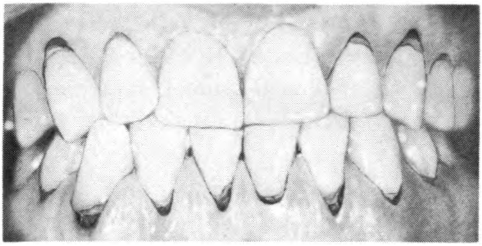

Figure 163.—Erosion.

There are several theories regarding the cause of erosion. One is that the mechanical wearing away of tooth structure is caused by the use of improper dentifrices and undesirable tooth brushing technics. Another is the chemical theory which states that acids are responsible. It is thought to be a combination of these and other factors. Calcification of the dentinal tubuli and deposition of irregular dentin are seen under these areas. Erosion can progress to the point where the crowns of the teeth are almost severed from their roots. It is seen particularly in the teeth of individuals who work with dynamite, marble and acid, in which instances it is known as an occupational disease. Since erosion also occurs frequently in the mouths of individuals not engaged in these occupations, the real causative factor is not definitely known. Another form may be evident after a slow caries process has been spontaneously arrested in these areas; the exposed dentin, although stained darker in color, is hard and shiny. Mastication has provided this high polish and caries-resistant area. The condition is known as EBURNATION.

Abrasion and Attrition

By abrasion and attrition is meant the loss of substance of a tooth from wearing processes. In abrasion, one or more teeth may show wear which is generally brought about by biting some foreign substance such as a pipestem, thread or bobby pin. Wrong use of the toothbrush or nervous biting habits will also cause abrasion. In attrition, wear involves all the teeth and is considered a normal loss of tooth structure due to the mastication of food. The nature of attrition depends on dietary habits and may vary in individuals of the same or different races. In normal attrition the cusps and contact points of all teeth show uniform wear.

In abrasion or attrition the dentinal tubuli under the worn areas may become calcified and secondary or irregular dentin may be deposited in the pulp immediately below them. The pulp is more often damaged by abrasion than by attrition. A possible explanation is that the foreign body or abrasive causes such rapid wear on certain areas that the tooth is unable to provide a suitable defense. In attrition, slower and more equally distributed wear takes place which enables the pulp to act by calcifying the tubuli and depositing secondary dentin at a rate equivalent to the destructive process. In both cases hyperplastic or secondary cementum may be laid down about the roots of teeth. In attrition, the deposition may be uniform, whereas in abrasion it may be uneven, caused by the abnormal forces that are brought to bear upon the tooth.

The peridontium is stronger and wider when teeth show normal attrition.

Resorption

In addition to dental caries, three types of loss of tooth substance — erosion, abrasion and attrition — have been discussed. All of these may be seen clinically. A fourth condition, known as RESORPTION, is best demonstrated by the roentgenogram. Resorption is the dissolution of tissue by body fluids or cellular activity. Cells which are active in the resorption of bone and cementum are known as OSTEOCLASTS and CEMENTOCLASTS. It is evident most often in the alveolar process and in the roots of teeth. Certain types of resorption are normal or physiologic. For example, the roots of deciduous teeth are normally resorbed just prior to the eruption of the permanent teeth which follow, or are succedaneous to, the deciduous teeth.

There is a physiologic resorption of bone seen in elderly individuals too, and in edentulous areas where permanent teeth have been extracted. Healthy bone is constantly being resorbed and rebuilt — resorption being effected through osteoclastic action and decalcification, and laid down through osteoblastic action with subsequent calcification. This phenomenon is the basis for the treatment applied by the orthodontist who moves malposed teeth slowly into proper occlusion. It is also important in the repair of fractures and the healing of tooth sockets.

Many pathologic types of excessive calcific deposits occur such as those seen in pulps (pulp stones), those found upon roots (cementomas and cementicles) and the so-called tori (torus palatinus and torus mandibularis). Treatment, however, is rarely indicated unless such "growths" are rapid or disfiguring. Resorption is seen often in roots of permanent teeth and may be a result of many factors; pathosis and trauma are thought to be two causes of such resorption. Systemic (endocrine) disturbances and some disease entities are characterized by bone and root resorption.

Observation of Dental Abnormalities by the Technician

Symptoms of the mouth are more often seen by the dental officer and his technician than by any other medical team. Although it is not a technician's duty or privilege to diagnose oral lesions, it is important that any suspicious areas seen by him be referred to the dental officer. Opportunities for this important health service are afforded the technician while giving oral prophylaxis, taking X-rays and preparing the patient for treatment. Figures 164 and 165 show examples of conditions that the

Figure 164.—Epithelioma of lip (cancer).

Figure 165.—Typical questionable lesion.

technicians might observe. Any part of the mouth which appears abnormal in size, shape or color should have the immediate attention of the dental officer.

CHAPTER 8

DENTAL MATERIALS

Dental materials described in this chapter are those used in restorative dentistry and include: gold, dental amalgams, silicate and zinc phosphate cements, acrylic resins, gypsum products, impression materials and waxes.

Gold and Its Alloys

Pure gold foil, the casting gold alloys, solders and the wrought gold alloys represent the more important forms in which gold is used in dentistry. Each has its particular applications and corresponding superiorities. Foil can be malleted (cold welded) into a strong hard mass which, in hardness, approximately duplicates the 22-carat, casting gold alloys. The adaptation, fit, permanence, and freedom from future disturbances make gold foil one of the best filling materials available to the dentist. The cast restorations can be prepared to protect weaker portions of a tooth. Wrought gold alloys yield the maximum in mechanical properties. Swaging, drawing and rolling of the cold-welded foil produces a refinement in the grain structure. Greater strength, hardness and elasticity are obtained in the wrought than in the cast form.

The softer alloys, high in gold content, meet the needs for the simplest inlay in a protected location. These alloys can be swaged and burnished to an exact fit. The exposed inlay and three-quarter crown require a harder, stronger gold. An inlay used as a bridge abutment or pontic must have great strength. The single piece appliance terminates in a clasp, occlusal rest or facing for the attachment of a porcelain tooth, and demands the utmost in strength and resiliency. Gold, silver and copper can be combined to produce an alloy far superior in strength to any one of these metals alone.

CHEMICAL COMPOSITION OF GOLD ALLOYS FOR CAST INLAYS

	Gold	Silver	Copper	Platinum	Zinc	Nickel
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Soft	94.7	3.5	1.5	0.1	----	----
Medium	83.3	8.3	8.3	----	----	----
Hard	78.8	7.0	7.8	3.0	1.1	----

Solders for 18-carat and 20-carat gold alloys are five element alloys consisting of gold, silver, copper, zinc and tin. The designation "solder for 18 carat" should not be misinterpreted. It means only that the solder is proper for use in joining or building up 18-carat gold alloy inlays and appliances and does not indicate the carat of the solder. Solder for use with 18-carat alloys is roughly 16 carat, and solder for use with 20-carat alloy may be from 17.5 to 19.4 carat in fineness.

POROSITY: It is now believed that porosity in dental castings is caused by occluded gas, or localized shrinkage or a combination of both. The inclusion of gases can be minimized by care in melting and the use of a flux when alloys susceptible to gas inclusions are melted. The voids can be coaxed from the essential part of the casting by attaching a mass of wax around the sprue immediately above the wax pattern for the inlay. To be most effective this reservoir must be of such size and so placed that the gold will remain molten until every part of the appliance or inlay has solidified. If the reservoir freezes first the mold will not be properly filled.

CASTING SHRINKAGE: The casting shrinkage of gold may be divided into three parts: 1. The contraction of the liquid metal, on cooling from the temperature at which it enters the mold to the freezing point. 2. The contraction of the metal on changing from the liquid to the solid state. 3. The contraction of the solid gold on cooling from the freezing point to room temperature. At the National Bureau of Standards it was found that this shrinkage value was 1.2 percent. This means that if an inlay is cast into a mold at room temperature, the inlay will be roughly 1.25 percent too small after it has cooled to room temperature.

HEATING THE GOLD: Hydrogen and air mixtures are excellent fuels for melting gold alloys. There is not the danger of over-heating that is present when oxyacetylene and oxyhydrogen flames are used. The large brush flame is wasteful. The flame should spread over the alloy being melted and can be used to cause the button of molten gold to spin and thereby uniformly mix the different elements just before casting. This is accomplished by moving the flame to the side of the button. The inner blue oxygen cone of the flame must not be permitted to touch the alloy for it will chill the metal. The use of a reducing flame and flux, such as fused borax, or borax and charcoal, is a protective step which will aid in the prevention of porosity.

Dental Amalgam Alloy

The first known amalgam restorations were inserted over a century ago, and were made from silver coin filings and mercury. As dentistry progressed it became evident to practitioners that experimentation was necessary in order to develop a dental amalgam with more desirable properties. The early works of Dr. G. V. Black, the father of modern dentistry, showed the effects of chemical composition and physical structure on dimensional change, strength and flow of amalgam restorations. Today the American Dental Association together with the research activities of the National Bureau of Standards have brought forth specifications for dental amalgam which have constantly improved the quality of amalgam restorations.

CHEMICAL COMPOSITION: The chemical composition of an average dental amalgam alloy is shown on page 301.

Silver imparts strength, durability, color and gives the alloy desirable expansion qualities during the set. Tin makes the amalgam easier to work, retards the setting time, counterbalances the tendency to excessive expansion, but also increases flow. Copper is included in the alloy because it increases the hardness of the restoration and also speeds up the setting time. Mercury, although an indispensable ingredient, imparts undesirable characteristics to an amalgam if it is added in incorrect proportions. Too little mercury produces a brittle, rapid-setting amalgam. Too much mercury in the amalgam produces weaker physical properties and

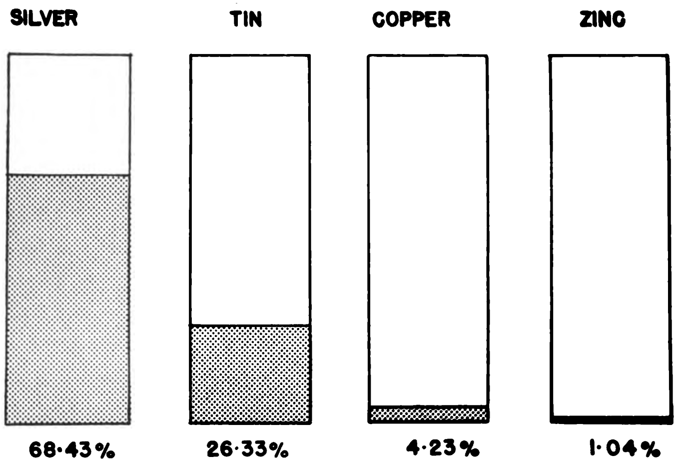

Figure 166.—Chemical composition of an average amalgam alloy.

an excessive expansion, with pressure on the tooth pulp, sometimes so great that a restoration must be removed within 24 hours after insertion to stop the tooth from aching. However, most of the excessive expansion, corrosion, blister formation and postoperative pain are caused by moisture contamination of the amalgam. This moisture is frequently introduced by palming, condensation of moisture on the amalgam or instruments or by plugging the amalgam in a wet cavity. Every precaution should be made to exclude moisture.

SETTING CHANGES: When finely cut particles of alloy are placed in a mortar and mercury is added, the formation of a new alloy immediately begins. To hasten amalgamation, it is common practice to rub the mixture. This causes the particles of alloy to be in intimate contact with the mercury which starts a chemical action. As long as free mercury is present in excessive amounts the amalgam will not set completely, but when it combines with other metals, setting takes place. The setting is due to the disappearance of the liquid, and the liquid mercury can only disappear by combining with one or more of the metals present. The cause of hardening of amalgam is similar to the cause of hardening of cements. In both cases, a solid and a liquid are mixed and the product sets when the liquid disappears by combining with the solids.

As previously stated, when mercury is added to a dental alloy and trituration is begun, the formation of a new alloy starts immediately. The mercury combines or reacts with all the metals. However, the main reaction is the combination of mercury with the silver-tin compound (Ag_3Sn), the most important compound in the dental alloy filings. Mercury combines with the silver in this compound, forming a silver-mercury compound (Ag_3Hg_4), thus setting the tin free to react with excess mercury. This new compound of silver-mercury is the primary agent in causing amalgam to set. The free tin reacts with mercury to form a tin amalgam which is a plastic mass carrying enough excess mercury to allow sufficient working time. In other words the final setting or hardening time is retarded to allow sufficient time for manipulation. Tin amalgam will not set for long periods of time. It keeps the mass workable until excess mercury is expressed or combined with other metals.

When a dental amalgam is formed, the greater portion of alloy filings does not go into solution. Only small particles are entirely dissolved (unless the mass is overtriturated). Larger particles are partially dissolved and this solution forms a coating on the outside of each particle in which setting changes take place later to bind the mixture into one compact mass.

After amalgam has been triturated to the satisfaction of the assistant, an immediate microscopic examination would disclose a large portion of undissolved alloy particles, containing the original metals — silver, tin, copper and zinc, surrounded by a solution of a silver-mercury compound in a tin amalgam, all of this in the presence of free mercury. As soon as sufficient silver-mercury compound is formed, this compound starts to crystallize out of the solution because it has a higher melting point than mercury. The crystals grow and interlock with each other around the larger (undissolved) particles in the mix to bind them all together to give a hard compact mass. The larger undissolved particles of alloy act as rock or aggregate in concrete, thus providing additional strength. It can readily be seen that any excess mercury present during this crystallization process will retard complete hardening.

PROPERTIES UNDER CONTROL OF MANUFACTURER: There are many factors under the control of the manufacturer which influence the properties of amalgam. Among them are:

1. Purity of the ingredients.
2. Proper chemical balance.
3. Protected melting conditions.
4. Particle size.
5. Proper annealing of the alloy.

These factors influence the constancy of volume of the final amalgam and insure that the alloy in each bottle will have the same composition and structure.

The first three factors are self explanatory. It seems reasonable that impurities would have an injurious effect; an improperly balanced alloy, made up of some metals which cause expansion and others which cause shrinkage, would be unsatisfactory; and, that the formation of oxides, from unprotected melting conditions, would be disastrous.

PARTICLE SIZE influences amalgam in the following respects:

1. Expansion decreases as particle size becomes smaller. Crushing strength is also decreased. Reduction in particle size has somewhat the same effect as does an increase in condensation or trituration pressure. It tends to decrease expansion.
2. As trituration time is lengthened, the tendency toward lessened expansion is evident for all particle sizes.
3. Care should be exercised when triturating an alloy of small particle size in a mechanical amalgamator to avoid over-trituration which results in lowered expansion or shrinkage of the amalgam.

Annealing

When the metals making up a dental alloy are melted together by the manufacturer and allowed to cool, the alloy is subjected to tremendous strains. The molten mass solidifies or cools first on the outside. The inner crystals are of different structure than the outer crystals. The outer portion of the molten mass solidifies first, thus subjecting the inner portions to strains which deform them as they solidify. To correct this the alloy is annealed or heated slowly, which allows the crystalline structure to reorganize.

The annealed ingot is machined to produce the filings. This operation causes strain in the particles which must be relieved by annealing at 100° C. If this is not done the filings anneal slowly at room temperature producing a constantly changing unstable alloy.

Properties Under the Control of the Dental Officer and the Dental Technician

There are many factors under the control of the operator and the technician which influence the properties of amalgam. Consideration of the following factors will produce a better amalgam:

Undertrituration

If the mortar and pestle are too smooth the particles will slip ahead of the pestle, resulting in a failure to coat them properly with mercury. Glass mortars and pestles, as well as metal mortars of the pressure-regulating type, should be reconditioned occasionally. This is accomplished by grinding #FFF carborundum powder and water (just as though a mix of amalgam were being prepared) for 1½ minutes. Undertrituration causes the resultant amalgam to be slow setting, high expanding and considerably weaker.

Overtrituration

Prolonged trituration breaks down the particles unduly and produces a fast setting, low expanding or shrinking amalgam. When an automatic trituration device is used, it is easy to overtriturate.

Condensation time

The dental officer should start to pack immediately, or crystals of the silver-mercury compound will start to form and the delay will result in a breaking down of these crystals when condensation is started. The technician can help by never starting the mix too soon. The dental officer should tell the technician how large a mix he desires to use and when to commence trituration.

Manufacturer's instructions

These should be followed carefully. Directions are furnished regarding proportions of alloy and mercury, trituration pressure and time, (see section concerning technic for Mixing of Amalgam).

Condensation pressure

Generally speaking, the more pressure that is used and the larger the condensing or plugger points, the stronger will be the restoration. Four to eight pounds of thrust are recommended in condensing amalgams. Extremely good condensation may be obtained with either hand condensation or by the use of a mechanical condenser. When this instrument is used, however, it is doubly necessary to have a well adapted, firm matrix. Some amalgam investigators believe that, when using the mechanical condenser, better condensation may be obtained by using the largest condensing point that will fit into the cavity. The same holds true for hand condensation.

Use of more than one mix

When larger cavities are being filled the dental officer may require more than one mix. When necessary to use more than one mix, the technician should have the second mix ready for the dental officer by the time he is ready to use it. The operator should tell the technician when to begin this second mix. Any delay may result in a poor bond or junction of the two different mixes of amalgam employed.

Dangers of moisture

Moisture, in any form, which contacts freshly triturated amalgam is injurious. Experiments conducted at the National Bureau of Standards and elsewhere have proved that there are four definite effects of such contamination: (1) Excessive expansion (delayed), (2) pain beginning shortly after insertion of the filling, (3) lowered crushing strength, and increased flow, and (4) blister formation on the surface of the amalgam.

The following points must be considered if moisture contamination is to be avoided:

MULLING: Specimens of amalgam mulled in the hand when perspiration is present show expansions or "delayed growths" as high as 229 microns per centimeter. Control specimens, mulled in a rubber dam or a finger cot, expanded only 3.5 microns per centimeter which is within the specification limit (3 to 13 microns per centimeter).

ADDITION OF MOISTURE: When saliva, salt water, or ordinary tap water was added to amalgam prior to trituration, excessive expansion resulted.

USE OF ZINC ALLOY: The above experiments were conducted using specimens of dental alloys containing 1.2 percent zinc. When nonzinc alloys were used no excessive expansion resulted. (This does not mean that moisture is not injurious to nonzinc alloys.) It is necessary to prevent moisture from contacting amalgam when it is plastic, if "delayed growth" of amalgam is to be prevented.

Experiments proved that alloys containing zinc form hydrogen gas when moisture is present at the time the amalgam is triturated. Nonzinc alloys do not. Tests disclosed that at times, pressure of 2,000 pounds per square inch is exerted by the gas which forms throughout the amalgam. This is ample to cause it to flow. Amalgam containing zinc (1.2 percent) was prepared, free from contamination, and only a few gas bubbles appeared on the surface. No delayed expansion resulted.

The excessive expansion caused by contamination of amalgam by moisture does not become evident during the first 48 hours following insertion of a restoration. Gas pressure is built up slowly.

Experiments have proved that temperature has little effect upon the dimensional changes of amalgam. Amalgams do have a higher crushing strength during cooler periods of the year. It has been found, however, that if amalgam is triturated at a temperature below the dew point (temperature at which moisture collects), sweating of the amalgam containing zinc occurs and the resultant contamination with moisture causes excessive delayed expansion.

Moisture is introduced into amalgam by: mulling in a moist palm, triturating amalgam at a temperature below the dew point, moisture in the cavity or accidental contact with saliva during condensation. To avoid this, all equipment should be dry and amalgam should be mulled in a rubber dam, squeeze cloth, or a clean piece of linen cloth. The temperature should be such that no moisture collects; and, saliva must be kept out of the cavity both before and during insertion of the restoration.

CONTAMINATION OF ALLOY AND MERCURY: Dental alloy and mercury should be carefully guarded against contamination by foreign matter. The containers in which these materials are received should be kept stoppered when not in use. Mercury which has previously become contaminated by particles of alloy is not fit for use. Any contaminated alloy or mercury should not be returned to the container. It should be saved as scrap along with the excess amalgam remaining after the insertion of the restoration.

ADDITION OF MERCURY: If one drop of mercury is added to a partially set mix of average size, the compressive strength of the resulting amalgam will be about ONE-TENTH of the normal strength. It is sometimes difficult for dental technicians to see why they should not add the same mercury to a mix that was squeezed out of it only a few minutes before. Such practice leads to disastrous results for, once amalgam has begun to crystallize or harden, the addition of mercury lowers the crushing strength tremendously, regardless of whether it is new mercury or mercury that was once a part of the same amalgam.

Excessive mercury causes undue expansion. A patient who has received such a restoration would likely return within 24 hours complaining of pain. Moisture contamination causes delayed expansion, because the tremendous pressure from the release of the hydrogen gas is not exerted until after 48 hours. In this case, the patient may return after 48 hours complaining of pain.

TARNISH AND CORROSION: There is almost no solubility of amalgam in mouth fluids. After years of service there is scarcely a perceptible loss of exposed surfaces. The edges, which should be the first to show evidences of solution, may not deteriorate. The metallic taste which usually discloses the presence of metals in solution is seldom detected for long in a mouth containing properly placed amalgam restorations unless in contact with gold alloys.

Tarnish, in amalgam restorations, indicates a chemical reaction whereby salts adhere to the fillings, and frequently cause dissatisfaction. Tarnish occurs whenever sulfides are present in the mouth. One factor in corrosion and tarnishing is the contact of dissimilar metals in the mouth. The saliva becomes an electrolyte (conductor) and a galvanic current is set up. The metal which is the more electropositive of the two will be corroded at a more rapid rate than if contact between the two metals is not maintained.

Specimens of amalgam in contact with gold alloys were attacked when immersed in a one percent sodium chloride solution. During a 6 months' immersion in this solution, the amalgam was badly pitted and a heavy precipitate was formed. Analysis showed the precipitate to be mostly tin, with only a trace of silver, copper and zinc. Mercury was not detected. (This helped to dispel the old fear that individuals possessing many amalgam restorations might be in danger of mercury poisoning.) The lack of homogeneity throughout the amalgam structure furnishes the elements necessary for local galvanic action. A rough surface of amalgam has different galvanic properties from those of a polished surface.

There are differences in the properties of electrolytes. The products arising from debris and food decay between two adjacent teeth are different from those in normal saliva. Therefore, it is possible to have one type of electrolyte at the gingival margin and another at the occlusal surface. The resulting changes in surfaces will probably cause galvanic disturbances between the two and lead to further deterioration. Well placed dental amalgams remain bright and polished if good oral hygiene is practiced.

Mixing technic

1. Read and follow the manufacturer's directions.
2. Employ a clean mortar and pestle.
3. Time the mixing procedure, triturating according to the manufacturer's instructions.
4. Unify the mix by using a clean piece of rubber dam, a rubber finger cot or a piece of clean linen (squeeze cloth).
5. Roll the amalgam into a "rope" and divide into segments. As each segment is used, it is placed in a squeeze cloth and the mercury is expressed with finger pressure. If any portion of the amalgam is too dry it should be discarded since it will not form a homogeneous mass with the underlying

portion of the restoration. As previously stated, if one drop of mercury is added to a partially set mix of the average size, the compressive strength of the resulting amalgam will be about one-tenth of the normal strength. NEVER add mercury, for once the amalgam has begun to crystallize or harden, the addition of mercury lowers the crushing strength.

6. If one mix is not of sufficient amount for the cavity at hand, it may be necessary to make two or three. Do not mix large masses of amalgam, because the last segments may start to crystallize before they can be condensed into the cavity.

CEMENTS

Today, cements hold an important position among the therapeutic agents employed in dentistry. They are used extensively because they have certain definite practical advantages over metallic filling materials such as a natural appearance, greater speed of manipulation than metals and alloys and lower heat conductivity. Even though cements are used extensively, they are generally considered the least permanent of the available materials for restorative dentistry. They are relatively soft, soluble and shrink during setting.

Zinc oxychloride

Zinc oxychloride is hardly ever used because it disintegrates very readily and the products of disintegration are corrosive. For these reasons the cement cannot be used in contact with soft tissues.

Zinc oxide-eugenol

The zinc oxide-eugenol cement is used extensively as a pulp-capping material and temporary cement. Composition of a typical cement of this class consists of: Zinc oxide, hydrogenated rosin, zinc acetate, eugenol and olive oil.

Copper phosphate cements

The two types of copper phosphate cement in most common use today are the red and black copper cements, which derive their names from the presence of either red cuprous oxide or black cupric oxide. They are thought to be somewhat bacteriostatic.

Zinc phosphate cements

The principal constituents of zinc phosphate cement powders are zinc oxide, nine parts and magnesium oxide, one part. The liquids always include phosphoric acid and aluminum phosphate. In most instances zinc phosphate is also present. The phosphates in the solution temper the reaction between the powder and liquid during mixing and to a large extent control the rate of reaction. What compounds are formed as a result of the reaction between powder and liquid is not definitely known, but they are generally considered to be essentially one or more of the zinc phosphates. They are crystalline in structure.

Properties of Cements

Consistency

It is common knowledge among the users of cements that, to produce mixes of the same consistency, the amount of powder required for a given quantity of liquid will vary with different cements. If measured amounts of cement powder are to be used it is more essential to follow the manufacturer's directions to obtain mixes of the same consistency than to estimate the amounts of the powder.

Setting time

A reasonable setting time is from 6 to 10 minutes at mouth temperature. Practically all the cements used today come within this range. Cement mixed to seat an inlay will set more slowly than cement mixed for a temporary filling or a cement base. The time of setting is DECREASED by using a warm slab, by incorporating the liquid rapidly, by increasing the amount of powder in the mix, or by using a liquid which has too much water in it. The time of setting is INCREASED by using a mix of thinner consistency, by mixing on a cold slab, by incorporating the powder slowly and over a longer mixing time, or by using a liquid which has lost some of its water.

Average crushing strength

Compressive strength	Pounds per square inch
Zinc phosphate cement	3,000 to 19,000
Amalgam	45,000

Solubility and disintegration

One of the main defects of zinc phosphate cement is its solubility in the mouth. Tests show that currently popular cements have a solubility and disintegration of from 0.05 to 0.20 percent during the first 7 days following their insertion. They are also readily attacked by sulfides which arise from the breakdown of certain foods in the mouth.

Thermal conductivity

The zinc phosphate cements, because of their low thermal conductivity, can be used to prevent or decrease the thermal shock which occurs when metallic fillings are placed near the pulp. Tests made at the National Bureau of Standards on the conductivity of dental cements showed them to be between one one-hundredth and one two-hundredth as conductive as alloys akin to those used in making cast gold inlays. A cement lining of sufficient thickness, in a deep cavity is therefore an effective thermal insulator giving protection to the pulp from thermal changes.

Adhesiveness

A test of the adhesive qualities of a cement for uniting two flat sections of teeth showed that its adhesiveness was negligible. The forces holding restorations are mechanical in their nature and depend upon either the mechanical interlocking of material in roughened surfaces or upon the frictional resistance of surfaces between which irregular sandlike particles have been placed. The difficulty experienced in the removal of an inlay from a tooth is the result of the crushing strength of the cement which is interlocked between the inlay and the surface of the cavity.

Contamination with moisture

The effects of moisture at the surface layer of cement, prior to complete set is a serious matter. The plastic cement, in contact with water prior to the completion of the chemical reactions will

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not develop a smooth, hard, glossy surface. The water absorbed by the phosphoric acid causes it to take on a dull, soft, and relatively soluble surface layer. Liquids exposed in unstoppered bottles or spread on mixing slabs will extract moisture from the air if the humidity is high. Most of the liquids lose water if exposed to air of low humidity. Therefore, the safe procedure is to keep the bottle tightly stoppered at all times, except when withdrawing liquid. The set cement must not lose water or it will shrink and crack.

Heat of reaction

When the powder and liquid are mixed, heat is generated as in any chemical reaction. This heat is called the heat of reaction. It causes the cement to set too rapidly if it is not controlled. If the cement sets too rapidly, less powder can be incorporated. This will cause the crushing strength of the cement to be decreased, and the cement will be more soluble in the oral fluids. In mixing zinc phosphate cement, the following steps are considered to be cardinal principles:

1. Use a cool, clean glass slab (25 percent more powder can be incorporated than if a warm slab is used). Do not, however, cool the slab below the dew point of the atmosphere. Divide the weighed or estimated amount of powder into 6 segments.
2. Incorporate one segment of powder at a time.
3. Spatulate, with a circular motion, over a wide area on the slab, holding the blade of the spatula flat against the slab.
4. Spatulate each segment of powder for 15 seconds before bringing in the next segment. The mix is completed in 1½ minutes.

These four principles constitute the mixing technique, and they also control the heat of reaction.

Silicate Cement

Silicate cements are universally supplied in the form of powder and liquid which are mixed just before the restoration is made, placed in the tooth while in a plastic state and allowed to solidify or set in the tooth. Time is such an important factor in the use of this material, that the dental officer can not obtain the best results if he has to both mix and insert the filling material.

Powder

The powder is a complex glasslike material. The major constituents are silica (40%), alumina (30%), flux (20%), and lime (10%). The first step in the preparation of silicate powder at the manufacturer's plant is the removal of impurities, notably iron. If iron is present, it will combine with sulfur compounds in the oral cavity to form black sulfides which will discolor the restoration. The purified ingredients are then weighed, thoroughly mixed and melted in a special clay crucible. The manufacturer uses these crucibles but once. The material is then poured, cooled, ground and sifted. In some instances, zinc and other oxides are added to the powder to help neutralize the acid liquid when the cement is mixed prior to insertion in the cavity. Silicates are made first as a pure white material and the delicate shades are produced by the addition of small amounts of chemically inert pigments. The color of the silicate powders received by the dental officer can readily be affected by contamination with dust or dirt. It takes only one part of soot in 100,000 parts of cement powder to cause a detectable change in color.

Liquid

The liquid consists of chemically pure phosphoric acid (50%), water (40%) and aluminum and zinc phosphates. The latter are added to partially neutralize the phosphoric acid. The liquid is then adjusted to a definite specific gravity and acid content. The limits of satisfactory performance of silicate liquids are narrow and most trouble occurs through changes in their water content. For this reason, extreme care should always be taken to keep the liquid bottle tightly stoppered, opening it only long enough to take out the required amount of liquid for the mix, and then making the mix immediately after the liquid has been placed on the slab. If the humidity is low, the liquid will give off water which will cause the cement to set slowly or if sufficient water has been lost, not to set at all. If the humidity is high, the liquid will absorb water. The neck of the liquid bottle should be wiped off once every two or three days. When the water evaporates from the liquid, salts are deposited upon the neck of the bottle. This results in a poor fitting bottle cap. It also produces a liquid which will give a slow setting mix.

Setting

Everything that takes place when a silicate cement sets is not definitely known. In the first reaction, the powder goes partially into solution in the acid liquid. The smaller particles of silicate powder and the outer layer of the larger particles are broken down into free silicic acid and phosphates of all the metals present. These phosphates and the silicic acid are colloidal. The colloidal silicic acid holds a certain amount of water. The initial set probably starts when the silicic acid starts to gel. The final result is an interlocked mixture of colloidal phosphate, hardened silica gel and undissolved particles of powder. The undissolved particles of powder provide strength to this material similar to the aggregate used in concrete.

As can be seen from the foregoing paragraph, the setting reaction is complicated. There are two outstanding points about this reaction which should be remembered: (1) The reaction proceeds at a rapid pace once it is started, and like all chemical reactions, the temperature has a decided effect upon the rate of reaction. If the temperature is raised, the speed is increased; if it is lowered, the reaction slows down; (2) This reaction is not reversible, it goes only toward completion. The silica gel that is formed is similar in action to another colloid, gelatin, in that ONCE FORMED it will not reform if punctured or cracked.

The basic objective in the proper mixing of silicate cement is to have most of the setting reaction take place after the silicate has been placed in the cavity in order that the end products of reaction will be undisturbed and developed as fully as possible. Heat will accelerate the reaction and a cool slab used for spatulation will slow down the reaction.

Mixing technique

1. Use an exact ratio of powder to liquid. This ratio should represent the maximum amount of powder that can be incorporated so as to keep the amount of gel in the restoration at a minimum.

2. Mix the liquid and powder on a glass slab cooled to a temperature just above the dew point. The lowered temperature of the slab aids the operator to wet each powder particle with the liquid before any appreciable amount of the chemical reactions have taken place, thus minimizing injury to the gel.
3. The mixing should be quickly accomplished so that the setting reactions may take place undisturbed within the cavity.

ACRYLIC RESINS

The most commonly employed acrylic resin at the present time, is a derivative of coal, water and air. These three substances are converted into a clear, colorless liquid by some twenty complex chemical processes. This liquid is then converted into a granulated powder resembling sugar in appearance. Methyl methacrylate denture base material comes in two bottles; one contains a liquid (monomer) and the other a powder (polymer). The two are mixed together until a doughy substance is formed, with which the mold is filled. The flask is heated for a period of time, changing the dough to a solid. The difference between the solid and the liquid is one of molecular weight. The liquid can be changed to a solid by heat, and, if the solid so formed is heated to a much higher temperature, it changes back to the liquid. The process of changing the liquid to a solid is known as polymerization. The best technique for the processing of acrylic resins may be found in the directions issued by the manufacturers. It is most important that each step in these directions be followed in every detail.

EFFECT OF WATER: Methyl methacrylate resins absorb water and expand accordingly. If a denture has been permitted to dry out for several days there will be a shrinkage of 1 percent across the posterior dimension. The same denture placed in water will expand approximately to its original dimension. Methyl methacrylate dentures should therefore be kept moist, and immediately after polishing should be immersed in water so that when final adjustments are made they will be at dimensional equilibrium.

INJECTION AND COMPRESSION MOLD: Equally satisfactory dentures can be made by use of injection or compression technics.

Shifting of the teeth and the so-called opening of the bite encountered in some cases of compression-molded dentures are the direct result of improper packing of the resins in the mold. The trial packing should be continued, using cellophane as a separating medium, until no flashes appear when the edges of the flask are in even contact. A mistake is usually made by adding additional material at this time creating a flash of resin which changes the original vertical dimension of the denture in the mouth and on the articulator.

POROSITY: Porosity in dentures may be caused by a number of factors. Insufficient material in the mold will result in porosity, for the resin must be under compression during polymerization. The mold must be full without a flash when the flask is closed. This provides sufficient compression to avoid any porosity. The addition of excess resin at the final closure of the flask to produce an over-filled mold, in reality causes less pressure to be exerted upon the resin. A flash of resin spreads out between two halves of the flask and causes a distribution of load over a much greater surface of resin, thereby reducing the pressure upon the resin which is actually in the mold cavity.

Another cause for porosity in methyl methacrylate resin is improper mixing. This can be demonstrated by taking clear resin and delaying packing until at least 5 minutes after the mix. If the resin is packed immediately after mixing it will frequently have gas bubbles throughout. Monomer may be vaporized if the resin is heated too rapidly. This type of porosity is frequently localized in those portions of the mold which are located farthest from the outside of the flask and which radiate heat more slowly than sections of the mold nearer the outside of the flask. Heat is evolved as the resin polymerizes so that frequently, temperatures reached in the interior of the denture may be far higher than the temperature of the water in which the flask is immersed. This heat involved in polymerization is in direct ratio to the mass of resin employed; therefore, the thicker the denture, the greater the amount of heat evolved, and the more careful one should be in the processing of the case.

TECHNIQUE OF PROCESSING: The most effective processing is accomplished by holding the case at 160° F. for approximately 9 hours. If this schedule is followed, it is not necessary to raise the temperature of the bath to 212° F. — in fact, it is best to avoid such a high temperature. The effect of processing temperatures may easily be demonstrated by processing one case for 9 hours at 160° F. and the other case from room temperature to 212° F. in 1 hour and boiling for ½ hour. When these two cases are removed from their casts after processing and are then reinserted on their casts, it will be evident which of the two cases will fit the cast better. The effect is even more pronounced when heavy thick dentures are processed. Because of the foregoing reasons, a repair should be processed at 160° F. and not at 212° F.

PLASTER OF PARIS

PLASTER OF PARIS received its name from the fact that gypsum, from which it is derived, was mined first near Paris, France. The chemical formula of gypsum is $CaSO_4.2H_2O$. When gypsum is heated sufficiently to drive off some of the water of crystallization it changes to plaster of Paris, $CaSO_4.\frac{1}{2}H_2O$ (calcined gypsum). This resultant product is composed of granules which are in turn made up of smaller granules. Plaster of Paris is very porous because of this aggregation of granules and, when water is added, the plaster ($CaSO_4.\frac{1}{2}H_2O$) again changes to gypsum ($CaSO_4.2H_2O$). Some of the plaster dissolves in water and crystallizes as fine, interlacing, definitely shaped crystals. This causes the plaster-water mixture to harden or set.

FACTORS IN MANIPULATION: (1) The water-plaster ratio: The more water used per given amount of plaster, the longer the setting time will be and the lower the crushing strength. The average ratio used for a good ordinary mix is 60 parts of water to 100 parts of plaster by weight. Since this ratio may vary somewhat with different brands of plaster, the ratio recommended by the manufacturer of a given plaster should be used for the best result. (2) Water temperature: If the water is between 68° F. and 86° F. no significant change in setting time of the plaster occurs. Higher temperatures accelerate the set while lower temperatures retard it. (3) Spatulation: The longer and the faster the mix is spatulated, the quicker it will set. One half to one minute is the desirable time range for hand spatulation. Continuing the spatulation after crystals have formed produces a softer plaster with a lower crushing strength. (4) Accelerators and retarders: These should be considered as adulterants to be used with reason. Accelerators are used more commonly than retarders. All sulfates except iron sulfate, act as accelerators and hasten the setting time if a small amount is used. If used in a large amount they may act as retarders. For example, a 3 percent solution of sulfate will hasten the setting time of a certain mix, but if a 12 percent solution is used, the setting time will be retarded. A 4 percent solution of sodium chloride is an excellent accelerator except when the plaster is to be used for making casts, in which case a rough surface may result. Colloidal substances: Blood, serum and glue all act as retarders. A 1 or 2 percent solution of borax is an effective retarder, and provides a smooth creamy mix that is comparatively free of air bubbles.

DENTAL STONE: Stone (hydrocal) is identical with plaster chemically, but differs in physical properties because of the different method employed in its manufacture. The stone is made by superheating the gypsum with steam, until the aggregates common to plaster, are broken up into individual particles. The resulting stone is then modified to meet the specific purpose for which it is intended. Dental stone contains: Rochelle salt (potassium and sodium tartrate) 1 to 5 percent, retarder 0.1 percent, pigment 0.5 percent, and sufficient hydrocal to make 100 percent. Dental stone is less porous than plaster and only half as much water is required to make a proper mix. The normal ratio is 30 parts of water to 100 parts of stone by weight. Being two or three times stronger than ordinary plaster, stone is better suited to use as a cast material and for other purposes in the prosthetic laboratory where a stronger material than plaster is desired.

THE CARE AND MIXING OF PLASTERS: All plasters should be kept in sealed containers which are impervious to moisture. They tend to become deadened if exposed to water vapor hence care must be exercised in stowage of these materials. Cleanliness also is essential for a uniformly good mix. Dirt and other impurities may affect the smoothness of the mix and weaken the final product. Particles left in the mixing bowl from a previous mix serve as crystallization centers and cause the mix to set faster, to be rough, and to be generally unsatisfactory.

1. Use only powder which has not become contaminated with impurities and does not contain any lumps.
2. Use the proper ratio of water and powder.
3. Use the water at room temperature.
4. Use a clean, flexible plaster bowl.
5. Use a clean, stiff spatula with a smooth rounded end that will reach every part of the plaster bowl without scraping or cutting its surface.
6. Place the water in the bowl, sift the powder into it, allow it to slake down beneath the water, and then vibrate the bowl to dispel all possible air bubbles.
7. Spatulate with a rapid stirring motion for not over one minute, contacting the entire inner surface of the bowl with the spatula so that no powder is left unincorporated. Whipping the mix incorporates air and must be avoided.
8. After spatulation is complete, vibrate the mix well to remove all remaining air bubbles and then pour immediately.

IMPRESSION MATERIALS

Impression materials are used to make a negative likeness of the structures of the mouth and teeth.

An impression material, to be of any value, must be plastic and of such nature that, when placed on structures of the mouth or teeth, will form itself around them, become semirigid in this shape or form, and maintain this shape after it has been removed from the mouth.

Four types of impression material are in common use today:

1. COMPOUND. — Compound is a thermoplastic impression material that is soft when heated and becomes hard and brittle upon cooling. It comes in different colors (black, white, red, green) and in different shapes(sticks and cakes) all of which are handled in approximately the same manner.

Compound is used most often in making snap impressions for study models of dentulous and edentulous mouths. For this purpose it usually is heated in a water bath at approximately 130–140° F.

Compound also is used in making impressions of teeth for the purpose of making a metal die or model of an individual tooth. As a rule, green stick compound is used for this purpose and for making an impression of a tooth preparation; it usually is softened by heating over an open flame.

2. HYDROCOLLOID—AGAR TYPE—Hydrocolloid (agar type) is a thermoplastic material that becomes a thick soupy paste when heated, but returns to a rubber consistency upon cooling.

A special mixing device and special impression trays are required for this material. Hydrocolloid impressions must be poured immediately and not allowed to stand or dry out, or they will become useless.

Hydrocolloids are used for:

a. Partial denture impressions.
b. Crown and bridge impressions.
c. Inlay impressions.
d. Immediate full denture impressions.
e. Duplication of models.

3. HYDROCOLLOID—ALGINATE TYPE.—Alginates are furnished in powder form, in lead or tin containers. They are mixed with water in a rubber bowl, and spatulated to form a light paste. They become rubbery in about three minutes. They are used for:

a. Making impressions of the mouth where the teeth present undercuts.
b. Crown, bridge and inlay impressions.
c. As a WASH or lining for full denture impressions. The material is applied as a lining inside a rigid impression, which is then reinserted in the patient's mouth. The original rigid impression in this case actually now serves as a tray; the final impression will be in the alginate wash.

4. IMPRESSION PASTES.—Impression pastes used as washes for edentulous impressions are essentially zinc oxide-eugenol cements. The many brands available are usually furnished in one of two ways—two tubes of paste or as liquid and powder. Directions must be followed carefully in the mixing and use of these materials.

Impression paste can be very difficult to remove from the spatula used in mixing and handling. The paste can be wiped off easily with a paper towel or dental napkin if the spatula is first covered with a liberal amount of vaseline and held over a flame for a few seconds until the vaseline melts well into the paste. Xylol is an excellent solvent.

Waxes

Dental waxes with special physical properties are used for different dental purposes. For example, wax used in making an inlay pattern must contrast in color with the tooth, must be hard so it can be carved easily at mouth temperature, and must take accurate impressions—retaining the fine lines and details of the cavity preparation.

Wax used in other procedures, such as denture construction, need not be so accurate or so hard as inlay wax, nor have so high a fusing (melting) temperature. Wax used for boxing (as a retaining wall for poured plaster) should be molded easily at room temperature, and need not be hard or accurate. Another type of wax is used which becomes very sticky when melted. This wax usually has rosin added to it, and it is quite adhesive. It is hard and brittle when cold.

CHAPTER 9

DENTAL ROENTGENOGRAPHY

The X-ray or roentgen ray was discovered by Wilhelm Konrad Von Roentgen in November 1895 in Wurzburg, Bavaria. Its first demonstration in the United States was at New York University, and it probably was first used in dentistry in this country by Dr. C. Edmund Kells of New Orleans in 1896. The use of the X-ray in dentistry has gradually increased until an X-ray examination now plays a prominent part in most diagnoses of dental disorders.

The making of shadow pictures with X-rays is called roentgenography (pronounced rent-gen-og'raf-e). Roentgenography has many synonyms—X-ray, radiography, actinography and skiagraphy.

OPERATION OF THE X-RAY UNIT

The unit now in most common use in the U.S. Navy is the General Electric Wall type, though at some activities the Ritter or Weber Mobile type is used. Regardless of the type of unit at hand, the operating procedures are practically the same because there is little variation in the construction of X-ray units in general.

Inside the housing, which is mounted on the panel of the General Electric Wall mounting, is a TRANSFORMER which can change the voltage and amperage of the alternating current it receives according to its ratio. At the top of the housing are two meters called the current indicator and the compensator voltmeter. In the middle of the housing is the circuit breaker — the main switch for the X-ray unit. At the bottom of the housing is the compensator dial and indicator, with which the current is regulated. On the left is the TIMER, the device which controls the elec-

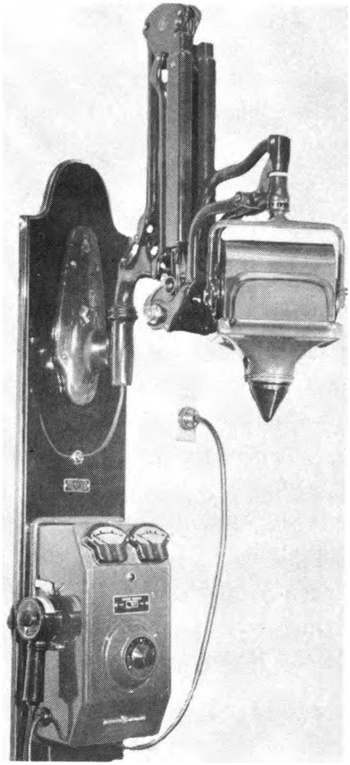

Figure 167.—General Electric wall wall-mounted X-ray unit.

Figure 168.—Panel of General Electric wall-mounted X-ray unit.

tric current for exposing the X-ray film to the roentgen ray for a given period of time. It hangs on a hook, and is attached by an electric cable to the contents of the housing.

The X-ray unit has three switches:

The first switch, the CIRCUIT BREAKER, connects the unit to the main electric current supply.

When the timer is lifted off the hook, a second switch, the HOOK ASSEMBLY SWITCH, automatically allows current to go into the transformer.

When the third switch, the exposure push button on the timer, is pushed after the timer indicator has been set for an exposure, the electric current actually begins to generate X-rays.

The circuit breaker might be likened to turning on the ignition switch of an automobile; the lifting of the timer from the hook is like pressing on the starter button to set the engine running; and pressing the button on the timer is like engaging the transmission to actually put the automobile in motion.

Above the housing, on the wall board for mounting the wall type X-ray unit, is an adjustable arm which allows easy positioning of the head of the unit. The head, containing the X-ray TUBE, is the "business end" of the X-ray unit, wherein the X-ray is generated. The CONE extends from the head of the unit; this enables the technician to direct the X-ray more accurately at the area to be roentgenographed.

Adjusting the electric current

When the circuit breaker switch is "ON" and the timer is lifted off the hook, the voltage registers in the compensator voltmeter. If the voltmeter pointer does not show the proper voltage, an adjustment must be made by turning the compensator dial indicator until the reading is within the proper range. This adjustment may only be made when the timer is on the hook; otherwise, an electric arc may jump inside the housing and damage the compensator.

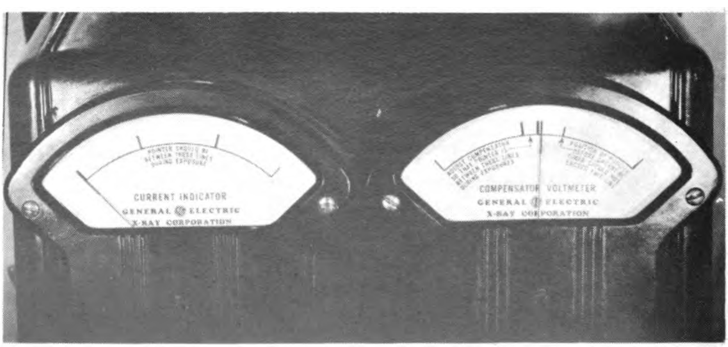

Figure 169.—Current indicator and compensator voltmeter, with no electric current entering the X-ray tube. Instrument panel before generating X-rays.

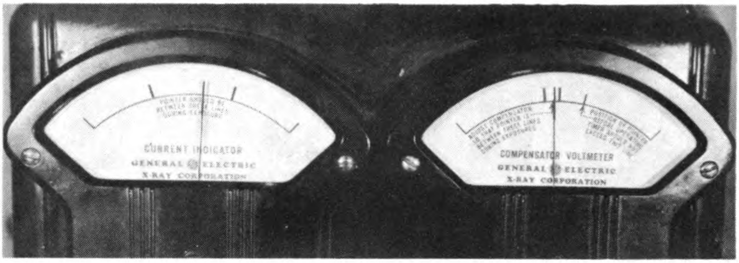

Figure 170.—Current indicator and compensator voltmeter, while X-rays are being generated. Instrument panel during generation of X-rays.

When the button on the timer is pushed to generate X-rays, the technician should watch the other meter, the current indicator, to see that the proper amount of current is passing during actual operation of the X-ray tube. If the amount of current registered is out of the proper range, an adjustment may be made by means of the indicator on the compensator dial (again with the timer hook HELD down). If resetting the compensator does not bring the current indicator pointer within the proper range, the unit should be adjusted by a qualified repairman.

Operating the timer

In order to operate the timer, the desired exposure time in seconds is set on the dial of the timer by means of the timer indicator, after which the timer exposure push button (A) is held down firmly. The generation of X-rays is stopped automatically when the time runs out. The reset button is (B).

Protection of the X-ray Unit

The X-ray unit is a delicate and valuable piece of equipment which may be easily damaged. In areas remote from supply depots, replacement is a slow procedure.

Aboard ship the X-ray unit should be secured when it is not in use. The extension arm which supports the head should be folded tightly and secured with a strap or clamp to keep it from opening up. The head should then be secured to the bulkhead with another strap or clamp. This will prevent the head from moving

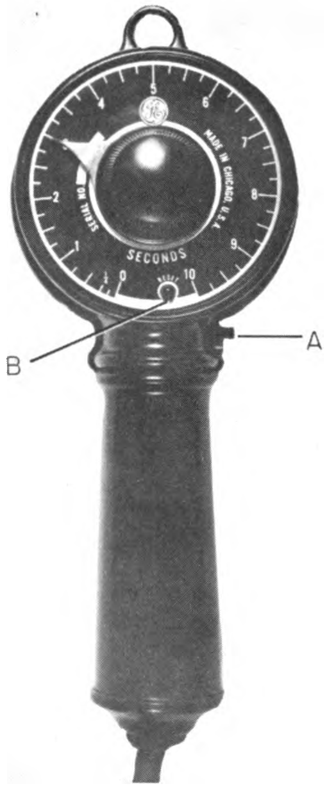

Figure 171.—X-ray timer.

when the ship rolls or pitches. The X-ray unit head should be laid on a bunk during gunnery exercises and propped with pillows, to make sure that shock will not cause damage.

The fragile cone should be pointed upward when not in use. It is less likely to be broken when in this position.

The setscrew which secures the head to the flexible arm should be checked at intervals. This occasionally works loose and, when it does, the head may fall off.

The circuit breaker switch should always be pushed to the "OFF" position when adjusting the electric current by means of the indicator on the compensator dial. Adjustment of the compensator while the electric current is going through it results in burned points in the rheostat.

Dental assistants, for their own safety, should remember that the X-ray unit is a high voltage apparatus. All work or adjustment, other than ordinary adjustment with the indicator of the compensator dial, should be done by a qualified dental repairman.

How the X-ray is generated

The negative part of the electric current, from which the X-ray is developed, is made up of ELECTRONS, tiny particles invisible to the human eye. Inside the X-ray tube the electric current is projected across a space where it strikes a tungsten target with great force. The impact of the electrons on the tungsten causes the tungsten to give off X-rays. The newly formed X-rays have properties and characteristics which are very important:

1. They emerge in straight lines from the target.
2. They affect photographic films or plates.
3. They penetrate all substances; the greater the atomic weight of substance, the less penetration. Thus lead is a very good shield, effectively stopping rays.
4. They cause secondary radiation when they strike objects—which means that while most of the rays penetrate solid substances, some rays are reflected.
5. They cause the fluorescence ("glowing") of certain crystals, such as calcium tungstate or barium sulfocyanide. By the use of these crystals on coated plates next to the film the effect of the X-ray may be increased. These plates are called INTENSIFYING SCREENS.
6. They cause irritation of living tissue cells. In excessive amounts, they cause necrosis of tissue cells. Repeated mild X-ray irritation may cause cancer.

At their point of origin the X-rays leave the target in all directions, but the metal casing of the X-ray head controls them so that the rays escape only through the opening into the cone. Their escape is further narrowed by the use of a metal filter within the cone. This filter allows a still smaller amount of the original X-ray stream to escape and directs the rays more accurately.

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By comparing the central beam of the X-ray with the light from a spotlight, the problem of understanding the divergence of the X-ray beam becomes more simple. The narrow CENTRAL BEAM of an X-ray widens slightly as it leaves the cone. At the standard operating distance of eight inches (from the target—not from the tip of the cone) it becomes necessary to aim the cone so the area being roentgenographed will be within a $4\frac{1}{8}$ inch circle.

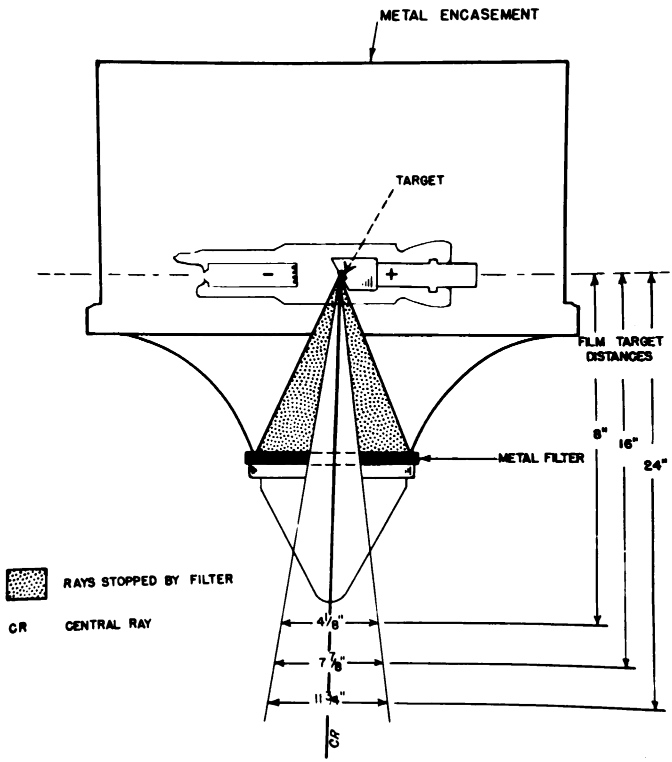


Figure 172.—Divergence of central ray.

The following example illustrates the difference between the action of ordinary light and that of the X-ray: When a tooth is placed in front of a piece of cardboard and a flashlight beam is turned on it, a uniformly dark shadow of the tooth appears on the cardboard. But, if a tooth is placed in front of a film packet and the X-ray beam is turned on it, shadows of the enamel, dentin, pulp, and other structures will all be registered on the film in varying intensity because the ray goes through the tooth. The less dense the material, the more X-ray passes through, and the more intense the shadow.

X-RAY DANGERS AND PROTECTION

The X-ray is very dangerous. Many dentists and patients have received X-ray burns, with terrible after effects.

The technician must never hold the film packet in the patient's mouth while the machine is "ON"; this practice is one of the great hazards of dental roentgenography.

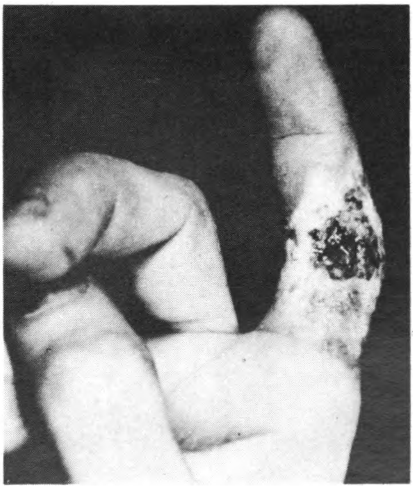


Figure 173.—Malignant X-ray burn resulting from repeated exposure of the technician while holding film packets in the mouths of patients.

It must also be remembered that the 4½ foot cable is put on the unit for the purpose of enabling the operator of the X-ray unit to stand behind the head of the unit out of range of the X-rays when the timer exposure button is pushed. Before the timer button is pushed, the technician must STAND BACK of the X-ray unit head.

The patient also is subject to overexposure and should always be asked if roentgenograms have been made during the previous 2 weeks. The dental officer should be consulted before additional films are exposed if the patient has had more than four or five roentgenograms made of the same area within the past 2 weeks.

The X-ray unit, in its modern form, is perfectly safe if the technician exercises normal precaution:

1. In the first place it must be remembered that the effects of X-ray exposure are cumulative. That is, today's dosage piles up with tomorrow's and next week's until the safety limit has been exceeded. The National Committee of Radiation Protection measures X-ray exposure in a quantity known as roentgens, abbreviated "r", and gives 0.3 "r" per week as the maximum permissible dose, either single or cumulative. To convert the "r" into something understandable, it may be changed into exposure time for a full mouth series of periapical roentgenograms. The technician is exposed to 0.01 "r" when standing about three feet from the cone, and in front of it whenever a full mouth series of periapical roentgenograms is made (14 films). From this it is apparent that the technician who makes 30 full-mouth series of periapical roentgenograms per week is getting the full safe limit of roentgen rays, if exposed to the X-rays each time a full-mouth series is made.
2. The exposure to radiation DECREASES with the distance.
3. In activities where large numbers of roentgenograms are made, technicians should be provided with the additional protection of a lead shield behind which they should stand during the exposure periods.

The most satisfactory simple check on whether a technician is risking overexposure, in spite of observing all precautions, is as follows:

Fasten a penny or paper clip securely over the exposure side of a periapical film packet with the adhesive tape. This must be carried in a pocket of the clothing for a week, and then processed. If the penny or clip is outlined on the film it is evident that the technician is being subjected to radiation.

If this simple test indicates considerable exposure to X-rays, further tests must be made for exposure to radiation, using techniques described in Clinical Dental Roentgenology, McCall and Wald, 2d edition, 1947, Saunders. TECHNICIANS MUST SEEK PROTECTION FROM X-RADIATION.

X-RAY FILM

Dental roentgenograms are divided into two general classes: intra-oral and extra-oral. Intra-oral roentgenograms are made by placing the film packets inside the mouth. Extra-oral roentgenograms are made by placing the film packets, film holders or cassettes adjacent to the head or face and directing the X-ray through the head, jaw or other area being roentgenographed.

Intra-oral films are of several types:

1. Periapical, 1¼" x 1⅝".
2. Posterior bitewing, 1¼" x 2⅛".
3. Anterior bitewing, 15/16" x 1-9/16".
4. Occlusal, 2¼" x 3".

The periapical film is the film most commonly used. It is used to roentgenograph about three teeth of one jaw, and shows the crowns, roots, and investing tissues. While the periapical film is manufactured for making periapical roentgenograms, it may also be used for making bitewing type roentgenograms.

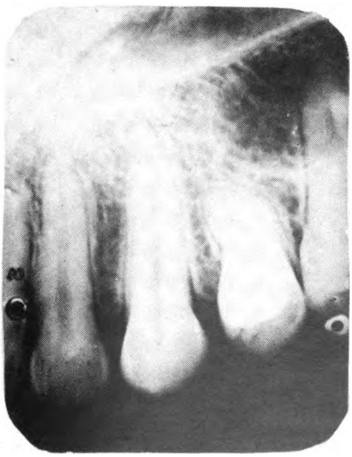


Figure 174.—Periapical roentgenogram.

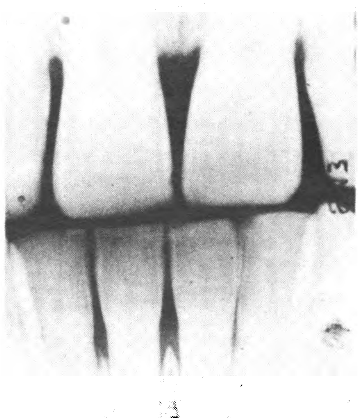


Figure 175.—Anterior bitewing roentgenogram.

The BITEWING FILM records a shadow picture of the crowns and coronal thirds of the roots of both upper and lower teeth on one film.

The anterior bitewing film may picture three or four lower teeth and two or three opposing upper teeth. The posterior bitewing film may picture four or five lower teeth and four or five opposing upper teeth.

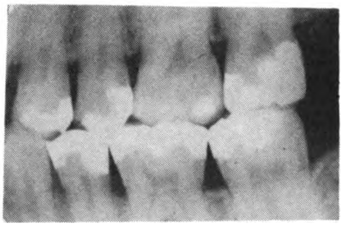


Figure 176.—Posterior bitewing roentgenogram.

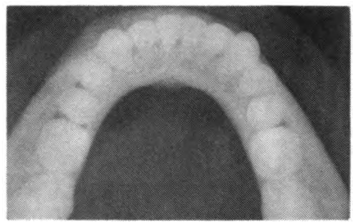


Figure 177.—Occlusal roentgenogram.

The OCCLUSAL FILM is a larger film which is placed horizontally between the occlusal surfaces of the upper and lower teeth. This film enables the operator to picture most of the upper arch and palate, or a large part of the body of the mandible and adjacent structures.

Extra-oral roentgenograms are by necessity made on larger films, such as 5″ x 7″, 8″ x 10″ or larger. These films are not supplied in individual packets and are therefore not immediately ready for use. Because of their size they are packed in boxes, and must be unpacked in a darkroom and be individually inserted into a lightproof cardboard film holder; or into an aluminum film holder called a cassette, which may have intensifying screens. Extra-oral films will be discussed in greater detail in a later section.

The storing of X-ray films

X-ray films, like any other sensitized photographic material, must be protected from many different hazards: The films must be kept in a cool, dry place or they will deteriorate rapidly. They should never be kept near steam lines or radiators.

Many chemicals affect films adversely. Films should never be stored in drug rooms or near chemical laboratories, since exposure to the vapors usually present in such places, may result in decomposition.

Since films are sensitive to X-rays, even at a great distance, they must be kept in lead or lead-lined containers. When several films are to be exposed, they should be taken ONE AT A TIME from the dispenser, exposed, and dropped into a lead or lead lined receptacle. This protects them from being fogged by secondary radiation—the reflection of rays about the room when X-rays are being generated.

Large boxes containing extra-oral films should be stored standing on edge and not flat, so that the films will not be pressed together.

A minimum film stock should be maintained. The oldest film should be used first. By so doing the stock of film will always be fresh and not exceed the exposure limit date.

HOW TO MAKE DENTAL ROENTGENOGRAMS

ANGULATION is the procedure of pointing the cone on the head of the X-ray unit at the correct angle for exposing a film to the X-ray. This procedure actually positions the X-ray tube in the head of the X-ray unit to the angle required for properly directing the center beam of the X-ray to the film. Angulation is important, whatever the type of film to be exposed. Failure to point the cone correctly will result in a distorted roentgenogram, loss of detail or other defects that reduce or destroy the value of the film.

The principles of angulation are explained under periapical X-ray technic.

Periapical roentgenograms

Pointing the cone on the head of the X-ray unit involves two factors: the "side-to-side" pointing of the cone, which is called HORIZONTAL ANGULATION, and the "up-and-down" pointing of the cone, called VERTICAL ANGULATION.

Horizontal angulation

If a light is flashed on two spheres placed side by side and touching in such a manner that shadows of two full circles in contact at one point result, the light must be pointed from directly

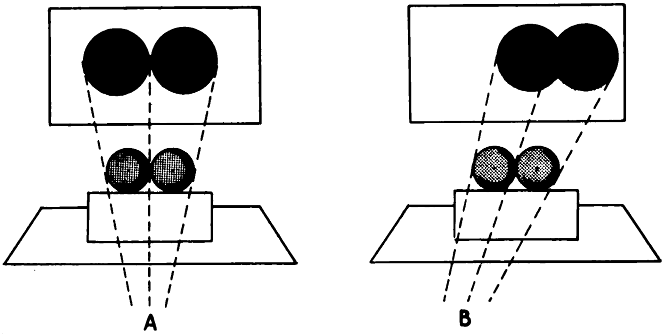


Figure 178.—The effect of horizontal angulation of light related to shadows.

in front and exactly at the contact point of the two spheres. If it is directed from one side or the other, the shadows will overlap, like a blocked-in numeral "8" in a horizontal position.

Similarly, if a shadow picture (a roentgenogram) of 3 or 4 abutting teeth is to be made and not have the shadows of any portion of the teeth overlap, the film packet must be held parallel in a mesiodistal direction to the long axes of the teeth. The central

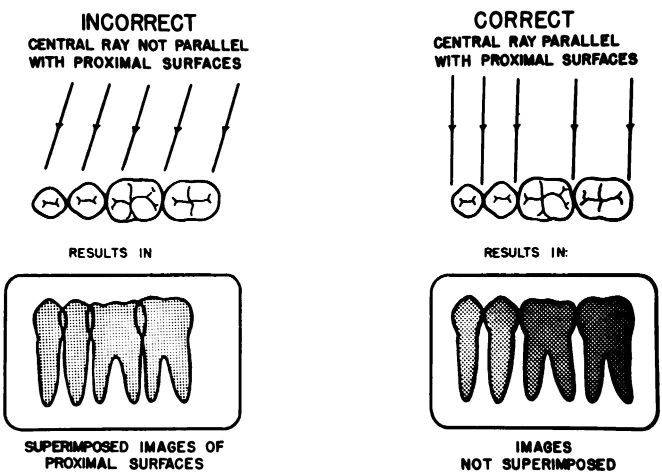


Figure 179.—Horizontal angulation.

ray must be directed at right angles to the plane of the long axes of the teeth and the center of the film packet, so that the central ray penetrates in a direction parallel with the proximal surfaces of the teeth.

Pointing the cone to show distinct proximal surface images instead of overlapped proximal surface outlines is a matter of judgment. The method of general choice is to observe the film packet, teeth, and direction of the cone and make an estimate of the perpendicular relation between the central ray and the plane of the long axes of the teeth and the center of the film packet.

Vertical angulation

While horizontal angulation controls the width and overlapping of images, vertical angulation controls the length of images. In order to understand vertical angulation, the shadow image on an X-ray film may, for example, be compared to a man's shadow on the pavement. Just before and after noon the man's shadow

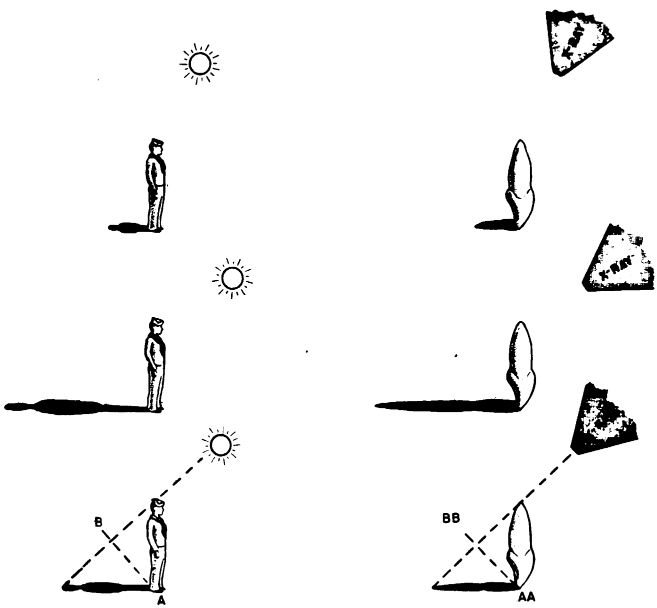


Figure 180.—Foreshortening and elongation of shadow images resulting from variations in vertical angulation.

is short. In the early morning or late evening, when the sun is low, his shadow is long. At one time in the morning and at one time in the afternoon his shadow is exactly as long as the man is tall; that time in fact, would be about midmorning and about midafternoon, when the sun would be at right angles to the imaginary line (line A—B, fig. 180) that bisects (divides into two equal parts) the angle formed by the man and the pavement where his shadow falls.

This principle is used in making periapical roentgenograms. In order to make an X-ray picture with the shadow or image the same length as the tooth, the cone is pointed at right angles to the imaginary line (line AA–BB, fig. 180) that bisects the angle formed by the long axis of the tooth and the surface of the X-ray film packet. Actually, the film packet is not placed in the mouth at right angles to the long axis of the tooth.

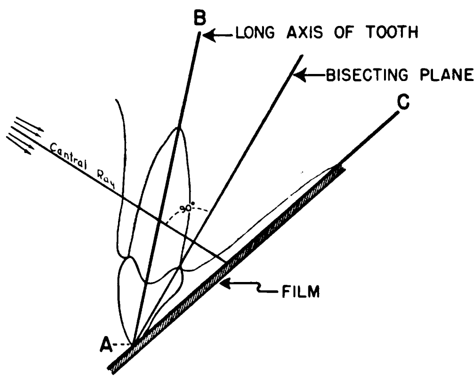


Figure 181.—Central ray at right angles to bisecting plane.

This "Rule of Isometry," formulated in 1907 by Cieszynski, is used regardless of the angle that is formed (as the angle BAC in fig. 181) by the long axis of the tooth (line A–B) and the surface of the film packet (line A–C). The central ray is always directed at right angles to the bisecting plane of the angle formed between the long axis of the tooth and the surface of the film packet.

Arbitrary angulations for making periapical roentgenograms

Because it is difficult for students to visualize the different planes and angles in the mouth, it is best for them to begin making periapical roentgenograms by directing or pointing the cone according to a standard table of vertical angulations. This will make it unnecessary for them to attempt to visualize the imaginary plane which bisects the angle formed by the long axis of the tooth and the surface of the film packet. The following is the standard table:

Maxillary teeth	*Plus*	*Mandibular teeth*	*Minus*
Molars	20°	Molars	5°
Bicuspids	30°	Bicuspids	10°
Cuspids	45°	Cuspids	20°
Lateral incisors	40°	Lateral incisors	15°
Central incisors	40°	Central incisors	15°

The use of these arbitrary angulations will result in satisfactory images except in the case of unusual mouths, for which the technician must learn to make suitable deviations from the table.

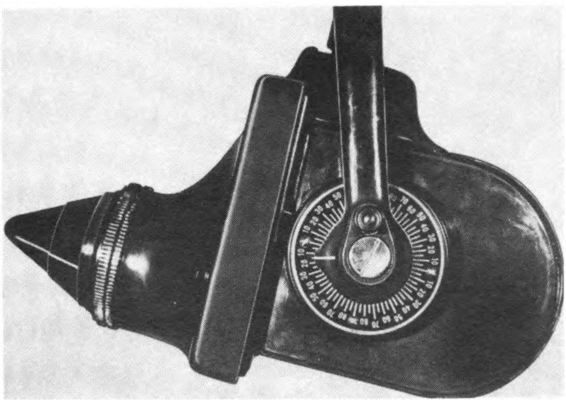


Figure 182.—X-ray unit head with a minus 15 degree setting.

The arbitrary angulations are applied by setting the X-ray unit cone according to degrees of angles marked on one end of the housing of the head of the X-ray unit. Minus angles are readings taken from below the horizontal plane on the angulation guide. Minus readings indicate that the cone is pointed upward, and are used for lower teeth when periapical films are to be exposed.

Plus readings are taken from above the horizontal plane of the angulation guide and indicate that the cone is pointed downward. They are used for upper teeth when periapical films are to be exposed. The illustration, figure 182, shows a reading of minus 15, the correct setting for mandibular central and lateral incisors.

Head position of patient for making periapical roentgenograms

In order to use the arbitrary angulations for making periapical roentgenograms, a fixed head position for the patient must be used. When making upper roentgenograms, the technician must seat the patient in an erect position so that an imaginary line from the ala of the nose (outer border of the nostril) to the tragus of the ear is parallel with the floor.

This makes the occlusal plane of the upper teeth parallel with the floor. The head should be level so that an interpupillary line (between the pupils of the eyes) will also be parallel with the floor.

When the lower teeth are being roentgenographed, the patient's head is tilted back slightly so that an imaginary line from the angle of the mouth to the tragus of the ear is parallel with the floor. Thus, when the mouth is open the occlusal plane of the mandibular teeth is parallel with the floor.

Figure 183.—Head position for making maxillary periapical roentgenograms.

Figure 184.—Head position for making mandibular periapical roentgenograms.

Placement of the film packets for making periapical roentgenograms

The film packet should be placed in the mouth with the exposure side centered behind the area to be roentgenographed. For the posterior teeth (molars and bicuspids) the film packet is placed with its long dimension horizontal and with one edge of the film packet slightly visible above the occlusal surfaces of the lower teeth or below the occlusal surfaces of the upper teeth. The edge of the film packet should be parallel to the occlusal plane of the teeth so that the images of the teeth will be in approximate parallel alignment with the edge of the film.

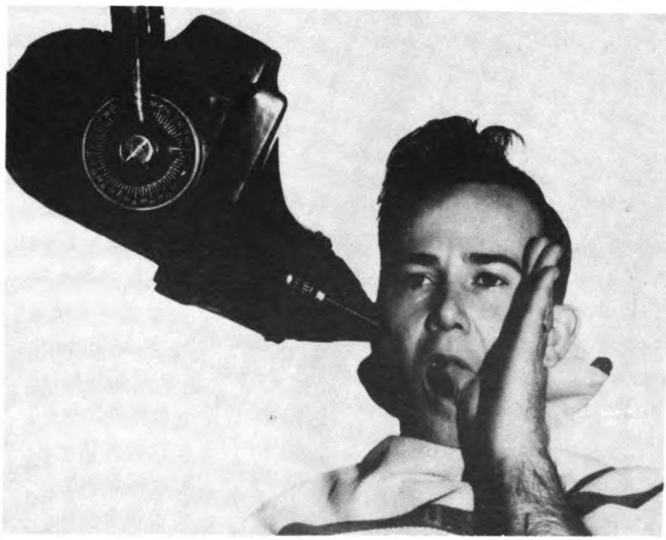


Figure 185.—Tube and patient position for maxillary posterior periapical roentgenogram.

For anterior teeth (incisors and cuspids) the film packet is placed with the long dimension vertical, and one edge of the film packet slightly visible beyond the incisal edges of the teeth.

Certain types of films have emulsion on both sides. The lingual aspects of these films may be identified by the depressed side of an embossed dot in one corner of the film. The location of the

Figure 186.—Tube and patient position for maxillary anterior periapical roentgenogram.

embossed dot on the film is indicated by a printed dot near a corner on the back of the film packet. When placing this type of film packet in the mouth for the purpose of making a roentgenogram this printed dot should always be toward the occlusal surface or incisal edge of the tooth which is to be roentgenographed. This is very important for two reasons:

1. The embossed dot on the film will not appear in an important diagnostic area.
2. The films may be lined up more easily for mounting since the embossed dots will indicate the occlusal or incisal direction of each film.

Holding the film packets for making periapical roentgenograms

The film packet always should be held by the patient, never by the technician. (The technician must not be exposed to x-radiation in this manner). On the upper jaw, the patient's thumb is used to support the film packet, and the index finger is rested on the face to steady the hand as in figure 186. On the lower jaw the index finger is used to hold the film packet, with the rest of the fingers clenched and the thumb resting under the mandible to support and steady the hand. The patient should close the mouth until the upper teeth touch the fingers. This will prevent the lower jaw from moving while the film is being exposed.

During roentgenography of the upper or lower jaw of the right side of the mouth, the patient uses the left hand; on the left side of the mouth, the right hand is used. Additional support can be gained by the patient using the free hand to support the other elbow. The finger pressure on the film packet should be light. Bending the film packet with excessive pressure will distort the image on the film in the same manner that a curved mirror will produce a distorted reflection.

Direction of the cone for making periapical roentgenograms

Even when the technician knows the angulation to apply to the cone, it is a problem to know exactly where to center it, because the film packet and the teeth are covered by the cheek and lips. For this reason imaginary lines are projected on the face.

Figure 187.—Patient position for mandibular anterior periapical roentgenogram.

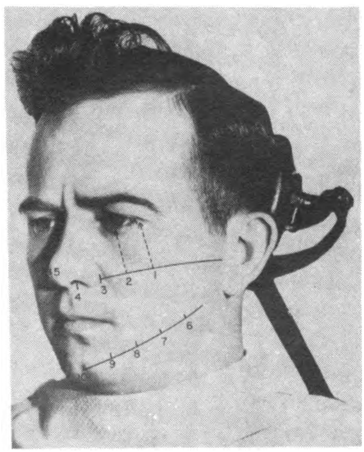


Figure 188.—Cone targets for periapical roentgenograms.

For the upper jaw

An imaginary line is projected from the ala of the nose to the tragus of the ear. Points are laid out on this line below anatomical landmarks to aid the technician in pointing the cone.

1. For the upper molars the tip of the cone is centered on the imaginary line below the outer angle of the eye and below the zygoma (cheek bone).
2. For the bicuspids the cone is centered below the pupil of the eye.
3. For the cuspid, the cone is centered below the ala of the nose.
4. For the lateral incisor, the cone is centered half way between the ala and the tip of the nose, on the edge of the nostril.
5. For the central incisors, the cone is centered through the tip of the nose.

For the lower jaw

An imaginary line is projected ¼ inch above the lower border of the mandible from the angle to the symphysis (fig. 188).

The points at which the cone is directed on the lower jaw are immediately below those described for corresponding teeth of the upper jaw.

Number of exposures for a full mouth series of periapical roentgenograms

The standard Navy, full mouth periapical X-ray examination requires a series of fourteen, 1¼″ and 1⅝″ roentgenograms. Sometimes additional films are needed in order to adequately include all of the teeth. The standard series includes the following separate roentgenograms:

MAXILLARY: (a) The right molars, (b) the right bicuspids, (c) the right cuspid area; (d) the two central incisors, (e) the left cuspid area, (f) the left bicuspids, (g) the left molars. This makes a total of seven roentgenograms for the upper teeth.

MANDIBULAR: the lower teeth are roentgenographed in a similar manner.

Exposure time for periapical roentgenograms

Because of varying density of bone and teeth in different areas, exposure time (the number of seconds to be set on the timer when making roentgenograms) is not the same for all teeth. Average exposure times for periapical roentgenograms are as follows:

Maxillary teeth

	Seconds
Molar	4¼
Bicuspid	3
Cuspid	2¼
Lateral incisor	2½
Central incisor	3

Mandibular teeth

	Seconds
Molar	3
Bicuspid	2½
Cuspid	2½
Lateral incisor	2
Central incisor	2

Exposure time, along with the tables for angulation, should be memorized and also should be posted in the X-ray room.

Order of steps for making roentgenograms

For the purpose of clarity this presentation of the subject of intra-oral periapical roentgenograms began with a discussion of angulation and progressed through head position, placement of the film packet, holding of the film packet, directing of the cone, and exposure time. In practice, the application of these factors to the patient is somewhat different. The technician will actually work in this order:

Seat the patient.

Look at the X-ray request to determine the tooth or teeth to be roentgenographed.

Ask the patient to remove all partial and full dentures. If the patient is wearing glasses have him remove them.

Adjust the head position.

Place the film packet in the mouth.

Direct the cone to the proper angulation.

Center the cone.

Set the timer for the proper exposure time.

Expose the film.

Variations in horizontal angulation

Normally, the horizontal angulation for making a roentgenogram is obtained by pointing the cone at a right angle to the plane of the long axes of the teeth and the center of the film packet in such a manner as to avoid superimposing (overlapping) contact points and proximal surfaces of the teeth.

Sometimes a different horizontal angulation is purposely used. When making a roentgenogram of a multirooted upper tooth, for example, a horizontal angulation with the central beam of the X-ray directed at a right angle to the plane of the film packet may show one root image overlapping another. In order to disclose the covered root, it is necessary to move the cone to one side.

Whenever there is any question of superimposition of one object or area over another, it becomes necessary to change the horizontal angulation, just as it would become necessary to step to one side to see an object hidden by another.

Bitewing roentgenograms

A full mouth, periapical X-ray examination consists of fourteen 1¼″ x 1⅝″ periapical films. It is generally considered however, that, in addition to these, a complete dental X-ray examination requires bitewing roentgenograms of at least the bicuspids and molars. While it may be desirable to also include bitewing roentgenograms of the incisors and cuspids, it is not usually necessary because the periapical roentgenograms of these teeth are, with a few exceptions, adequate for the purposes for which bitewing roentgenograms are made.

The bitewing film is better suited for the purpose for which it is intended than the periapical film. The low vertical angle of projection of the X-ray and the vertical position of the film packet permit the X-rays to pass through the tooth crown and the coronal third of the root at virtually a right angle to the long axis of the tooth. By this procedure, areas are revealed that may be obscured in the periapical roentgenogram because of the high angle from which the X-rays are projected. This type of roentgenogram is especially valuable because it more accurately reveals incipient caries and recurrent caries in proximal surfaces, pulp stones or nodules, recession of pulps, resorption of the alveolar crest of the supporting bone of the teeth, overhanging gingival margins of restorations, faulty proximal contacts of restorations, and deposits of serumal or salivary calculus.

The posterior bitewing film is supplied in a packet with a paper fin or tab which extends across the middle of the long aspect of the exposure side of the film packet. The anterior bitewing film is supplied in a packet with a paper fin or tab which extends across the middle of the short aspect of the exposure side of the packet.

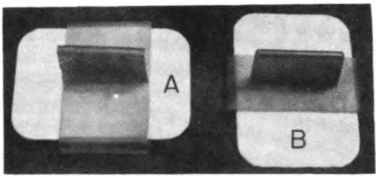


Figure 189.—A—Posterior bitewing film. B—Anterior bitewing film.

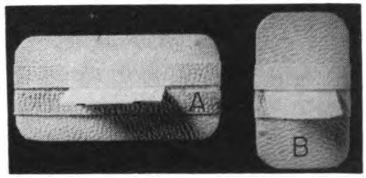


Figure 190.—Periapical film packets prepared with bitewing rubber film holders for making bitewing type roentgenograms of: A—posterior and B—anterior teeth.

Periapical X-ray films may be used for making bitewing type roentgenograms when bitewing films are not available. When this is necessary a special rubber film holder must be used. The holder for posterior teeth has a fin or tab which extends across the middle of the long aspect of the exposure side of the periapical film packet when it is positioned in the holder. The holder for the anterior teeth has a fin or tab which extends across the middle of the short aspect of the film packet when it is positioned in the holder.

In the mouth, the fin or tab extends from the film packet or the rubber holder between the occlusal or incisal surfaces of the upper and lower teeth. The film is held in place by having the patient close his teeth on the tab.

Patient position

The patient's head should be positioned in such manner as will cause the occlusal surfaces of the teeth to be parallel with the floor when the mouth is closed.

Film placement

The inclination of the lingual surfaces of the teeth must be determined and the film packet bent slightly to conform with this inclination. While curving the film packet in this manner produces some elongation of the image, this bending is necessary to keep the film as nearly at a right angle to the central ray as possible in the occlusal area. The film packet must be placed inside the lower teeth and the patient must close down on the paper or rubber tab. This places half of the film packet inside the upper teeth and half of it inside the lower teeth. The film packet is stabilized when the teeth close on the tab. The technician should not pull on the tab while the patient closes because this bends the film packet inside the mouth.

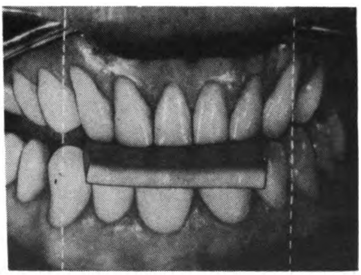


Figure 191.—Anterior bitewing film position.

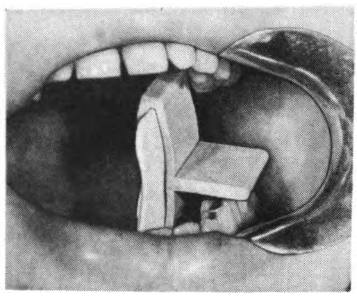


Figure 192.—Placement of bitewing film for posterior roentgenogram.

When using the 1¼″ x 1⅝″ periapical film for making the posterior bitewing type roentgenogram of the molars, the film packet is placed with its long dimension horizontal and with the mesial border slightly anterior to the mesial contact point of the lower first molar.

When using the 1¼″ x 1⅝″ periapical film for making the posterior bitewing type roentgenogram of the bicuspids, the film packet is similarly placed, but with the mesial border just anterior to the distal contact point of the lower cuspid.

When using the 1¼″ x 1⅝″ periapical film for making the anterior bitewing type roentgenogram, the film packet is placed vertically, with the teeth to be roentgenographed centered against the film packet. The central beam of the X-ray is directed between the contact points of the central incisors for a roentgenogram of these teeth. For the lateral incisor and cuspid roentgenogram, the film packet is also placed vertically, with the teeth to be roentgenographed centered against the film packet. The X-ray is directed through the contact points of the lateral incisor and cuspid.

When using the 1¼″ x 2⅛″ posterior bitewing film, the film packet should be placed so that the anterior edge will come well forward into the region of the mesial edge of the lower lateral incisor.

When using the 15/16″ x 1-9/16″ anterior bitewing film, the film packet should be placed with the central incisors centered against the film packet. For a roentgenogram of the lateral incisor and cuspid the film packet should be centered on the contact point of these teeth.

Excessive bending of the film

It should be kept in mind that excessive bending of the film packet results in elongated images of the upper teeth. Where the inclinations of the teeth are such that considerable bending of the film packet is necessary with consequent excessive elongation, it may be necessary to make separate periapical roentgenograms of the upper and the lower teeth in that area, still using the bitewing angulation.

Angulation

The cone is directed at the edge of the paper or rubber tab or fin, midway between the mesial and distal edges of the film packet for all exposures. An angulation of plus 8 is used throughout.

Exposure time

Bitewing films should be exposed for four seconds if the cone is placed close to the cheek or lips.

Making occlusal roentgenograms

The POSITION OF THE PATIENT varies with the exposure to be made.

The film packet is placed between the teeth and the patient is instructed to close the teeth against it. Another technique is to place the film packet against the occlusal surfaces of the teeth and have the patient hold it against the upper teeth with the thumbs, or against the lower teeth with the index fingers—depending on the area to be roentgenographed.

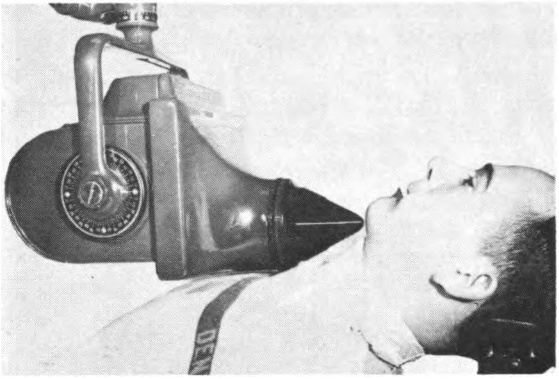


Figure 193.—Tube and patient position for mandibular occlusal roentgenogram.

Figure 194.—Tube and patient position for maxillary occlusal roentgenogram.

Figure 195.—Tube and patient position for maxillary occlusal roentgenogram.

Making extra-oral roentgenograms

Cassettes:

The making of extra-oral roentgenograms requires the use of a piece of equipment which is not used with other types of dental films. As mentioned previously, extra-oral films come in boxes and are not supplied in individual packets; therefore, the films must be placed in holders called CASSETTES before they can be exposed.

A cassette is a hinged, light-proof, aluminum box in which the film is placed prior to exposure. The cassette contains two intensifying screens, which are fluorescent when contacted by the X-rays. The screens light up and produce more intense exposure of the film without requiring an increase in exposure time.

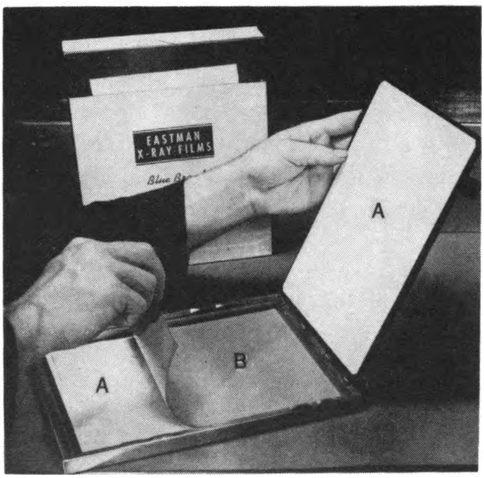


Figure 196.—Cassette. A—Intensifying screens. B—Film.

The screens in the cassette have the appearance of pieces of celluloid, and care should be taken not to soil them when the cassette is open. This is one of the reasons why processing materials should not be mixed on benches which are used for handling films, film packets, cassettes, cardboard film holders, and the metal holders which are used for processing films. Cassettes should be handled carefully. They should never be open, except during the brief period when a film is being inserted or removed. The hands of persons handling cassettes must be dry and free from processing materials. This precaution also applies to the handling of films and film packets and the cardboard film holders.

When loading the cassette, it is necessary to remove the black paper in which the film is wrapped. This must be done gently, the bottom paper being permitted to drop off before the film is dropped into the cassette. The top paper must be removed from the film before the cassette is closed. In removing the film after exposure, the film should be permitted to drop out of the cassette. The fingernails or sharp instruments should never be used for the purpose of picking a film from a cassette. Loading and unloading cassettes must always be done in the darkroom.

It is impossible, in this section on extra-oral roentgenograms, to cover all of the extra-oral types of pictures which occasionally are required by a dental officer. All types of head pictures are described in general X-ray textbooks and many are described in manuals issued by manufacturers of X-ray equipment and films. However, the two most common extra-oral dental roentgenograms or "plates," as they are frequently called, are roentgenograms of the ramus of the mandible and roentgenograms of the body of the mandible.

Roentgenogram of the ramus of the mandible

Patient and cassette position

The right arm of the dental chair is lowered for a roentgenogram of the right side of the mandible; the left arm is lowered for the left side. The patient is seated sidewise with the head extended backward. The headrest is so adjusted that when the cassette is placed on the headrest and the patient's head is against the cassette, the cassette will be at a 45° angle with the floor. The head of the patient is placed so that the ear is flat against the center of the cassette.

Cone Position

The cone is adjusted with a plus 15° angulation and directed just behind and beneath the angle of the mandible. The central ray should pass through the ramus of the mandible on the side to be roentgenographed. The front surface of the housing of the head of the X-ray unit (line AB, fig. 197) should be parallel with the upper edge of the cassette (line CD, fig. 197).

Figure 197.—Correct position for roentgenogram of the left ramus of the mandible.

Exposure time

Because the cassette has intensifying screens, an exposure of only ½ to ¾ second is used.

Roentgenogram of the body of the mandible

Patient position

The head position of the patient is the same as for the ramus of the mandible except that the head is rotated forward so that the body of the mandible is flat against the cassette. The body of the mandible should be just below the center of the cassette. This exposure is commonly referred to as a "lateral jaw."

Cone position

The cone is directed just below the angle of the mandible, on

Figure 198.—Roentgenogram of the body of the mandible.

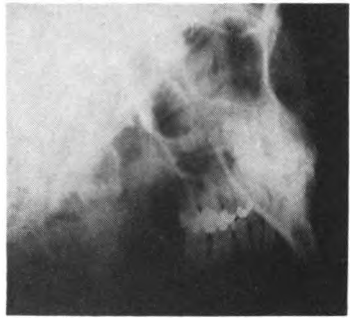


Figure 199.—Lateral jaw roentgenogram.

the side not being roentgenographed, so that the center beam of the X-ray will pass through the first molar region of the side to be roentgenographed. The angulation of the cone should be plus 25°.

Exposure time ¾ second.

Roentgenograms of the bones of the face

Patient position

Two frequently used positions for the "P A" or posteroanterior roentgenogram are as follows:

A. Place the patient's nose and forehead against the cassette which is held parallel with the floor, against the chair headrest.
B. Place the nose and chin against the cassette which is positioned as in the above technic.

Cone position

A. The cone is adjusted so that the central ray is perpendicular to the cassette; the cone touches the back of the head at the occipital crest.
B. With cone touching the neck 1½″ below the occipital crest, direct the central ray parallel to the occlusal line of the teeth (approximately plus 70°).

Exposure time

4 seconds; with grid, 8 seconds.

Figure 200.—Relation of film, patient and cone for taking roentgenogram of bones of the face.

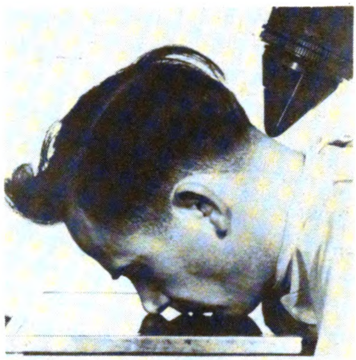


Figure 201.—Variation of Figure 200.

Figure 202.—Roentgenogram of bones of the face.

Figure 203.—Tube, patient and film position for roentgenogram of bones of the hand.

Trunk and extremity roentgenograms

In some ships and at some stations the only X-ray facilities are those in the dental departments and it may be necessary to make some types of roentgenograms which normally would be made with the more powerful medical X-ray units. Figures 203 through 209 will serve as guides for making the more common nondental roentgenograms. The dental X-ray unit is operated at the standard electric current indicator reading for all types of roentgenogram—dental and nondental.

Figure 204.—Tubo, patient and film position for roentgenogram of the elbow.

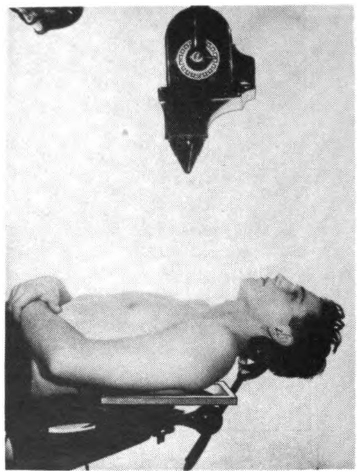


Figure 205.—Tubo, patient and film position for roentgenogram of the shoulder.

If it is necessary for the technician to refer to a medical textbook for the technic for making an unusual roentgenogram, it must be remembered that the medical X-ray unit operates at from 30 to 100 milliamperes instead of the 10 milliamperes of the dental unit. Medical X-ray units are operated at a greater target-film distance. Moreover, medical roentgenograms are not always made with cassettes and intensifying screens. For some types of medical roentgenograms the film is placed in cardboard film holders because less X-ray radiation is required than with the use of cassettes. All of these reasons indicate why the exposure time which may be stated in the medical text can not be used with a dental X-ray unit.

Figure 206.—Tube, patient and film position for roentgenogram of the feet.

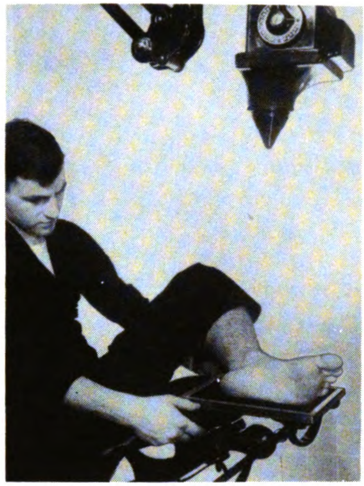


Figure 207.—Tube, patient and film position for roentgenogram of the ankle.

Figure 208.—Tube, patient and film position for roentgenogram of the knee.

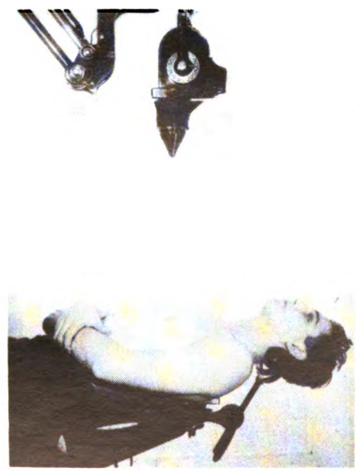


Figure 209.—Tube, patient and film position for roentgenogram of the chest.

Roentgenograms of the extremities are made with the dental X-ray unit at a target-film distance of 24 inches. Roentgenograms of the trunk, such as chest plates, are made at a target-film distance of 36 inches.

The cassette or cardboard film holder is always in a horizontal position. The cone is directed downward at a 90° (vertical) angle.

It is assumed that the available cassettes will contain intensifying screens.

PROCESSING X-RAY FILMS

The darkroom

The processing of X-ray films is done in the darkroom. Some light is furnished by a safelight which provides sufficient illumination for handling films. Light furnished by the safelight is usually of a ruby red color, and of an intensity that will not affect undeveloped film within a reasonable time (1 minute at 3 feet). Safelight bulbs should be 10 watts; brighter lights should not be used. The minimum permissible distance from a safelight to the handling area of dental films is 3 feet.

The processing tank has three sections for holding:

a. Developer solution

b. Running rinse water

c. Fixer solution

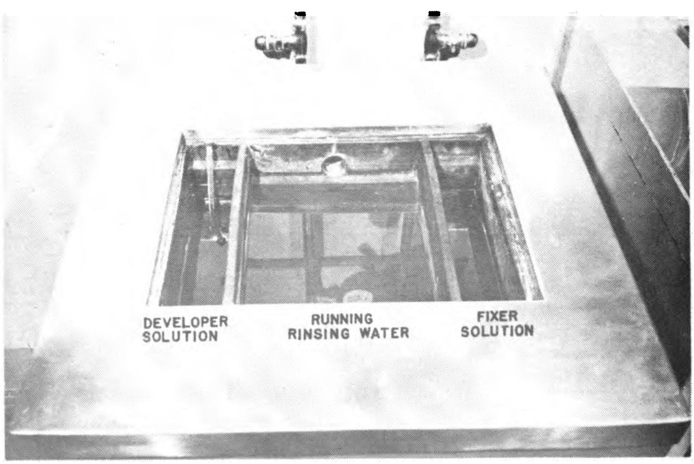


Figure 210.—Processing tank.

The developer solution should be in the left section, the running rinsing water should be in the center section and the fixer solution should be in the right section of the processing tank. The contents of each section should be indicated in large lettering in a conspicuous place near each section of the processing tank. Conspicuous lettering on the top of each lid should indicate the lids for the developer solution section and the fixer solution section.

A FLOATING THERMOMETER should always be in the section of the processing tank containing developer solution.

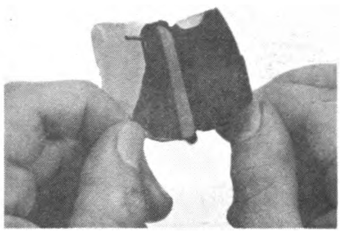


Figure 211.—Removal of film by the edges.

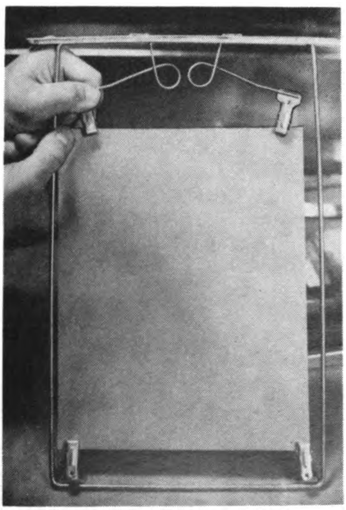


Figure 212.—Film holder for processing extra-oral films.

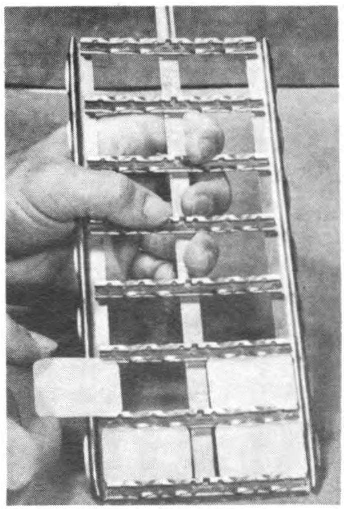


Figure 213.—Film holder for processing periapical and bitewing films.

Film holders or hangers of several types for processing X-ray films should be conveniently available in the darkroom. One type should be for periapical films and bitewing films, and the other types for larger films such as occlusal and extra-oral films.

Films should be handled by the edges when they are removed from packets, cassettes or cardboard film holders and carefully inserted into the metal processing film holders or hangers.

An interval timer alarm clock for timing the immersion periods of films in the processing solutions should be in a convenient place in the darkroom.

The equipment of the darkroom should include:

A white enamel bucket for mixing solutions, 2 glass graduates (1,000 cc.) for measuring solutions and a glass stirring rod about 16 inches long.

Time-temperature processing

The amount of time required for the developing of X-ray film depends largely upon the temperature of the developer solution. The ideal time-temperature ratio is a developing time of 4½ minutes in a developer solution at a temperature of 68° F. Variations from this are allowable:

	Temperature	*Time*
	° F.	*Minutes*
	60	6½
	65	5
Ideal	68	4½
	70	4
	75	3

A copy of this time-temperature processing table should be posted in a conspicuous place in the darkroom for the convenience of all persons who may process film. When fresh developer solution is being used it may become necessary to reduce the developing time by a minute or more. When developer solution has been used for some time it may become necessary to extend the developing time by a minute or more.

A great many films may be processed in a gallon of developer solution, but this solution should be changed before it becomes dark brown in color. In the average naval dental activity developer solutions should be changed every three weeks.

The chief loss of potency of developer solution is caused by exposure of the solution to air. The developer solution section of the processing tank should always be covered, except when inserting or removing films.

Developing

The temperature of the developer solution must be checked, after which the interval timer clock must be set for the proper developing time. The film is then placed in the developer solution and agitated slightly to release air bubbles. It is removed when the bell rings.

Rinsing

The running water in the center rinsing section of the processing tank should be approximately the same temperature as the developer solution and fixer solution. The developed film should be dipped into the center rinsing section of the processing tank and agitated for from 15 to 30 seconds for the purpose of washing off all traces of the developer solution. The water should be shaken from the film after which the film must be placed in the fixer solution. The alkaline developer solution should not be carried into the acid fixer solution. Particular care must be exercised that no fixer solution gets into the developer solution. Both solutions should be kept tightly covered, especially at sea because of the ship's motion.

Fixing

The fixer solution removes the unaffected halide salts and hardens the emulsion. Films should be briskly agitated when they are placed in the fixer solution, and left there for approximately 10 minutes or until all trace of the light yellow-appearing emulsion disappears. All of the foregoing steps are accomplished in the darkroom with no light except the safelight. After a film has been in the fixer solution for 3 minutes, light will no longer affect the emulsion.

Washing

From the fixer solution the films are placed in the water in the center rinsing section of the processing tank for washing. They must be washed for at least 20 minutes in running water. This step is just as important as the others and must not be slighted.

Drying

Films should be dried thoroughly. The time involved depends on the humidity and circulation of air. Films should never be dried in a temperature exceeding 100° F., or near a source of heat such as a radiator, because such practice results in curled film.

Processing X-ray films at high temperatures

Occasionally it may become necessary to process X-ray films at temperatures in excess of 78° F., especially in tropical climates where refrigerated tanks may not be available. In order to accomplish this, sodium sulfate (desiccated) is added to the developer solution in amounts shown below in the table. The other phases of processing are also changed markedly.

Temperature F	78 to 80	90	100	110
Grams sodium sulfate per gallon of developer solution	200	300	600	800
Developer solution (minutes)	3 to 4	3	2	1
Fixer solution (minutes)	10	5 to 10	5 to 10	5 to 10
Washing in running water (minutes)	15	15	15	15

In making up the fixer solution for high temperature processing only one-half the amount of water recommended in the instructions which come with the powders is used.

The films should be carried from the developer solution to the fixer solution without rinsing. For this reason it is necessary to change the fixer solution more frequently than under ordinary circumstances.

It must be remembered that at 110° F., the developer solution is saturated with sodium sulfate and with a drop of from 5° to 10° in temperature, crystallization will occur. The temperature must be carried back to 110° to redissolve the crystals.

Preparation of solutions

X-ray film developer solution and fixer solution must be mixed in accordance with the instructions on the containers. An enameled bucket, preferably white, should be used for mixing solutions. Two 1,000 cc. glass graduates and a glass rod for stirring are also necessary accessories.

Causes of faulty roentgenograms

Faulty roentgenograms result from many types of errors. There are 16 different classes of faults:

1. No image—caused by:
   - (a) Electric plug not in, circuit breaker switch off, timer not lifted from hook, timer button not pushed down hard, or the voltage compensator indicator not on a contact point.
   - (b) Film placed in fixer solution before being placed in developer solution.
   - (c) X-ray unit head not making proper contact with electric current supply due to loose locking-collar.
2. Thin image—caused by:
   - (a) Insufficient exposure or developing time.
   - (b) Use of excessively cold or exhausted developer solution.
   - (c) Use of diluted developer solution.
3. Dense image—caused by:
   - (a) Too long exposure to X-rays or too long developing time.

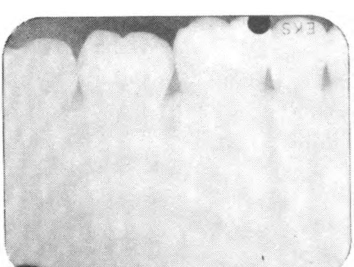


Figure 214.—Thin image.

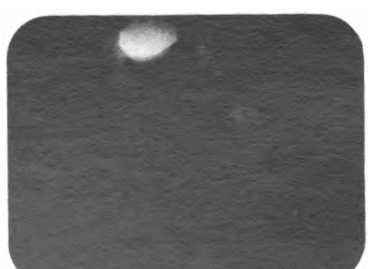


Figure 215.—Dense image.

(b) Use of a too warm developer solution.
(c) Use of a concentrated developer solution.
4. Partial image—caused by:
(a) Film not completely immersed in the developer solution.
(b) Film in contact with another film in the developer solution.
(c) The center beam of the X-ray is focused off the film in periapical films or off center in bitewing or extra-oral films.
5. Foreign image—caused by:
(a) Eyeglasses, rubber dam clamps, removable bridges, partial dentures, amalgam in tooth sockets, shot in tissues.
(b) Radiopaque objects in the cone.
(c) Fingers interposed between the film packet and the cone.
6. Blurred image—caused by:
(a) Movement of the patient, film or X-ray unit head.
(b) Double exposure.
7. Distorted image—caused by:
(a) Film packet bent during exposure.
(b) Improper angulation.

Figure 216.—Foreign image.

Figure 217.—Distorted image (right).

8. Fogged film—caused by:
   (a) Unintentional exposure of film to X-rays because of improper storage.
   (b) Use of over-age film or film that has been exposed to heat or chemical fumes.
   (c) Improperly mixed or contaminated developer solution.
   (d) Safelight screen: bleached, thin or cracked.

NOTE: Fog may be described as a dark gray appearance of the film, with a loss of detail and an absence of the contrasting light elements of the picture. (The roentgenogram lacks contrast or sparkle.)

9. Stained or streaked film—caused by:
   (a) Dirty solutions.
   (b) Unclean film holders or hangers.
   (c) Insufficient fixing or washing.

Figure 218.—Fogged film.

Figure 219.—Stained film.

Figure 220.—Black spots on film.

Figure 221.—Fingerprinted film.

10. Black spots—caused by: bending the film packet to the extent that the packet cracks open and admits light.
11. Fingerprinted films—caused by: handling the films by flat surfaces instead of placing fingertips on the edges.
12. Reticulation—caused by: carrying the film from a warmer to a colder solution or use of processing solution of over 80° F. Reticulation is a netlike appearance of the film. The film may appear to be covered with little globules.
13. Herringbone image—caused by: placing the type film packet which has one smooth surface and one "pebble effect surface," in a manner which causes the smooth surface to be toward the cone.

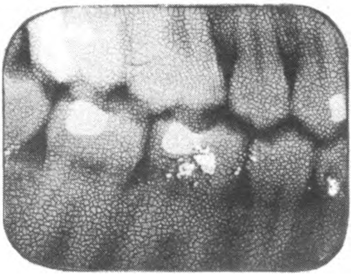


Figure 222.—Reticulation.

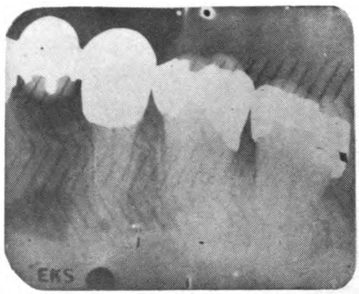


Figure 223.—Herringbone image.

14. Bleached image—caused by: leaving film in a freshly mixed fixer solution for too long a time, especially at elevated temperatures.

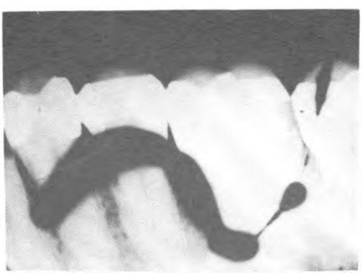


Figure 224.—Black areas on film.

Figure 225.—Crescent shaped lines.

15. Black areas on film—caused by: discharge of static electricity, due to pulling a film from its paper wrapping too rapidly in a dry atmosphere.
16. Crescent-shaped lines—caused by: damage to the emulsion resulting from sharp bending of the film packet.

Mounting dental roentgenograms

Dental roentgenograms must be mounted in their anatomical relationship in cardboard film mounts. In mounting them it should be remembered that roentgenograms are viewed as if the observer were looking from the back of the patient's head forward and out through the teeth. Regular film has a glossy side which has no emulsion and a dull side which is the emulsion side. Films should be mounted with the glossy side toward the observer. The so-called radiatized films have emulsion on both sides and are therefore dull on both sides. They have an embossed dot in one corner, the depressed side of which indicates the lingual aspect of the film. These films are mounted with the raised side of the

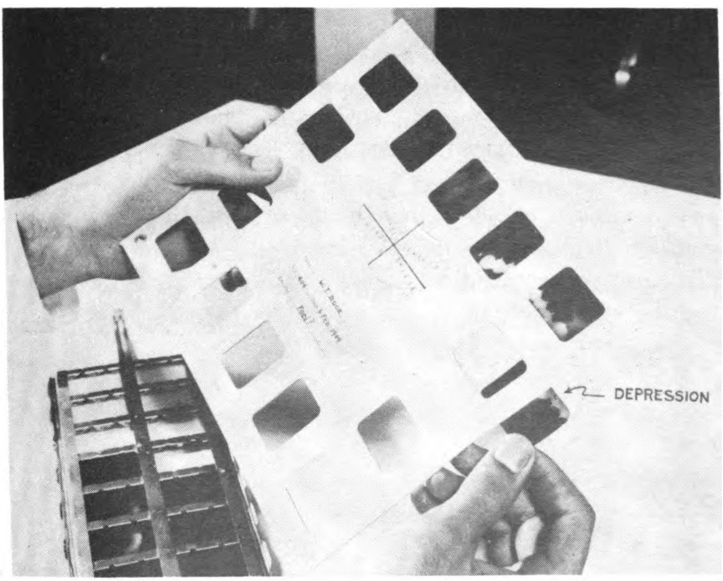


Figure 226.—Periapical film mount.

embossed dot away from the observer (the depressed side of the embossed dot facing the observer).

Film packets having an embossed dot in one corner should be placed in the mouth with the printed dot (on the back of the film packet) directed toward the occlusal surfaces or incisal edges of the teeth. As long as this direction is obeyed, periapical films may be speedily and easily mounted in their proper places. The embossed dots will all be in the same corner of the films.

Filing films

Roentgenograms are filed, and maintained carefully because of their future value. Roentgenograms over six months old are not considered of value for diagnosis of dental disorders, yet these older films are very valuable for comparison with current roentgenograms of the same area for the same person at a later date. When the dental officer is noting treatment or patient progress they are of further value as records.

Individual films are stored in envelopes which are available for that purpose, in alphabetical order of the names of the persons for whom the roentgenograms were made. Essential data should be written on the envelope as follows:

Name, Rate or Rank, Age and Date of Exposure.

Files of films which are mounted in cardboard film mounts also should be maintained and similar information should be written on the mounts.

Roentgenograms in film mounts should be filed intact in mounts as should individual films in small envelopes. A larger envelope will be most satisfactory for keeping all roentgenograms for one individual in one location.

CHAPTER 10

OPERATING ROOM ASSISTANCE

The efficiency of a dental operating room is measured by the teamwork between the dental officer and his assistant. Achievement of speed and consideration of patient welfare will be most effective when there is mutual understanding and interdependence between the two team members. Application of the Golden Rule and anticipation of the movements of the dentist are the foundation stones for a successful career as a dental assistant.

Answering the Telephone

The following adaptation from a Signal Corps pamphlet is presented in part:

1. Speak directly into the instrument. Speak in well modulated, courteous and distinct tones. Identify activity by name, giving your rating and name. Example: "Oral Surgery, dental technician Jones speaking, Sir."
2. Compensate for lack of facial expressions that extend courtesy with such phrases as, "I'm sorry, Thank you, Please, Would you mind?"
3. Make the person who talks to you over the telephone glad that he called. The expression in your tone of voice should be that of genuine desire to be helpful. Be cheerful and businesslike.
4. Keep an appointment book, note pad and pencil adjacent to the telephone.
5. Try to conclude the conversation without calling the doctor to the telephone; his chair time is valuable. If it is necessary that the doctor come to the phone, you should remain near the patient and observe his needs. Wash operative debris from the mouth with a stream of warm water, adjust the

saliva ejector or perform any service that will make the patient comfortable until the dental officer returns.

6. The size of a military establishment makes it difficult for a stranger to know where to call to obtain information. When you receive a call that does not relate to your work, do all you can to assist. The reputation of your organization will be enhanced if you attempt to complete all of the calls which you receive.

Preparation for the Patient

Before a patient is admitted to the operating room, the assistant should remove every trace of the materials used in treating the previous patient—operating instruments, wax drinking cup, glass slabs, cotton rolls, handpiece or wax. A new cover should be placed on the bracket table, a clean headrest cover on the chair, spray bottles refilled if necessary, saliva ejector removed from the tubing, and the top of the cabinet covered with a clean towel or wiped with an antiseptic solution. The chair arms, top of waste receptacle and cuspidor should be wiped off. The assistant should turn the switch of the operating unit to an ON position and should check the light, air syringes, spray bottles and water syringe. The patient's dental chart, roentgenograms, study models or other pertinent data should be placed on the instrument cabinet or some other suitable stand for the convenience of the doctor. The chair should be placed in a lowered position to facilitate the seating of the patient. The platform of the chair should be about 8 inches from the floor and the bracket table and engine arm should be swung out of the way in order that the patient may seat himself without difficulty. The height and inclination of the back of the chair, and the headrest should be set for the average person; this setting is marked on the chair. If these preparations are carried out before the patient enters the operating office, a feeling of security will be created in the patient when he observes a clean and orderly operating room.

Seating the Patient

The assistant should stand behind the chair as the patient is being seated in order to make immediate adjustments for his comfort. The patient will usually place the left foot on the platform and slide back against the backrest, which should then be elevated or lowered until its top is on a line with the lower part of his shoulder blades. In this position the backrest provides the most support. Care must be taken to adjust the chair so that the point of greatest pressure is near the top of the backrest and across the lower part of the patient's shoulder blades when he sits back normally. If this part of the chair is too low, the patient will attempt to shift it by sliding forward in the chair. The headrest should be adjusted to support the patient's head at the base of the skull, with his head and neck held as if he were sitting in a normal erect position without a back support. In this upright position muscle strain is at a minimum and swallowing is easiest.

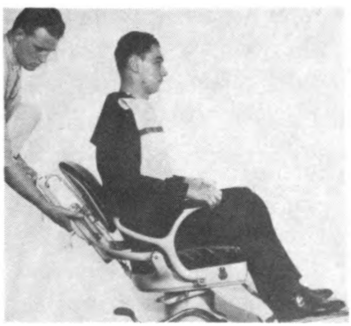


Figure 227.—Adjustment of backrest.

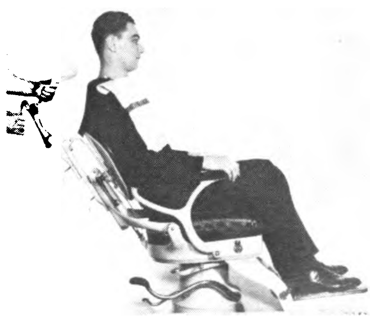


Figure 228.—Adjustment of headrest.

Figure 229.—Patient properly seated.

Breathing is difficult if the head is too far forward. The inclination of the chair varies according to the operation. For example, when operating on mandibular teeth, the chair should be slightly off the vertical position. A good rule is to have the occlusal plane of the patient's mandibular teeth parallel with the floor when the mouth is open. If the patient is tipped too far back, the anterior teeth will cut off the light to the posterior part of the mouth.

After the chair has been adjusted to a comfortable and proper operating position, take a dental towel from the cabinet, unfold and fasten with a clip around the patient's neck to provide maximum protection. Then instruments for the operation may be taken from their proper place in the cabinet and laid on the bracket table. The dental handpiece and saliva ejector to be used should be placed after the patient is seated, so that their cleanliness is apparent to him. Before his arrival, air and water syringe tips should have been wiped with a gauze napkin moistened with alcohol or some other suitable agent. Mouth mirror, explorer, and cotton pliers should also be set out after the patient is seated. They should be neatly arranged in the center of the bracket table on a gauze napkin—never hanging over the edge. The operating light should be turned on and adjusted to the field of operation as the doctor approaches the patient.

Assisting the Dental Officer

No part of the dental assistant's duties is more important than providing competent assistance during the operation. He must be familiar with each step of the operation to anticipate the needs of the doctor and to have the instruments and materials at hand when required.

As the operation progresses the instruments and materials no longer required should be removed. The dental assistant, by judicious use of the air and water syringes, can keep the operative field free from tooth and other debris; he should exercise care so that debris is not blown into the face of the operator, patient, or assistant. Assistance as directed in the changing of mandrels, burs and mounted stones will contribute to the speed of the operative procedure. As instruments are returned to the bracket table, a piece of gauze is used to wipe them clean. The wiping of spoon excavators, scalers and plastic instruments is helpful.

Familiarity with operative procedures will enable the assistant to pass the proper instruments from the bracket table to the hands of the operator. In accomplishing this, the instrument should always be lifted from the bracket table by the end of the handle and passed to the operator with the working end toward the patient's mouth. It should only be necessary for the operator to withdraw an instrument a short distance away from the patient before the assistant removes it from his grasp and replaces it with the instrument needed for the next step of the operation.

As medicaments are needed they should be placed on the bracket table and identified for the doctor. Following preparation of the cavity in restorative procedures, a cement base or cavity lining may be needed. Anticipate their use either by query of the operator or by knowledge of his operating routine.

Instruments should be kept clean and neatly arranged on the bracket table at all times. They should be removed as soon as the operator has finished using them. For example, instruments used in cavity preparation normally may be removed when the filling material is to be prepared for insertion. If a cement base is required it should be mixed in sufficient time to be of the proper consistency when required. Amalgam, silicate cement or other material to be inserted should be prepared by the assistant to be ready when needed.

Usually instruments used in preliminary steps will be sterilized for the necessary length of time, and may be removed when instruments from successive steps are placed in the sterilizer. Instruments should always be cleansed and scrubbed with soap and water before sterilizing. Instruments, with movable working parts such as handpieces, matrix retainers and other instruments susceptible to corrosion, may be sterilized in mineral oil, brought to 250° F. in a specially adapted sterilizer. Dressings, linens and materials used in oral surgery must be autoclaved. Sterile instruments used in oral surgery must never be touched by the bare hands but should be handled by sterile instrument forceps, sterile towels, or when wearing sterile gloves.

As the operation nears completion only those instruments actually being used will still remain on the bracket table. Other instruments will have been sterilized, or be nearing completion of sterilization, and will be ready to be dried and put away. Instruments should never be allowed to accumulate on the sterilizer stand or cabinet top. They should be placed in their proper trays as soon as cleansed and sterilized. Instruments which need resharpening should be laid aside before sterilizing. When the operation is completed, the towel is removed and the chair lowered. The treatment performed is recorded immediately and the patient is given a future appointment, if necessary. Then the operating room is cleaned and made ready for the next patient. At the close of the working day, a careful check of the operating room should be made, all instruments should be in their respective places, and the stock of materials should be checked and replenished where necessary. The instrument cabinet should be clean in all its parts; vitreous instrument trays washed periodically, all instruments and materials within the cabinet should be arranged efficiently and systematically. No personal gear should be stowed in any of the drawers of the cabinet.

The personal cleanliness of the dental assistant is of prime importance. Hands and forearms must be scrubbed in sight of the patient, fingernails must be clean and the hair neatly trimmed. Rings, wristwatches and other jewelry, which prevent scrubbing the hands and forearms, should not be worn. The clothing and general appearance of the dental assistant may have a great influence on the patient's impression of cleanliness in the dental operating room. This creates a feeling of confidence which helps to make the patient feel he is in competent hands.

Nomenclature of Dental Instruments and Accessories

Hand instruments are usually divided into parts: handle, shank, blade and cutting edge. The HANDLE is ordinarily straight and of a size to comfortably fit a finger grasp so that it may be used most effectively. The SHANK is that part of the instrument between the blade and the handle. The BLADE is the terminal part of the instrument which carries the working point or cutting edge. The CUTTING EDGE is the beveled working end of the instrument. In the case of an amalgam condenser the terminal or working end is called the NIB. The working surface or end of the nib is called the FACE.

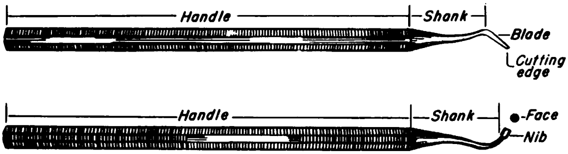
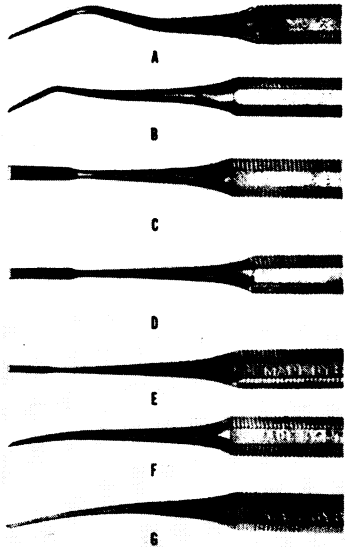


Figure 230.—Parts of a hand instrument.

Dr. G. V. Black, the father of modern dentistry, classified instruments in the following manner: ORDER names which denote the purpose for which the instrument is to be used, as mallet, excavator, clamps; SUBORDER names which define the manner or position of use of the instrument, such as hand mallet, molar clamp; CLASS names which describe the working point of the instrument, such as spoon excavator, inverted cone bur; SUBCLASS names which indicate the shape of the shank, such as binangle, contra-angle. He also evolved the instrument formula by which instruments could be readily duplicated anywhere. The number of a gingival margin trimmer is given as 15–95–8–12R. The first two digits (15) of the formula designate the width of the blade in tenths of a millimeter, the third and fourth digits (95), its length in millimeters, the fifth digit (8) represents the angle which the blade forms with the axis of the handle, expressed in hundredths of a circle (centigrades). With instruments in which the cutting edge is at an angle to the length of the blade, the sixth and seventh digits represent the angle made by the edge with the axis of the handle, expressed in centigrades. The letter (R) or (L) signifies that the instrument is one of a pair, made in rights and lefts in order to work efficiently on both sides of a cavity. Instruments supplied to the armed services generally have a number near the nonworking end of the handle. For example, the instrument just described may be identified by the number 77; it is a gingival margin trimmer.



A—Instrument, Cutting, Black, No. 81 (Binangle chisel).
B—Instrument, Cutting, Black, No. 83 (Binangle chisel).
C—Instrument, Cutting, Black, No. 84 (Chisel).
D—Instrument, Cutting, Black, No. 85 (Chisel).
E—Instrument, Cutting, Black, No. 86 (Chisel).
F—Chisel, Wedelstaedt, No. 41.
G—Chisel, Wedelstaedt, No. 42.

Figure 231.—Chisels.

A—Instrument, Cutting, Black, No. 51 (Enamel hatchet).
B—Instrument, Cutting, Black, No. 52 (Enamel hatchet).
C—Instrument, Cutting, Black, No. 53 (Enamel hatchet).
D—Instrument, Cutting, Black, No. 54 (Enamel hatchet).
E—Instrument, Cutting, Black, No. 77 (Gingival margin trimmer).
F—Instrument, Cutting, Black, No. 78 (Gingival margin trimmer).
G—Instrument, Cutting, Black, No. 79 (Gingival margin trimmer).
H—Instrument, Cutting, Black, No. 80 (Gingival margin trimmer).

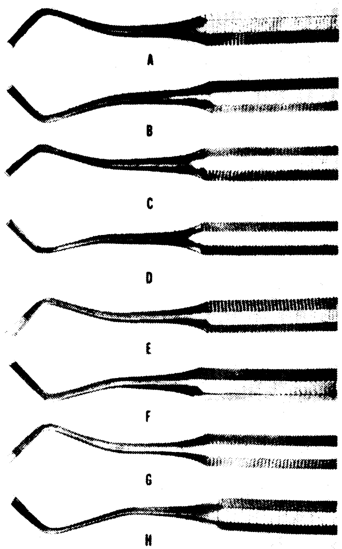
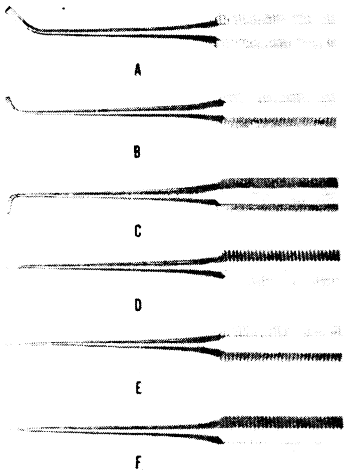
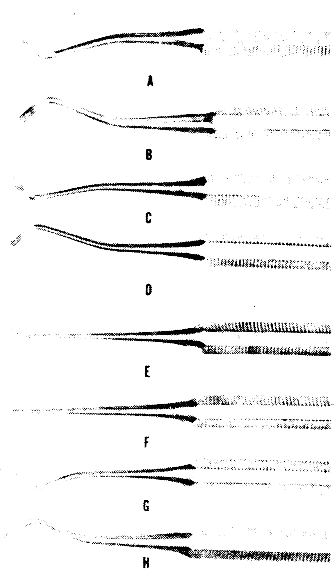


Figure 232.—Enamel hatchets and marginal trimmers.



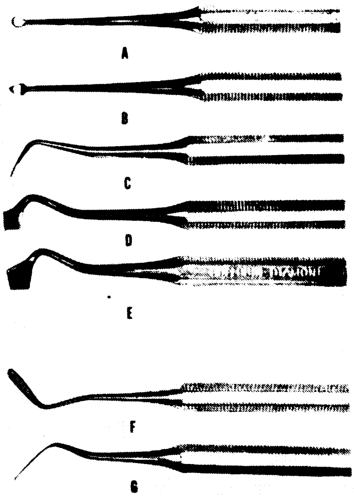
A—Instrument, Cutting, Black, No. 8 (Hatchet).
B—Instrument, Cutting, Black, No. 17 (Hatchet).
C—Instrument, Cutting, Black, No. 23 (Hatchet).
D—Instrument, Cutting, Black, No. 29 (Hoe).
E—Instrument, Cutting, Black, No. 30 (Hoe).
F—Instrument, Cutting, Black, No. 34 (Hoe).

Figure 233.—Hatchets and hoes.



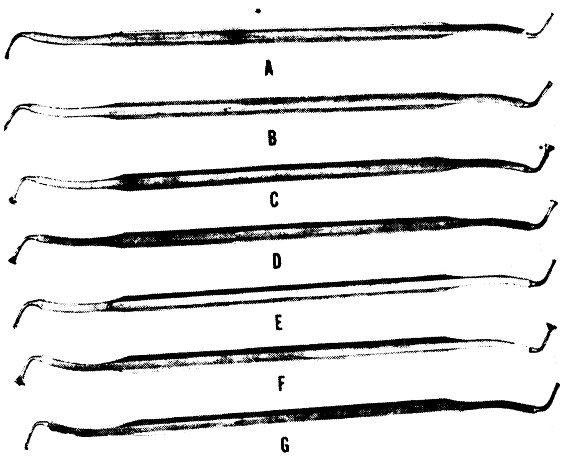
A—Instrument, Cutting, Black, No. 63 (Spoon).
B—Instrument, Cutting, Black, No. 64 (Spoon).
C—Instrument, Cutting, Black, No. 65 (Spoon).
D—Instrument, Cutting, Black, No. 66 (Spoon).
E—Excavator, Darby-Perry, No. 5.
F—Excavator, Darby-Perry, No. 6.
G—Excavator, Darby-Perry, No. 21.
H—Excavator, Darby-Perry, No. 22.

Figure 234.—Spoons and excavators.



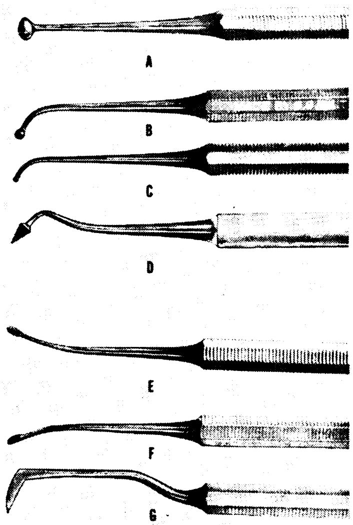
A—Instrument, Cutting, Black, No. 89 (Discoid).
B—Instrument, Cutting, Black, No. 92 (Cleoid).
C—Carver, Amalgam, Frahm, No. 1
D—Carver, Amalgam, Frahm, No. 2.
E—Carver, Amalgam, Frahm, No. 3.
F—Instrument, Plastic, Gregg, No. 2.
G—Instrument, Plastic, Gregg, No. 3.

Figure 235.—Carving and plastic instruments.



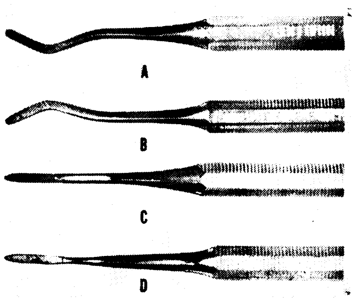
A—Plugger, Amalgam, Sweeney, No. 1.
B—Plugger, Amalgam, Sweeney, No. 2.
C—Plugger, Amalgam, Sweeney, No. 3.
D—Plugger, Amalgam, Sweeney, No. 4.
E—Plugger, Amalgam, Sweeney, No. 5.
F—Plugger, Amalgam, Sweeney, No. 6.
G—Plugger, Amalgam, Sweeney, No. 7.

Figure 236.—Amalgam pluggers.



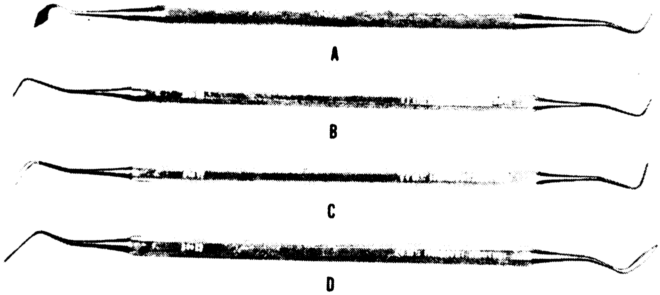
A—Burnisher, Ovoid, Medium.
B—Burnisher, Round, Large.
C—Burnisher, Round, Small.
D—Burnisher, Stellite, "J" (Double end).
E—File, Finishing, Rhein, No. 31.
F—File, Finishing, Rhein, No. 32.
G—Knife, Finishing, Black, No. 8.

Figure 237.—Burnishers, files, and knife.



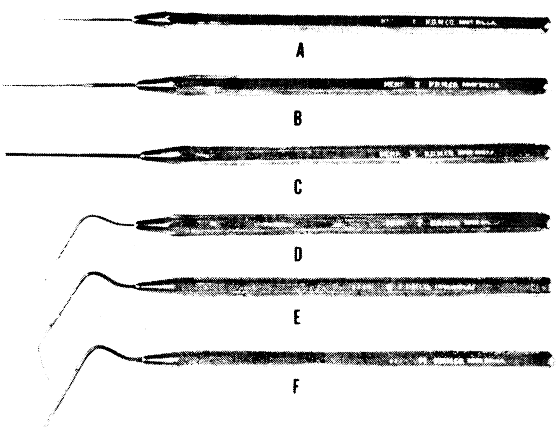
A—File, Periodontal, Bunting, No. 15.
B—File, Periodontal, Bunting, No. 16.
C—File, Periodontal, Bunting, No. 17.
D—File, Periodontal, Bunting, No. 18.

Figure 238.—Periodontal files.



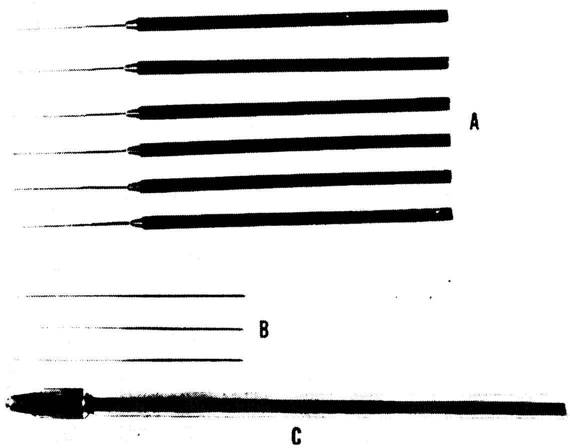
A--Carver, Amalgam, Stellite "H".
B—Carver, Wax and Amalgam, Hollenback, No. 1.
C—Carver, Wax and Amalgam, Hollenback, No. 2.
D—Carver, Wax and Amalgam, Hollenback, No. 3.

Figure 239.—Wax and amalgam carvers.



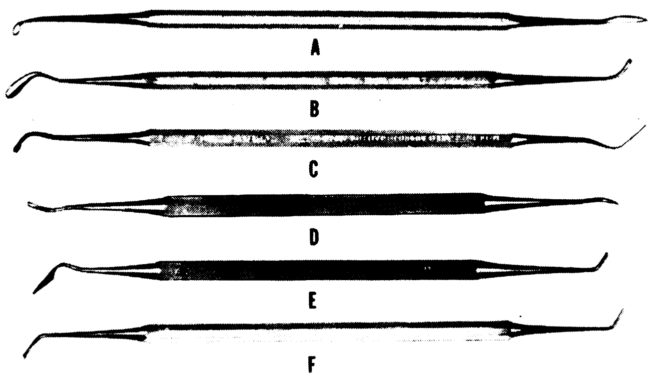
A—Plugger, Root Canal, No. 1.
B—Plugger, Root Canal, No. 3.
C—Plugger, Root Canal, No. 5.
D—Plugger, Root Canal, No. 7.
E—Plugger, Root Canal, No. 9.
F—Plugger, Root Canal, No. 11.

Figure 240.—Root canal pluggers.



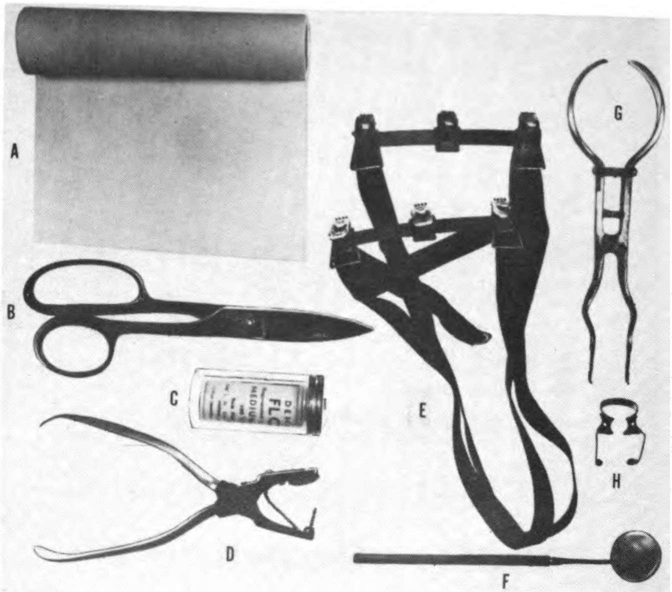
A—File, Root Canal, Long Handle, Assorted, 6a.
B—Broach, Root Canal, Barbed, Extra Fine, 12a.
C—Holder, Broach.

Figure 241.—Root canal files, broaches and broach holder.



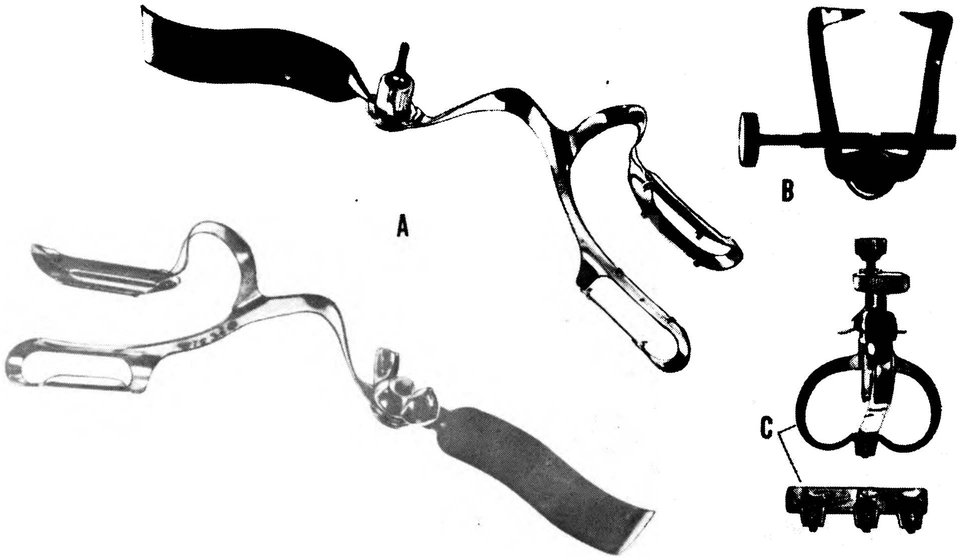
A—Instrument, Plastic, Woodson, No. 1.
B—Instrument, Plastic, Woodson, No. 2.
C—Instrument, Plastic, Woodson, No. 3.
D—Instrument, Plastic, Stellite, No. 1-2.
E—Instrument, Plastic, Stellite, No. 5-7.
F—Instrument, Plastic, Ladmore, No. 3.

Figure 242.—Plastic instruments.



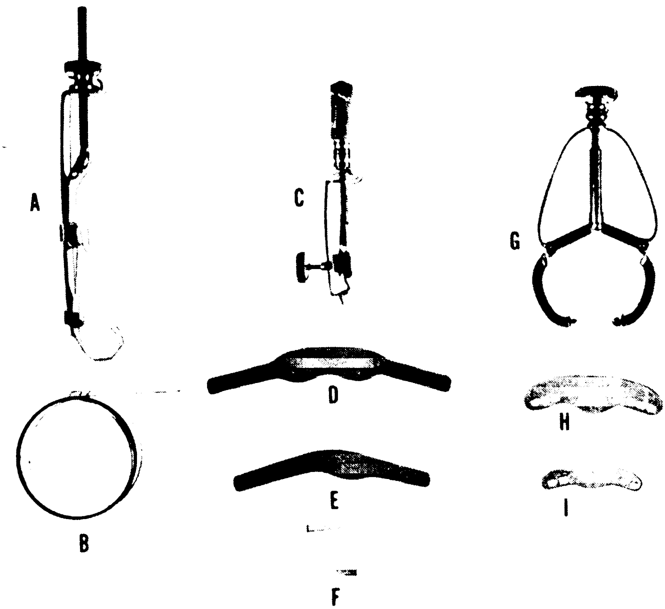
A—Rubber Dam.
B—Shears, Metal Plate, Straight.
C—Floss, Dental.
D—Punch, Rubber Dam.
E—Holder, Rubber Dam.
F—Mirror, Mouth, No. 4.
G—Forceps, Rubber Dam Clamp.
H—Clamp, Rubber Dam, No. 40.

Figure 243.—Rubber dam set-up.



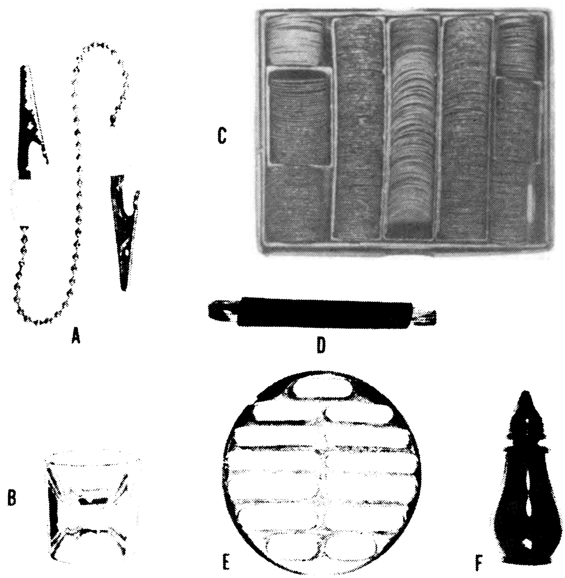
A—Holder, Cotton Roll, Right and Left.
B—Separator, Curve Jaw, Elliot.
C—Clamp, Cervix, Multiple Jaw.

Figure 244.—Cotton roll holders, separator and cervix clamp.



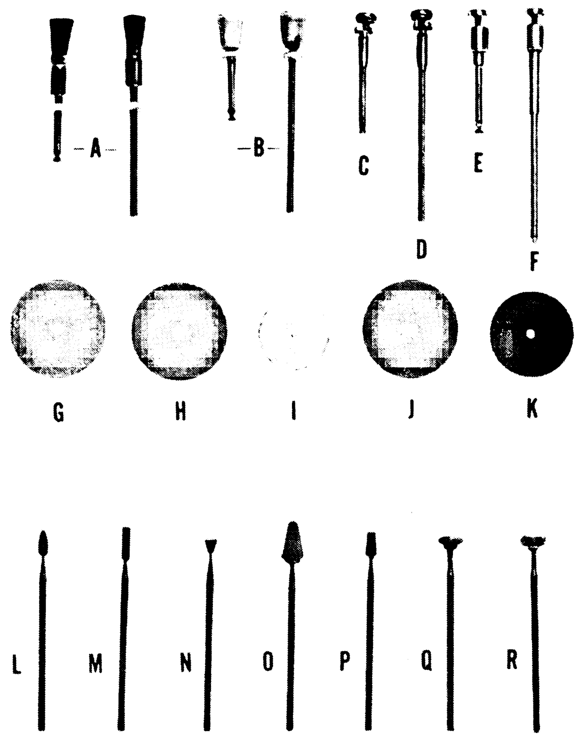
A—Retainer, Matrix, Siqveland.
B—Strip, Matrix.
C—Retainer, Matrix, No. 9.
D—Band, Matrix, Molar, Medium, No. 9.
E—Band, Matrix, Bicuspid, Medium, No. 9.
F—Wedge, Matrix, Celluloid.
G—Retainer, Matrix, No. 1.
H—Band, Matrix, Molar, Medium, No. 1.
I—Band, Matrix, Bicuspid, Medium, No. 1.

Figure 245.—Matrix retainers and bands.



A—Holder, Napkin.
B—Pot, Medicine. (dappen dish)
C—Disk, Paper, Assorted.
D—Brush, Scratch.
E—Holder, Cotton Pellet.
F—Holder, Mercury.

Figure 246.—Operating accessories.



A—Brush, Mandrel Mounted, Assorted.
B—Cup, Polishing, Rubber.
C—Mandrel, AHP, Morgan-Maxfield.
D—Mandrel, SHP, Morgan-Maxfield.
E—Mandrel, AHP, Screwhead.
F—Mandrel, SHP, Screwhead.
G—Disk, Diamond, Safesided, ⅞ inch.
H—Disk, Metal, Safesided, ⅞ inch.
I—Disk, Rubber, Sulci, Wheel Shape (Burlew).
J—Disk, Silicon Carbide, Double Cutting, ⅞ inch.
K—Disk, Silicon Carbide, Separating, ¾ inch.
L—Point, Silicon Carbide, SHP, Cone.
M—Point, Silicon Carbide, SHP, Cylinder.
N—Point, Silicon Carbide, SHP, Inverted Cone.
O—Point, Silicon Carbide, SHP, Large Rounded Cone.
P—Point, Silicon Carbide, SHP, Tapered Cylinder.
Q—Point, Silicon Carbide, SHP, Knife Edge.
R—Point, Silicon Carbide, SHP, Wheel with Rounded Edges.

Figure 247.—Operating accessories.

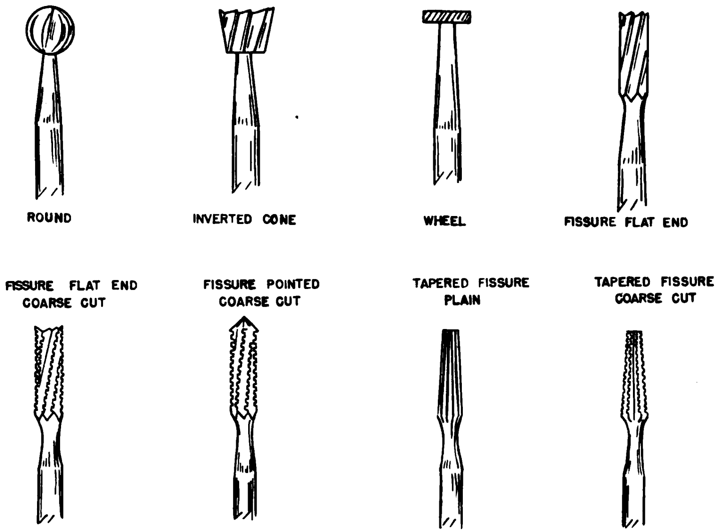
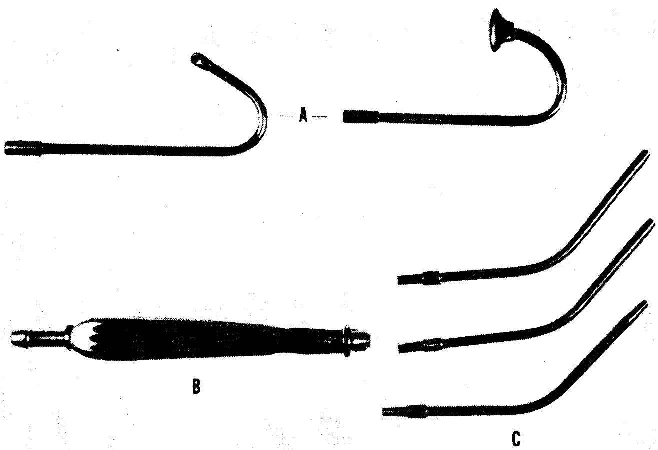


Figure 248.—Burs.

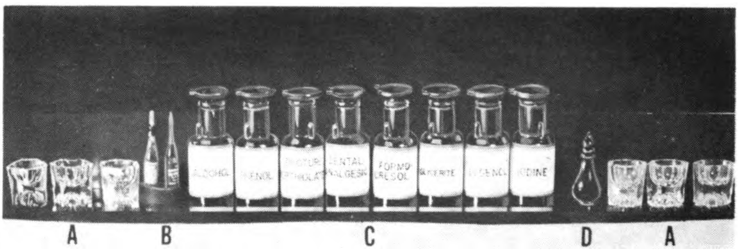


A—Mouthpiece, Saliva Ejector.
B—Handle, Aspirator Tip.
C—Tips, Dental Aspirator.

Figure 249.—Ejector and aspirator tips.

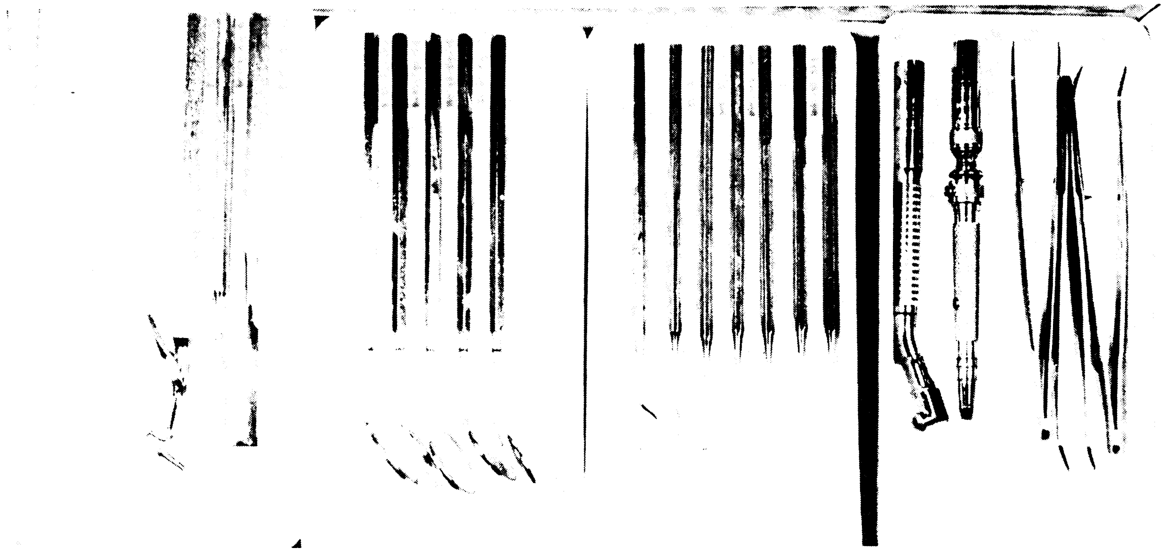
Arrangement of the Dental Instrument Cabinet

The system explained herein has been devised in an effort to secure a uniform arrangement of instruments in the dental cabinet and to maintain each in an assigned place. It is readily understood that most dental officers will have a few favorite instruments, so space has been left in the various trays for inclusion of these instruments of personal choice. On receipt of questionnaires from over two hundred operators, no definite agreement could be made on Drawers ELEVEN and TWELVE, hence they have been left undesignated. Surgical instruments have been included in the cabinet to offer a setup for the small clinic and the officer on independent duty. Opinion was equally divided as to whether burs should be placed in trays for the convenience of operator and assistant or placed in bur blocks.



A—Pot, Medicine, Glass.
B—Holder, Ammoniacal Silver Nitrate Ampule.
C—Bottles, Dropping, Amber.
D—Holder, Mercury.

Figure 250.—Medicine tray set-up.



Left to right—

Tray One	*Tray Two*	*Tray Three*	*Tray Four*
Carrier Amalgam	Mouth Mirrors	Explorer No. 23	Handpiece, Contra-angle
Spatula, Cement No. 324		Explorer No. 17	Handpiece, Straight
Spatula, Silicate No. 2		Explorer No. 6	Pliers No. 6
			Pliers No. 17

Figure 251.—Left, Drawer 1.

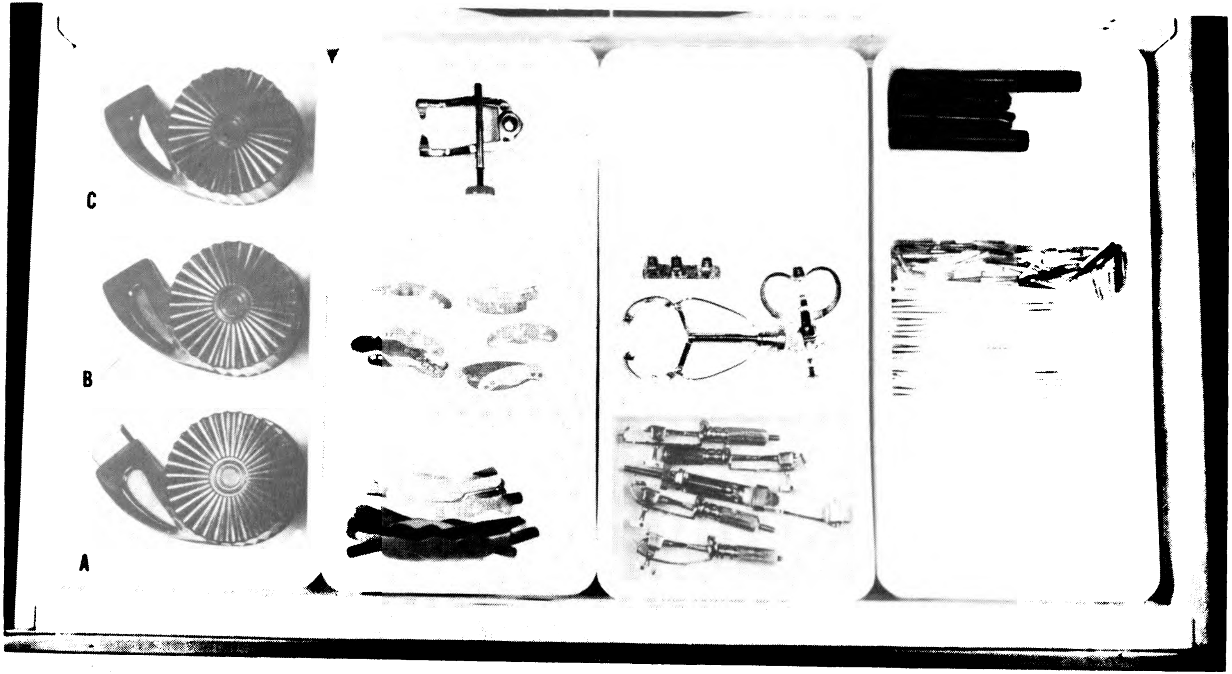


Figure 252.—Left, Drawer 2.

Left to right—

Tray One	*Tray Two*	*Tray Three*	*Tray Four*
Space A	Space A	Space A	Space A
Dispenser, Strip (Articulating Paper)	Bands, Matrix, Assorted, No. 9	Retainer, Matrix, No. 9 Retainer, Matrix, Siqveland	
Space B	Space B	Space B	Space B
Dispenser, Strip (Celluloid)	Bands, Matrix, Assorted, No. 1	Retainer, Matrix, No. 1	Toothpicks, Round Wedge, Matrix, Celluloid
Space C	Space C	Space C	Space C
Dispenser, Strip (Matrix)	Separator, Curved Jaw (Elliot)		Impression Compound, Sticks

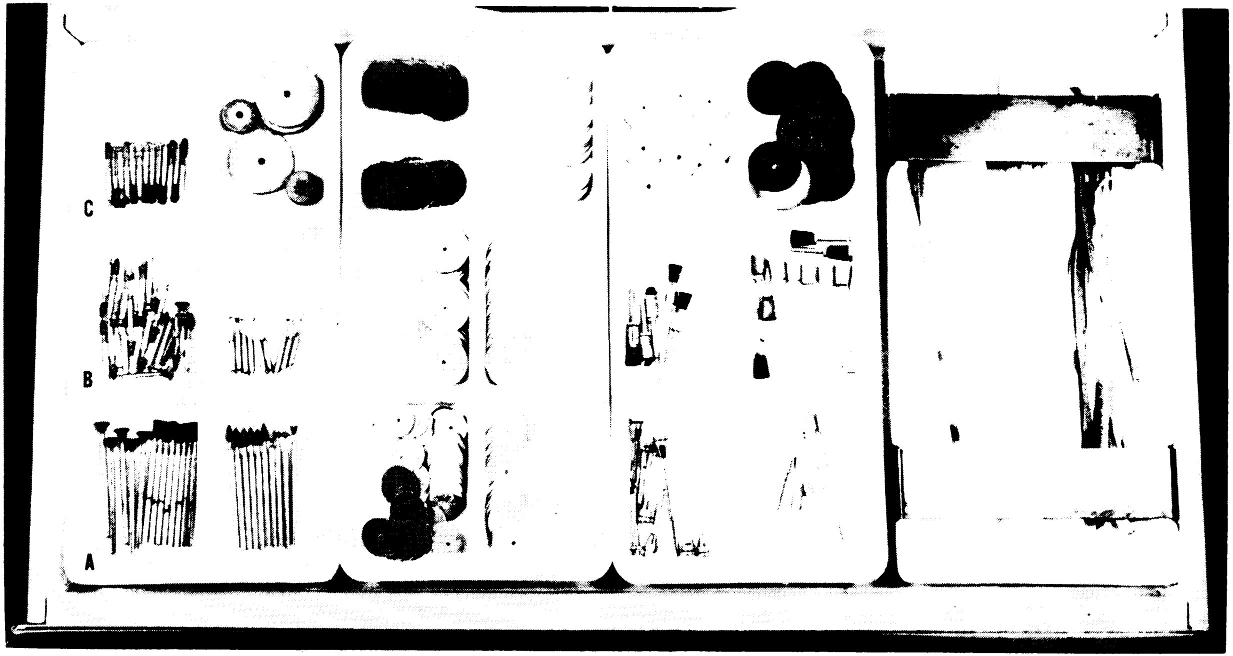


Figure 253.—Left, Drawer 3.

Left to right—

Tray One		Tray Two		Tray Three		Tray Four
Space A	Space A^1	Space A	Space A^1	Space A	Space A^1	
Point, Silicon Carbide, SHP	Point, Sil Carbide, SHP	Disk, Paper	Disk, Paper	Mandrel, AHP Mandrel, SHP (Morgan-Max)	Mandrel, AHP Mandrel, SHP (Screwhead)	
Space B	Space B^1	Space B	Space B^1	Space B	Space B^1	
Point, Silicon Carbide, AHP	Bur, Finishing AHP Bur, Finishing SHP	Disk, Paper	Disk, Paper	Brush, Mandrel Mounted, Asstd.	Cup, Polishing Rubber	Strip, Polishing, Cuttlefish Strip, Polishing, Steel
Space C	Space C^1	Space C	Space C^1	Space C	Space C^1	
Point, Silicon Carbide, AHP	Unmounted Stones	Disk, Paper	Disk, Paper	Disk, Impregnated Rubber	Disk, Silicon Carbide	

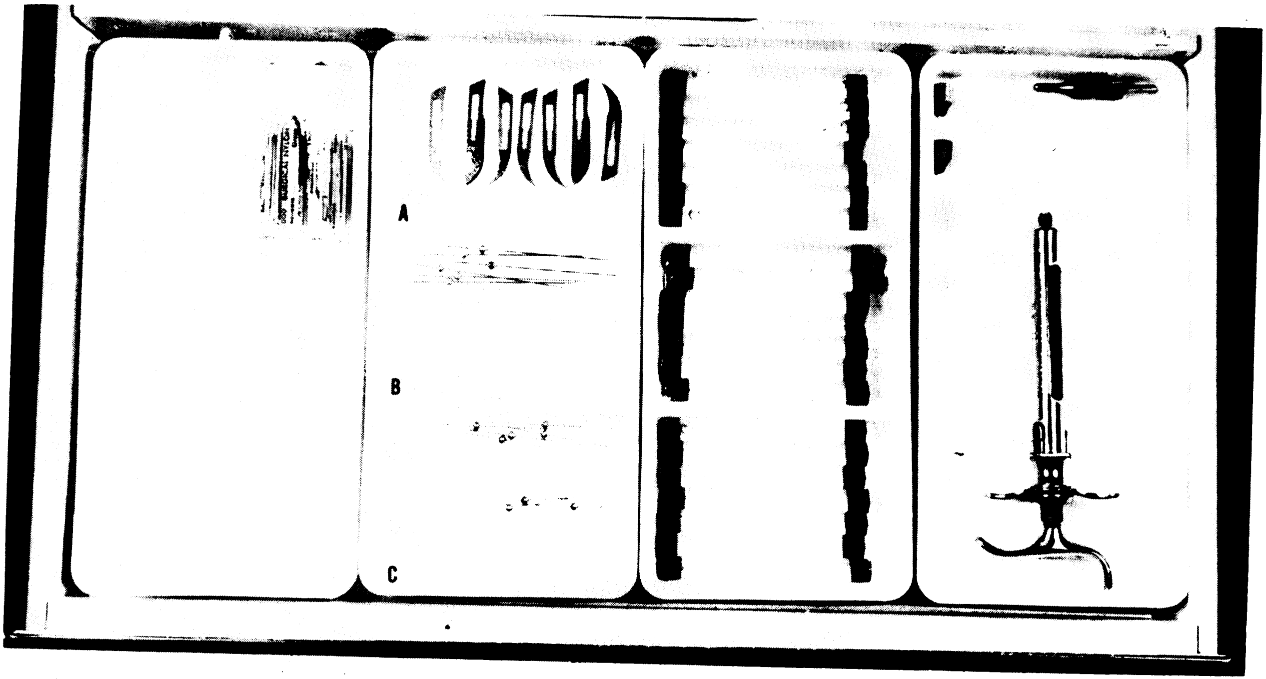
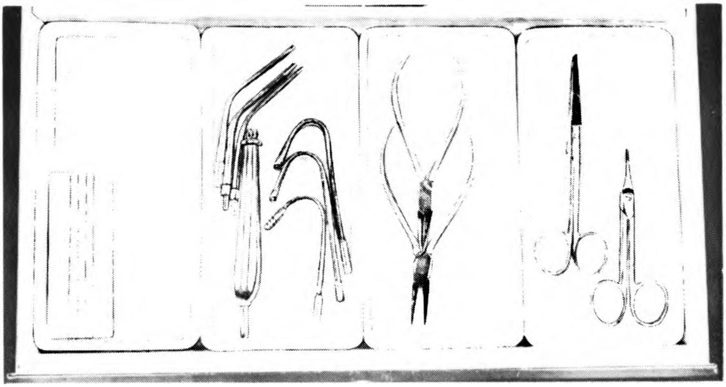


Figure 254.—Left, Drawer 4.

Left to right—

Tray One	*Tray Two*	*Tray Three*	*Tray Four*
	Space A		
Suture, Surgical Handle, Operating Knife	Blade, Operating Knife	Anesthesia Solution Cartridges	Syringe, Hypodermic, Cartridge Type Long Hubs Short Hubs
	Space B		
	Needle, Anesthesia, 1″		
	Space C		
	Needle, Anesthesia, 1⅝″		



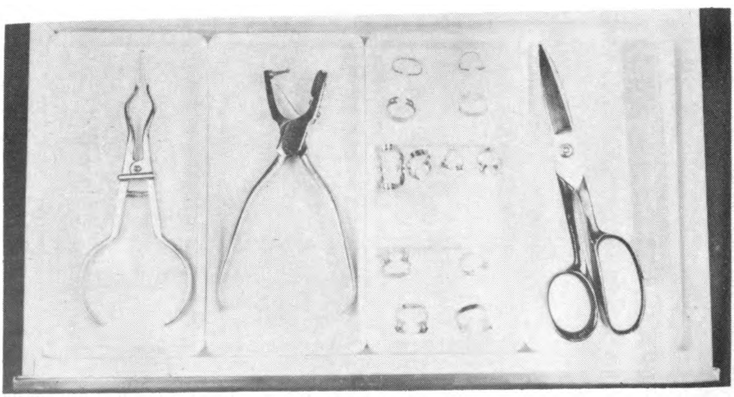
Left to right— *Tray One*
Scissors, Suture
Scissors, Tissue

Tray Two
Pliers No. 136
Pliers No. 137

Tray Three
Tip, Dental Aspirator
Handle, Aspirator
Mouthpiece, Saliva Ejector

Tray Four
Stone, Arkansas

Figure 255.—Left, Drawer 5.



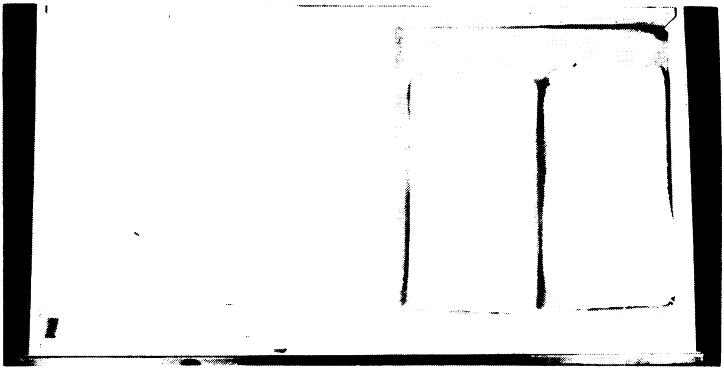
Left to right— *Tray One*
Forceps, Rubber Dam Clamp

Tray Two
Punch, Rubber Dam

Tray Three
Clamps, Rubber Dam

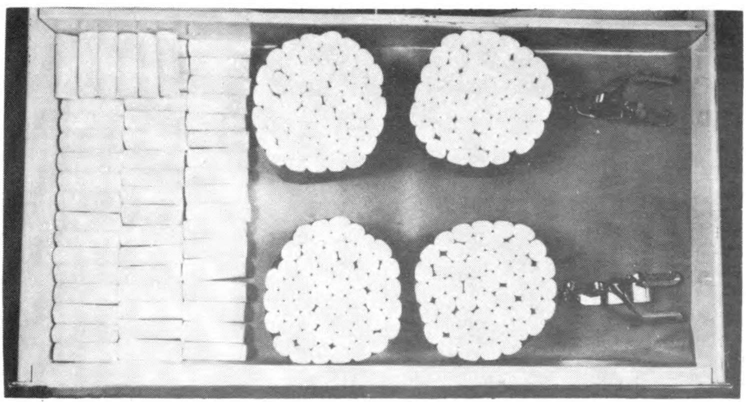
Tray Four
Rubber Dam
Shears, Metal Plate, Straight

Figure 256.—Left, Drawer 6.



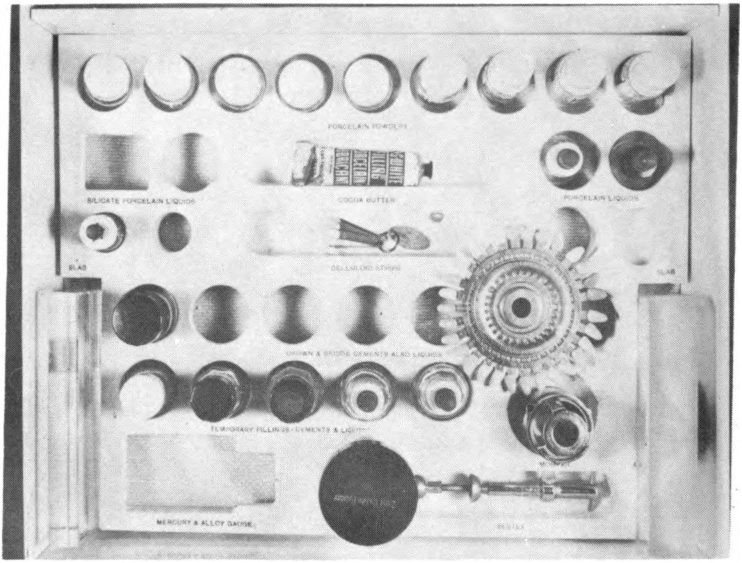
Gauze Face Napkins for use with Rubber Dam
Napkins, Gauze, 500's (6 by 6 inches)

Figure 257.—Left, Drawer 7.



Cotton Roll, ½", 100's
Holder, Cotton Roll, Right and Left

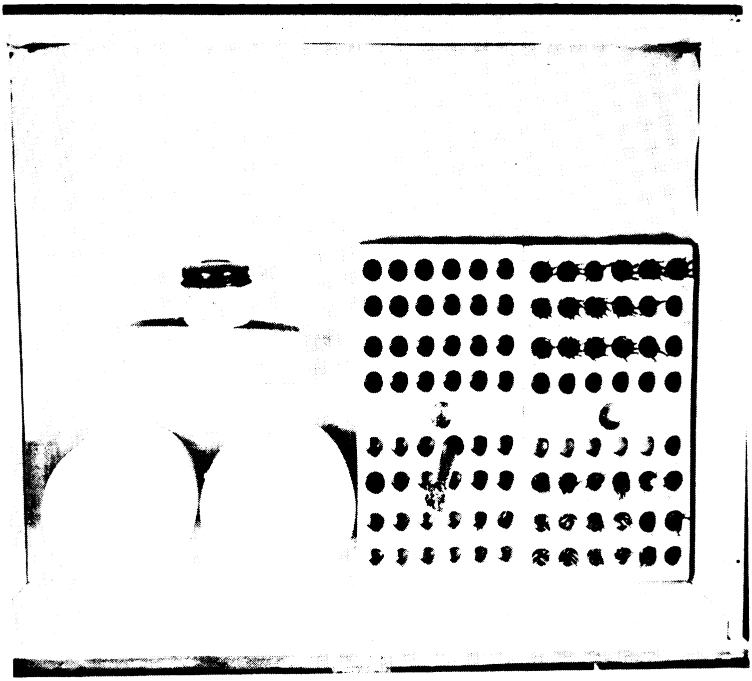
Figure 258.—Left, Drawer 8.



Cements
Silicates
Slabs
Cocoa Butter
Shade Guides

Mortar and Pestle
Alloy
Mercury
Zinc Oxide Jar

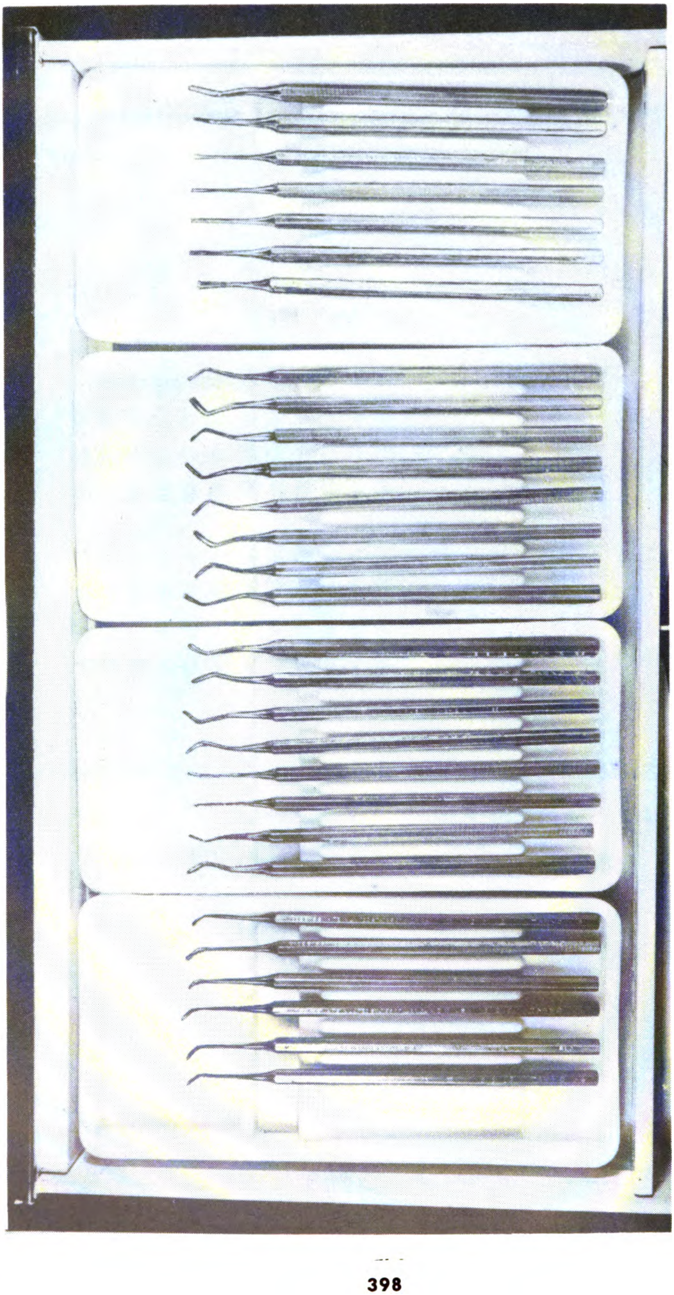
Figure 259.—Left, Drawer 9.



Pumice Jar Chalk Jar Bur Block Bur Block

Polishing Powder

Figure 260.—Left, Drawer 10.



Tray One

Figure 261.—Right, Drawer 1.

Left to right—

Tray One

Instrument, Cutting, Black, No. 81: (Binangle chisel)
Instrument, Cutting, Black, No. 83: (Binangle chisel)
Instrument, Cutting, Black, No. 84: (Chisel)
Instrument, Cutting, Black, No. 85: (Chisel)
Instrument, Cutting, Black, No. 86: (Chisel)
Chisel, Wedelstaedt, No. 41
Chisel, Wedelstaedt, No. 42

Tray Two

Instrument, Cutting, Black, No. 51: (Enamel hatchet)
Instrument, Cutting, Black, No. 52: (Enamel hatchet)
Instrument, Cutting, Black, No. 53: (Enamel hatchet)
Instrument, Cutting, Black, No. 54: (Enamel hatchet)
Instrument, Cutting, Black, No. 77: (Gingival margin trimmer)
Instrument, Cutting, Black, No. 78: (Gingival margin trimmer)
Instrument, Cutting, Black, No. 79: (Gingival margin trimmer)
Instrument, Cutting, Black, No. 80: (Gingival margin trimmer)

Tray Three

Instrument, Cutting, Black, No. 63: (Spoon)
Instrument, Cutting, Black, No. 64: (Spoon)
Instrument, Cutting, Black, No. 65: (Spoon)
Instrument, Cutting, Black, No. 66: (Spoon)
Excavator, Darby-Perry, No. 5
Excavator, Darby-Perry, No. 6
Excavator, Darby-Perry, No. 21
Excavator, Darby-Perry, No. 22

Tray Four

Instrument, Cutting, Black, No. 8: (Hatchet)
Instrument, Cutting, Black, No. 17: (Hatchet)
Instrument, Cutting, Black, No. 23: (Hatchet)
Instrument, Cutting, Black, No. 29: (Hoe)
Instrument, Cutting, Black, No. 30: (Hoe)
Instrument, Cutting, Black, No. 34: (Hoe)

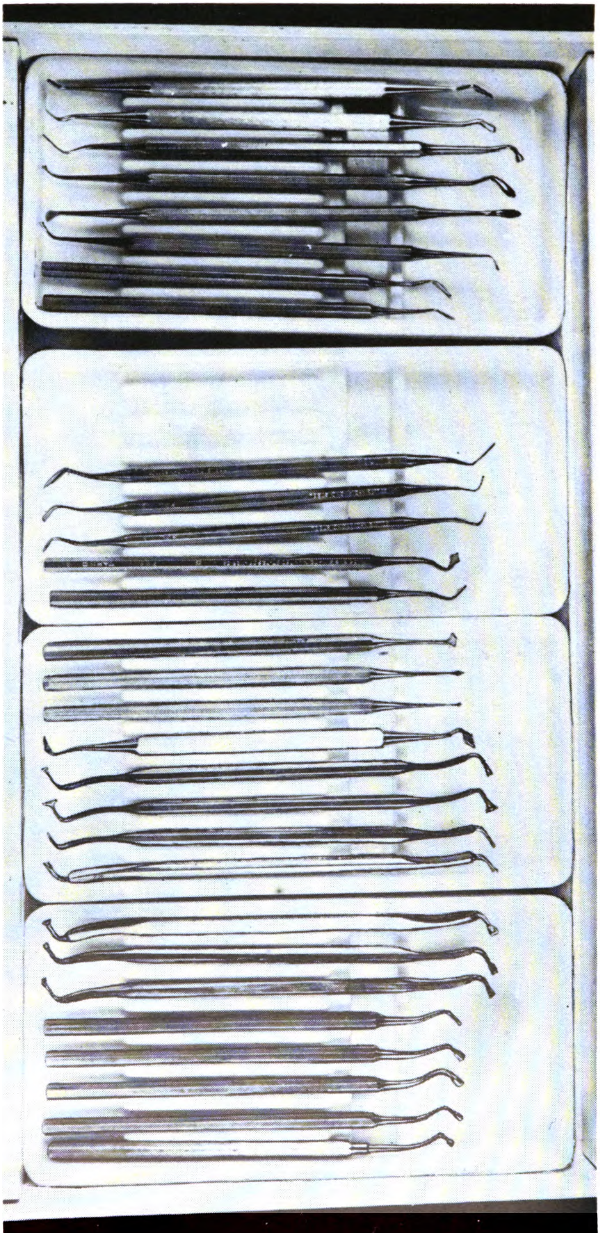


Figure 262.—Right, Drawer 2.

Left to right—

Tray One	*Tray Two*	*Tray Three*	*Tray Four*
Plugger, Amalgam, Black, No. 1	Plugger, Amalgam, Sweeney, No. 4: Double end	Carver, Amalgam, Frahm, No. 2	Instrument, Plastic, Gregg, No. 2
Plugger, Amalgam, Black, No. 2	Plugger, Amalgam, Sweeney, No. 5: Double end	Carver, Amalgam, Frahm, No. 3	Instrument, Plastic, Gregg, No. 3
Plugger, Amalgam, Black, No. 3	Plugger, Amalgam, Sweeney, No. 6: Double end	Carver, Wax and Amalgam, Hollenback, No. 1	Instrument, Plastic, Woodson, No. 1
Plugger, Amalgam, Black, No. 4	Plugger, Amalgam, Sweeney, No. 7: Double end	Carver, Wax and Amalgam, Hollenback, No. 2	Instrument, Plastic, Woodson, No. 2
Plugger, Amalgam, Black, No. 5	Carver, Amalgam, Stellite, No. 14: "H". Double end	Carver, Wax and Amalgam, Hollenback, No. 3	Instrument, Plastic, Woodson, No. 3
Plugger, Amalgam, Sweeney, No. 1: Double end	Instrument, Cutting, Black, No. 89: (Discoid)		Instrument, Plastic, Stellite, No. 1-2
Plugger, Amalgam, Sweeney, No. 2: Double end	Instrument, Cutting, Black, No. 92: (Cleoid)		Instrument, Plastic, Stellite, No. 5-7
Plugger, Amalgam, Sweeney, No. 3: Double end	Carver, Amalgam, Frahm, No. 1		

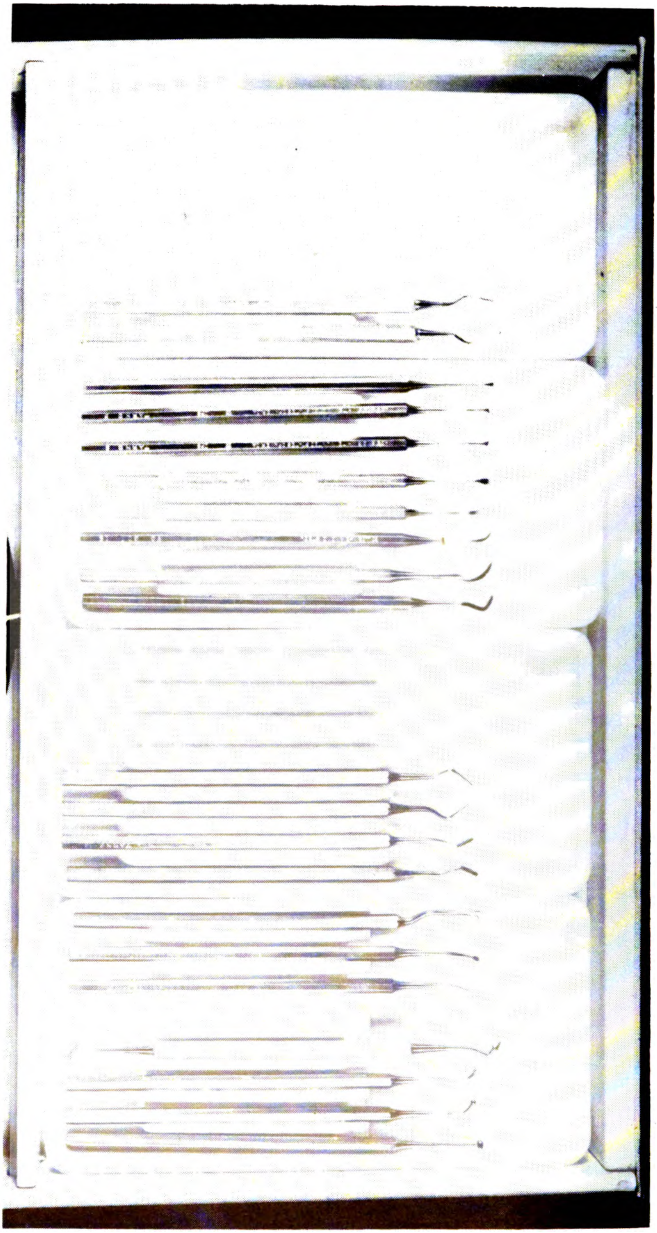


Figure 263.—Right, Drawer 3.

Left to right—

Tray One	*Tray Two*	*Tray Three*	*Tray Four*
Burnisher, Ovoid, Medium	File, Periodontal, Bunting, No. 15	Scaler, No. B	Scaler, Gracey, No. P-1
Burnisher, Round, Large	File, Periodontal, Bunting, No. 16	Scaler, No. 6	Scaler, Gracey, No. P-2
Burnisher, Round, Small	File, Periodontal, Bunting, No. 17	Scaler, Younger-Good, No. 15	
Burnisher, Stellite, No. 15, "J": Double end	File, Periodontal, Bunting, No. 18	Scaler, No. 33	
File, Finishing, Rhein, No. 31		Scaler, No. 34	
File, Finishing, Rhein, No. 32		Scaler, Darby-Perry, No. 5	
Knife, Finishing, Black, No. 8		Scaler, Darby-Perry, No. 6	
		Scaler, Zerfing	

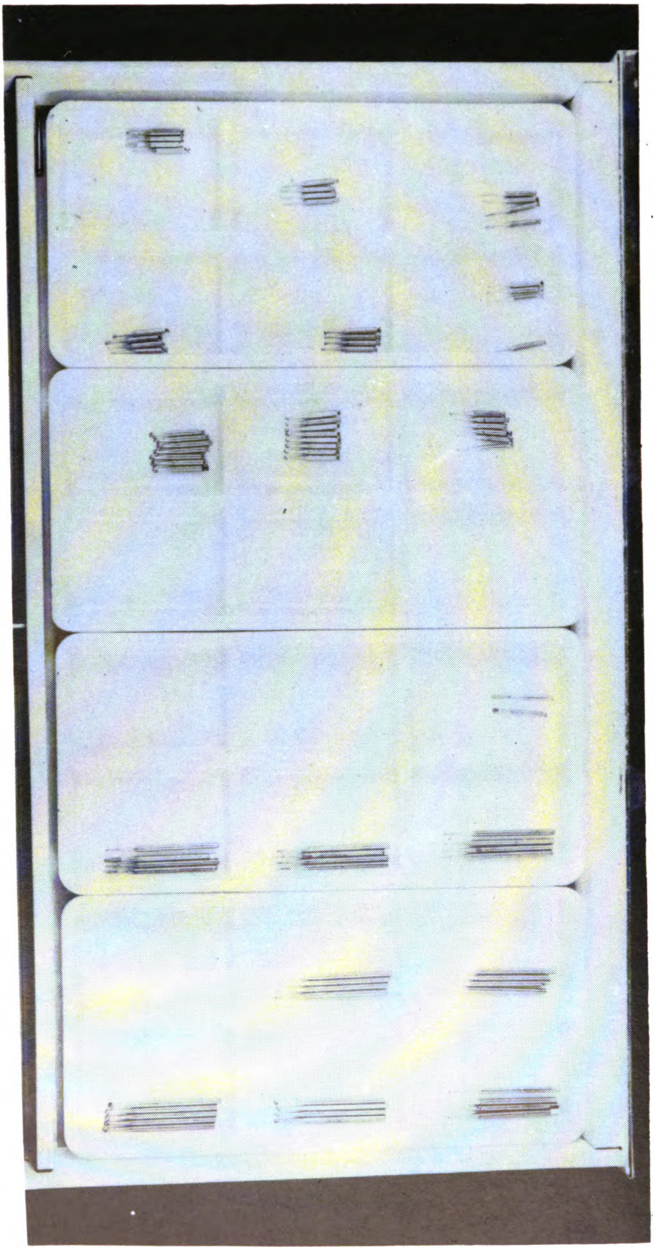
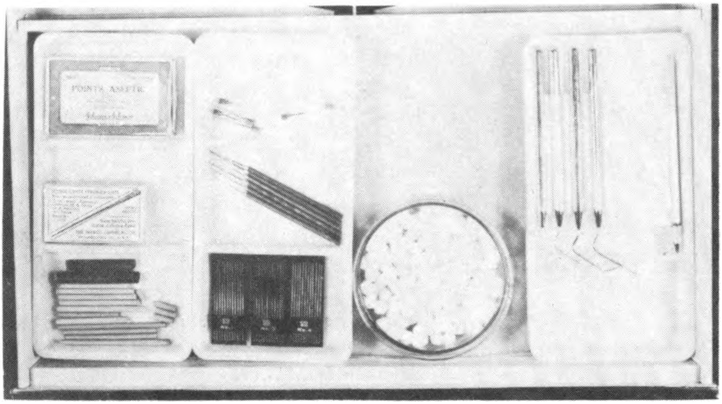


Figure 264.—Right, Drawer 4.

Left to right—

Tray One		*Tray Two*		*Tray Three*		*Tray Four*	
Space A Bur SHP	Space A^1 Bur SHP	Space A Bur SHP	Space A^1 Bur AHP	Space A Bur AHP	Space A^1 Bur AHP	Space A Bur AHP	Space A^1 Bur AHP
Space B Bur SHP	Space B^1 Bur SHP	Space B Bur SHP	Space B^1 Bur AHP	Space B Bur AHP	Space B^1 Bur AHP	Space B Bur AHP	Space B^1 Bur AHP
Space C Bur SHP	Space C^1 Bur SHP	Space C Bur SHP	Space C^1 Bur AHP	Space C Bur AHP	Space C^1 Bur AHP	Space C Bur AHP	Space C^1 Bur AHP



Left to right—

Tray One
Space A
Gutta Percha

Space B
Points, Gutta Percha

Space C
Points, Antiseptic

Tray Two
Space A
Broaches, Barbed

Space B
Files, Long Handle

Space C
Files, Short Handle

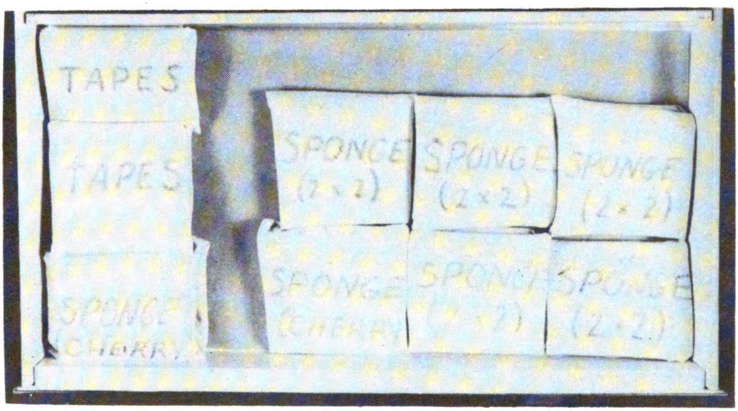
Tray Three
Petri dish for autoclaved
Cotton Pellets

Tray Four
Plugger, Root Canal 5
Plugger, Root Canal 9
Plugger, Root Canal 11
Holder, Broach

Figure 265.—Right, Drawer 5.

Sterile Rubber Gloves

Figure 266.—Right, Drawer 6.



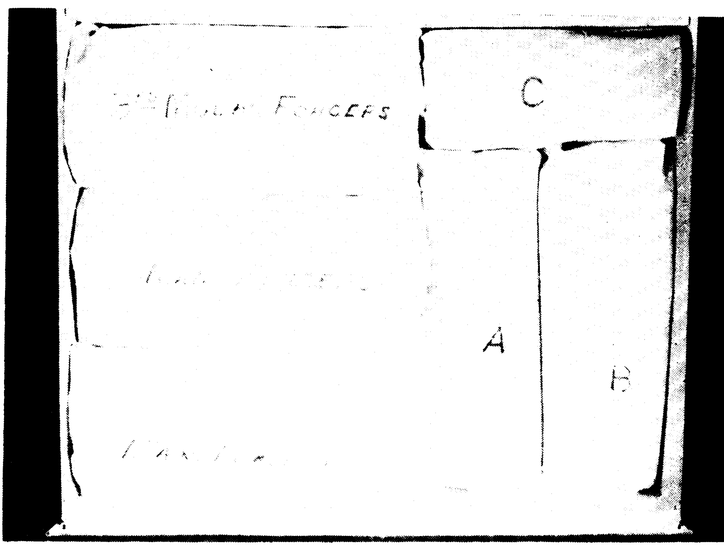
Sterile Tapes

Sterile Sponges

Figure 267.—Right, Drawer 7.

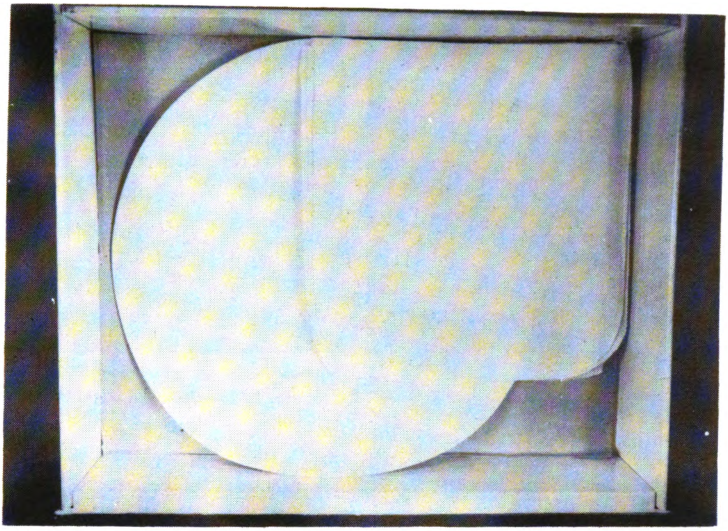
Sterile Towels

Figure 268.—Right, Drawer 8.



Sterile Packs for Oral Surgery

Figure 269.—Right, Drawer 9.



Bracket Table Covers Headrest Covers

Figure 270.—Right, Drawer 10.

CHAIR PROCEDURES

The dental assistant in the start of his career must bear in mind that no two dental officers will follow the same technics in rendering similar services whether it be scaling the anterior teeth of a patient or performing an extraction of an upper central incisor. The following illustrations will serve to give the uninitiated, suggestions as to how they may be able to plan their aid to the dentist. Figure 271 illustrates a setup that an operator may use in placing a compound restoration. Here the operator has finished the cavity preparation, the assistant has removed the cutting instruments from the bracket table and has set out the armamentarium for the placing of a reinforced matrix: the retainer of the operator's choice, a toothpick, compound, celluloid wedges, a hemostat to aid in the insertion of the wedges, mouth mirror, cotton pliers and explorer.

In figure 272 the operator has completed the placement of the matrix and is ready to proceed to the INSERTION and CONDENSATION

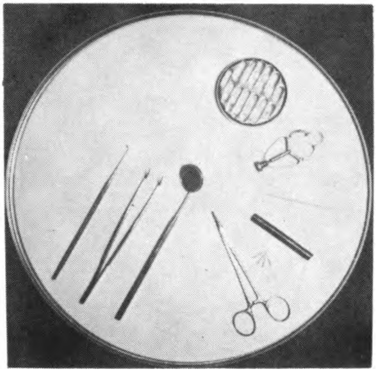


Figure 271.—Matrix application set-up.

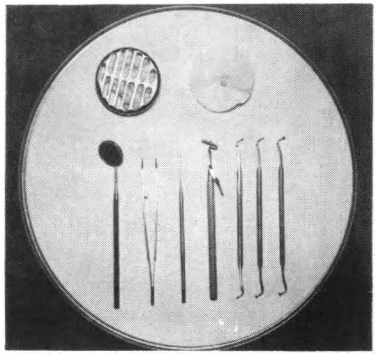


Figure 272.—Amalgam condensing set-up.

of the amalgam mix. The armamentarium consists of the pluggers of choice, the amalgam carrier, the first portion of the amalgam, mouth mirror, cotton pliers and explorer.

Keep the bracket table clear of instruments and materials which are not to be used again. Do not allow the instruments to become mixed, and try to group them in the order in which they will be used.

Mixing of Zinc Cement

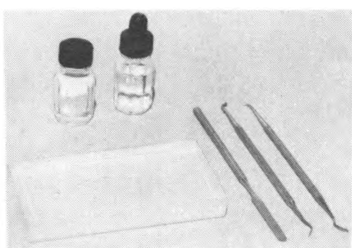
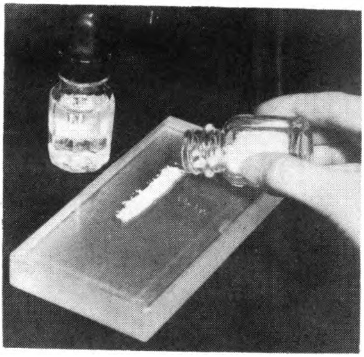


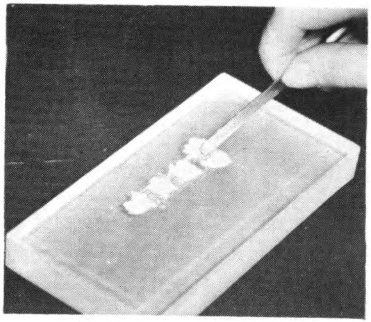
Figure 273.—Layout for a cement mix.

Powder, liquid, cement, spatula, mixing slab, plastic instruments.



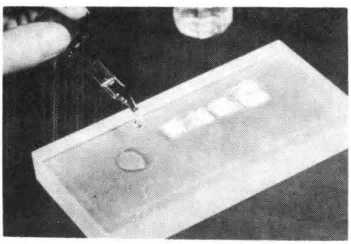
Roll the neck of the bottle, allowing the desired amount of powder to fall on the slab.

Figure 274.—Rolling neck of bottle.



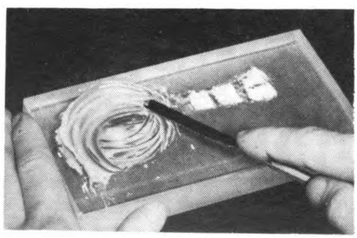
Divide the powder into four portions, one of which, divide into halves.

Figure 275.—Division of the powder.



The amount of powder rolled out, will govern the number of drops of liquid.

Figure 276.—Placement of liquid.



Incorporate the first powder portion into the liquid and mix over a wide area until smooth.

Figure 277.—Incorporation of first powder portion.

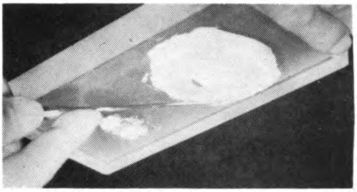


Figure 278.—Spatulation in wide circular motion.

Add the two remaining quarter portions of powder, spatulating in a wide circular motion.

Add one, eighth portion and then small amounts of the last eighth portion until the consistency of the mix is correct.

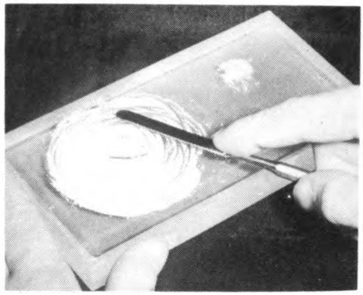


Figure 279.—Addition of powder until consistency is correct.

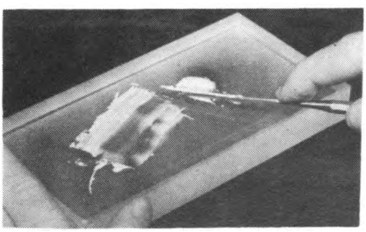


Figure 280.—Snapping mix off spatula.

Wipe the mix off the end of the spatula onto a clean portion of the mixing slab.

The mix in the illustration is satisfactory for a base. For the cementation of an inlay or crown the mix should be of a more creamy consistency.

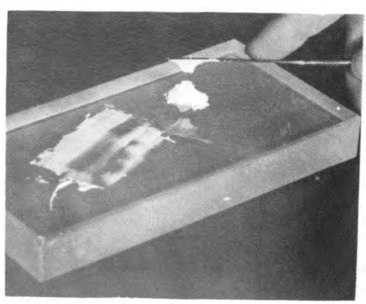
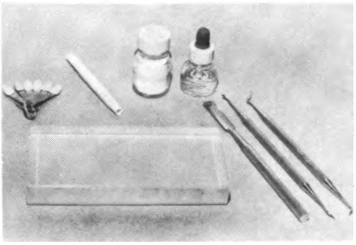


Figure 281.—A "stiff" mix.

When mixing a cement be sure that the slab and spatula are clean and free from the residue of any previous mix. Do not add liquid to thin a mix; it is better to start a new mix of cement. The mix should be complete in 1½ to 2 minutes.

Mixing of Silicate Cement



Shade guide, measuring device, silicate powder, liquid, mixing slab, silicate cement spatula, stellite plastic instruments.

Figure 282.—Layout for a silicate mix.

A mixing slab with a built-in thermometer can be used, however, the slab temperature is governed by the humidity of the atmosphere at the time. At the time of this writing it is not on the Armed Forces Supply Table.

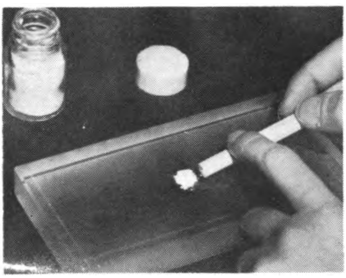


Figure 283.—Placement of powder on slab.

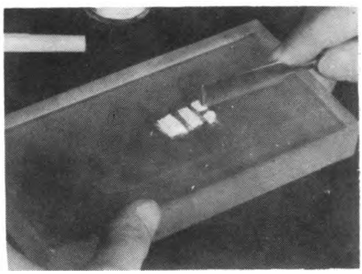
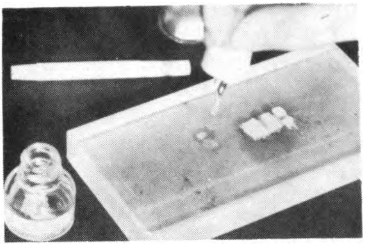


Figure 284.—Division of the powder.

Place the desired amount of powder on the slab.

Divide the powder into half portions. Further divide one of the halves thus making a half and two quarter portions. Further divide one quarter portion of powder on the surface of the slab so you have a half, a quarter, and two eighths.



Shake the liquid before drawing the pipette out from the bottle. Place the liquid upon the slab. Two drops is the recommended minimum.

Figure 285.—Placement of the liquid.

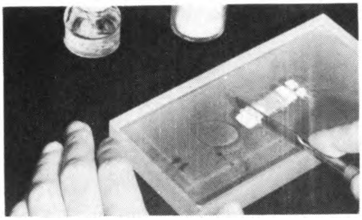


Figure 286.—Incorporation of the first portion.

Incorporate the first portion of powder into the liquid, holding the spatula flat and mixing in a small area with a sweeping motion.

Bring the quarter portion into the mix and spatulate thoroughly in a small area.

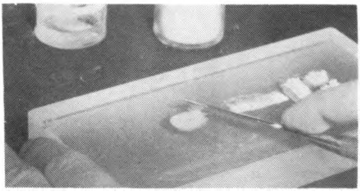


Figure 287.—Mixing in a sweeping motion.

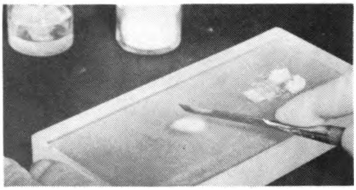


Figure 288.—Mixing in a small area.

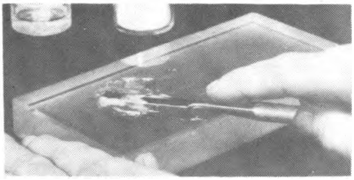


Figure 289.—Incorporation of all the powder.

Bring the remaining portions of powder into the mix. Some dental officers prefer the mix not to follow the spatula.

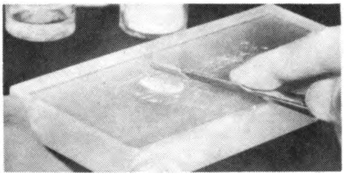


Figure 290.—A desirable consistency.

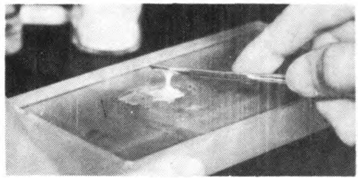


Figure 291.—A test for consistency.

A second type of mix favored by many operators is of such consistency when completed that the mix follows the spatula for approximately a quarter of an inch prior to breaking. The entire mixing time should not exceed one minute.

Mixing of amalgam

In order to set the Crescent proportion scale to any desired ratio of mercury and alloy it is necessary to loosen the thumbscrews and to move the assembly to the desired number marked on the scale beam. Tighten the thumbscrews firmly, then turn counterbalance screw (A) in or out, whichever is required, to balance the beam so that the pin (D) will come to rest lightly. It is then ready for use and will deliver the same ratio of alloy continuously whether you put 7 grains or 70 grains of mercury into the mercury cup. The scale is now set at 11 parts of mercury to 9 parts of alloy.

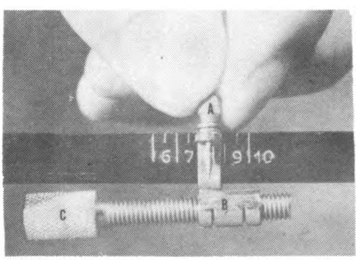


Figure 292.—Loosening the thumb screws.

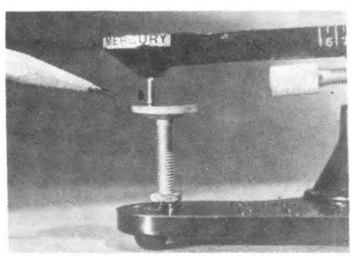


Figure 293.—Balance pin D.

To set the scale for the proportion of alloy and mercury specified by the manufacturer, a conversion formula is employed. For example, if the manufacturer of the alloy specifies 8 parts of mercury to 6 parts of alloy, the formula is as follows:

$$\frac{\text{Parts of alloy x 11}}{\text{Parts of mercury}} = \text{number at which scale should be set.}$$

The number 11 in the above formula is a constant.

Substituting the above specifications in this fraction, the answer is the same:

$$\frac{6 \times 11}{8} = 8\tfrac{1}{4}$$

Bring scale beam (E) to balance by adjusting screw (C) and the scale will deliver a proportion equal to 8 parts of mercury and 6 parts of alloy. The same formula applies to any specified proportion within the range of this instrument.

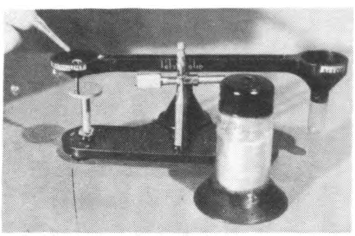


Figure 294.—Placement of the mercury.

The size of the mix desired will govern the amount of mercury. However, no more than 8 drops of mercury should go into any one mix.

Alloy is placed in the alloy cup until the scale tips and the mercury drops into the capsule of alloy.

The proper amount of alloy has caused the scale to tip.

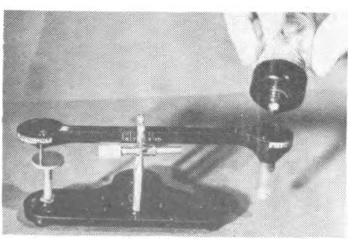


Figure 295.—Placement of the alloy.

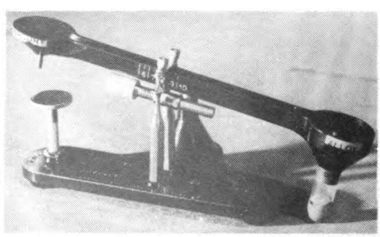


Figure 296.—Mercury dropping into alloy capsule.

Figure 297.—Mortar and pestle for mechanical amalgamator.

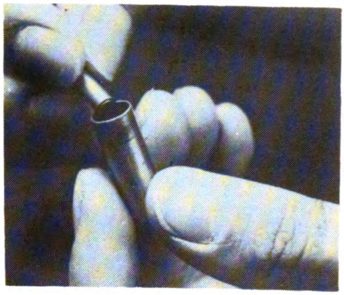


Figure 298.—Placement of pestle in mortar.

Two types of mortar and pestles are shown, Steel and Bakelite.

Place the steel pestle within the capsule.

Pour the weighed alloy and mercury into the capsule using the funnel supplied with the scale.

Place the capsule in the mechanical mixer and adjust the mixing time in accordance with the alloy used. The time chosen for this alloy was 7 seconds.

After mixing, remove the pestle and replace the mix in the capsule for mulling.

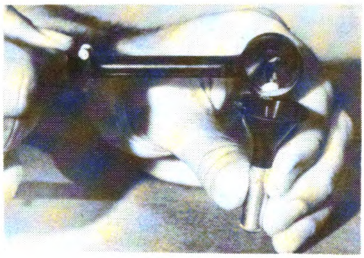


Figure 299.—Placement of mix in capsule.

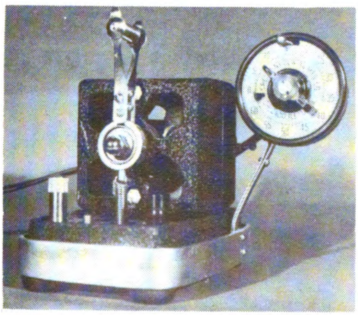


Figure 300.—Mixing time set according to manufacturer's instructions.

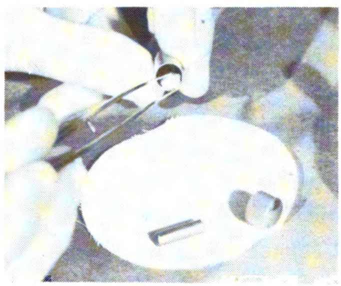


Figure 301.—Replacement of mix.

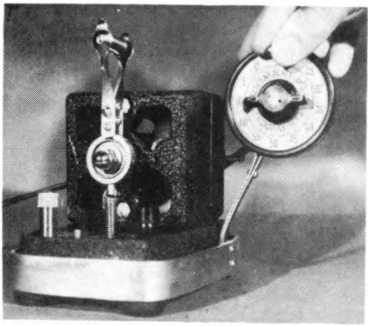


Figure 302.—Mulling the amalgam.

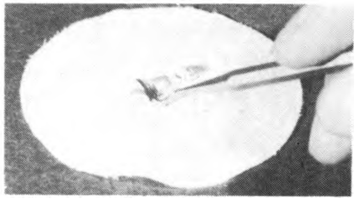


Figure 303.—Segmenting the amalgam roll.

Figure 304.—Placing first portion of amalgam on clean cloth.

Figure 305.—Squeezing first portion of amalgam.

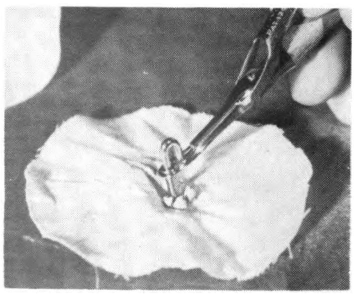


Figure 306.—Picking up the amalgam by carrier.

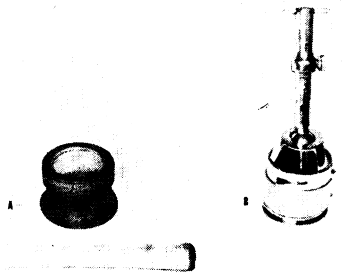
Place the capsule back on the machine and turn switch on for a second or two.

The resultant mix, in the form of a roll, is placed on an amalgam squeeze cloth, and segmented according to the setting time of the alloy. With a quick setting alloy, the rope of amalgam can be divided into 3 portions. With slower setting alloy, the rope may be divided into 5 or 6 portions.

Push the first portion of the segmented mix onto a clean squeeze cloth.

Using finger pressure squeeze the mix, expelling the excess mercury.

The amalgam is now ready for the operator. Pick a portion of the squeezed portion up with an amalgam carrier and hand the carrier to the operator.



Glass mortar and pestle (A). Steel mortar and pestle with adjustable pressure regulator (B).

Figure 307.—Types of manual mortar and pestle.

The size of the desired mix determines the number of capsules used.

A—Holder, Mercury
B—Alloy
C—Weighed capsules of alloy and mercury.

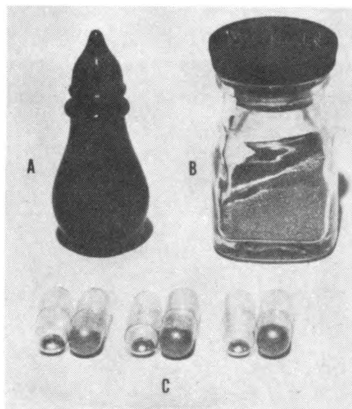


Figure 308.—Mercury and alloy.

A pressure of 4–7 pounds is exerted in the mixing, taking care continually to press all portions of the mix against the sides and bottom of the mortar.

Figure 309.—Use of the glass mortar and pestle.

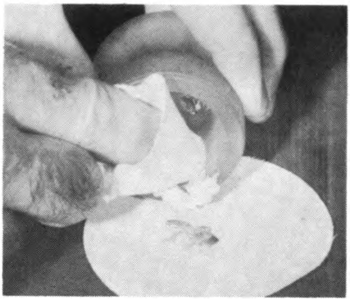


Figure 310.—Removal of mix from mortar.

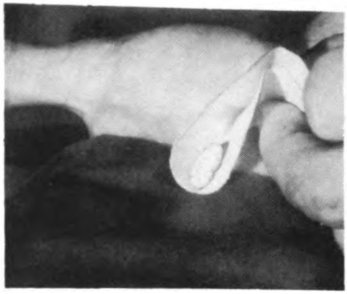


Figure 311.—Placing the mix on rubber dam.

After trituration is completed, the mix is removed from the mortar with a clean squeeze cloth on a finger.

If mulling is desired, the resultant mix is placed on a piece of clean rubber dam or in a clean finger stall and rubbed.

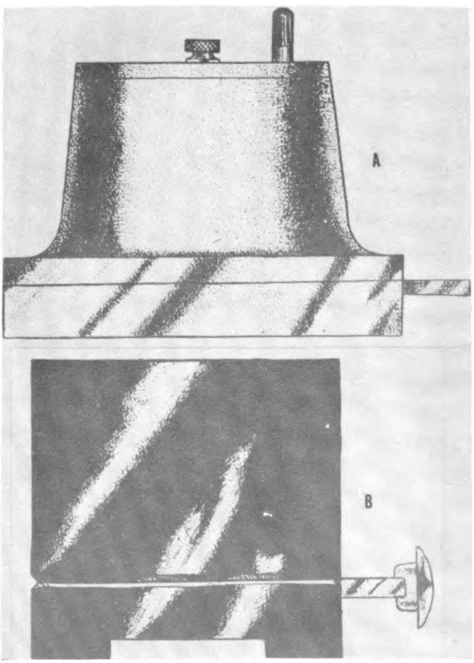


Figure 312.—Garhart and Caulk amalgam dispensers.

Two popular devices for measuring the correct proportions of mercury and alloy are shown in the above illustration. The Garhart Universal Amalgam Meter will be described first. This instrument is provided with six metal tubes of different sizes, any one of which may be used to vary the amount of mercury required. The amount of alloy supplied by the mixer remains constant. Greater or less plasticity of the amalgam mix is obtained by using a larger or smaller tube in the dispensing lever.

1. Read the label that is affixed to the cover of the box because it indicates the size of the tube with which the meter is set. If it is not the correct size, then the tube should be changed to deliver either a larger or smaller proportion of mercury according to the requirements of the alloy.
2. Fill the compartments with alloy and mercury, replacing the cover in a closed position by means of the two thumbscrews. Always insert the "alloy feeder" in the alloy compartment before filling it with alloy.

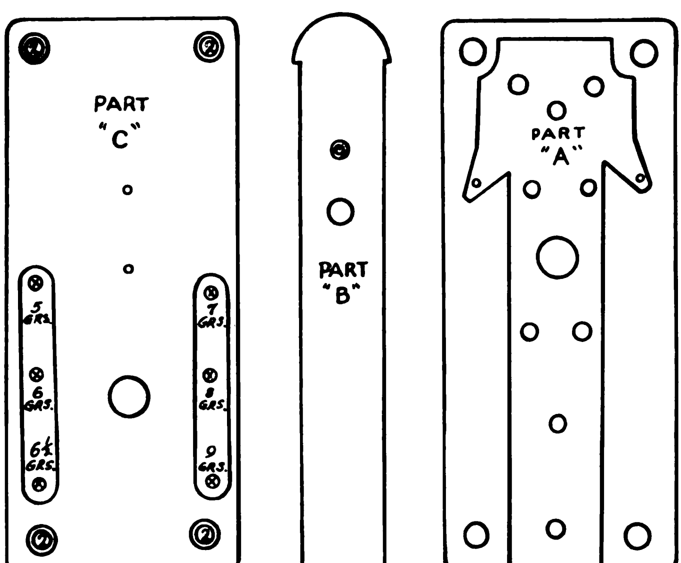


Figure 313.—Base of Garhart amalgam meter.

3. Turn the handle of the alloy feeder to either the right or left, four revolutions being sufficient to prevent the alloy from airlocking in the compartment.
4. Place the meter over a mortar and press the lever forward until it has reached the extreme end of its travel. Hold it momentarily and then permit it to return slowly to about one-half the length of its movement, before you suddenly release it. The forward movement of the lever discharges the fixed amount of alloy into the mortar and the complete return of the lever releases the correct proportion of mercury.

In order to change the proportions of mercury, remove the two thumbscrews from the cover, then lift the cover, turning it to a clockwise position and transfer the mercury to a clean vessel. Remove the cover and alloy feeder and transfer the alloy to a clean sheet of paper. Clean both compartments with a soft cloth before removing the four screws from the bottom of the meter. Lay the meter on its side with the bottom section facing you, and the extended lever portion facing the right hand position. Remove the four setscrews as shown in figure 313, parts (A) and (C).

After the removal of the screws turn the base section upward and the lever will be exposed to view. Access is now gained to the six monel metal mercury measuring tubes which are located in the bottom portion of the alloy mercury compartment. Two flat retaining springs prevent these tubes from dropping out of their respective compartments. The springs may be easily removed by using the tip end of a penknife. You will notice one empty compartment is provided for storing the tube that is present in the lever, and the number of this compartment indicates the size of the tube that is now in the lever. Transfer the tube from the lever to this empty compartment and select the one most suitable for your requirements. Should a mix of greater plasticity be desired, then transfer the next larger size tube to the lever. If a stiffer mix be desired, then transfer the next smaller size tube to the lever. These tubes are rated in capacity according to numbers (5,6,6½,7,8,9), number 5 being the smallest capacity tube. After the exchange of tubes is completed, replace the 'spring retainers' and reassemble the two sections, making certain that all four screws are securely tightened.

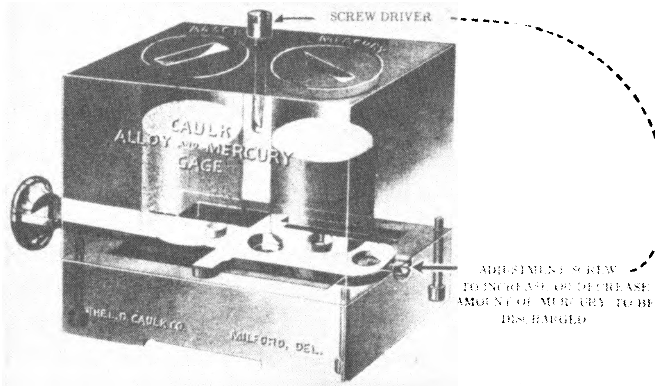


Figure 314.—Caulk alloy and mercury gage.

The Caulk alloy mercury gage is illustrated in figure 314. One stroke of the plunger spills just enough alloy and mercury for a small mix. The arrow points to an adjustable screw for changing the consistency of the mix as desired. The amount of alloy delivered by the gage remains constant, while the amount of mercury may be varied. Before using this type of gage, it is necessary to invert it several times in order to have the particles of alloy well mixed.

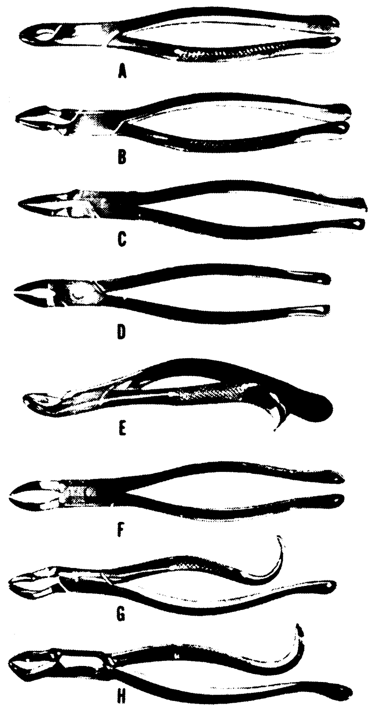
Surgical Technic

Modern surgical technic is founded on the work of Lord Joseph Lister, who, in March 1867, published the first of a series of articles on the antiseptic principles of the practice of surgery. From this work has been evolved the modern aseptic methods which aim to prevent the entrance of micro-organisms into the tissues. These aseptic precautions account for nearly all the details of present day operating room technic.

Before an operation, it is necessary to make sterile and keep sterile: the patient's skin, the hands and clothing of the surgeon and his assistant, and all instruments and materials that come in contact with the wound or are handled by the surgeon and his assistants. During the operation the oral surgeon and his assistants must not touch anything that is not sterile. A great responsibility rests upon the assistants who are detailed to the oral surgery operating rooms. The most perfect surgery may be a complete failure if there is the smallest break in the chain of asepsis for which the assistants are responsible. It is the efficiency of the operating room crew that makes aseptic surgery possible. The term aseptic surgery is used to describe that mode of surgical practice in which everything used at the time of the operation and at subsequent dressings, as well as the wound itself, is kept free from pathogenic bacteria. Such a practice produces a sterile, or surgically clean condition. To maintain that condition REQUIRES CONSTANT VIGILANCE BEFORE, DURING AND AFTER AN OPERATION, AND NO FAILURE OF TECHNIC, HOWEVER TRIVIAL, MUST BE ALLOWED TO PASS UNCORRECTED.

Oral surgeons agree that to expect strict asepsis throughout oral surgery is unreasonable since the mouth is a difficult field in which to produce and maintain sterility. However, they also agree that the aseptic technic MUST be practiced to prevent cross infection of patients. Cross-infection means transmitting infection from one patient to another. It is true that persons have a great tolerance for organisms of their own bodies but little tolerance for those found in others. The surgical procedures followed in the oral surgery clinic of a hospital dental service cannot be the same as those in the field, where the dental officer may not have an assistant. In the one instance, the aseptic chain can be maintained without being broken; in the other case the chain will be broken by the nature of the physical equipment and lack of adequate linens or gowns. Regardless of the situation, every effort should be made to establish and maintain a sterile technic with the means at hand. It is possible to be surgically CLEAN without producing a condition of absolute sterility.

The following illustrations will serve to acquaint the technician with instruments commonly employed in oral surgery procedures. A complete understanding of the instrument nomenclature will enable the technician to be an efficient assistant to the dental officer. The tray set-ups are a basis upon which the technician can elaborate in assisting different operators in the surgical field.



Instrument nomenclature

A—Forceps, Tooth Extracting, No. 1, Winter. For extracting upper anteriors.

B—Forceps, Tooth Extracting, No. 286: Bayonet shape. For extracting upper anteriors, bicuspids and roots.

C—Forceps, Tooth Extracting, No. 65: Bayonet shape. For extracting upper anteriors and roots.

D—Forceps, Tooth Extracting, No. 150A. For extracting upper anteriors, bicuspids and roots.

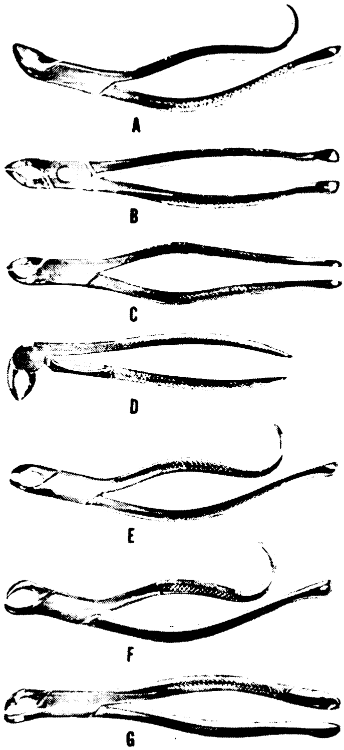
E—Forceps, Tooth Extracting, No. 18L. For extracting left upper first and second molars.

F—Forceps, Tooth Extracting, No. 53L: Bayonet shape. For extracting left upper first and second molars.

G—Forceps, Tooth Extracting, No. 10H. For extracting upper molars.

H—Forceps, Tooth Extracting, No. 210. For extracting upper third molar.

Figure 315.—Maxillary forceps.



A—Forceps, Tooth Extracting, No. 103. For extracting lower anteriors, bicuspids and roots.

B—Forceps, Tooth Extracting, No. 151. For extracting lower anteriors, bicuspids and roots.

C—Forceps, Tooth Extracting, No. 203. For extracting lower anteriors, bicuspids and roots.

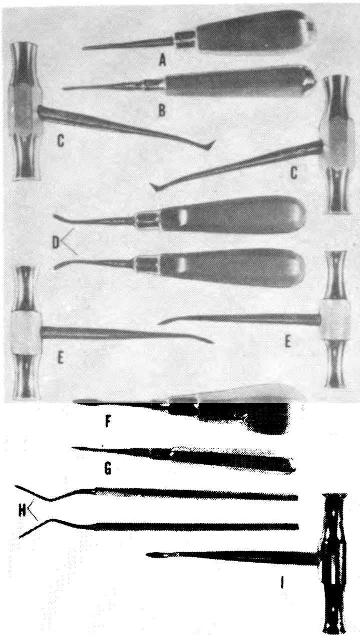
D—Forceps, Tooth Extracting, Hawk-bill. For extracting lower anteriors and bicuspids.

E—Forceps, Tooth Extracting, No. 15. For extracting lower first and second molars.

F—Forceps, Tooth Extracting, No. 16. Hornbeaked. For extracting lower first and second molars.

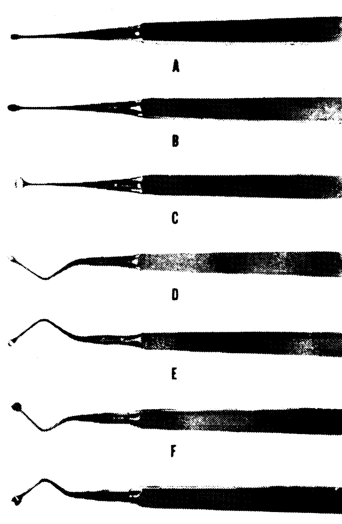
G—Forceps, Tooth Extracting, No. 217. For extracting lower third molars.

Figure 316.—Mandibular forceps.



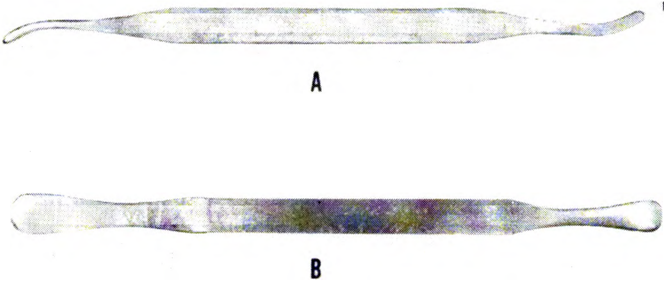
A—Elevator, Root, No. 34S.
B—Elevator, Root, No. 301.
C—Elevator, Root, Barry, Nos. 320, 321.
D—Elevator, Root, Miller, Nos. 73, 74.
E—Elevator, Root, Seldin, Nos. 1R, 1L.
F—Elevator, Root, Stout, A.
G—Elevator, Root, Apical Fragment, Howard, No. 1.
H—Elevator, Root, Apical Fragment, Woodward, Nos. 3E, 4E.
I—Elevator, Winter, No. 135.

Figure 317.—Elevators.



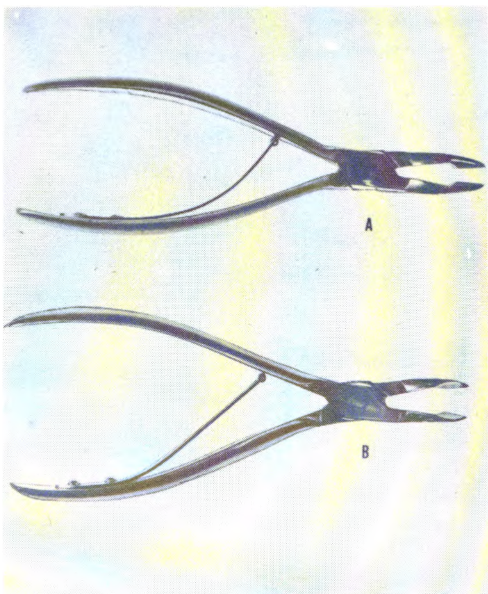
A—Curette, Alveolar, Molt, No. 1.
B—Curette, Alveolar, Molt, No. 2.
C—Curette, Alveolar, Molt, No. 4.
D—Curette, Alveolar, Molt, No. 5L.
E—Curette, Alveolar, Molt, No. 6R.
F—Curette, Alveolar, Molt, No. 9L.
G—Curette, Alveolar, Molt, No. 10R.

Figure 318.—Curettes.



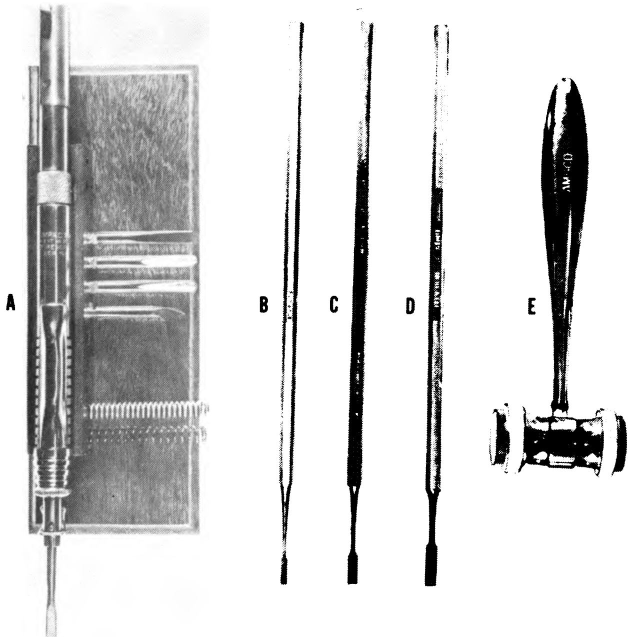
A—Elevator, Periosteal, Seldin, No. 22, double ended.
B—Elevator, Periosteal, Seldin, No. 23, double ended.

Figure 319.—Periosteal elevators.



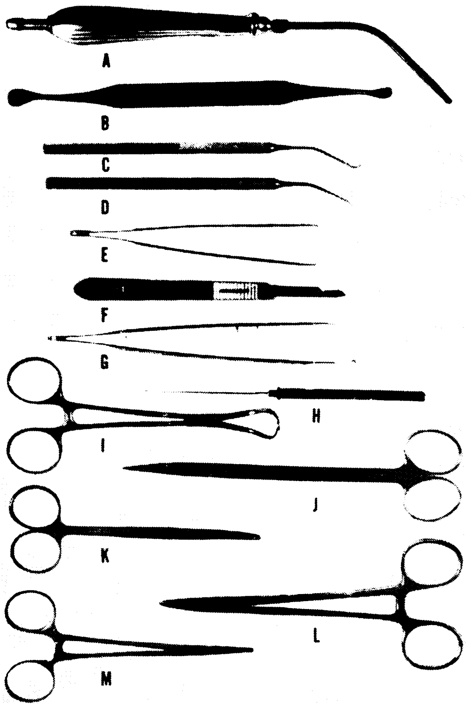
A—Forceps, Bone, Rongeur, No. 1A.
B—Forceps, Bone, Rongeur, No. 4A.

Figure 320.—Rongeur forceps.



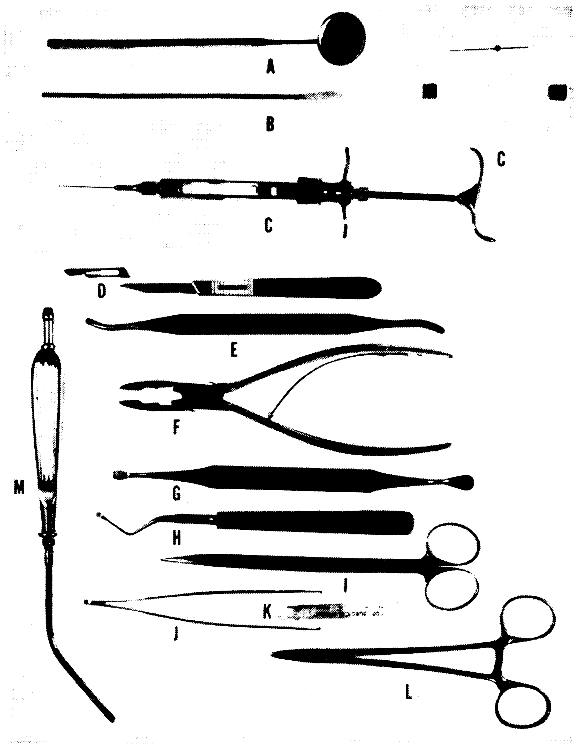
A—Mallet, Oral Surgical, Engine Driven, Dudley, with five (5) impactor (chisels, elevator and gouge) points.
B—Chisel, Osseous, Stout, No. 1.
C—Chisel, Osseous, Stout, No. 2.
D—Chisel, Osseous, Stout, No. 3.
E—Mallet, Surgical.

Figure 321.—Surgical chisels and mallet.



A—Aspirator Handle and Tip.
B—File, Bone, Seldin, No. 11.
C—Retractor, Tissue, Thoma, No. 1.
D—Retractor, Tissue, Thoma, No. 2.
E—Forceps, Tissue, Spring, 5½ inch.
F—Handle, Operating knife, No. 3—Blade, Operating knife, No. 15.
G—Pliers, No. 17.
H—Probe, Abscess, Silver.
I—Clamp, Towel, Backhaus, 5½ inch.
J—Scissors, Oral Surgical, Saw-Toothed, 6¾ inch.
K—Scissors, Oral Surgical, Curved, 5 inch.
L—Forceps, Hemostatic, Straight, 6¼ inch.
M—Forceps, Hemostatic, Mosquito, 5 inch.

Figure 322.—Surgical instruments.



A—Mouth mirror.
B—Applicator.
C—Syringe, Anesthesia, Needles and Carpule.
D—Scalpel, Handle and Blades.
E—Elevator, Periosteal.
F—Forceps, Bone, Rongeur.
G—File, Bone.
H—Curette.
I—Scissors, Oral Surgical.
J—Forceps, Tissue.
K—Suture.
L—Holder, Needle.
M—Aspirator Handle and Tip.

Figure 323.—Alveolectomy set-up.

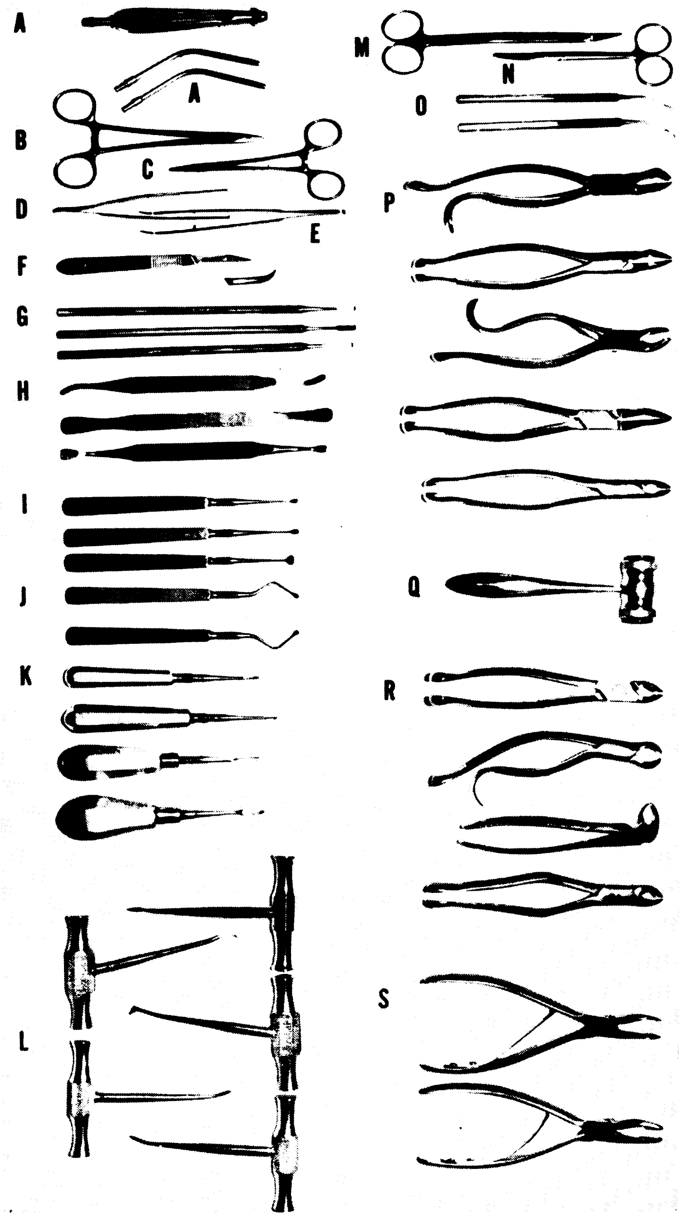
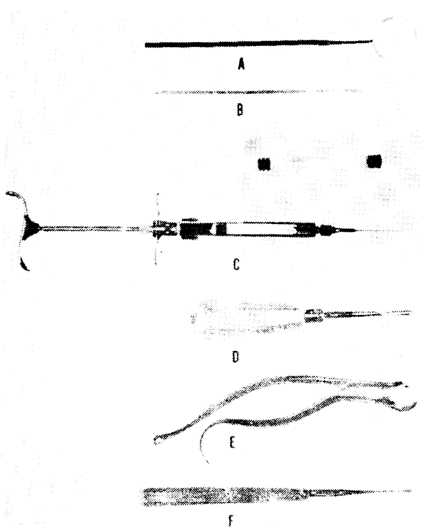


Figure 324.—A reserve surgical table.

A—Aspirator Handle and Tips.
B—Holder, Needle.
C—Forceps, Hemostatic.
D—Forceps, Tissue.
E—Pliers, College.
F—Forceps, Tissue.
G—Chisel, Osseous, Stout, 1, 2, 3.
H—Elevator, Periosteal.
I— File, bone.
J—Currette, Alveolar.
K—Elevator, Root.
L—Elevator, Crossbar Handle.
M—Scissors, Oral Surgical, Saw-Toothed, 6¾", Dean.
N—Scissors, Oral Surgical, curved 5", Double blunt.
O—Retractor, Tissue, Thoma, No. 1.
P—Forceps, Maxillary.
Q—Mallet, Surgical.
R—Forceps, Mandibular.
S—Forceps, Bone, Rongeur.

Figure 324.



A—Mouth mirror.
B—Applicator.
C—Syringe, Anesthesia and Carpule.
D—Elevator.
E—Forceps, Tooth extracting.
F—Curette.

Figure 325.—A simple extraction set-up.

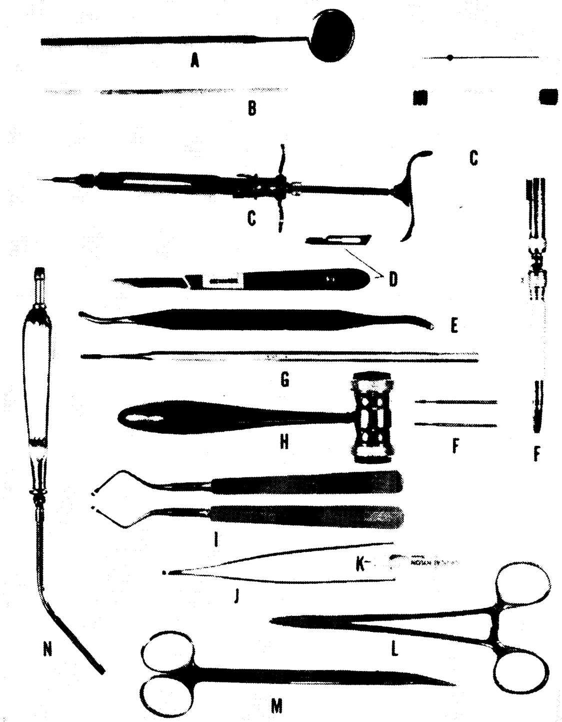


Figure 326.—Apicoectomy set-up.

A—Mouth mirror.
B—Applicator.
C—Syringe, Anesthesia, Needles and Carpules.
D—Scalpel, Handle and Blades.
E—Elevator, Periosteal.
F—Handpiece, Straight, and crosscut fissure burs.
G—Chisel, Osseous.
H—Mallet, Surgical.
I—Curettes.
J—Forceps, Tissue.
K—Sutures.
L—Holder, Needle.
M—Scissors, Oral Surgical.
N—Aspirator Handle and Tip.

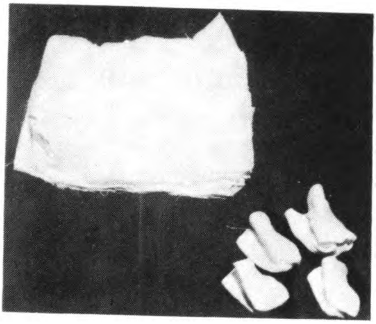


Figure 327.—(A) Simple technic in sponge making.

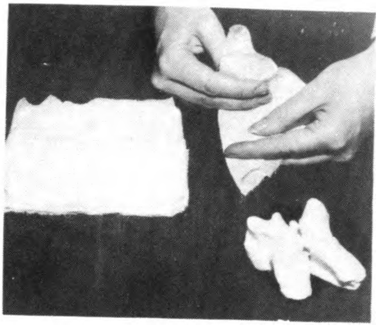


Figure 327.—(B)

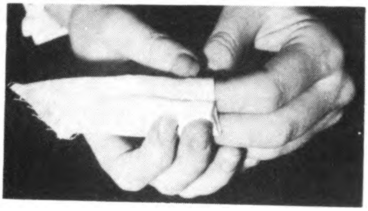


Figure 327.—(C)

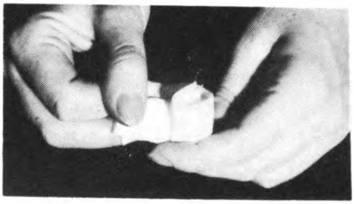


Figure 327.—(D)

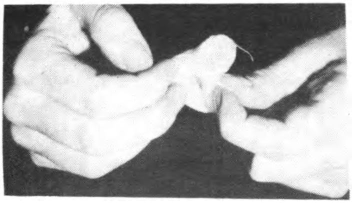


Figure 327.—(E)

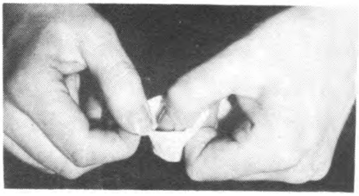


Figure 327.—(F)

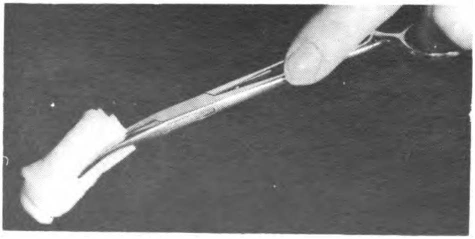


Figure 327.—(G)

A—Sterile Gauze Sponges.
B—Forceps, Instrument.
C—Sterile Tongue Depressors and Applicators.
D—Sterile Towels.
E—Sterile Burs.
F—Antiseptic Solution.

Figure 328.—Accessory table and linen hamper.

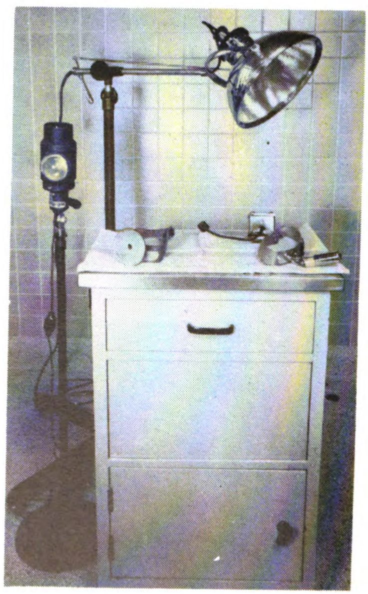


Figure 329.—Accessory lighting.

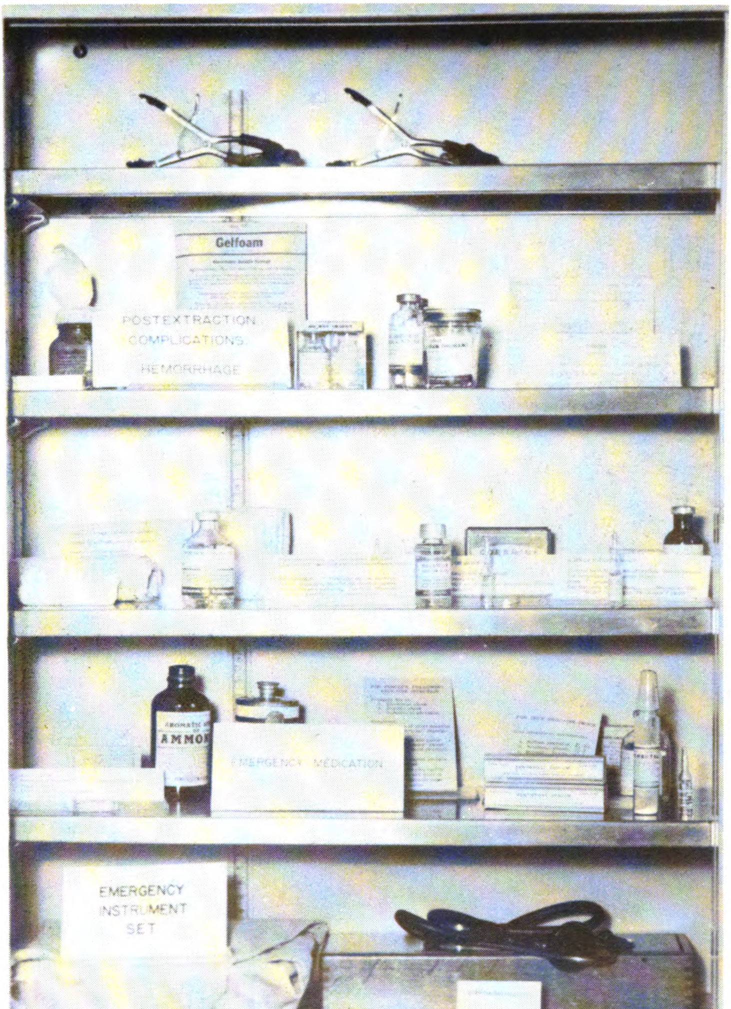


Figure 330.—Accessory cabinet.

Figure 331.—Medicine cabinet.

STERILIZATION

When any operation is performed in the oral cavity, the dental officer must be certain that all instruments used in the operation are sterile. He delegates the duty of sterilizing the instruments to the dental assistant. If the assistant neglects this particular phase of his duty he may jeopardize the life of the patient. Close adherence to a sterilizing procedure as established by the dental officer is imperative. Before instruments are sterilized they must be washed free of debris, saliva and blood with soap and water.

There are two general methods of sterilization: heat and chemical. "Wet" heat (boiling water) will be used in most offices. The instruments are immersed in boiling water, containing one percent sodium carbonate, for a period of 20 minutes.

Oil sterilization

Liquid petrolatum can be used in a specially constructed sterilizer for sterilizing cutting instruments and handpieces. The instruments are immersed in the hot oil, which is kept at a temperature of 250° F., for a period of two minutes. The oil in the average dental operating room becomes discolored after a period of about two weeks and should then be replaced.

Steam Under Pressure

The autoclave is a sterilizer using steam under pressure. A vacuum is first created to insure penetration of the steam, and when the proper reading of negative pressure (vacuum) is registered in the gage, superheated steam is admitted to the chamber. The articles therein are subjected to a steam pressure; the force and time is governed by the nature of the articles. Towels, sponges, field cloths, applicators and suture material are sterilized by autoclaving at 20 pounds pressure for 20 minutes. Rubber gloves are also autoclaved but, because of their inability to withstand such heat and pressure, they are sterilized at 15 pounds pressure for 10 minutes. All articles should be wrapped before being placed in the autoclave. Wrapped articles are commonly called packs.

After autoclaving, all organisms will have been killed and the dressings or other articles will be safe for use. Ordinarily, one such sterilization is sufficient to preclude the possibility of infec-

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tion. Many oral surgeons favor repetition of the above procedure at least once. The process of repeated sterilization, either by steam or boiling, is termed FRACTIONAL STERILIZATION.

Figure 332.—Autoclave and sterilizer.

Instructions for operating the autoclave shown in the above figure are:

1. Turn on hot water supply valve at the rear of the autoclave, fill the water tank until the gage (on the front lower panel of the autoclave) registers one-half full. Be sure to turn the valve all the way off, or the autoclave will flood.

2. Turn waste valve on top of the chamber all the way off.
3. Place material to be autoclaved in tray and slide tray into the chamber.
4. Close the door and tighten the wheel as far as it will go, then loosen one-half turn.
5. If you are autoclaving rubber gloves, turn the switch on the lower part of the front panel straight up or one-half way between OFF and ON. This will bring the pressure to 15 pounds. If you are autoclaving instruments, sutures or field cloths, turn the switch all the way to ON position. Such action will cause the pressure to rise to 20 pounds.
6. It takes 15–20 minutes for the pressure to start going up when the autoclave is cold. When it does start up, the automatic lock in the middle of the wheel on the door comes out and locks the door so it cannot be opened until the pressure is let off and the knob pushed in.
7. When sterilizing is completed, turn the switch (step 5) to OFF position.
8. Open waste valve (step 2) all the way.
9. When pressure returns to 0, push the safety knob in (step 6) and turn the wheel to open the door.
10. Contents of the autoclave are now ready for surgical use.

Sterilization by dry heat

Sterilization in an oven requires a temperature of 150° to 165° for a period of an hour. This method is applicable in the sterilization of glassware used in the bacteriologic laboratory.

Chemical sterilization

Several medicaments are in common usage in the dental profession at the present time. Among them are: Zephrin chloride tincture (1 oz. to 240 cc. of water), Metaphen tincture, and Phenol in saturated solution.

Sterilization of Packs

Rubber dam and rubber gloves are the two most common articles of rubber employed in the average dental operating room. Before use, the rubber dam should be washed in lukewarm water and soap, followed by successive rinsings, placed in a flat position and wrapped in muslin. Rubber gloves require more consideration. After, or during washing they are tested for leaks, dried, then the cuff or wrist is turned down for approximately 2 inches, a piece of gauze is placed well into the palm, followed by another gauze pad in the wrist. This is done to insure permeability of the interior of the glove by steam. A regular muslin pack or wrapping is used with the left hand glove placed in the left side of the pack and the right hand glove placed in the right hand side. A small muslin container of talcum powder is placed within the pack but NOT within the confines of the rubber glove.

Glass syringes are cleansed of all matter, tested to see if working freely and then placed in cool water. The water is brought to boiling and kept at this temperature for 15 minutes. Before the needles are placed in boiling water, they are washed and a wire is inserted in the lumen of each. The wire will aid in the prevention of clogging of the needle by the presence of salts in hard water.

Large packs are sterilized for 60 minutes under 20 pounds pressure with 20 to 30 minutes vacuum allowed for drying. Small packs are sterilized for 30 minutes under 20 pounds pressure with 15 to 20 minutes vacuum allowed for drying. Enamel ware, glassware and rubber goods are sterilized for 15 minutes under 15 pounds pressure with no vacuum. Solutions in flasks are sterilized separately for 15 minutes at 15 pounds pressure. Pressure at conclusion of sterilization period is allowed to decrease gradually. No vacuum is used on solutions. Sharp instruments are sterilized in oil in a hot oil sterilizer at a temperature of 250° F., or above, for 2 minutes. Sharp instruments can also be sterilized in an 87½ percent solution of phenol for 15 minutes, rinsed in plain sterile water, and then placed in 95 percent alcohol for 20 minutes. Other instruments are placed in trays and boiled for 20 minutes. A 1 percent solution of sodium carbonate (3 teaspoons to the quart) raises the boiling point of water about 5 degrees, prevents rust and removes organic matter.

Sutures

There are two principal kinds of sutures and ligatures, absorbable and nonabsorbable. The former are buried beneath the tissue surfaces and the latter are commonly used to suture surface tissues. The principal varieties of absorbable sutures are plain gut and chromic gut. Gut sutures are made from the submucous coat of sheep intestine. The plain gut is supposed to last from 8 to 10 days in the tissue. Chromic gut sutures are prepared in four types, to last 10, 20, 30 and 40 days in the tissue, but the rate of absorption is very variable. They are usually issued in plain glass tubes which may be sterilized by boiling or submerging in a special suture sterilizing solution. Nonabsorbable sutures are made of silk, cotton, silkworm gut, horsehair, silver wire and plastic material such as nylon. Those most commonly used in oral surgery are silk and cotton.

Suture materials which are dispensed in tubes have been rendered sterile by the manufacturer. The tubes themselves are sterilized in two ways. Tubes marked "Boilable" are sterilized by boiling for 15 minutes. Tubes not marked boilable are stored in 5 percent phenol solution and then placed in 95 percent alcohol for 20 minutes just prior to operation. Suture materials such as silk and linen, not dispensed in tubes, are sterilized in the autoclave under 15 pounds pressure for 15 minutes. Horsehair, silkworm and silver wire sutures are sterilized by boiling for 15 minutes prior to operation.

Instruments

Most surgical instruments are made of special steel. They are nickel or chrome plated to prevent rusting. The newer instruments are made of stainless steel which is not plated and prove highly desirable in that they do not chip or show wear from sterilization and scrubbing. After an operation, all metal instruments should be washed carefully to remove blood and other foreign matter. They should then be dried and carefully examined for debris in the crevices and breaks in the plating. They are sharpened if they need it sterilized, then wiped with sterile petrolatum to prevent rusting, and placed in the instrument cabinet.

Care of the Sterilizer

The water sterilizer should be emptied each night, the instruments and bur trays removed, the interior wiped out, and the lid

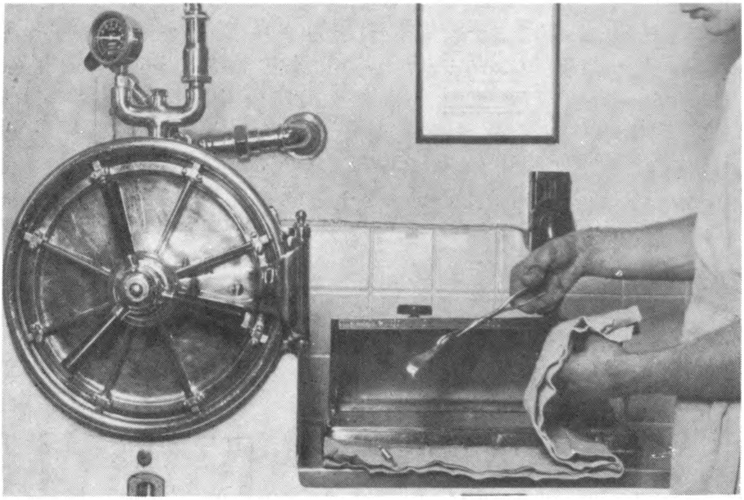


Figure 333.—Sterile instruments placed on sterile towel.

left open. The latter step will keep the assistant from inadvertently turning on the switch in the morning without first filling the sterilizer with water. Soap-impregnated steel wool will serve to remove scale that may accumulate. Another method is the use of acetic acid in the water and allowing the contents to boil for an adequate period.

The oil sterilizer is not emptied at the close of each working day. It is replenished with fresh oil or silicone at two week intervals.

The autoclave should be checked for leaking valves and false pressure readings. The safety valve should not be tampered with by the dental assistant unless he be qualified in the field of dental repair.

The chemicals employed in cold sterilization should be changed or replenished as required.

In order to develop an aseptic technic within the dental operating spaces the dental assistant should bear the following in mind during the performance of his day's duties:

1. Instruments stored in cabinets are NOT considered sterile and must be sterilized prior to use.

2. When an instrument is dropped to the floor, pick it up, wash it, and place it in the sterilizer. Rewash your hands before returning to the side of the operator at the chair.
3. Instruments used in the treatment of a patient with infectious disease should be sterilized twice. A careless assistant can be responsible for transferring an infectious disease from one patient to another.

PATIENT CARE

Comfort of the patient, following an extraction or other oral surgery, should be of prime importance to the technician. Patients placed in the recovery room following surgery will either require constant or frequent observation by the dental technician, as well as the dental officer, until final disposition. The assistant must not dispense medication unless ordered to do so by the oral surgeon. Information concerning a patient's case, contemplated operative procedures, treatment and diagnosis should never be discussed by the dental technician with the patient or others. A safe rule to follow at all times is never to divulge any patient information over the telephone.

Approved hospitals have wards or beds for oral surgical patients. Responsibility for the continuous care of such patients by dental personnel does not cease by placing them in bed. The oral surgeon and his assistants provide continuous care for oral surgical cases; consultation or assistance of other specialists is obtained in accordance with the patient's requirements.

SHARPENING INSTRUMENTS

The most important factor in the sharpening of dental instruments is the use of a high grade Arkansas stone. The stone selected should be hard and of fine grit. Most stones are purchased in a tight-fitting wooden box, in the top of which should be placed an oil-soaked piece of woolen or felt cloth. This prevents the stone from drying out. Instruments should not be sharpened on the same spot of the stone, but the sides as well as the middle and the edge should be used to prevent uneven wearing of the stone. Dirty oil should be rubbed off at once, as the pores of the stone will absorb the oil along with the fine particles of steel and cause the surface of the stone to become glazed. Ammonia water will usually clean a glazed surface from the stone.

When using the stone, first moisten its surface with a few drops of machine oil, then pass a chisel over it with a few long, firm strokes. Be sure to maintain the bevel at the correct angle. Generally the instruments which are used for cutting soft structures have long thin bevels and those in use on hard tissues have short bevels. Stones are supplied with various-sized grooves on one surface. These grooves can be used for sharpening spoon excavators and other instruments which have curved cutting edges that fit these grooves. Mounted sharpening stones, for use in the handpiece, can be used to advantage in the sharpening of the points on elevators. rongeurs and spoon excavators.

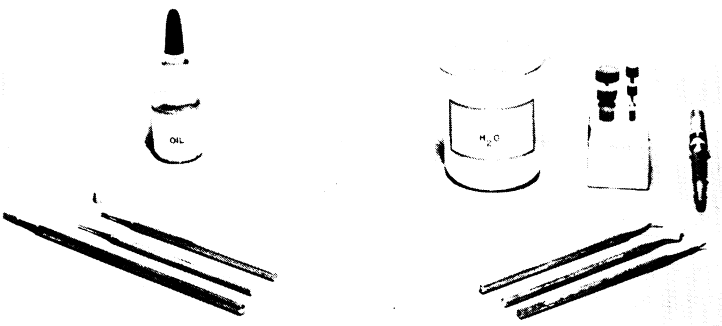


Figure 334.—Armamentarium for instrument sharpening.

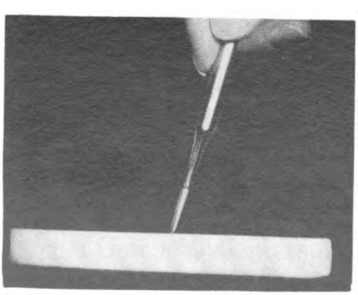


Figure 335.—Incorrect bevel.

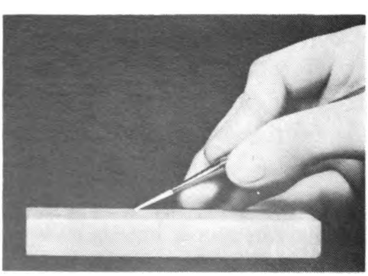


Figure 336.—Correct bevel and instrument position.

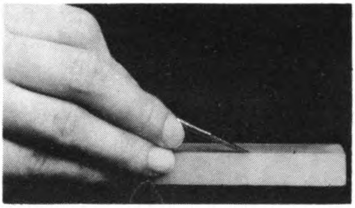


Figure 337.—Correct position for surgical chisel.

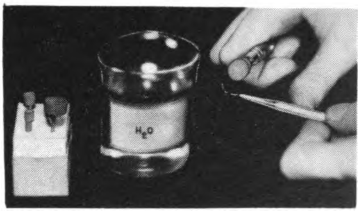


Figure 338.—Mounted stone and sickle scaler.

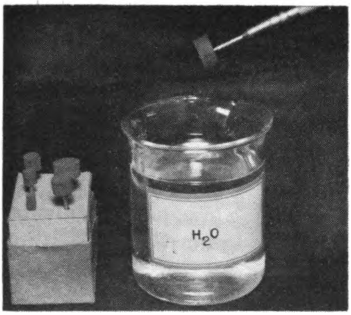


Figure 339.—Mounted wheel used for sharpening instruments.

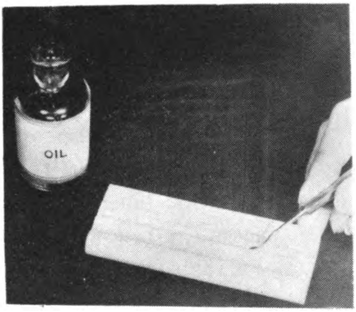


Figure 340.—Correct use of grooved stone.

HELPFUL HINTS

1. Be neat and be courteous at all times. Apply the Golden Rule.
2. Do not engage in lengthy conversations with patients.
3. Do not discuss the diagnosis or treatment of the case with the patient.
4. Do not divulge any information concerning patients over the telephone unless the caller is known to yourself.
5. Patients brought from another service within the hospital are your responsibility until returned to that service. Par-

ticular vigilance should be exercised with patients under the treatment of the neuropsychiatrist.

6. A patient in the recovery room should have a dental assistant in constant attendance.
7. Do not leave the operating room without permission of the doctor.
8. Patients who have toothaches or other dental emergencies must be taken care of as soon as possible.
9. An effort should be made to give appointments for times that will fit the convenience of the patient.
10. Keep a memorandum or "want list" of all supplies and equipment needed for the operation of the dental operating spaces and draw them at authorized times from the storeroom.
11. Man is a product of his environment. Keep the operating spaces immaculate.

SECURING THE DENTAL OPERATING SPACES

The Dental Operating Spaces in the military services cover many square feet of space and as a result of the largeness of the establishments, a routine must be established in the proper securing of these spaces. The following was used at the U. S. Naval Training Center, Farragut, Idaho and is offered as a skeleton plan from which the reader may develop his own procedure. Upon the conclusion of the working day, the assistant should see that the following is accomplished:

DENTAL CHAIR

(a) Dusted
(b) Clean headrest covers
(c) Lowered to lowest position

DENTAL UNIT

(a) Dusted
(b) Waste trap in cuspidor emptied and cleaned
(c) Cuspidor cleaned, and polished if bright
(d) Electric switches off
(e) Bunsen burner out

(f) Water supply to cuspidor off
(g) Compressed air off, if the unit is fitted with a cut-off valve
(h) Compressed air released from rubber tubing, if air is off
(i) Foot controller placed on foot platform of dental chair

ILLUMINATOR

(a) Dusted
(b) Electric switch off

DENTAL INSTRUMENTS

(a) Cleaned
(b) Sterilized
(c) Polished if required
(d) Handpieces cleaned, and oiled
(e) In proper places in dental instrument cabinet

DENTAL INSTRUMENT CABINET

(a) Dusted
(b) Locked
(c) Key removed and stored in proper place

WASTE RECEPTACLE

(a) Emptied
(b) Lined with clean paper sack
(c) Top cleaned, and polished if bright
(d) Placed on platform of dental chair

DENTAL INSTRUMENT STERILIZER

(a) Emptied
(b) Cleaned inside and outside
(c) Bright surfaces polished
(d) Dry inside
(e) Lid opened
(f) Electric switch off

ROOMS IN GENERAL

(a) Neat desk blotter
(b) Desks cleaned and polished
(c) Windows locked

(d) Wash basin cleaned
(e) Clean towels placed
(f) Shades lowered to a point halfway between top and bottom of windows
(g) Water in lavatory off
(h) Lavatory clean
(i) Waste receptacles emptied
(j) Steam radiators off, when heat is not necessary
(k) Lights out
(l) Door locked

SURGERY

(a) All narcotics under lock and key, and key in the possession of duty officer
(b) Night emergency tray placed on bracket table
(c) Osteotomes, needles sharpened
(d) Inhalation anesthesia equipment, valves secured

DENTAL X-RAY ROOM

(a) X-ray machine cleaned and dusted
(b) Electric switch of machine off
(c) Electric switch of dental illuminator off

X-RAY DARKROOM

(a) X-ray film processing tank cleaned
(b) Adequate quantity of solutions in X-ray processing tanks
(c) Water supply to X-ray film processessing tanks turned off
(d) All X-ray film removed from X-ray film processing tank solutions
(e) Lid in place on X-ray film processing tank
(f) Safelight out
(g) Electric switch to fan off
(h) Sink cleaned
(i) Water supply to sink off
(j) Cabinets and work bench cleaned and dusted
(k) Lights out

Air-compressor room

(a) Electric switch to air compressor off
(b) Petcock on air compressor opened
(c) Air and condensed moisture drained from air compressor tank
(d) Lights out

Reception room and appointment desk

(a) Benches and furniture dusted
(b) Drinking fountain cleaned
(c) Lights out when not in use
(d) Typewriters covered
(e) Clock accurate
(f) Ashtrays emptied and cleaned

Wash rooms

(a) Porcelain installations cleaned
(b) Lavatories cleaned
(c) Wash faucets off
(d) Adequate supply of paper hand towels in towel receptacles
(e) Adequate toilet paper
(f) Shower stalls cleaned
(g) Shower curtains presentable
(h) Soap receptacles cleaned
(i) Lights out when not in use

Locker rooms

(a) Furnishings dusted
(b) Ash receptacles cleaned
(c) Lockers neat and clean inside, doors closed
(d) Lockers lined up
(e) Lights out when not in use

Key locker

(a) Locked at all times
(b) Key in custody of duty officer

PASSAGE

(a) Bulletin board neat, obsolete memorandums removed
(b) Blackboard neat, obsolete notices erased
(c) Clocks accurate
(d) Lights out when not in use

PROSTHETIC LABORATORY

(a) Burn-out furnaces, water baths, vacutrol, boil-out tanks, lathes and dental engines, switches off
(b) Polishing lathe blower switch off
(c) Air and gas valves closed
(d) Plaster bowls, spatulas cleaned and neatly stowed
(e) Plaster, artificial stone and investment bins checked and filled
(f) Crucible rings, flasks, cleaned and stowed
(g) All instruments, mounted stones cleaned and returned to instrument drawers
(h) Boil-out tanks cleaned and wax residue removed
(i) Water tank in the Leiman lathe filled
(j) Casting wells cleaned out
(k) Tension released on casting machine
(l) Casting ovens cleaned out
(m) Tops of all laboratory benches cleaned
(n) Foot rheostats placed on bench top while deck is being swabbed
(o) Lights out

CHAPTER 11

ORAL HYGIENE

Oral hygiene is all intelligent effort expended to maintain the hard and soft tissues of the mouth in a state of health normal for the individual.

This chapter discusses the principles and procedures which the dental technician must understand and follow in order to maintain the health of his own teeth and mouth tissues, to perform oral prophylaxis under the supervision of a dental officer, and to instruct others in oral hygiene. Also explained is the role of saliva in the formation of calculary deposits (tartar) on teeth, the origin of stains, something about dentifrices and how to brush teeth—the most important single factor in the maintenance of oral hygiene under the control of the patient.

Formation of Calculus

The periodontium

Before the formation of calculus is discussed, the relation of the tooth to its supporting structure, the periodontium, will be reviewed.

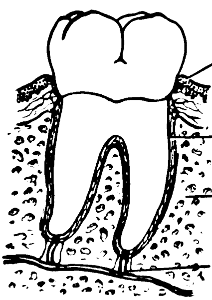


Figure 341.—The periodontium.

The periodontium consists of the periodontal membrane, alveolar process (alveolar bone and supporting bone or spongiosa) and gingival tissues. Figure 342 illustrates the positions of the epithelial attachment, alveolar bone and the fibers of the periodontal membrane. The normal position of epithelial attachment varies with the patient and the location of the tooth.

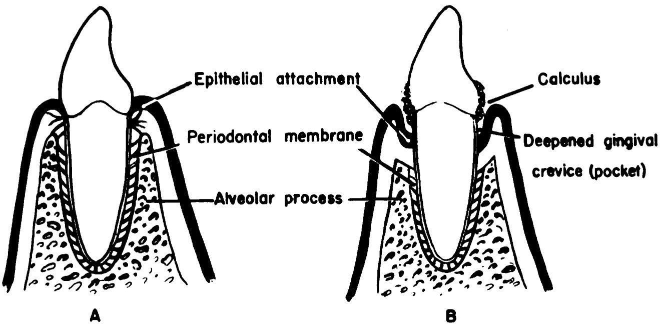


Figure 342.—Effect of calculus on the periodontium.

The periodontium and calculus

Figure 342 shows how calculus can affect the periodontium. Calculary deposits accumulate in the direction of the apices of the teeth. This means that greater calculary deposition will cause deeper crevice formation and further calculous formation. It can be seen that the epithelial attachment has receded from the neck of the tooth and that there has been a resorption of the alveolar process, combined with a loss of fibers of the periodontal membrane. Damage of this type causes permanent loss of portions of the periodontium. This condition, formerly called "pyorrhea alveolaris" is now known as periodontoclasia or periodontosis.

Since a tooth is no better than its supporting structures, it may be likened to a beautiful home resting on a poor foundation. When a large portion of the periodontium is lost, there is additional stress on the subnormal remaining structures, which increases the rapidity of the destructive process. The loss of alveolar and supporting bone may result, leaving ridges inadequate for the construction of well fitting dentures, when the extraction of the teeth becomes necessary.

Saliva

The formation of calculus is a rather complex process. One of the factors in its formation is the stagnation of saliva. Wherever this stagnation exists, there is a tendency for calculus to accumulate.

Saliva is a combination of the secretions of all glands of the mouth. The salivary glands—the parotid, the submaxillary and the sublingual—empty their contents into the mouth, as do the small mucous glands which are distributed throughout the mucous membranes. Saliva may be defined as a clear, alkaline, somewhat viscid fluid secreted by the salivary glands. Saliva serves to moisten and soften food and to keep the mucous membranes moist. A digestive ferment, ptyalin, which converts starch to maltose and is the first enzyme to act, is contained in saliva. Saliva also contains mucin, serum-albumin, globulin, leukocytes and epithelial debris.

Bacterial plaques

Mucin, a yellow white, sticky substance, is precipitated from stagnant saliva and combines with the loose epithelial tissue cells (shed from the oral tissues), bacteria and food debris to form thin gelatin-like layers on the surfaces of the teeth, called MUCOUS or BACTERIAL PLAQUES. (Bacterial plaques are also thought to be involved in dental caries.) When such layers form on tooth surfaces, they provide a base or foundation upon which calcium and phosphorous salts precipitate from the saliva. Eventually huge

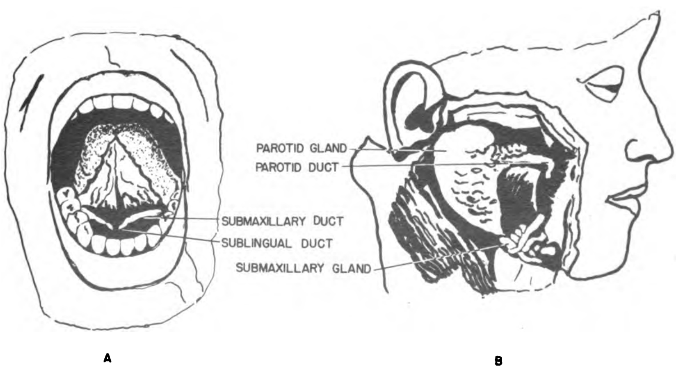


Figure 343.—Salivary ducts.

masses will form in layers if left undisturbed. Mucin, being sticky and threadlike, provides a binding network for the different substances present in the calculus.

Where calculus forms

There is a greater tendency for bacterial plaques and calculus to accumulate where there is stagnation of saliva. Many areas of the teeth—especially the cusps—are "self-cleansing"; friction of food, cheeks, tongue and contact with opposing tooth surfaces prevent accumulation of plaques and tartar. However, in "sheltered" areas, such as between the teeth and in the gingival crevices, debris and mucin tend to remain.

There appears to be greater tendency for calculus to form on tooth areas nearest the salivary gland duct openings. The duct opening of the parotid gland is opposite the maxillary second molar. The sublingual and submaxillary glands empty their secretions onto the floor of the mouth just behind the mandibular incisors.

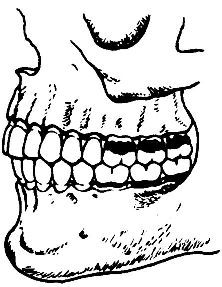


Figure 344. — Calculus from parotid gland.

Figure 345.—Calculus from sublingual gland.

Kinds of calculus

Calculus is of two types—SALIVARY or SUPRAGINGIVAL, and SERUMAL or SUBGINGIVAL.

Salivary calculus is hard in structure, closely resembling hardened crown and bridge cement. It tends to accumulate on exposed portions of the teeth and prosthetic restorations.

Serumal calculus accumulates on the teeth inside the gingival crevices. This type is darker in color and much harder than salivary calculus. Its origin has not been fully determined. Some investigators think it is an exudate from the blood serum under conditions of gingival irritation and inflammation. Others believe it to be a product of the saliva.

Stains

Red and green stains are quite common in the mouths of young patients. Chromogenic (color-producing) bacteria which attach themselves to the enamel cuticle cause these stains. The enamel cuticle, which protects the crown during its formation, is worn away—partly because of mastication—after the tooth has erupted. Some areas of the tooth do not receive heavy use, and remnants of the cuticle remain and provide a resting place for chromogenic bacteria.

Red and green stains generally are found on the anterior teeth. The brown or black stains are usually seen on the teeth of heavy smokers, and are tarry precipitates. Black stains may be associated with the water supply or may be noticed also in individuals who are under treatment of a physician for iron deficiencies.

Prophylaxis Procedure

The patient's lips, gums, tongue, cheeks and throat should be examined thoroughly for any sign of an unusual condition. If any departure from normal is noted, the dental officer should be informed before any treatment is rendered.

The patient should be seated comfortably in the chair. When the patient is in one position it will not be possible to see all areas of the mouth. Therefore, at different stages of the prophylaxis, the chair position should be changed to allow the greatest amount of light to reach the area which is being treated.

Complete instruction in this procedure is given to all dental enlisted personnel during their technology courses. Their training is continued throughout their years of service. In all cases of oral prophylaxis, or other treatments, experienced personnel rendering such treatment will continue to be supervised and further trained by dental officers.

A training motion picture, No. MN–3542, "Oral Prophylaxis by a Dental Technologist," shows principles and technics to be followed in this important procedure.

Detection of calculus

To detect the presence of calculus, it is essential to have adequate, well directed light to illuminate the various areas of the mouth. The mirror can be used to reflect light against the internal surfaces of the teeth. When serumal calculus is present, it generally causes an inflamed appearance of the gingivae immediately overlying it. The gingivae may be red or purple, have a shiny appearance and bleed easily in these areas.

By directing a blast of air into the gingival crevice where calculus is suspected, the free gingiva is separated from the neck of the tooth and it is possible to observe the crevice and any calculary deposits therein. If there is too much saliva present, the patient should be instructed to expectorate and the region should be isolated with cotton rolls.

A second method entails the use of the small diagnostic lamp on the unit. Adjusted to its greatest brilliance, the light can be directed through the interproximal areas which are then visible directly or reflected in the mouth mirror. This method is generally used in the posterior region, where the main operating lamp may not be bright enough to be of value when reflected into inaccessible areas. By use of this method, accumulations of interproximal calculus will show up as dark areas.

The presence of calculus can also be determined by the use of a DISCLOSING SOLUTION. A disclosing solution, such as Skinner's or Buckley's Dental Glycerite, serves this purpose. The solution is applied to the teeth and will stain any deposits of calculus. Supragingival calculus will stain more readily with a disclosing solution than will the subgingival type. Since enamel is smooth and hard, iodine may be washed off the surface easily when the mouth is flushed. Any deposits which may be present will retain the stain, hence the name "disclosing solution."

Calculary deposits also may be detected by the use of a blunt instrument. The convex back of a spoon excavator blade can be used gently to push away the free portion of the gingivae to expose the calculus.

In an experienced operator's hands the use of an explorer or thin scaler will disclose the presence of calculus, particularly if it is situated rather deeply. The difference in texture of the surfaces can be felt as the instrument touches calculus or tooth. The epithelial attachment at the bottom of the pocket is felt as a gentle resistant to further introduction of the scaler blade. Calculus will present a rough, flinty touch and will impede the action of the blade. Clean cementum feels smooth and velvety when the blade is planed across its surface. The cemento-enamel junction feels like a slight bump or ledge when it comes in contact with the blade of the scaler. Enamel, on the other hand, is very hard and smooth to the tactile sense.

Removal of calculus

The removal of these deposits from the surfaces of the teeth is an extremely important procedure in dental treatment. The thorough removal of calculus from teeth usually does more for the health of the gingivae than any other single procedure. The dental technician must train himself to become hypercritical of the appearance of the gingival tissues, and to note the presence or absence of calculus in areas below the gingival crest. Care must be exercised in the exploration of gingival crevices and in the removal of any deposits. Scaling may produce bleeding which will interfere with visibility and make it necessary to scale partially by touch or tactile sense.

Instrumentation

A wide variety of instruments is used to remove calculus. Such instruments are called scalers. Ability to master the use of a few instruments effectively will be of more help than learning the use of many instruments. Scalers are divided into two types: those used to "push" calculus off the surface of the tooth and those designed to "pull" it off. A few scalers lend themselves to both "push" and "pull" action.

The Zerfing and D.P. #5 and #6 are small "push" scalers with a single cutting edge, used to remove calculus from between the maxillary and mandibular anterior teeth.

The Zerfing is the only scaler entirely limited to a "push" motion, the remainder being primarily the "pull" type; a few may be em-

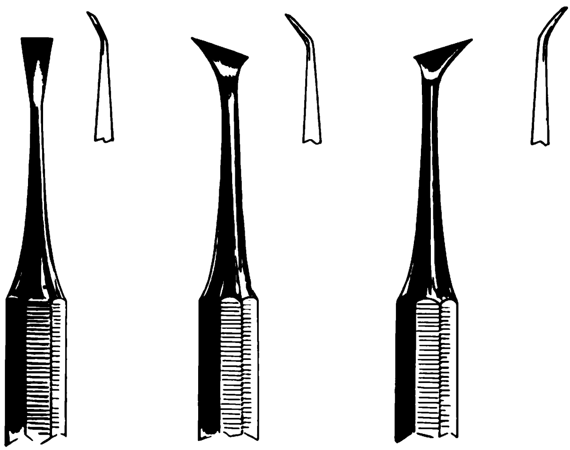


Figure 346.—Push action scalers.

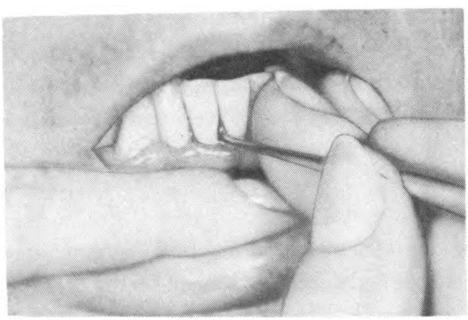
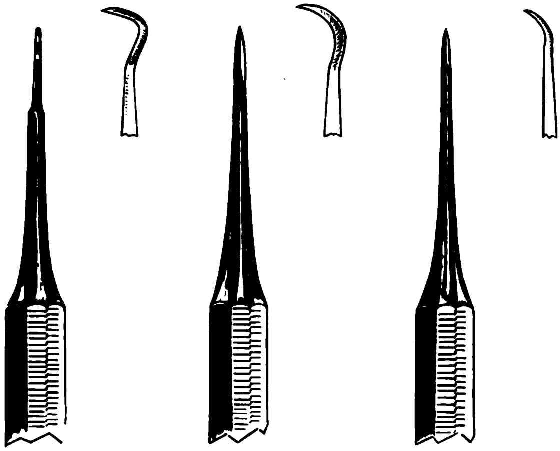


Figure 347.—Zerfing scaler in use.

ployed with either action. The Zerfing is not to be used when the interdental papillae are close to the contact points. In young individuals, the interdental papilla usually is attached to the proximal surfaces almost to the contact point. In older patients, the interdental papillae are farther cervically because of the normal deepening of the crevices. When the gingival crevice deepens, calculary formation is much greater. The Zerfing scaler is used, therefore, to a greater extent on older patients. This scaler is extremely valuable when huge amounts of calculus have accumulated on the mandibular teeth. These deposits can be removed in many instances with a single motion of the scaler.

The B, #6 and Younger-Good scalers are all of the sickle type. They are used with a "pull" motion and are particularly useful in



B   6   YOUNGER-GOOD 15

Figure 348.—Sickle scalers.

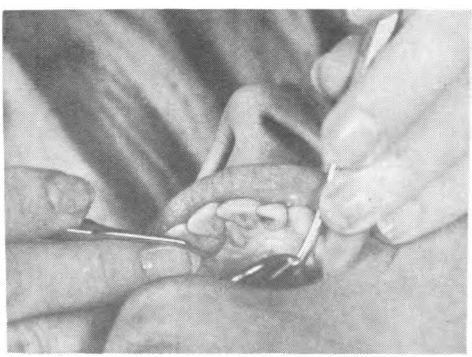


Figure 349.—"B" scaler in use.

removing gross deposits from the anterior teeth and from teeth as far posterior as the mesial surface of the second bicuspid. The Younger-Good, having a more slender working edge than the #6, is less liable to damage the interseptal papillae in the bicuspid region.

Scalers #33 and #34 will serve to remove large deposits from the lingual surfaces of the anterior and posterior teeth, with just enough of a point to reach around the linguomesial and linguodistal surface angles of these teeth.

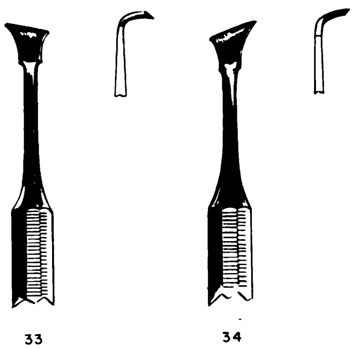


Figure 350.—Scalers 33 and 34.

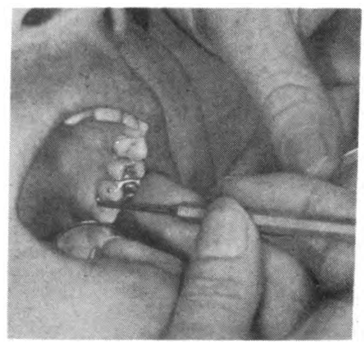


Figure 351.—Scaler 33 in use.

Jaquette #1, #2, and #3 and the Gracey #P–1 and #P–2 are instruments that can be used for the removal of thin deposits in the gingival crevices. Their use requires a well developed sense of touch.

In the hands of many operators, the Black spoons #63, #64, #65 and #66 prove adequate scaling instruments. With these instruments it is possible to push back gently the free margin of the gingivae and at the same time "scoop out" the calculus. The instruments which lend themselves to both "push" and "pull" actions are the B scaler (an outstanding example) and the Darby-Perry #5 and #6, previously mentioned.

Properly used, scaling instruments will do the patient no harm but, if improperly used, they will lacerate and injure healthy gum tissue. Permanent damage can be done. In view of this, a scaling

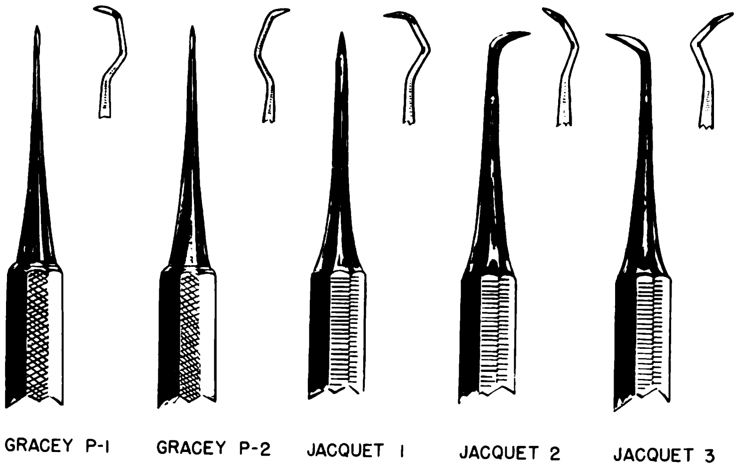


Figure 352.—"Pull" scalers.

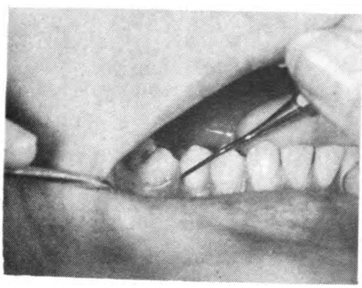


Figure 353.—Gracey "P-1" in use.

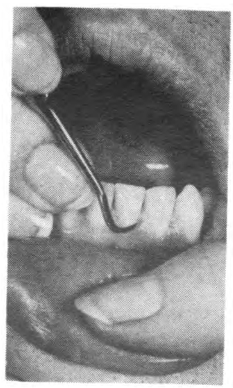


Figure 354.—"B" (Push-Pull) scaler in use.

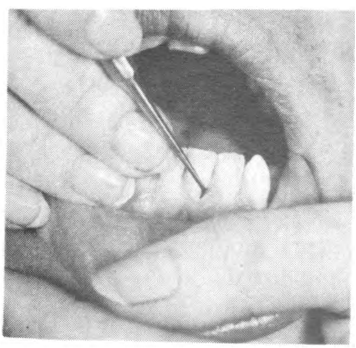


Figure 355.—D.P. #6 (Push-Pull) scaler in use.

instrument never should be used unless a fulcrum on some solid, immovable area is utilized, so that, if the scaler slips, the distance it may travel is limited. The palm grasp, with the thumb as the fulcrum, transmits the greatest force. It also provides a positive form of control over the instrument.

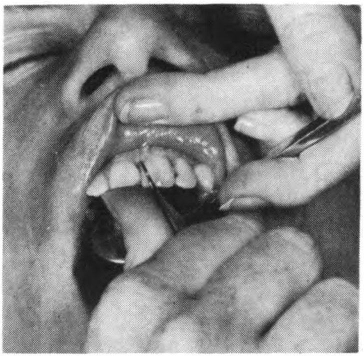


Figure 356.—Palm grasp.

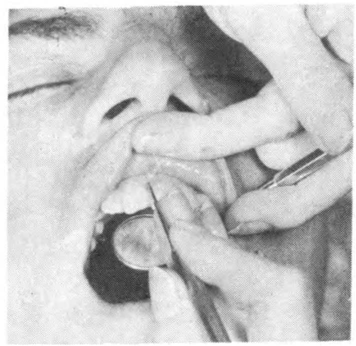


Figure 357.—Pencil grasp.

The pencil grasp does not permit so great a transmission of force to the instrument. However, it does allow more acute tactility. In this position the third or fourth finger acts as a fulcrum or steadying influence when placed on the incisal or occlusal surface of a tooth. It follows that there are some indications for both methods of instrument grasp. Clinical instruction and practice will make these indications clear. The thumb or finger which is to be used as a fulcrum never should be placed on soft, freely movable tissue such as the cheek, lip or chin. Either the teeth or the mucous membrane of the alveolar process should be used as a fulcrum.

The following points are to be observed when scaling:

1. All cases of inflamed or ulcerated gums should be referred to the dental officer for observation. No scaling or polishing should be done in these cases without his approval.
2. The blade of the scaler must be applied in the gingival crevice with a firm, well controlled, gentle motion. When a deposit is found, the tip of the blade should be allowed to drop below or to the side of the foreign body and then, with a gentle

pull or push movement, the blade should be brought to the top of the crevice. At all times, the working point of the scaler must be in contact with the surface of the tooth.

3. By the use of the proper scalers for different areas, changing the direction of the stroke when necessary, most subgingival or serumal calculus can be removed.
4. Scaling should not cause undue pain. If prophylactic procedures are painful, extreme care must be used to prevent traumatizing the tissue. The warm water syringe is used to wash away any capillary oozing from the free gingivae. The patient should be told that the slight reddish color of the expectorated water is NOT a sign of tissue injury or severe bleeding.
5. When the cementum is clean, operating in this area should be terminated. Cementum, being soft, will wear away rapidly. SCALING IS A SLOW, CAREFUL PROCEDURE.

Use and care of the handpiece

After the removal of all calculary deposits by scalers, the teeth will be ready for polishing. Fine pumice is mixed with water or some other suitable binder such as glycerin. A thin paste mix is preferable, since there is little tendency for it to whip out of the patient's mouth. This mix is placed in a dappen dish which should be within reach on the bracket table. Many operators ask the patient to hold the dish high on his chest on the right hand side. The mix is applied to the teeth with a rubber cup either in a straight or in a contra-angle handpiece. It is imperative that only handpieces designated "Pumice" or "Prophylaxis" be used.

After all the surfaces of the teeth have been polished with pumice and whiting, fine linen strips may be used to polish the interproximal surfaces. This is more easily accomplished on the anterior teeth. Pumice or whiting may be placed on the grit side of a narrow strip and passed between the teeth to polish the proximal surfaces. Extreme care must be exercised to avoid cutting the gum tissue or damaging the gingivae.

Dental floss is then used to remove any residue, and the patient's mouth is sprayed with an antiseptic mouthwash.

After dismissal of the patient, the handpieces must be thoroughly cleansed of pumice and debris. Handpieces which the dental officer employs for cavity preparation and other precision work should not be used for prophylaxis. Any abrasive, including pumice, will damage the gears and render the handpiece unfit for any delicate use. Handpieces used for prophylaxis or pumice should be marked.

Stain removal

Where the deposit of stain is not heavy, it usually can be removed with pumice in rubber cups and bristle brushes. Some operators remove light stains with pumice and an orangewood stick.

Where stain is heavy, particularly where it is incorporated within plaques and calculus, the operator must resort to instrumentation as well as the use of abrasives.

Routine for scaling

A definite routine should be learned and followed so that all surfaces of the teeth that are accessible and properly lighted can be treated from one position. The same system used in scaling teeth should be used in polishing in order that no surfaces may be overlooked. There are several acceptable methods, two of which will be considered in this chapter.

One popular method of instrumentation is to commence scaling at the distolingual angle of the lingual surface of the lower right last molar. The lingual surfaces of the right arch are scaled with the same instrument until the mesiolingual angle of the lingual surface of the lower right central incisor is reached. The mate to the instrument previously used, is employed to resume the scaling at the distolingual angle of the lingual surface of the lower left last molar, cleaning the lingual surfaces of the arch to the mesiolingual angle of the lower left central incisor. The distal, mesial, buccal and labial surfaces of the mandibular dentition are completed before attention is directed to the maxillary teeth. The dentition of the maxillary arch is treated in the same manner as that of the mandible. A second method of instrumentation is illustrated:

Left maxillary bicuspids and molars; buccal surfaces.
Right maxillary bicuspids and molars; lingual surfaces.
Left mandibular bicuspids and molars; buccal surfaces.
Right mandibular bicuspids and molars; lingual surfaces.

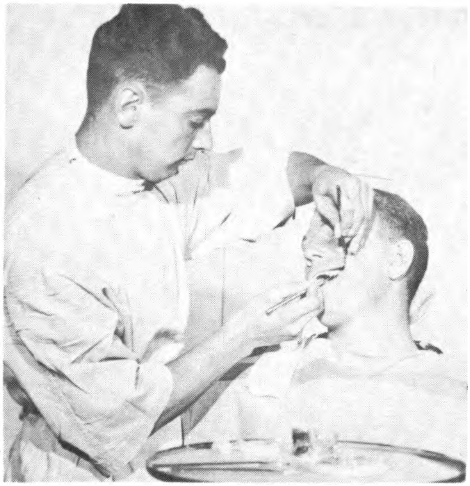


Figure 358.—Patient-operator position for buccal posterior.

Left maxillary bicuspids and molars; lingual surfaces.
Right maxillary bicuspids and molars; buccal surfaces.
Left mandibular bicuspids and molars; lingual surfaces.
Right mandibular bicuspids and molars; buccal surfaces.

Figure 359.—Patient-operator position for lingual posterior.

Maxillary anteriors; labial surfaces.
Mandibular anteriors; labial surfaces.

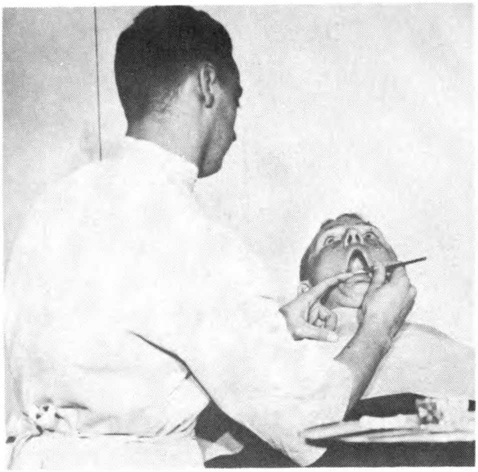


Figure 360.—Patient-operator position for labial anterior.

Maxillary anteriors; lingual surfaces.

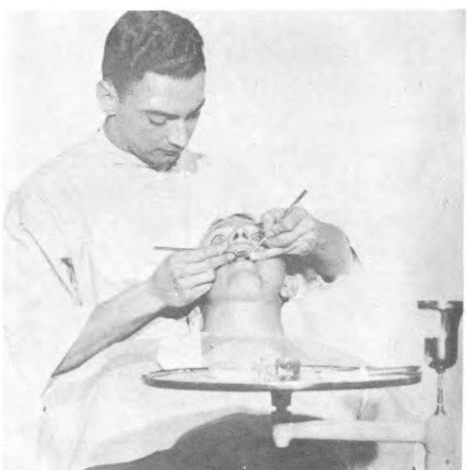


Figure 361.—Patient-operator position for lingual anterior.

Mandibular anteriors; lingual surfaces.

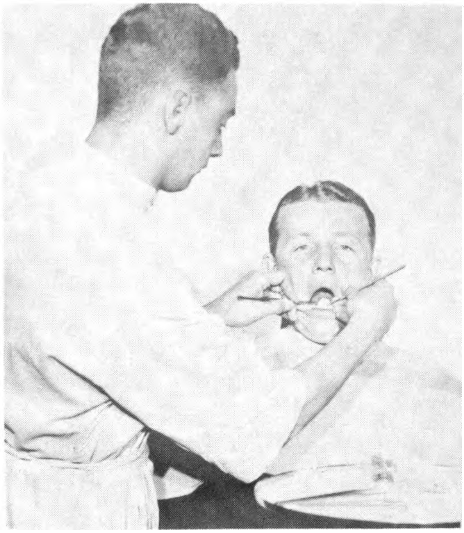


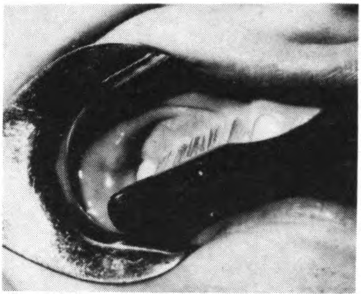
Figure 362.—Patient-operator position for lingual anterior.

Care of the Teeth at Home

It is an important duty of the technician to instruct the patient in matters of oral hygiene. The time consumed in teaching a system of mouth care is justified by the results. Such instruction, besides helping the patient to maintain oral health and contributing to his feeling of well-being, also aids in prolonging the life of restorations placed by the dental officer.

Tooth brushing

The patient should be told that the formation of calculus starts with the accumulation of soft food deposits and bacterial plaques about the necks of the teeth, and that the purpose of brushing is to remove these deposits. He should bring his toothbrush to the dental clinic at his last scheduled sitting, at which time he will receive instructions in correct brushing technique, as follows: The teeth should be brushed after each meal for a period of three or more



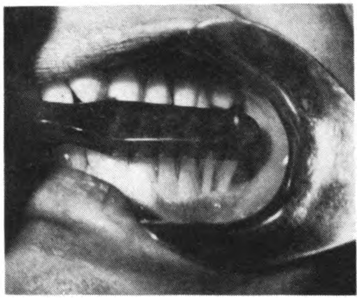


Figure 363.—Correct tooth brushing technique, upper teeth.

Figure 364.—Correct tooth brushing technique, lower teeth.

minutes. Care should be taken to brush every exposed surface of each tooth, the patient brushing from the gum with a single sweeping motion. Upper teeth are brushed in a downward direction and lower teeth are brushed upward. These motions will adequately cleanse the interproximal spaces with less chance of injury to the soft tissues. Cross brushing, especially when accompanied by an abrasive dentifrice, is believed by many to be one of the main causes of horizontal recession of the gingival tissues and abrasion of the tooth surfaces themselves.

Proper brushing is thought to provide stimulation of the blood supply to adjacent tissues. Chewing of modern foods does not provide adequate stimulation as did the chewing of coarser foodstuffs by primitive man.

In general, a few simple rules should be followed. Patients should be instructed to:

Brush the teeth after eating.
Brush each area at least five times.
Brush lower teeth UP.
Brush upper teeth DOWN.
Brush chewing surfaces with a scrubbing stroke.
Brush the surfaces next to the tongue as well as those next to the cheek.
Brush the teeth of each jaw separately in a definite order.

The brush

Toothbrushes are usually manufactured in three degrees of hardness—hard, medium and soft. The arrangement of the tufts varies also and one brand may be better than another for a particular patient's oral condition. The dental officer will examine the gingival tissue of the patient and prescribe the type of brush indicated. The toothbrush should always be kept clean, placed where it will dry quickly and not come in contact with another brush and should be stored in a container which permits air circulation. Each person should have two brushes which may be used alternately to allow them to dry thoroughly.

Dentifrices

The patient may ask whether he should use a paste or powder. This question, like the choice of a toothbrush, should be answered by the dental officer.

The Council on Dental Therapeutics of the American Dental Association has this to say on the subject of dentifrices: "A dentifrice is a substance used with a toothbrush for the purpose of cleaning the accessible surfaces of the teeth. Commercial dentifrices are available in the form of paste, powder and liquid. Most dentifrices contain flavors and soap or synthetic detergents. The powders and pastes contain abrasives such as calcium carbonate, one or more of the calcium phosphates, calcium sulfate, insoluble sodium metaphosphate, hydrated aluminum oxide, sodium bicarbonate and sodium chloride. Tooth pastes contain liquids such as glycerin, propylene glycol, sorbitol solution, water and alcohol and thickeners, such as starch, tragacanth and algin. Dentifrices are usually sweetened with saccharin, but some contain sugar * * *. The only demonstrated function of a dentifrice is to clean the teeth."

Currently appearing in the dental literature are reports and descriptions of dentifrices containing such drugs as ammonium, penicillin, chlorophyll and fluorine—all intended to reduce the ravages of dental caries. Although results are promising these compounds are still under investigation and as yet acceptable only for clinical trial. Scientists at the National Institute of Dental Research advocate treating the teeth of a child at the ages of 3 years, 7 years, 11 years and 15 years, with a 2 percent solution of sodium fluoride applied topically, as an aid in the control of dental caries.

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Dental floss

Dental floss is a valuable agent in cleaning certain areas of the teeth. Spaces not easily reached by a toothbrush can be cleansed by easing dental floss gently between the teeth. Snapping it down on the interseptal papillae can do considerable damage to this tissue.

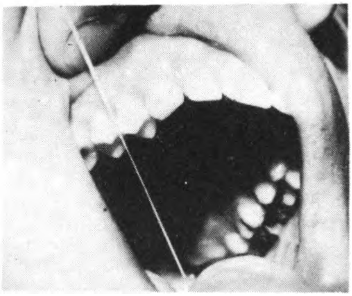

Figure 365.—Correct use of dental floss.

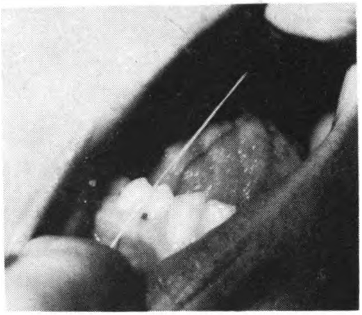

Figure 366.—Correct use of dental floss.

Mouthwashes

Since brushing the teeth is more effective than the use of antiseptic mouthwashes for the removal of bacteria in the mouth, these mouth rinses are recommended for "refreshant action" only where such use may add to patient comfort. Where certain types of diseased conditions exist, the dental officer will prescribe the agent to be used.

CHAPTER 12

PROSTHETIC LABORATORY PROCEDURES

Dental technicians who are not primarily assigned to dental prosthetic laboratory duties nevertheless must have a working knowledge of certain technical dental prosthetic laboratory procedures. They must be familiar also with methods used in the care and storage of the materials and equipment used in these procedures.

In two sections of this chapter—Boxing and Pouring Impressions and, Spruing and Investing Wax Inlay Patterns—portions have been taken from the 1948 edition of the *Handbook for Dental Prosthetic Technicians.*

Spatulation of Plaster of Paris and Stones

The plaster bowl is made of rubber and is flexible enough to allow it to conform to the shape of the spatula during the mixing process. The inner surface of the bowl is smooth and continuous. The spatula blade should be stiff and made of some material which will resist corrosion from moisture or chemicals which may be present in the mix. A thin-bladed spatula tends to "drag" and prevent proper mixing. The end of the spatula should be smooth and rounded to reach every part of the mixing bowl.

One of the chief obstacles to overcome during spatulation is the incorporation of air bubbles into the mixture. These weaken the hardened material and make the surface of the cast model imperfect. All possible precautions should be taken to avoid such a condition. For this reason the water is placed in the bowl first and the plaster or stone added. The powder may be poured slowly, but it is better to sift it into the water. It should be allowed to slake down until it is entirely beneath the water.

The mixture should be vibrated at this stage by jarring or by mechanical vibration to bring the large air bubbles to the surface where they are dispelled.

In hand spatulation, a rapid, stirring motion should be employed. At the same time all surfaces of the bowl should be wiped with the blade of the spatula, so that no plaster settles out or is wasted. Under no circumstances should the mixture be whipped; such a procedure incorporates air. All lumps should be smoothed out completely. Frequent jarring, turning and squeezing of the bowl during spatulation aid in the process of preparing the plaster.

The spatulation should be completed in 30 to 60 seconds. If the spatulation time is prolonged, the plaster will become too thick, the crystal formation will be broken up and the final product will be weak. After the mix is prepared, the bowl is jarred until no more air bubbles come to the surface. The plaster must be poured immediately.

If the mixture is too thick or too thin after spatulation, the natural tendency is to add more water in the first case, add more plaster in the second and continue spatulation. Such a procedure is not recommended if maximum strength is desired, since the addition of fresh plaster to a mix which has already been spatulated results in a heterogeneous mass. The first portion of plaster will be partially set before the second portion begins to crystallize. Disturbed crystal formation will result in both portions of plaster during hydration. A very thick mix signifies that the initial setting time has been shortened and the chemical reaction well started. The addition of water and continued spatulation always disturb the crystal formation. In either case, the only recourse is to throw out the mix and start spatulation again.

Boxing and Pouring Impressions

WARNING—Under no condition should the tissue-bearing part of a finished impression be touched with the fingers or with any instrument! Many impressions are taken with soft and easily distorted or marred materials, and, therefore, utmost care must be exercised to prevent damaging them during the "boxing-in" process.

Boxing

Impressions are "boxed" in order to confine the stone during the process of vibration. The "box" is also helpful in obtaining a reproduction of the peripheral border width. The impression is first "beaded." For this, a suitable strip of wax, 5 millimeters wide, may be cut from a piece of boxing wax by using a ruler and a sharp knife. Utility wax is even better for use in beading, since this wax is slightly tacky and will adhere readily to most impression materials.

Boxing and pouring of full denture impressions

The beading wax is placed around the maxillary impression 3 millimeters below the crest of the periphery, parallel to it, and luted to the impression from the underside. The round beading wax can be used as it is or in a flattened form. Some dental officers prefer

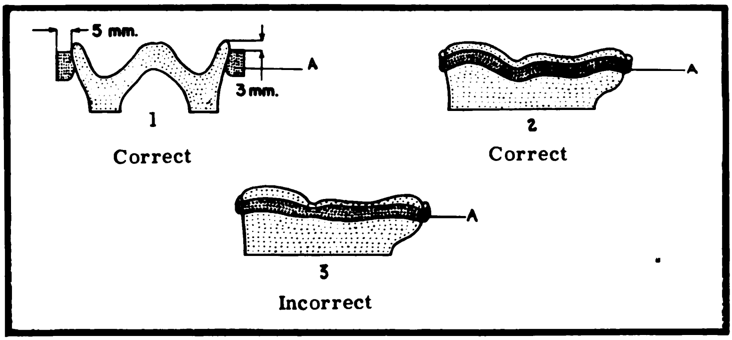

Figure 367.—Schematic drawings of the beading of a maxillary edentulous impression. Diagram 1—Cross section showing beading wax (A), 5 millimeters in width, place around the periphery 3 millimeters below the border and parallel to it, as in Diagram 2. Diagram 3—Beading wax placed incorrectly in relation to the peripheral border.

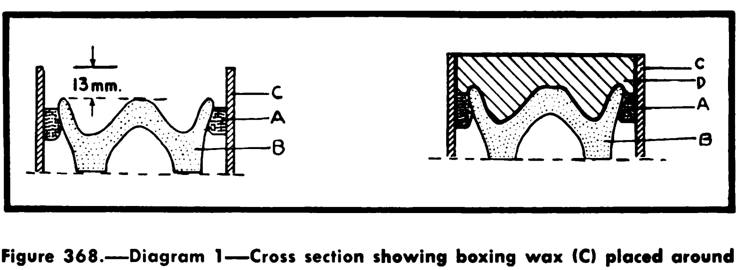

Figure 368.—Diagram 1—Cross section showing boxing wax (C) placed around the beading (A). Boxing wax extends approximately 13 millimeters above the highest point of the impression. Diagram 2—Cross section showing artificial stone (D) poured into boxed impression.

to have the beading terminate at the hamular notches rather than continue across the posterior border. Others will desire the same protection on the posterior border as on the rest of the impression.

When the beading wax is firmly luted around the impression, a sidewall is built against the beading to provide a "box" into which stone or plaster is poured. This sidewall may be made of boxing wax or baseplate wax cut to a suitable width to extend approximately 13 millimeters above the highest point of the impression.

Fixing or stabilizing alginate impressions

WHY: Most alginate impressions require fixing or stabilizing before stone or plaster can be poured in them. To understand why this must be done, two important properties exhibited by all hydrocolloidal impression materials must be defined:

1. IMBIBITION: if the impression is immersed in water, it will take up water and swell.
2. SYNERESIS: If the impression is kept in an atmosphere of less than 100 percent humidity it will lose water and shrink. The occurrence of either of these conditions in a dental impression would result in an inaccuracy of the cast.

WHEN: As soon as the impression is removed from the mouth, syneresis begins, and an exudate appears on the surface of the

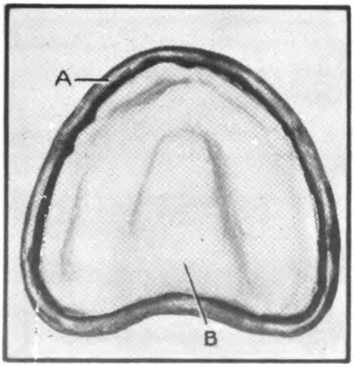

Figure 369. — Maxillary impression with beading (A) extending around the impression (B).

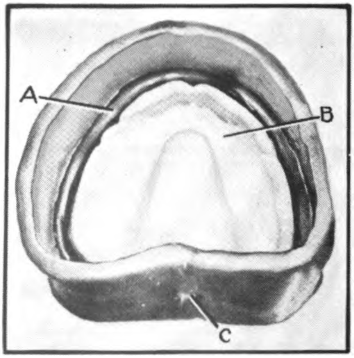

Figure 370. — Maxillary impression boxed to confine the stone. A, Beading; B, Impression; C, Boxing wax.

impression. This exudate will retard the hardening of the stone unless this reaction is overcome before the stone model is poured.

How: Fixing, the method by which syneresis is overcome, is done by immersing the impression in a 2 percent solution of potassium sulfate, usually for a period of 8 minutes.

Alginates used in the Navy are supplied with potassium sulfate in tablet form, together with instructions on how to prepare the solution.

If the impression was taken by hydrocolloid or with a material that does not set completely hard, boxing may be impractical. If this is so, a thick mix of stone is vibrated into the impression until it is full. The remainder of the mix is poured onto a glass slab or piece of waxed paper, and the filled impression is inverted onto it. Before it has completely set, the large bulk of excess stone is trimmed away.

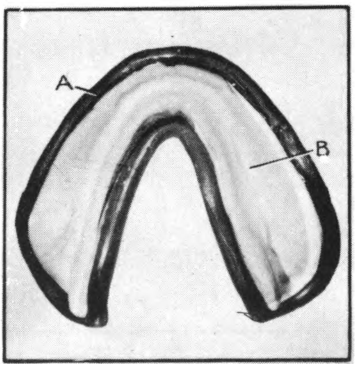

Figure 371.—Mandibular impression (B) with beading (A).

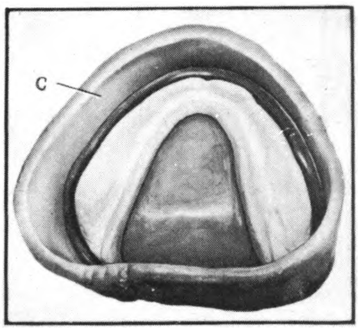

Figure 372.—Boxing wax (C) around the beaded mandibular impression.

After the plaster or stone mix has set for 20 minutes, the assemblage is placed in hot water to allow softening of the impression and to facilitate the removal of the cast. The cast is then trimmed, as required, care being taken to preserve the peripheral borders.

The mandibular (lower) impression is boxed and the cast is poured in the same manner as the maxillary impression with the exception that the lingual area must be filled in with baseplate wax

Figure 373.—Plaster or stone mix vibrated into box.

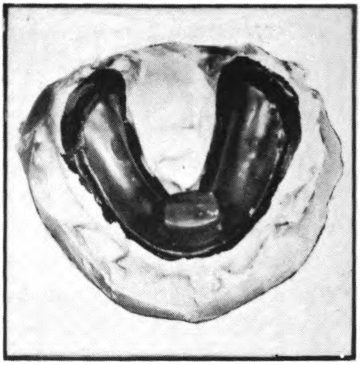

Figure 374.—Stone mix poured in and around impression which has been beaded but not boxed.

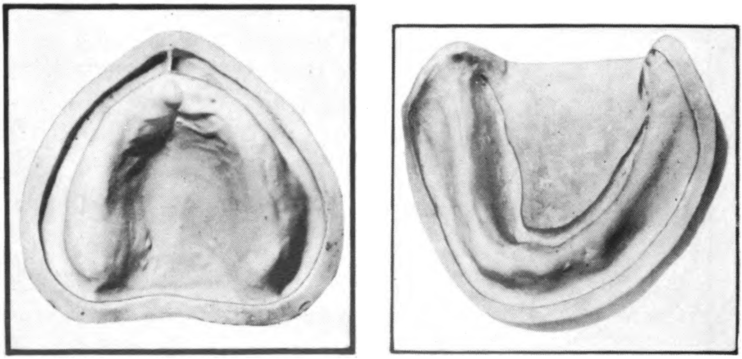

Figure 375.—Trimmed, edentulous maxillary and mandibular casts.

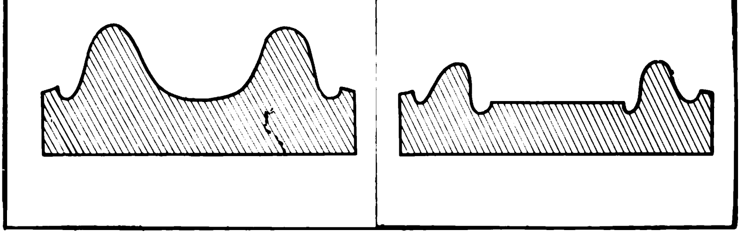

Figure 376.—Cross section of trimmed, edentulous maxillary and mandibular casts.

or boxing wax before the pouring of the stone. This wax should be made slightly concave to give less bulk to the cast.

Boxing and pouring of partial denture impressions

Usually, casts of partial denture impressions are poured without boxing. A thick mix of stone is vibrated into the impression until it is full. The remainder of the mix is poured onto a glass slab or piece of waxed paper, and the filled impression is inverted onto it. Before it has completely set, the stone is trimmed around the edges and scraped off the tray.

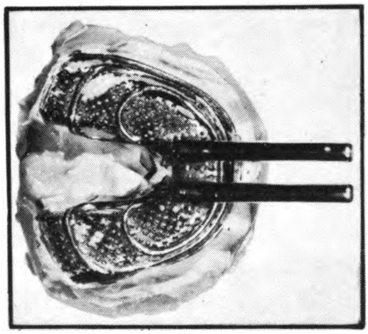

Figure 377.—Mandibular impression poured without boxing.

Some dental officers prefer to have these impressions boxed. The technique for preparing partial denture impressions for boxing is somewhat different from that used for full dentures, owing to the nature of the impression material. The primary danger in beading and boxing hydrocolloid impressions is the possibility of distortion of the elastic material. The material used for these impressions is a hydrocolloid and contains a great deal of water. For this reason, boxing wax will not stick to it. The impression first must be built up with plaster and then a sidewall of boxing wax luted around it.

A separating medium must be applied to the plaster so that the stone will not stick to it. Petrolatum is suitable for this purpose. The pouring of the stone for the case is essentially the same as that for full dentures, although great care must be exercised to make

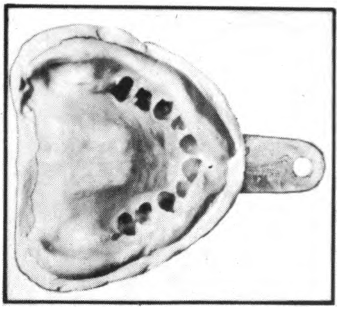

Figure 378.—Maxillary impression built up with plaster.

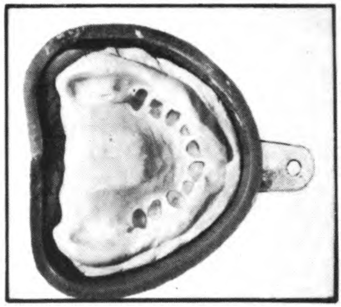

Figure 379.—Boxing wax applied around the plaster.

sure that the stone flows into the impressions of the teeth without trapping air. Tilting the impression to create a high point for pouring the stone will aid in bubble elimination.

A quicker and possibly easier way of boxing these impressions is to fold waxed paper in a 3-ply strip about 2 inches wide and 12 inches long. After filling the impression with stone or plaster, the folded paper should be wrapped around the impression and secured with a paper clip. This will form a containing wall into

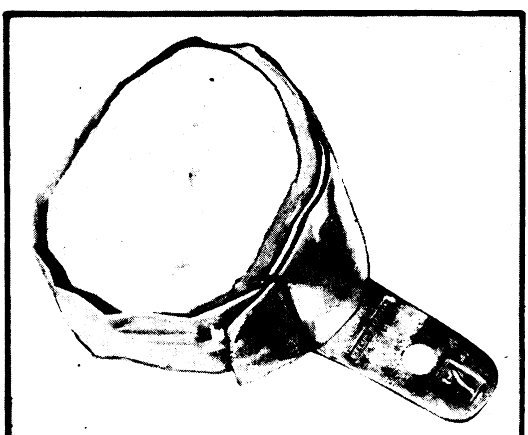

Figure 380.—Impression poured, with box made of waxed paper.

which the remaining material may be poured to the desired thickness.

When the lower impression of a partially edentulous mouth is boxed, the open space between the lingual flanges should be filled with a ball of waxed paper prior to applying the containing wall. The stone should be allowed to set for 30 minutes, after which the tray should be removed from the impression and the impression material separated from the cast. Then the stone cast will be ready to trim as required.

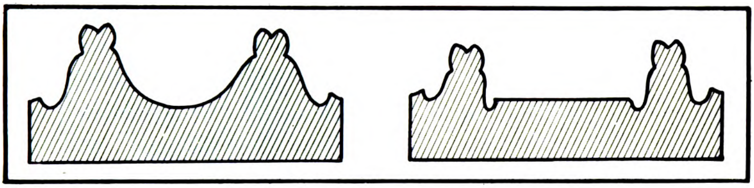

Figure 381.—Cross section of trimmed, partially edentulous maxillary and mandibular casts.

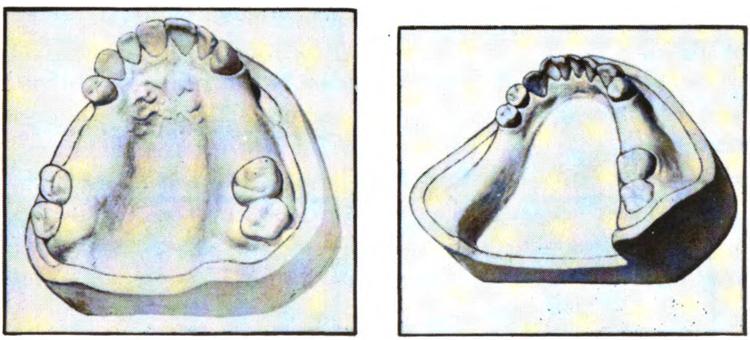

Figure 382.—Trimmed, partially edentulous maxillary and mandibular casts.

Spruing and Investing Wax Inlay Patterns

Inlays are restorations designed to fit specially prepared cavities in teeth. Permanently cemented in place, an inlay should restore the tooth to its proper contour, strength and function. It should be constructed so as to prevent subsequent decay of the

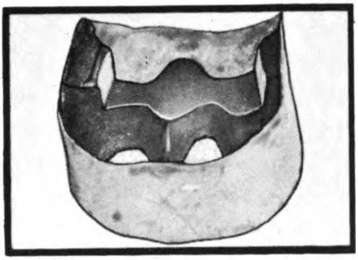

Figure 383.—Impression of cavity preparation.

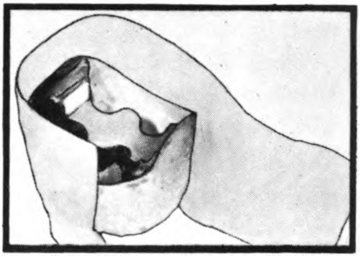

Figure 384.—Boxing the impression.

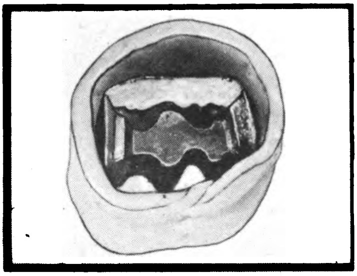

Figure 385.—Impression boxed.

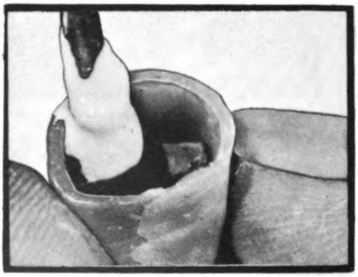

Figure 386.—Stone poured into boxed impression.

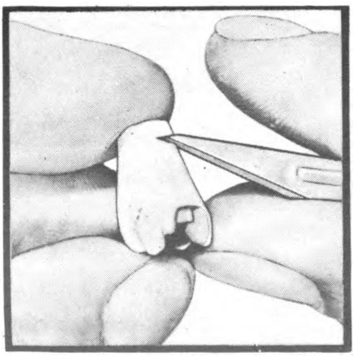

Figure 387.—Trimming the die.

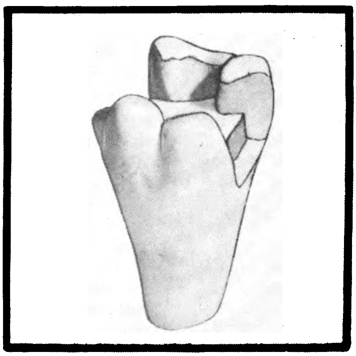

Figure 388.—Stone die.

surface it restores. Gold inlays are frequently used for bridge abutments.

A gold inlay is made by constructing a wax pattern and reproducing it in gold by means of a casting process. Inlays may also be made of acrylic resin or porcelain. Wax patterns may be made by the direct method, indirect method or a modified combination of both methods. In the direct method of inlay construction, the dental officer makes the wax pattern directly in the tooth. In the indirect method, a die or model is made of the cavity preparation and the wax pattern for the inlay is made on this die or model.

Construction of dies

Several materials are used for making dies. Among these are artificial stone, synthetic cement and amalgam. Electrodeposited copper dies are also commonly used.

Stone die

The impression is thoroughly cleansed with liquid soap and room temperature water to rid it of saliva and debris. A strip of waterproof paper, 40-gage tin foil or 28-gage sheet wax is secured around the impression to form a box. This box should extend between ½ and ¾ inch above the impression. Stone is mixed in accordance with the manufacturer's instructions; a small amount of mix is poured into the box and gently vibrated into the lowest portion of the impression. Care should be taken not to entrap any air. More of the mix is added until the box is filled. It should be allowed to stand until the stone has completely set and then separate the die from the impression. If the impression has been taken with colloidal material, the die can be easily withdrawn from it; if it were of compound, it would be necessary to soften the impression in hot water before attempting to separate the stone from it. The root portion of the die should be trimmed to a smooth, even taper.

Synthetic cement die

The impression is cleansed and boxed as for the stone die. The cement is mixed to a thick plastic consistency and small amounts of it are forced into all details of the impression. If manual pressure is used, care should be taken that the plugging instrument does not mar or scar the surface of the impression. Centrifugal force or vibration may also be used to force the cement into the impression; again care must be taken to prevent entrapment of air. The die may be separated from the impression after 15 to 30 minutes depending on the manufacturer's instructions.

Amalgam die

The impression is cleansed and boxed as for the other types of dies. When this is done, the boxed impression is reinforced with or invested in a ring of plaster of Paris to give it stability and prevent it from distorting when the packing pressure is applied. Enough time should be allowed after embedding the boxed impression in the plaster to dissipate all the heat generated during the setting of the plaster. The time may be shortened by immersing the impression in cold water after the plaster has begun to set. Amalgam should not be packed into the impression until it has thoroughly cooled. Enough amalgam should be mixed to fill the impression and the box completely; a small piece of wet amalgam is placed in the impression and forced into place by use of a small rounded orangewood stick or by a gentle tapping on the bottom of the invested impression. Additional amalgam is applied and condensed carefully until the boxed impression is two-thirds full, at which time larger pieces of amalgam, freed of their mercury, are worked down into the softer amalgam. When the box is filled, considerable force is applied to the amalgam in order to raise as much excess mercury as possible. After three hours the plaster and the box are cut away and the impression is warmed either in a flame or in warm water. Then the amalgam is separated from the impression and trimmed.

Construction of wax pattern

If the preparation is small, there should be sufficient tooth structure left to act as a guide in the carving of the wax pattern; if the preparation is large, the waxing will be facilitated if a record of the adjacent and opposing teeth is available. The record may be formed by the dental officer filling the cavity with softened wax and having the patient bite into it. This wax record is then placed

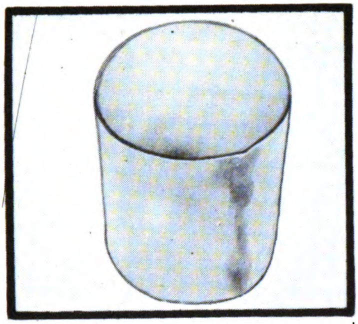

Figure 389.—Wax ring.

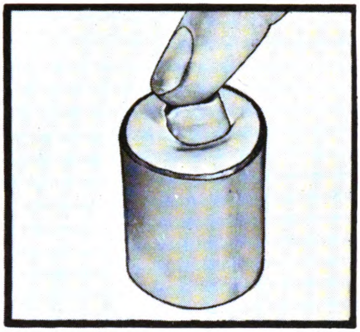

Figure 390.—Boxed impression forced into plaster.

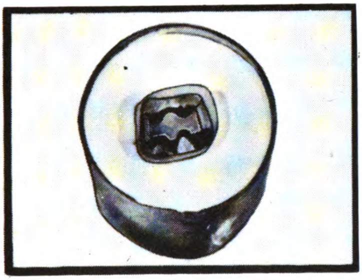

Figure 391.—Impression invested in plaster.

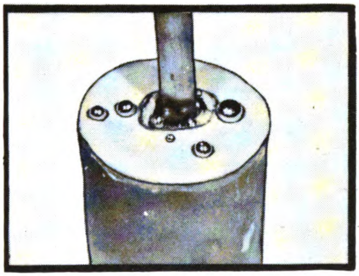

Figure 392.—Excess mercury expressed from mold.

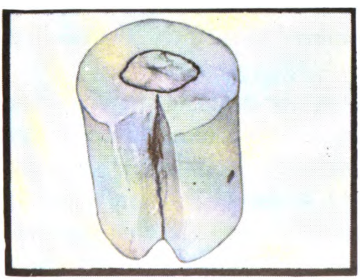

Figure 393.—Cuts for splitting investment.

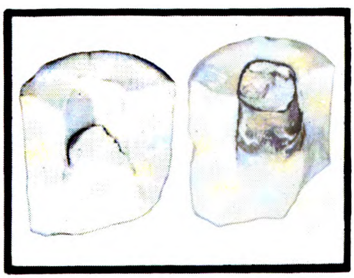

Figure 394.—Investment split.

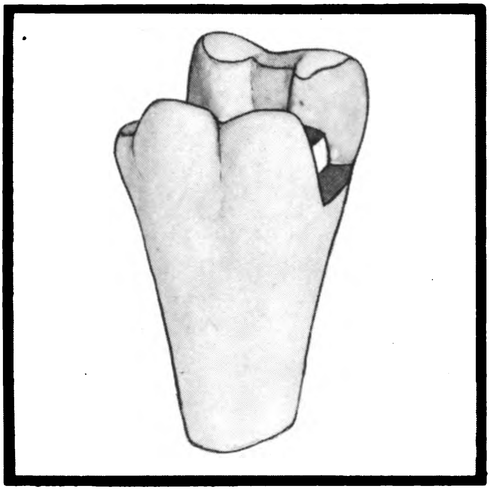

Figure 395.—Amalgam die trimmed.

on the die and the high points and depressions made by the opposing teeth used as guides in shaping and contouring the inlay.

Another method, of particular value when more than one restoration is to be made, is to mount the die on an articulator in its correct relation to casts of the other teeth. The root portion of the die should be tapered, oiled, seated in a hydrocolloid or other type impression of the teeth and a model made of it. This model should be mounted with a model of the opposing teeth on an articulator. If the models do not contain sufficient teeth to occlude accurately for mounting, a wax bite will be required. The die may be removed and replaced in the articulator as required to facilitate the carving of the wax pattern.

Where a completed die shows a preparation with a finishing line where the wax pattern is to end, it is well to cut a ditch into the die parallel to the finishing line and 1 millimeter below it. The upper side of this ditch should be beveled to a point just below the finishing line (approximately ¼ mm.). This ditch greatly facilitates the carving of the wax pattern, since the carving instrument simply follows the guide formed by the upper side of the ditch until all the wax is cut away from that section. The

Figure 396.—Die positioned in impression.

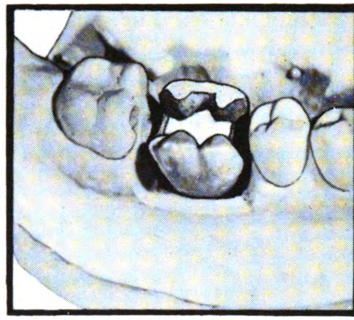

Figure 397.—Model poured.

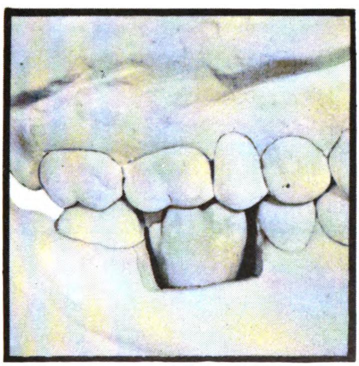

Figure 398.—Model mounted on articulator.

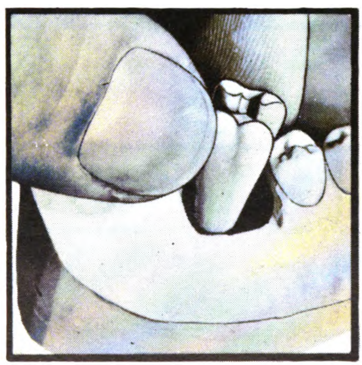

Figure 399.—Removing the die from model.

technician then knows that his pattern extends just below the finishing line on the preparation. Time used in cutting the ditch is made up in the carving of the pattern, since it will then not be necessary to remove the pattern in order to check the needed extension.

Before the waxing process is begun, the die should be cleansed and lubricated so that the wax pattern will not adhere to it. The die should be lubricated by wiping it with a cotton pellet saturated in a light oil; excess lubricant may be removed with another dry pellet of cotton. For adaptation to the preparation, the wax is softened with heat from a bunsen flame, an electric heating chamber or a water bath of 115° F. and then forced into place. All excess wax must be trimmed off and the pattern then carved to the required shape.

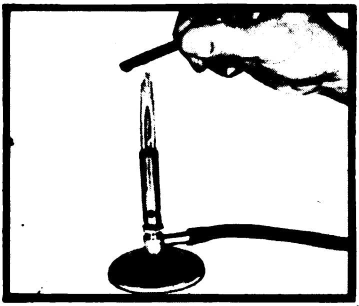

Figure 400.—Softening the wax.

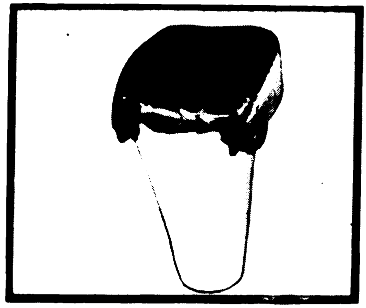

Figure 401.—Wax forced into place in the die.

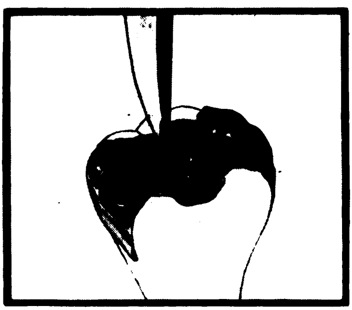

Figure 402.—Carving wax pattern.

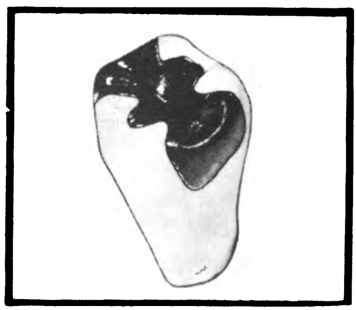

Figure 403.—Wax pattern.

Spruing

The wax pattern for a gold inlay is sprued, and placed in a sprue former. A shrinkage ball of wax is built between the pattern and the sprue former, and the pattern is invested and cast in accordance with the instructions for investing and casting procedures.

The size and length of the sprue pin as well as the location of its attachment are important factors in the success obtained in casting. For one or two surface patterns a single sprue pin of 14 to 16 gage is adequate, but for those patterns involving three or more surfaces, better results may be obtained by using the double or staple-shaped sprue pin. The sprue pin is heated and touched to a stick of wax; it is then inserted into the surface of the pattern. If it is of the correct temperature, the molten wax will unite with the wax of the pattern without any chance of displacement or distortion of the pattern itself. If the pattern is exceptionally thin where the sprue is to be attached, a drop or two of wax is added

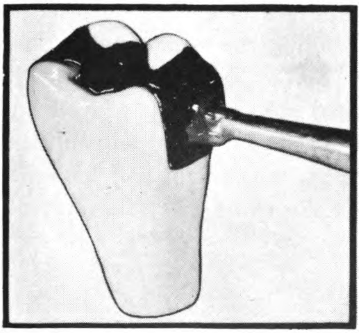

Figure 404.—Pattern sprued on die.

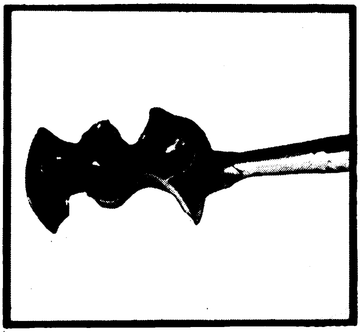

Figure 405.—Pattern removed from die.

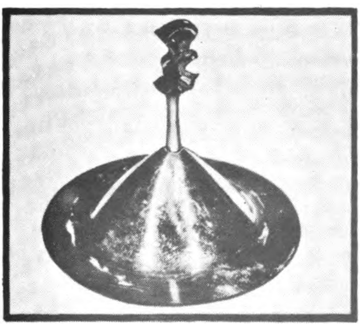

Figure 406.—Pattern on sprue former.

Figure 407.—Reservoir attached.

at the exact location of attachment. The wax pattern should not be drawn until the sprue pin and wax are thoroughly cooled to room temperature. The sprue pin is placed in the sprue former and a shrinkage reservoir is added to the sprue pin. It should be placed about 1/16 inch away from the pattern and care should be exercised to avoid heating the pattern during its construction.

The shrinkage reservoir

It is known that when molten gold enters a mold, solidification of the metals occurs from the outer walls inwardly. The crystal growth occurs at the expense of the residual molten metal within the mold. If the available supply of molten gold is limited to the amount contained within the mold, the solidified crystals approaching the center of the casting will lack sufficient molten metal to complete their development for filling the entire mold. This latter condition results in voids or porous areas in the casting. However, if a reservoir of additional molten metal is available during the solidification process, so that the crystals can continue to form until the entire mold is filled, the casting will be solid throughout. The size of the reservoir should be nearly as large as the bulk of the casting itself.

Investing

The aim of investing is to produce a mold so accurate that the casting which is formed in it will fit the tooth preparation without having to be ground or etched — one which may be pressed into place with strong finger pressure and seated with a light tap of a mallet. The casting must be smooth, nonporous and free of nodules and blisters. In addition, the wax pattern must be reproduced without any appreciable dimensional changes.

Since it is known that a normal approximate contraction of 1.25 percent occurs in the gold during the solidifying and cooling processes, an investing technique, in order to be successful, must compensate for this contraction. The one most generally used today and the one capable of producing the most satisfying results is the technique relying upon thermal expansion of the investment.

An investment expands in two phases — the setting expansion (0.3 percent) and the thermal expansion (up to 1.5 percent) when

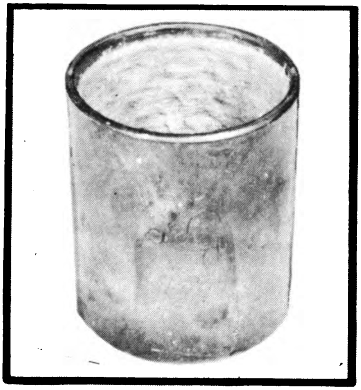

Figure 408.—Asbestos liner in ring.

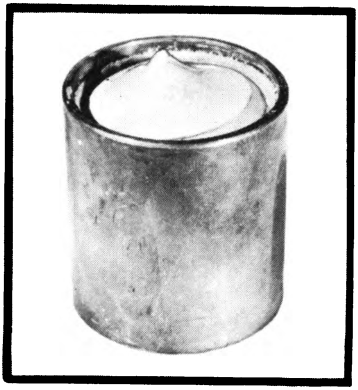

Figure 409.—Ring filled with investment mix.

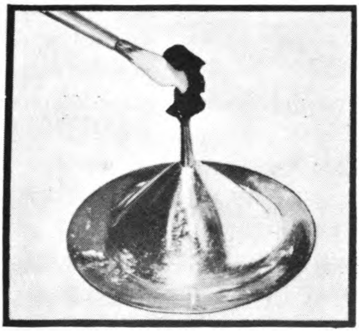

Figure 410.—Investment painted on wax pattern.

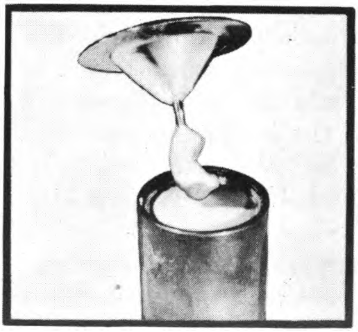

Figure 411.—Investing wax pattern.

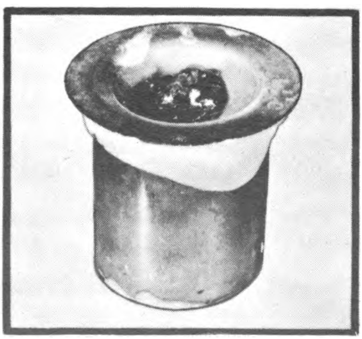

Figure 412.—Wax pattern invested.

the investment is subjected to heat. By taking advantage of both, it is possible to compensate for the 1.25 percent shrinkage which ordinarily occurs in casting gold alloys.

The technique discussed here is that set forth by the manufacturer of Kerr's Cristobalite Investment and Control Powder. A casting ring is selected of such a size that at least ¼ inch of investment will surround the pattern in all directions. A moist asbestos liner is placed inside the ring to allow an effective setting expansion, to serve as an insulator against a loss of heat during the casting process, to permit a free thermal expansion of the investing material and, finally, to facilitate the removal of the investment after the casting has been made. The Kerr precision balancer is used for proportioning investment material, control powder and water. The manufacturer's instructions must be carefully followed. The balancer is placed in position and proper amounts of investment and control powder are weighed at the point designated on the balancer. Room temperature water is also measured and weighed at the point designated on the balancer. The powder and water are mixed with a hand mechanical spatulator, the spatula making at least 120 revolutions. The mix is then vibrated into the inlay ring to within ¼ inch from the top. The wax pattern is thoroughly cleansed with a tincture of green soap. It is rinsed with room temperature water, and the excess moisture blown off with a blast of air. The pattern is then flooded with a debubblizer. After it has dried, it is coated with investment by use of a soft camel's hair or sable brush. Being careful to eliminate air bubbles, the technician should force the investment ahead of the brush. The thoroughly coated pattern is inserted into the inlay ring with a vibrating motion. It must not touch the ring, and it must not be disturbed by any motion whatever until the investment has thoroughly set. The vacuum method of investing may also be used. This procedure is described in the 1948 edition of the *Handbook for Dental Prosthetic Technicians* in the chapter on Investing Processes.

Casting technic

When the investment mold has dried completely, the sprue former is tapped away from the casting ring, and the sprue pin heated and removed.

The wax elimination, casting, quenching and pickling processes are the same as those presented in the 1948 edition of the *Handbook for Dental Prosthetic Technicians*, for the construction of cast partial denture frameworks.

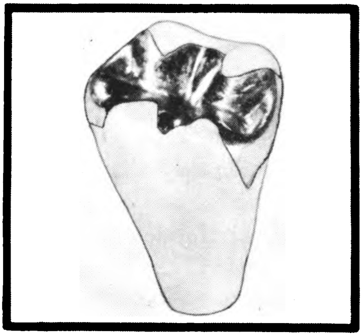

Figure 413.—Completed gold inlay.

Finishing technic

The success or failure of an inlay as a restoration is largely dependent upon the accuracy of fit between the margins of the inlay and those of the prepared tooth. For this reason the inlay should be returned to the dental officer with all margins or edges of the casting unpolished. The dental officer may then finish the margins of the casting while it is in place in the patient's tooth.

All margins of an acceptable casting should be sharp rather than rounded; should be dense, containing no porosity; and should be exact in every detail corresponding to the wax pattern.

With the casting in position in the die, the technician may polish its external or outer surfaces to within 1 millimeter of the margins, using fine stones, sandpaper disks, rubber wheels and points and finally, pumice. The inner surfaces of the inlay should never be ground or polished.

Care and Storage of Dental Prosthetic Laboratory Instruments and Materials

Instruments and materials in common use in the dental prosthetic laboratory require daily attention in order to maintain their efficiency and prolong their life.

The paramount rule in any laboratory is to maintain orderliness and cleanliness. Every item of equipment and supplies should be stored in a particular unit in a section of the laboratory where it can always be found. Every item should be returned to its assigned place when it has served its purpose or when the laboratory is secured for the day. The following items are classified according to the special care or attention they will require.

Plaster, stones and investing materials

These materials are hygroscopic in nature — able to absorb water from apparently dry air, and thus deteriorate to a point that endangers accuracy in model making and the casting of gold and special partial denture metals. Such materials should be plainly labeled and stored in tins which can be tightly covered. Placing in open bins adjacent to one another should be avoided to prevent the possibility of accidental mixing. Scoops for ladling out different powders should not be interchanged. Open bins should not be located where water from faucets can splash into the powders.

Cutting instruments for hand operating

The care of cutting instruments is directed to the preservation of their cutting edges. Cutting edges will become blunt from normal use and must be restored by means of sharpening stones—preferably the hand type. Motor-driven sharpening stones will overheat a blade and remove its temper, leaving a soft edge which will not remain sharp.

Cutting instruments must be cleaned of plaster, artificial stone and investment debris, for these materials hasten corrosion and rust which destroy a blade. When storing these instruments for short periods, thorough cleansing and light oiling will protect them from rust. When storing them for prolonged periods, they should be cleaned thoroughly, greased heavily and wrapped in waxed paper.

Cutting instruments for the dental engine handpiece

These are of the abrasive type such as small stone wheels and points, and of the cutting type such as steel burs of various shapes and sizes. A bur block will hold these items in readily accessible positions. They should be arranged in an orderly fashion in the block. Burs should be cleaned with a wire brush and should be discarded when they are dull or broken.

Stones lose their shape through wear. They can be trued or reshaped by revolving them against a coarser abrasive wheel.

When these items are stored, the screws of mandrels should be lubricated and the stones and burs kept dry; otherwise they require no special attention.

CHAPTER 13

EMERGENCY DENTAL TREATMENT

Emergency dental treatment is first-aid treatment given sufferers from disease and accidents involving the dental structures when regular dental care is not available. The treatments recommended are for the use of the dental technician for temporary relief of pain until the patient can consult a dental officer.

Dental technicians should undertake only simple measures indicated to relieve pain and should render first aid in the event of an accident.

All cases receiving dental first aid should be referred to a dental officer as soon as possible for further treatment. The technician rendering any type of emergency dental treatment should advise the patient that such treatment is only of a temporary nature. He should instruct the patient to return, or to consult a dental officer elsewhere, at the first opportunity if further care is necessary.

The effectiveness of dental first aid depends upon correct application of the remedies indicated for a particular condition.

The descriptions of symptoms and first aid treatments to follow are necessarily brief and are intended only for reference by the dental technician while determining the nature of and treating the dental conditions with which he may have to deal.

In order to give the proper emergency treatment, the technician should allow the patient to describe his various symptoms. He may have to question the patient to fully understand the chief complaint.

The technician must strive to understand and interpret the possible severity of the patient's complaints and to weigh the symptoms and findings carefully before proceeding with any treatment.

PRINCIPAL DENTAL EMERGENCIES

Painful Affections of the Teeth—General

In investigating a case of toothache, it is important to make a careful examination of the patient in a good light with the aid of a mirror and probe; to test the sensitivity of each questionable tooth to percussion, heat, and cold; to search thoroughly for sensitive areas (exposed dentin and cementum), hidden cavities, and exposure of the pulp; and to look for any signs of swelling or localized tenderness in the gums and alveoli.

In cases of doubt, roentgenograms of the teeth and jaws may be helpful. The possibility of pain being referred from the nasal sinuses or other areas, or of it being a form of neuralgia, must not be ignored.

Erosion and Pain—Exposed Dentin—Exposed Cementum

Patient's complaint: "Sensitive tooth." (Patient may point to or touch area that is sensitive.)

Symptoms

a. Neck of tooth is sensitive, causing it to be painful when brushed, when subjected to thermal changes or when contacted by sweets.
b. Painful when touched by explorer point.

Treatment

A tooth which does not ache regularly but which is sharply painful when brushed or when in contact with anything very cold, acid or sweet suggests the presence of exposed sensitive tooth structure. Such acute sensitivity may be caused by the commonly unclean clasp of a partial denture or by improper (usually horizontal) tooth brushing. Recession of the gum will result from continual bruising of the gingival tissue.

Over a period of time the gum will normally recede from the crown, exposing the more sensitive cervical area. This is often a source of extreme pain which can be relieved to some extent by carefully isolating the area with cotton rolls or gauze, drying it with warm air or cotton pellets. Silver nitrate should be carefully applied with a small piece of cotton followed by eugenol.

Phenol followed with alcohol on the exposed area is also effective. Extreme care must be used with these medicaments to avoid burning the gingival tissue.

Cavities

Patient's complaint: "Occasional or recurrent toothache."

Symptoms

a. Tooth painful to cold and sweets, and when food is impacted.
b. Cavity visible.

Treatment

"Decay" or SIMPLE CARIES is seen as a localized cavity containing decalcified tooth substance. Simple caries is usually painless except when subjected to thermal changes (usually cold), sweets, or pressure by some foreign material such as food particles in the cavity. The offending cavity may be seen by inspection of the mouth, or it may be discovered only through careful exploration with instruments or by an X-ray picture. Such cavities often are disclosed by the enamel breaking away during the eating process.

The cavity should be cleansed of food and other soft debris by the gentle use of instruments, washed with WARM water, and dried with pellets of cotton. Then a small pellet of cotton moistened with eugenol should be placed in the cavity, and retained by temporary stopping or cement.

Occasionally a patient points to a perfectly sound tooth and complains that it aches. It is possible, of course, that there is trouble in such a tooth, but it is always advisable to look at the other teeth on the same side of the jaw, both upper and lower, for a cavity and, if one is found, to cleanse it and apply a sedative dressing. This usually will relieve the pain in the tooth pointed out by the patient. Such pain in sound teeth is termed REFERRED pain.

Dental Pain Resulting from Chronically Involved Pulp

Patient's complaint: "Throbbing toothache, hurts worse when contacted by hot foods or liquids."

Symptoms

a. Severe throbbing and practically continuous pain.

b. Hypersensitivity of tooth to percussion and to heat.
c. Swelling of face.

Treatment

This is the most common type of severe dental pain — from a chronically inflamed pulp which has become infected through a cavity in the tooth or a pulp devitalized and gangrenous from infection or trauma. An inflamed and congested pulp is unduly compressed within the hard, unyielding walls of the pulp chamber.

Early in the process, the pain is apt to be sharp and is increased by temperature changes (particularly by cold). At this time the tooth may not be noticeably tender to percussion. Food and other soft debris should be removed gently with suitable instruments, after which the cavity should be washed with WARM water, dried with pellets of cotton, and then filled with other small pellets of cotton, the first of which is moistened with eugenol and placed in the deepest part of the cavity.

The technician should be certain that there is not enough medicament on this pellet to come in contact with the soft tissues of the mouth when it is placed in the cavity. The outermost pellet should be dipped in some cavity lining, such as tincture of benzoin, and packed lightly into place after removing the excess. The cavity lining or other similar liquid on the cotton pellet will form a gummy, impervious mass when it comes in contact with the saliva. The pulp thus may be protected from temperature changes and irritation by foreign material. The sedative dressing should be renewed every 2 or 3 days until a dental officer can see the patient.

Alveolar Abscesses

Patient's complaint: "Abscessed tooth" or "sore jaw."

Symptoms

a. If cavity is open, there is usually little pain.
b. Cold water gives temporary relief.
c. Hot water intensifies pain.

Treatment

If the treatment suggested for an inflamed pulp fails to give any relief, in all probability the pain is caused by a pulp which is partly or wholly putrescent, and may contain pus. In this case gases have formed and are exerting pressure through the root canal into the area around the apex of the tooth. This forces the bacteria and their toxins into the tissues at the end of the root and sets up an inflammation in the structures surrounding the root apex. Since this inflammation is outside the tooth and within the alveolus, any medicament applied to the tooth itself or in the cavity will fail to afford relief. Pain will continue until drainage is established naturally or artificially. This type of toothache (alveolar abscess) requires the services of a dental officer to establish drainage through the root canal or through the soft tissues and alveolar wall. Pending the establishment of drainage, the application of ice to the affected tooth or holding cold water in the mouth may relieve the pain.

When swelling is apparent, pain usually has ceased. The swelling indicates that the pus has worked its way to the surface through the path of least resistance.

Examination of the mucous membrane over the root or roots should be made at intervals to determine if an area of fluctuation is present. If one is found, the area should be isolated with cotton rolls and the tissue cleansed with merthiolate or metaphen. Then, a vertical incision or puncture should be made, with the point of a sterile scalpel, into the area, down to the bone in the direction of the apex of the tooth. If the actual abscess is thus reached, evacuation of the pus will result and relief will be almost immediate. Premature lancing will result only in bleeding.

A period of from 24 to 72 hours may elapse between the onset of pain and the appearance of the swelling. Sedatives such as aspirin or ½ grain of codeine may be administered every 4 hours for the relief of pain pending the appearance of the swelling.

Gum Abscesses

Patient's complaint: "Abscessed tooth."

Symptoms

a. "Gum boil" or fistula may be present.
b. Jaw or face swollen in area of affected tooth.
c. Tooth feels elongated and is tender to percussion.

Treatment

Periapical abscess.

These chronic abscesses, commonly called "gum boils", appear as small pimples or openings on the gums, usually not far from the root area of the involved tooth. This condition is rarely painful but by no means should be neglected, for in most cases it indicates the presence of an infected tooth. "Gum boils" should receive professional attention at the first opportunity so that absorption of the products of the infection may be terminated and local discomfort, if any, can be alleviated.

To relieve the discomfort of a very sore tooth with continuous, severe pain, the technician should remove any debris gently in a cavity if one can be found in the offending tooth. If there is a restoration in the tooth, it must be removed or an opening must be made through it into the pulp chamber to permit pus or gas to escape.

Patient's complaint: "Tooth feels too long."

Symptoms

a. Gingivae inflamed with deep interdental pockets.
b. Tooth painful to percussion.
c. Tooth may be loose and feel elongated.
d. Face may be swollen.

Treatment

Periodontal abscess or lateral abscess.

This condition usually is the result of long-continued irritation by food particles or some other substance, such as deep seated calculus or a bristle of a toothbrush, being tightly packed between two teeth or between a tooth and the gum. The pain is dull and constant, increasing rapidly in intensity, and localized about the affected tooth which is tender to percussion but not affected by heat or cold. The gum becomes red and swollen and suppuration may follow. The pocket along the root to the swollen area may be probed gently to evacuate any pus that may be present and the area should be washed with a stream of warm water. Use of dental floss may be necessary to remove the foreign material.

Tissue should be painted with glycerite of iodine, tincture of merthiolate or tincture of metaphen. Hot salt water used as a mouth rinse, along with analgesic drugs, will afford the patient relief until a dental officer can be seen. HEAT SHOULD NEVER BE APPLIED TO THE FACE IN DEALING WITH ANY TYPE OF ABSCESS.

Inflammation of Lower Third Molar Regions

Patient's complaint: "Infected or sore wisdom tooth."

Symptoms

a. Pain, inflammation and swelling in the third molar region.
b. Difficulty in opening and closing mouth.
c. Swollen lymphatic glands below mandible on affected side.
d. Elevated temperature, with malaise.

Treatment

The lower third molar teeth (wisdom teeth) often are the cause of extreme pain and swelling during their eruption. Upon looking into the mouth toward the angle of the jaw and just back of the last tooth, occasionally one may see a part of a tooth coming through the gum with swelling and redness in the vicinity. To relieve this condition a small instrument or blunt probe should be wrapped firmly with a thin layer of cotton, dipped in half-strength glycerite of iodine, and gently forced between the gum and tooth, worked carefully around the crown of the tooth. This simple treatment sometimes will result in the evacuation of a small amount of pus and relief will be afforded. The patient should be instructed to hold hot salt water—as hot as can be safely tolerated — in the mouth, forcing it back and forth over this area. This should be repeated every hour. Many times third molar flaps become infected with Vincent's micro-organisms and treatment in these cases should be watched carefully for any spread of the local infection. The mouth should be sprayed with a warm solution of sodium perborate or half-strength solution of hydrogen peroxide. Intramuscular injections of penicillin or other such antibiotics will aid in the control and eradication of the infection.

A pocket is usually present distally to these teeth, and it may be advisable to promote drainage by placing a very small wick of gauze moistened with eugenol in the pocket with a minimum amount of pressure.

Postoperative Treatment for Hemorrhage Following Extraction of Teeth

Patient's complaint: "Bleeding following extraction."

Symptoms

Large amounts of blood in the mouth immediately after extraction; hemorrhage has continued an hour or longer.

Treatment

Postoperative hemorrhage (primary).

Place Oxycel or Gelfoam in alveolus, over gauze pressure pad.

Patient's complaint: "Late bleeding following extraction."

Symptoms

Large amounts of blood in the mouth many hours after extraction, found often in the form of large, dark clots.

Treatment

Postoperative hemorrhage (secondary).

Hemorrhage may occur from a few hours to several days following the extraction of a tooth. It may originate from the alveolus (socket) or from the surrounding gum tissue. The origin of the bleeding must be determined and treatment applied in that area. The best way to control hemorrhage is by pressure and, if bleeding occurs from an alveolus, it should be packed with gauze. First the socket should be washed with warm saline solution or warm water to dislodge the blood and any portion of a blood clot which has formed. A small piece of gauze should be saturated with EPINEPHRINE or THROMBOPLASTIN, and firmly but gently packed into the socket, then a larger piece packed over it. The use of absorbable oxidized cellulose products to pack the socket has proved to be an excellent method of controlling hemorrhage. After the socket has been filled, several 6 by 6 inch gauze napkins, folded to produce a pack of appropriate size, should be placed over the socket and between the adjacent teeth to provide firm pressure when the jaws are closed. Pressure must be maintained, and the compress, if effective, should not be disturbed for several hours—

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preferably overnight. If bleeding persists, the treatment must be repeated. The patient should be instructed to avoid excitement and to remain in either a sitting or reclining position as much as possible for at least several hours. Sedatives may be given if required, but stimulants in any form should be avoided. If free bleeding continues beyond a 3-hour period, a dental officer or medical officer must be consulted. Constant and continued loss of blood can result in shock.

Patient's complaint: "Jaw aches where tooth was extracted."

Symptoms

a. Severe pain 3 or 4 days following extraction.
b. No clot present in the socket.

Treatment

Dry socket.

It occasionally happens that a day or more after the extraction of teeth, severe throbbing pain occurs in the alveolus from which a tooth has been removed. This condition, known as "dry socket," indicates that a normal blood clot has failed to form. The socket should be cleansed of debris by irrigating with warm saline solution, and a small piece of gauze, moistened with eugenol or coated with butyn ointment, placed very gently in the painful alveolus. Care must be taken not to exert pressure in packing the gauze. Some relief may be experienced quickly, although the discomfort may persist for many days. The irrigation should be repeated and the gauze dressing renewed daily. If a rise in temperature is observed and the patient seems ill, an abscess or even osteomyelitis (infection of the bone marrow) may be developing. The patient should be taken immediately to a dental officer or in his absence, a medical officer.

Vincent's Infection or "Trench Mouth"

Patient's complaint: "Bleeding gums" or "Sore mouth."

Symptoms

a. Inflamed gums which may appear necrotic between the teeth.
b. Spontaneously bleeding gingivae.
c. Swollen lymphatic glands below mandible.

d. Halitosis.
e. Excessive salivation.
f. Extremely tender gums.
g. Often fever and general physical unease.

Treatment

The symptoms of this disease vary according to the degree of virulence of the infection and the resistance of the patient. The patient usually complains of discomfort and bleeding of the gums while eating or brushing the teeth. There is a characteristic inflamed appearance of the gums and a film of deadened, white or grayish tissue about the teeth. The gum margins bleed readily when touched. There may be considerable pain and discomfort and moderate to high fever may be present.

Certain predisposing factors such as low tissue resistance, poor oral hygiene, and trauma develop this condition. It is probably not contagious or infectious of itself. However, among groups of people, for example aboard ship, where conditions are the same for all, and where diet, exercise, sleep and general health are about equal, Vincent's infection can spread from one person to another. Therefore, strict precautions are indicated. Mess gear and all articles which may come in contact with the mouth must be sterilized after use. It is advisable that patients with Vincent's infection wash and handle their own mess gear and keep it apart from other mess gear throughout the course of their treatment. Arrangements should be made to insure that this be done, and the patient warned that the disease may be transferred by anything that comes in contact with the mouth, such as cigarettes and drinking cups.

Treatment consists of encouraging oral hygiene and applying medicaments which will destroy or reduce the number and virulence of the causative organisms. During the acute stages of the disease the gingivae are extremely sensitive and the patient should be instructed to avoid citric fruit juices, to abstain from using alcohol, spices and hot foods, or any other irritant. Careful daily application of oxidizing agents and other antiseptics to the gingival margins and prolonged irrigation of the mouth several times daily is routine. No one method is found to be equally effective in all cases. A level teaspoonful of sodium perborate dissolved in a half glass of warm water and used as a mouthwash for a full minute every 3 hours has been found effective in many cases. Care must be exercised that the sodium perborate does not cause additional irritation of the tongue and other oral tissues. If new soreness in the mouth is observed, the treatment should be halted at once and another instituted.

Use of a mild solution of warm salt water every hour or so as a mouth rinse should be helpful in relieving pain and tenderness until proper assistance can be obtained from a dental officer. The teeth should not be brushed while the gingivae are acutely inflamed. Brushing should be resumed, with a soft brush, as soon as the condition improves.

Equal parts of hydrogen peroxide and water also may be effectively used as a mouthwash if fresh peroxide is available. This solution should be flushed about in the mouth for a full minute at a time, every two or three hours, in order to get the benefit of the oxidizing action.

When conservative treatment is not effective, systemic administration of penicillin may be indicated. Then full therapeutic dosage should be given intramuscularly for a period of 3 or 4 days and should be in conjunction with local treatment as outlined previously. The patient should be referred to a dental officer at the first opportunity.

The proper care and brushing of the teeth should be explained thoroughly to each patient after a clinical cure has been effected. When the infection has subsided to some extent, a preliminary prophylaxis should be given, with the operator exercising extreme care and gentleness.

Symptoms and Treatment of Fractures of the Maxillae and Mandible
(Especially when roentgenograms are not available)

Patient's complaint: "Unable to close my mouth; I was hit in the jaw."

Symptoms

a. Pain which is aggravated by movement.
b. Tenderness to pressure at point of fracture.
c. Swelling usually present at point of fracture.
d. Deformity due to muscular contraction. Teeth may not occlude properly.
e. Bleeding from the mouth.

Fractures of the jaw exhibit the symptoms common to fractures of all bones and, in addition, there may be a characteristic irregularity of occlusion of the teeth. As in other fractures, reduction and immobilization are indicated. If teeth are present, they will serve as the best guide for proper reduction and immobilization, the teeth of one jaw serving as a splint for the other.

First aid treatment

The first steps are accomplished by making the patient comfortable, immobilizing the fractured parts, and keeping the mouth clean. It may be necessary to administer sedatives. The patient should be kept in bed and cold applied to the outside of the face. This will help to control the swelling.

The bandage type of splint is next to useless as a reliable method of adequate fixation, and dental assistance should be secured as soon as possible. As a first aid measure, the Barton bandage may be useful in fractures of the upper jaw although it is not suitable for fractures of the mandible. The turns about the front of the chin are the objectionable feature of the Barton bandage for fractured mandibles. These turns may be omitted to make a figure-of-eight modified Barton bandage, passing under the chin and over the head, and around the forehead and occiput, repeating several times. This will serve as a temporary support for the mandible. Care must be exercised not to get the bandage too tight, or it will interfere with breathing and circulation.

The following is suggested as an additional method of providing first aid for fractures of the maxilla or mandible. The brim of an ordinary "white hat" is turned down or cut off. A 2 inch bandage is folded six or eight times in sufficient length to reach from the brim on one side of the patient's head under the chin and to within 1 inch of the brim on the opposite side. One end of the bandage is secured to the hat with a long safety pin. On the opposite side a safety pin is fastened to the hat and another near the end of the bandage. The two safety pins should be approximated and encircled with a rubber band. Additional rigidity may be obtained by applying adhesive tape to the bandage.

The mouth should be kept clean by irrigation several times daily, and a liquid diet should be administered. To avoid too great a loss of weight, there should be one or two extra liquid meals daily. Where there is any likelihood whatever of seasickness, means must be provided for the jaw fracture patient to get his mouth open immediately. Failure to do so can cause death by suffocation.

Dislocation of the Mandible

Patient's complaint: "Unable to close my mouth, hard to talk."

Symptoms

a. Trismus and pain.
b. Inability to close the mouth.
c. Swelling of the face from a blow.

Treatment

Dislocation of the mandible may affect both sides. It sometimes follows yawning, vomiting or laughing in persons disposed to this disorder. This displacement may result from a blow to the jaw if the mouth is open. Because of the tense, stretched muscles or torn ligaments, it is generally necessary to first obtain relaxation of the musculature. Hot applications to both sides of the face will aid in accomplishing relaxation. The thumbs are then placed inside the mouth against the outer surfaces of the molar teeth and the mandible grasped beneath the chin with the fingers of each hand. While a downward pressure is exerted with the thumbs, the chin is raised with the fingers and at the same time the mandible is pressed backward until the condyle slips past the eminence and into the glenoid fossa. If sufficient force is not obtained in this way, the thumbs may be placed over the occlusal surfaces of the molar teeth but first, they must be well wrapped with a towel or bandage to prevent injury when the teeth snap together. If the first attempt is unsuccessful, further rest and heat applications are given and the reduction tried again. When reduction has taken place, the mandible is immobilized for a short time by the application of a Barton bandage. It is considered advisable to place the patient on a soft diet for a few weeks to give the injured tissues a chance to heal.

CHAPTER 14

MAINTENANCE OF DENTAL EQUIPMENT

Adjustments and repairs may be necessary at times when the services of a trained maintenance man are not available. Repairs may be of a major or minor nature, but the technician is not expected to (nor should he) attempt to make a major repair. This outline will furnish guidance as to what repairs the technician may make. A fundamental knowledge of maintenance will extend the useful life of equipment and contribute to the efficiency of the dental clinic. The repairs covered in this chapter are the ONLY repairs that a general dental technician should undertake.

OPERATING UNIT

Engine

The motor runs but does not furnish power at the handpiece. This may be caused by:

1. Badly worn engine belt which does not grip the pulleys.
   Replace engine belt.
2. Setscrew in wrist joint pulley, loose or missing.
   Tighten or replace setscrew.
3. Carbon accumulation on the commutator.
   Turn off the main switch of the unit. Remove the engine housing cover, by releasing the thumb nut and felt washer. Clean commutator with carbon tetrachloride and a narrow soft cloth.

This may be facilitated by rotating the engine pulley by hand.

4. Worn brushes.
   Examine the brushes. If they are worn and the metal brush holder is touching or about to touch the copper commutator they are in need of replacement. Do so and then replace engine housing, felt washer and thumb nut.

Figure 414.—Tightening the setscrew.

Figure 415.—Releasing the thumb nut.

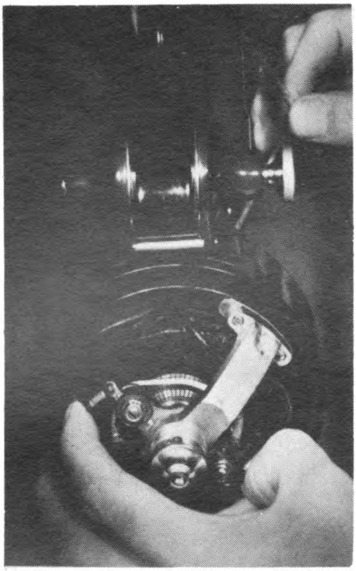

Figure 416.—Cleaning the commutator.

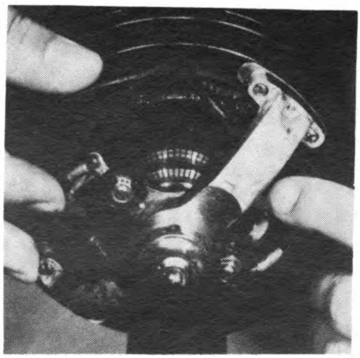

Figure 417.—Examination of brushes.

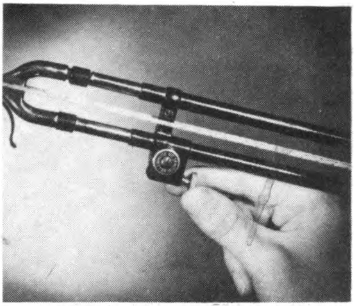

Figure 418.—Regulating the worm for belt adjustment.

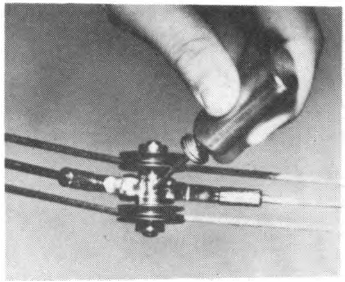

Figure 419.—Oiling the pulley shafts.

5. Extension arm-worm adjusted too loosely.
   Adjust worm gear for belt adjuster.
6. Pulleys on engine arm frozen.
   Oil pulley shafts.

The motor has stopped running.

1. Blown fuse in the main switch box.
   Try other electrical connections on the unit, such as spotlight. If these fail to work, replace fuse. If electric current is present the possibility of a blown main fuse is eliminated.
2. Main switch is off or defective.
   Check switch.

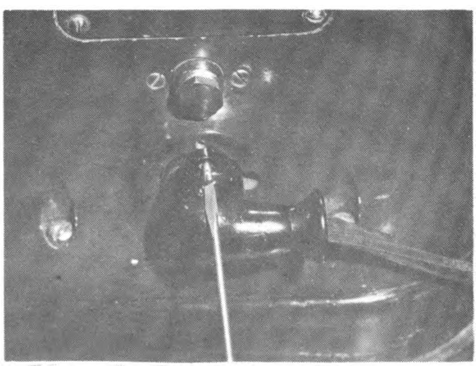

Figure 420.—Replacement of screw.

3. Foot controller cord may have been pulled out from the rear of the unit pedestal.
   Examine the foot control cable, making certain that it is firmly plugged into the unit. If the two screws holding the plug (Ritter E) are missing, replace screws.
4. Frozen bearing.
   Oil bearings.

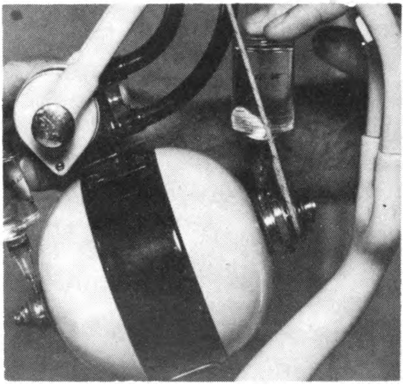

Figure 421.—Lubrication of bearings.

Figure 422.—Greasing worm-gear.

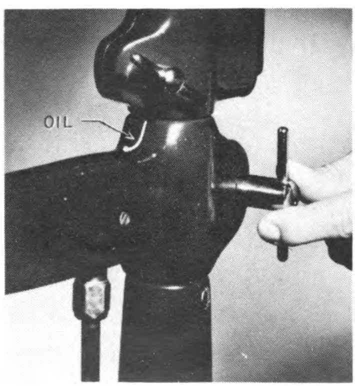

Figure 423.—Loosening the adjusting nut.

Engine Arm (Extension arm)

Engine arm fails to extend.

1. Extension worm frozen.
   Grease the extension and "work" the worm gear for belt adjuster until free.

Bracket Table

Fails to move freely.

1. Adjusting nut on support arm too tight or frozen.
   Loosen adjusting nut and oil.

Gas Burner

Poor mixture.

Escape of gas.

1. Adjust regulating sleeve.
2. Loose connection.
   Do not test for gas leaks with a lighted match. When a gas leak is suspected, a systematic checkup of all gas connections

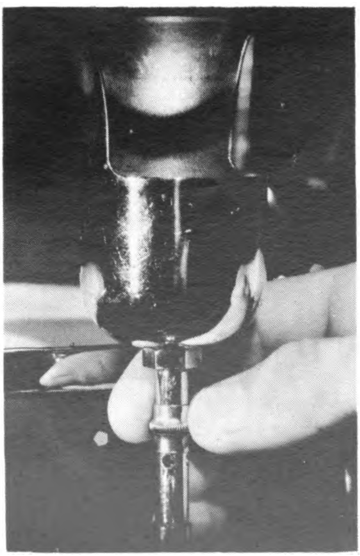

Figure 424.—Adjustment of regulating sleeve.

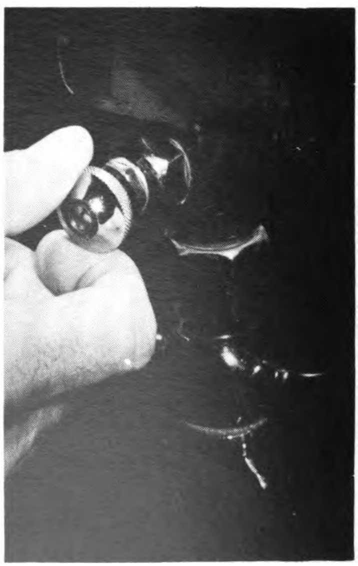

Figure 425—Closing the water pressure regulator and shutoff valve.

is the safest method. Place a drop of oil at the place suspected of leakage, if gas is present the oil will bubble.

Cuspidor

Insufficient water pressure.

1. Ship's water pressure or area water pressure low.
   Check with engineer or local water supply.
2. Clean-out plug clogged.
   Close water pressure regulator and shut-off valve.
   Remove clean-out plug, clean and replace washer if necessary.

Cuspidor valves leak.

1. Loose bonnet, packing nut.
   Tighten bonnet, packing nut.
2. Worn packing washers.
   Turn shut-off and regulating valve off. Replace packing.

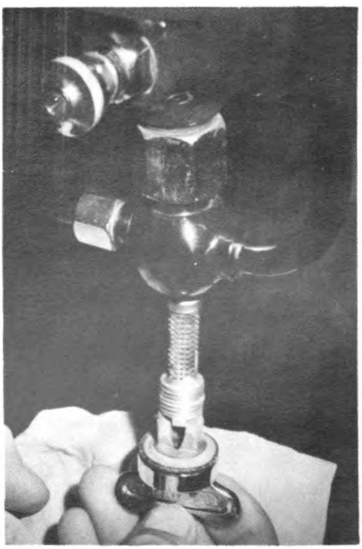

Figure 426.—Removal of clean-out plug.

Figure 427.—Tightening the bonnet and packing nut.

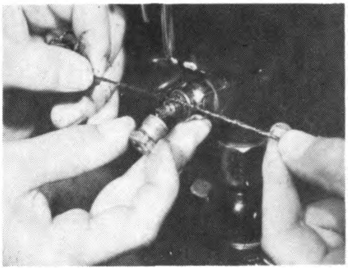

Figure 428.—Replacement of packing.

Figure 429.—Cleaning out trap.

Poor drainage from cuspidor.

1. Clogged gold trap.
   Clean out trap.

Saliva Ejector

Poor suction.

1. Saliva ejector tip, screen clogged.
   Remove ejector tip, screen; clean and replace.

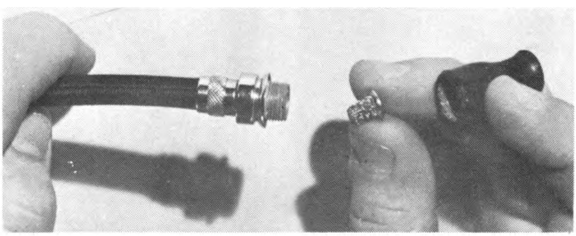

Figure 430.—Removal of ejector tip and screen.

2. Poor water pressure.
   Check valves and source of supply.
3. Ball check-valve stuck.
   Remove saliva ejector tubing and insert a broken explorer to free the ball check valve.
4. Clogged or worn tubing.
   Clean or replace.

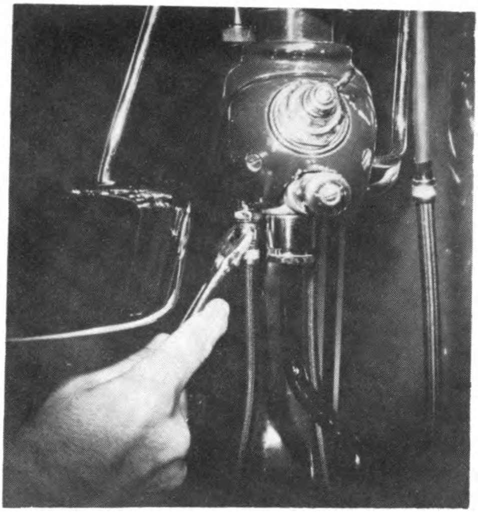

Figure 431.—Loosening ejector tubing.

Water Reservoir and Heater Section

Water reservoir loose.

1. Loose screw in name plate.
   Tighten screw.

Water reservoir fails to heat. (Set at Maximum cold.)

1. Reservoir switch off, main switch off.
   Snap switch to ON position.

Water leaks from supply valve on supporting arm.

1. Loose packing nut and bonnet.
   Tighten bonnet.

Water leaks from union nut on supply line from cuspidor, or coupling nut on supply line to reservoir.

Tighten union nut.

1. Loose coupling nut.
   Tighten coupling nut.

Figure 432.—Insertion of broken explorer.

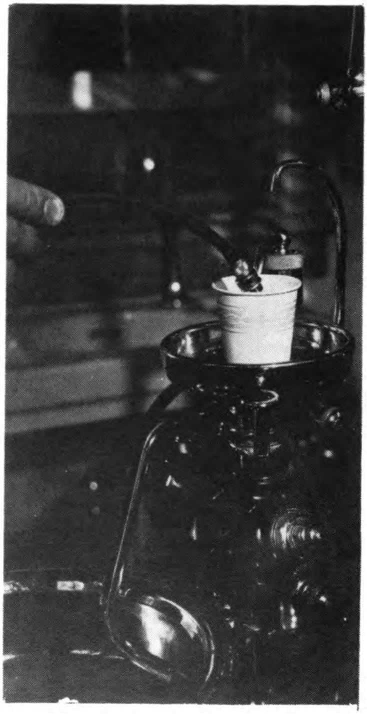

Figure 433.—Flushing tubing.

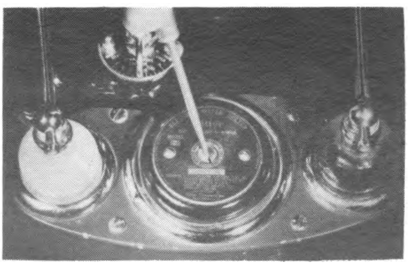

Figure 434.—Tightening the name plate screw.

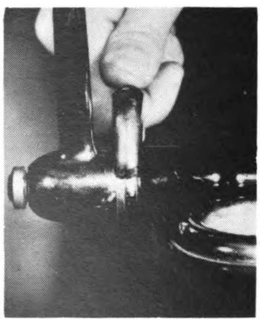

Figure 435.—Tightening the bonnet.

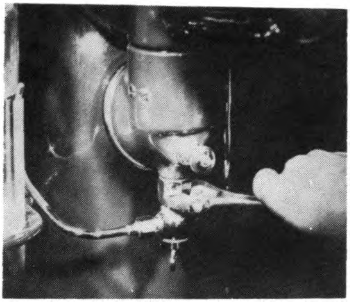

Figure 436.—Tightening the union nut.

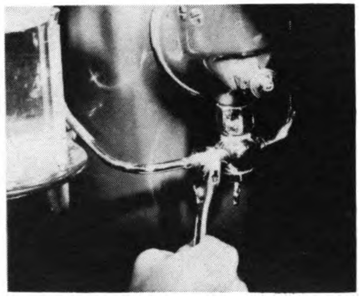

Figure 437.—Tightening the coupling nut.

Thermo Water Syringe and Resistance Regulator

Syringe fails to heat.

1. Master and low voltage switches off.
   Snap switches to ON position.
2. Regulating ferrule not engaged on the regulator.
   Engage and regulate as indicated.

Low water pressure from syringe nozzle.

1. Low water pressure in lines.
   Check source.

Figure 438.—Regulation of ferrule.

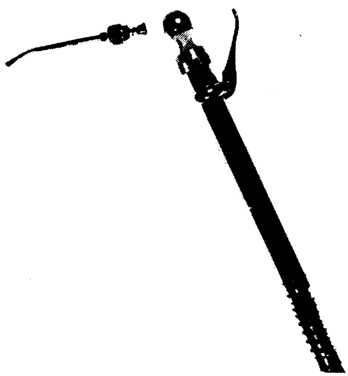

Figure 439.—Nozzle detached.

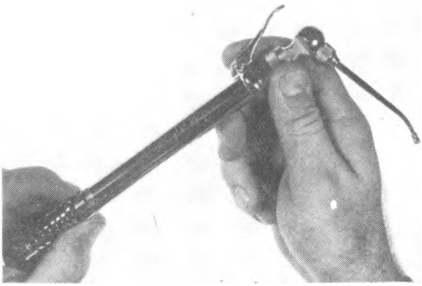

Figure 440.—Tightening the spring hose protector.

Figure 441.—Spring hose protector disengaged.

2. Nozzle clogged.
   Remove and clean.
3. Spring hose protector loose.
   Tighten spring hose protector.
4. Compression rod adjusted too short.
   Disengage spring hose protector. Remove valve body. To increase pressure, turn the compression rod counterclockwise. To decrease pressure, turn the compression rod clockwise.

Syringe handle becomes too hot.

1. Regulating ferrule too high.
   Turn regulating ferrule counterclockwise. To increase heat, turn clockwise.

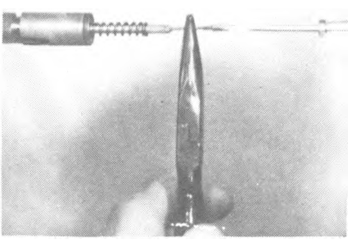

Figure 442.—Adjustment of compression rod.

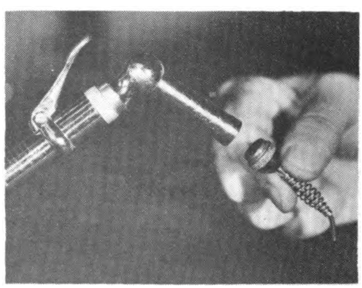

Figure 443.—Removal of syringe nozzle.

Leakage from handle.

1. Compression rod adjusted too long.
   Turn screw for compression rod clockwise.

Warm Air Syringe

Syringe fails to heat.

1. Master and low voltage switches off.
   Snap switches to ON position.
2. Syringe heating element loose.
   Remove syringe nozzle, insert screwdriver and tighten heating element in top of syringe.
3. Loose spring hose protector.
   Tighten spring hose protector.

Low air pressure.

1. Compressor off, main air valve off.
   Turn compressor on, main valve on.
2. Loose spring hose protector.
   Tighten spring hose protector.
3. Clogged nozzle.
   Remove and clean.
4. Compression rod adjusted too short.
   Turn adjustment screw for compression rod counterclockwise.
5. Knurled adjusting sleeve too far down.

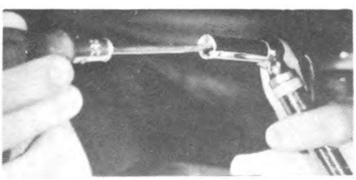

Figure 444.—Tightening the heating element.

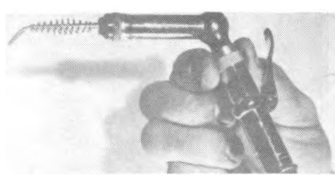

Figure 445.—Positioning knurled adjusting sleeve.

   Screw knurled adjustment sleeve upward.

Leak at nozzle tip with syringe not in use.

1. Body for head stuck down in tube.
   Remove body for head by first removing locking screws (2) from operating lever.

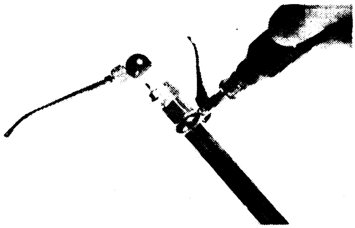

Figure 446.—Removal of operating lever.

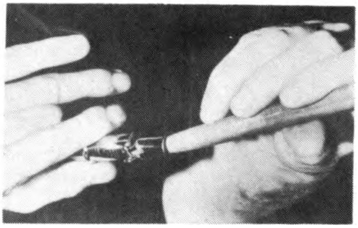

Figure 447.—Filing down a curled edge.

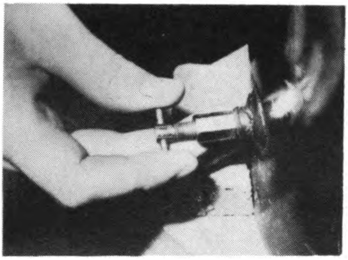

Figure 448.—Opening the drain.

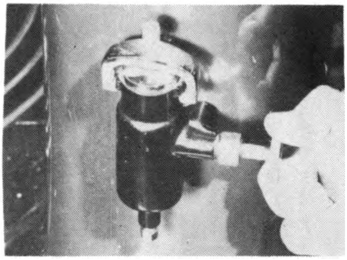

Figure 449.—Closing the valve.

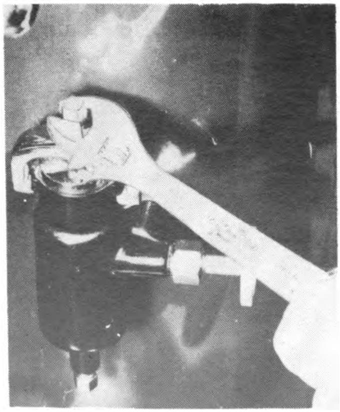

Figure 450.—Loosening hexagon-head screw on air-filter cap.

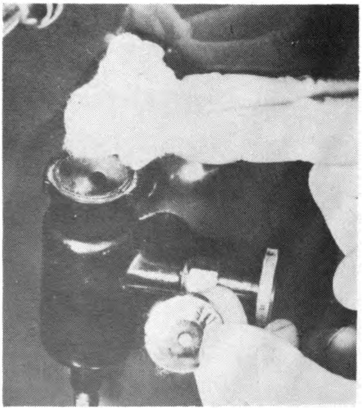

Figure 451.—Removal of cotton.

Loosen spring hose protector. Remove valve body. File down the curled edge within the tube.

Air is foul and wet.

1. Water in air compressor.
   Drain water.
2. Wet cotton in air filter and cut-off.
   Close valve for air filter on unit.
   Loosen hexagon-headscrew for holding air filter cap and remove cap.
   Remove cotton. Replace cotton in air filter and open cut-off valve.

Low Voltage Instrument Handles

Diagnostic lamp.

Mouth lamp flickers or fails to light.

1. Main or low voltage switch off. "A" regulator switch off.
   Snap switches to ON position.
2. Burned out lamp.
   Replace lamp.
3. Setscrew for selector knob, loose.

Figure 452.—Tightening setscrew.

Figure 453.—Vacuum bottle assembly.

Tighten setscrew.

Cautery and Pulp Testers.

The procedures are the same as above with this EXCEPTION: instead of the handle being attached to the "A" regulator, it is attached to the "B" regulator.

Aspirator

Lack of suction.

1. Clogged tip or leaking tubing.
   Remove and clean tip, remove and replace tubing.
2. Ill-fitting cap on bottle.
   Adjust cap.
3. Wet chamois disk in overflow valve.

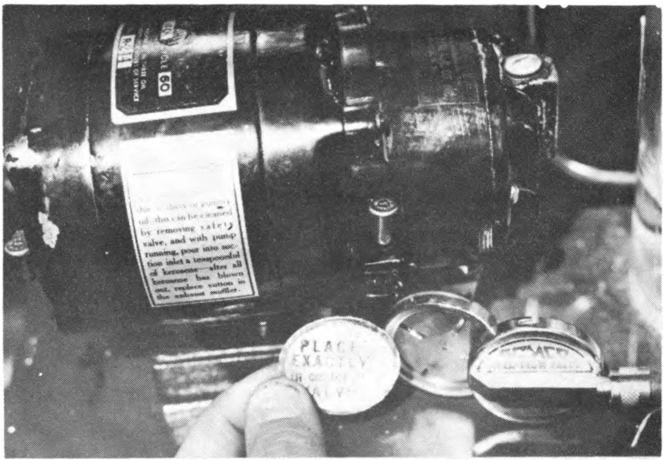

Figure 454.—Replacement of disk.

   Remove and replace with new disk.
4. Lack of oil in oil reservoir.
   Replenish oil supply.
5. Bearings frozen.
   Oil bearings.

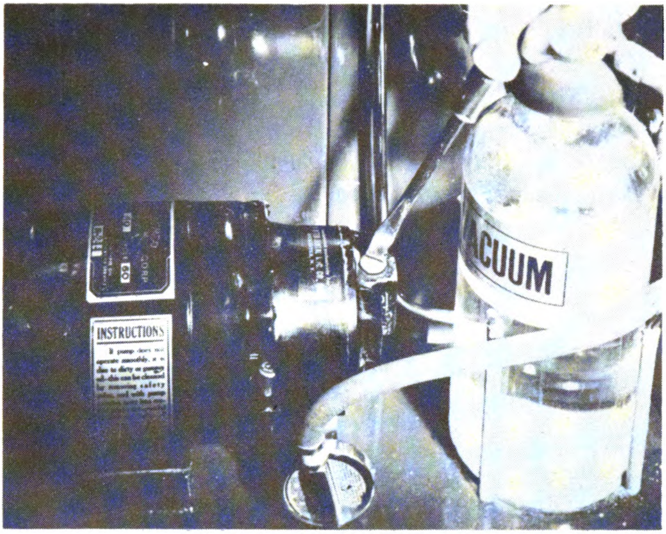

Figure 455.—Opening oil reservoir.

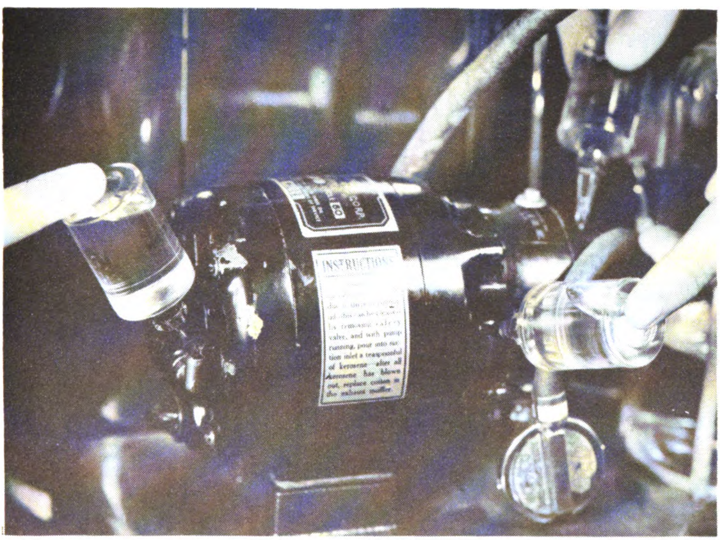

Figure 456.—Oiling bearings.

Castle Light

Lamp fails to light.

1. Master light switch off.
   Snap switches to ON position.
2. Burned out lamp.
   Remove and replace with new lamp.
3. Plug in extension arm loose.

Figure 457.—Removal of bulb from castle light.

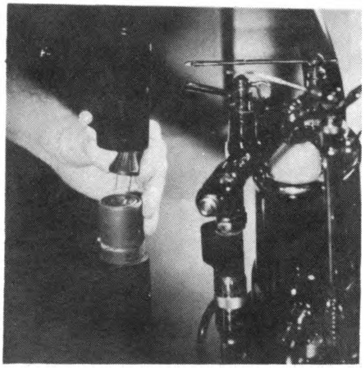

Figure 458.—Removal of extension arm.

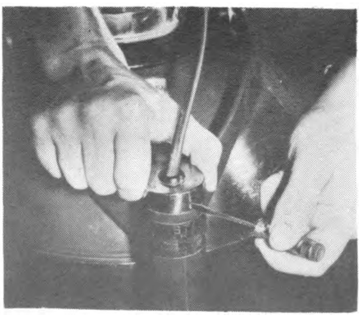

Figure 459.—Loosening setscrew.

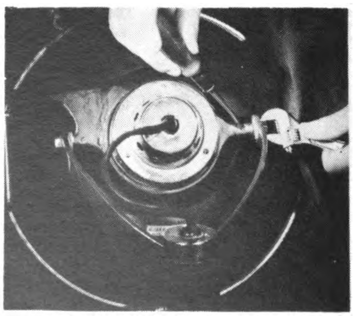

Figure 460.—Tightening setscrews.

Remove extension arm and replace plug.

Light swings back and forth.

1. Chrome adjusting sleeve loose.

   Loosen setscrew in chrome adjusting sleeve on top of yoke. Turn adjusting sleeve clockwise to tighten. Tighten setscrew.

Light slips up and down on yoke.

1. Yoke arm loose.

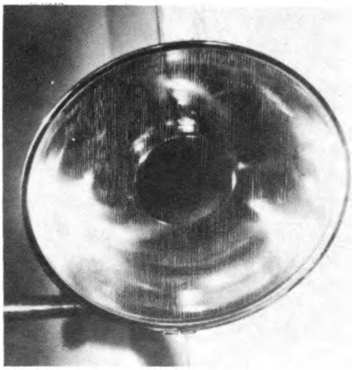

Figure 461.—Correct position of cover glass grains.

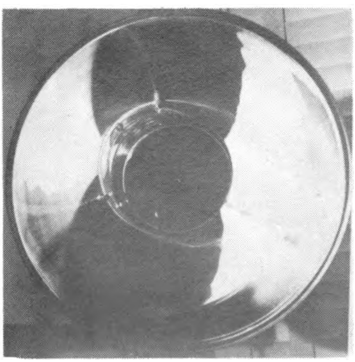

Figure 462.—Removing cover glass.

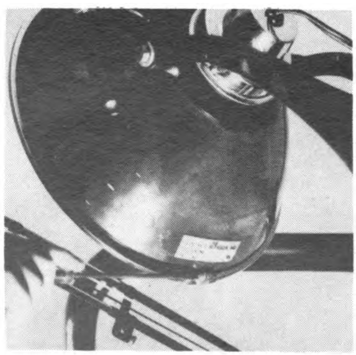

Figure 463.—Seating filter glass evenly.

Loosen setscrews on BOTH sides of yoke arm and tighten hexagonal nuts. Tighten setscrews.

Light does not give desired pattern.

1. Grains in coverglass (lens) not vertical.

   Adjust coverglass.

2. Filter glass not evenly seated.

   Remove coverglass.

   Seat blue filter glass evenly.

   Check metal shield around filter glass so that the bright areas on the reflector are horizontal. Replace lens, turn on light and throw the beam on the wall at a distance of 36 inches. Turn cap to each of the three positions and select desired pattern.

Ritter Foot Pump Chair

Headrest does not hold fast in its supporting slide.

1. Headrest slide setscrew loose.

   Tighten headrest slide setscrew, holding the spring and locker roller.

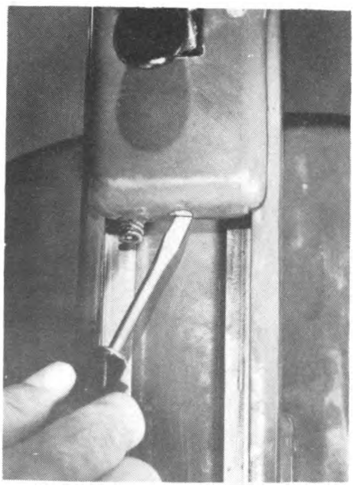

Figure 464.—Tightening headrest slide setscrew.

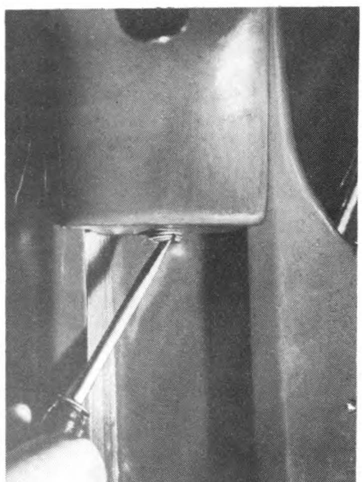

Figure 465.—Tightening back-slide, setscrew.

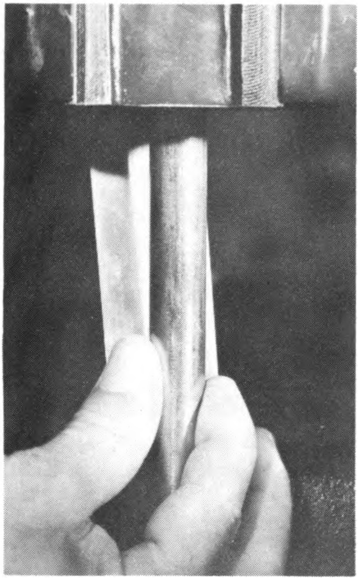

Figure 466.—Oiling back bar.

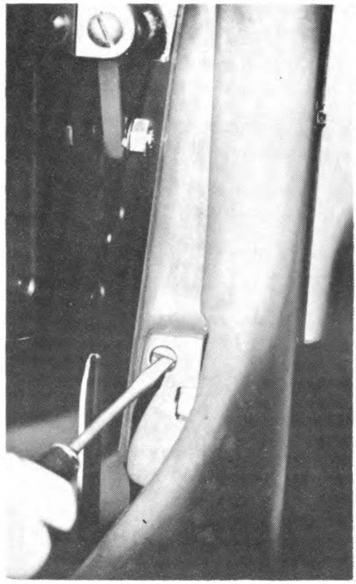

Figure 467.—Tightening setscrew.

Backslide does not hold fast in its slide.

1. Adjusting setscrew loose.
   Tighten clockwise, headless setscrew, holding adjusting spring and backslide locking roller.

Back lock does not hold when reclining the back pad.

1. Backslide gummed.
   Raise chair to highest position. Place back pad in extreme forward position.
   Clean thoroughly and oil by placing oil on fingertip and oiling back-bar. Tilt chair forward and backward several times. Tighten headless setscrew on bottom of compensating backslide.

Tilting lock does not hold.

1. Insufficient pressure on lever spring. Dirty.
   Raise chair to half height. Clean tilting bar and coat with film of oil at top of bar. Tilt chair backward and forward

a few times, increase tension on lever spring by turning cap screw.

Lowering speed too fast or too slow.

1. Speed regulator out of adjustment.

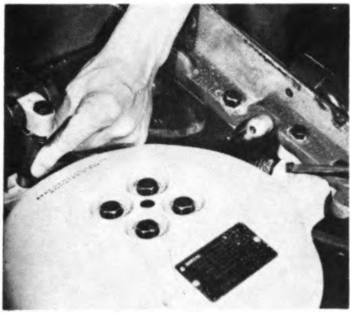

Figure 468.—Increasing tension; pointing to bar to be oiled.

Figure 469.—Turning speed regulator.

Turn speed regulator to left or right, until desired speed is obtained. To increase, turn counterclockwise; to decrease, turn clockwise.

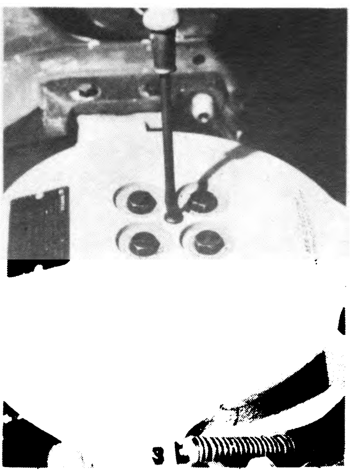

Figure 470.—Removing headless plug screw.

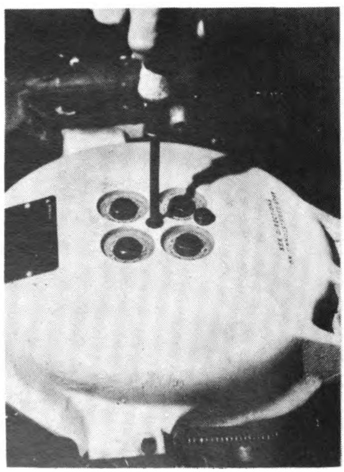

Figure 471.—Loosening air vent control screw.

Chair does not pump, or chugs and settles.

1. Foreign matter in oil may have settled on the valve seats and prevents closure.

   Place chair in lowest position. Remove seat. Remove headless plug screw in center casting.

   Insert screwdriver through the opening left by the headless plug screw and unscrew by one turn only, the screw controlling the air vent in head of pump. Pump raising lever vigorously. Tighten air vent screw and test.

Side arm slips.

1. Locking lever loose.

   Open locking lever. Using two broken instruments, place one on each side of the locking screw. Turn screw and test locking levers by tightening.

Motor Chair

Motor fails to start.

1. Main switch off.

   Snap master switch to ON position. Check connection cable to unit.

2. Mercury switches not in position.

   Remove the two screws from the panel at back of chair base.

   Check position of mercury switches.

Figure 472.—Opening locking lever.

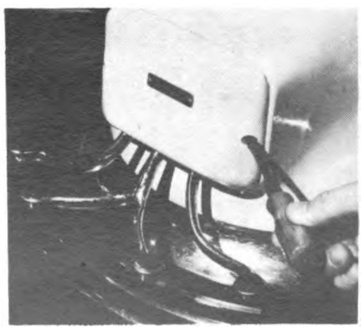

Figure 473.—Removing the two panel screws.

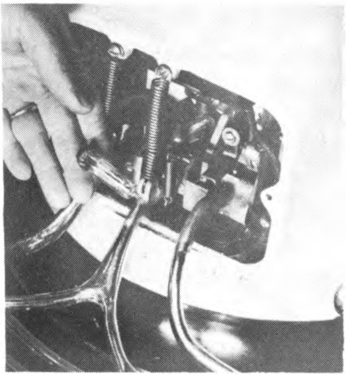

Figure 474.—Mercury switch out of position.

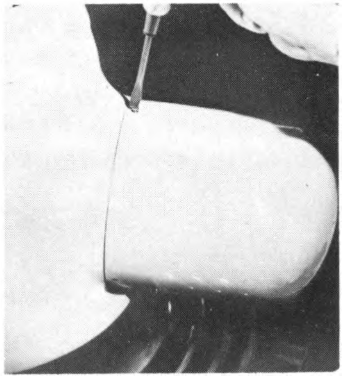

Figure 475.—Removing cover for motor.

Remove cover for motor.
Oil the motor.
Place oil in the three holes in the shaft housing.

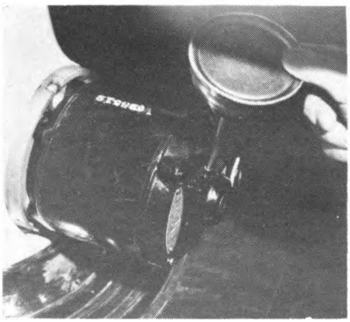

Figure 476.—Oiling the motor.

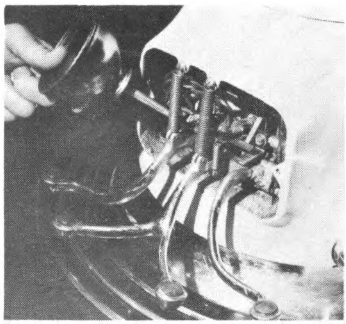

Figure 477.—Oiling shaft housing.

Air Compressor

Motor does not run.

1. Connecting plug, loose or out.
   Check plug and main source of electricity.

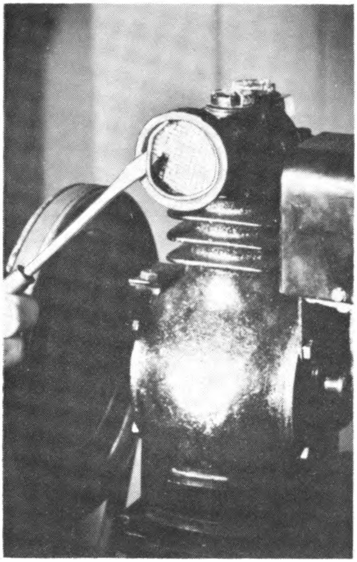

Figure 478.—Removing the retaining ring for filter.

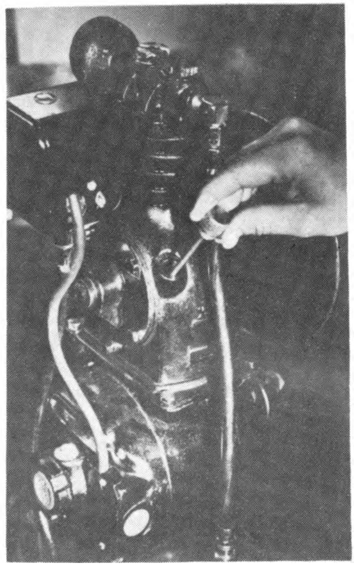

Figure 479.—Checking the oil level.

Damp and foul smelling air.

1. Water in tank.
   Unscrew petcock at bottom of compressor and drain.
2. Intake filter dirty.
   Remove cover and replace filter.

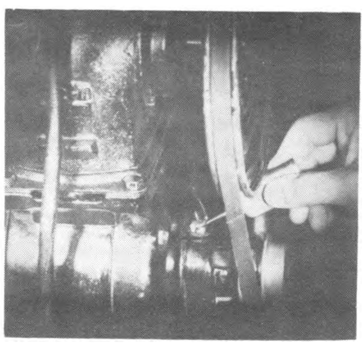

Figure 480.—Oiling the motor bearings.

Squeaks, knocks and rubbing noises.

1. Worn belt.

   Remove and replace with new belt.

   Lack of oil in pump section.

   Check oil level.

   Oil motor bearings.

Motor runs but no air builds up in tank.

1. Clogged intake filter in pump.

   Remove cover. Replace filter.

Foot Controller

Engine hums with foot controller lever in neutral.

1. Contact segments worn, filings between segments.

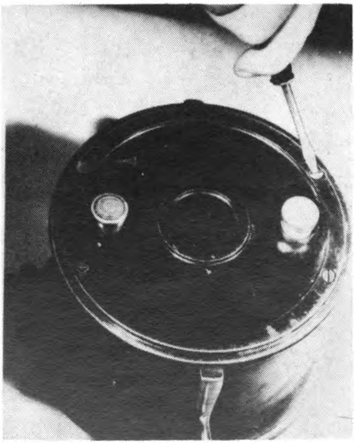

Figure 481.—Removing the cover-plate screws.

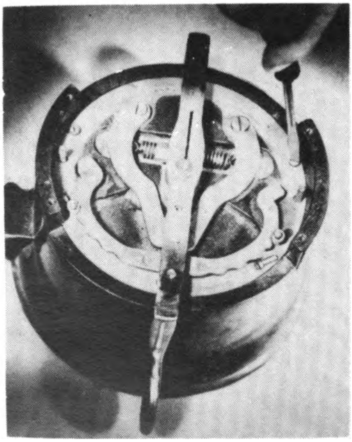

Figure 482.—Removing screws from the supporting plate.

Remove screws holding top cover plate and supporting plate.

Clean between contact segments with applicator stick.

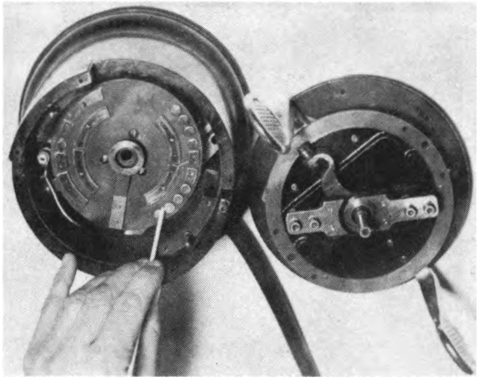

Figure 483.—Removing filings from between contact segments.

Sterilizer

AMERICAN. Pilot lamp out.

Remove false bottom. Remove lamp. Replace with new lamp.

PELTON CRANE.

Unscrew light cover. Unscrew lamp, counterclockwise. Replace with new lamp.

Light on but sterilizer fails to heat.

1. Loose wiring.

   Remove plug from receptacle, remove false bottom. Check wires to see if attached to terminal, also for possible shorts and open circuits.

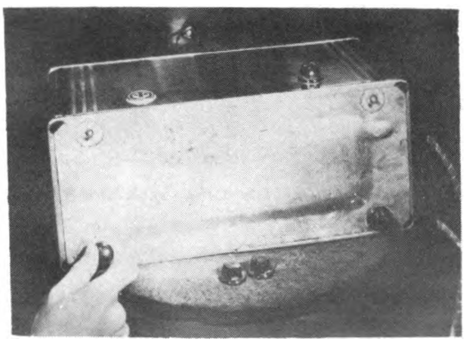

Figure 484.—Removing the false bottom.

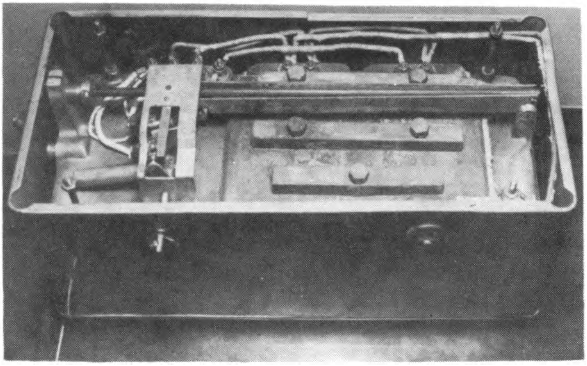

Figure 485.—Visual check of wiring.

Sterilizer plugged in but no light and no heat.

1. Male plug faulty or fuse blown.
   Remove plug, fuse and replace with new parts.
2. Circuit breaker not manually reset.
   Push in knob. Reset circuit breaker.

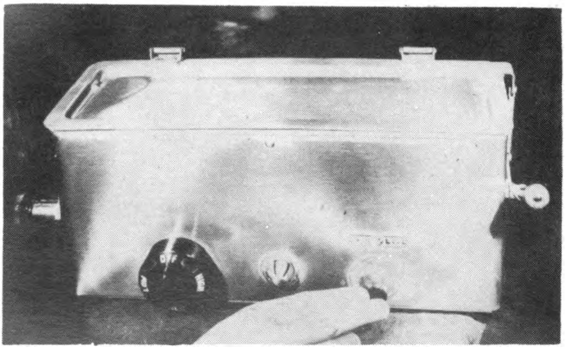

Figure 486.—Resetting the circuit breaker.

Dental Cabinet

The drawers stick.

1. Check lock in top of drawer. Remove drawers and check multiple locking arms. If one side is unlocked and the other side will not open, push all the drawers in as far as they will

go. This relieves a jammed locking arm. If one or two drawers are stuck, remove the nearest drawer to see if some misplaced instrument is jamming it.

MAINTENANCE

Operating unit

Daily:

- Release extension arm
- Flush saliva ejector system
- Empty cuspidor trap
- Turn off water, gas, electricity and air

Engine

Weekly:

- Blow out airlines
- Flush out spray bottle nozzles with clear water
- Oil pulleys in engine arm, one drop

Monthly:

- Oil motor, one drop
- Oil pulleys in wrist joint, one drop

Handpieces

After each patient, the handpiece is run for one minute in a solution of equal parts carbon tetrachloride (Stock #1–127–000) and liquid petrolatum, heavy (Stock #1–337–000) then placed in the hot oil bath, liquid petrolatum, heavy, for two minutes at 250° F., allowed to drain, wrapped in a sterile paper towel until ready to use. Any excess oil may be blown out with the air syringe at this time, and wiped off with a piece of gauze dampened with alcohol.

Foot controller

The foot controller should be oiled and greased once every 6 months. Remove the four screws from the top of the cover. Remove the four screws from the top of the inside controller plate. Take off plate. Clean the brass segments. Fill the lubrication holes with white vaseline.

Air compressor

Drain air and moisture from the tank, nightly. Check oil level in pump section weekly. Oil the electric motor monthly. One oil hole is at the end of each shaft.

Sterilizer

The hot water sterilizer should be drained of water and wiped dry each night. Lime scale may be removed from the sterilizer by one of the following three methods: (a) Glacial acetic acid (2 oz.) is added to the boiling water in the sterilizer and allowed to boil for 30 minutes.

Empty while still hot, and dry with soft cloth. Care should be taken while pouring the acid into the water. (b) Muriatic acid (10%) solution is added to boiling water for 10 minutes. Empty while hot, and wipe dry with a soft cloth. (c) The oil sterilizer is emptied and refilled according to usage. In the average office devoted to operative dentistry, the color of the oil will change in about three weeks' time. Empty the oil, dry the sterilizer with a soft rag and refill. The use of an acidic preparation will not be necessary.

Polishing lathes

These large, heavy duty grinding and polishing machines will be repaired by specially trained repairmen. Any decrease in their efficiency should be reported to the person in charge of the dental prosthetic laboratory who will arrange for the necessary servicing of the apparatus.

These machines have a suction apparatus for drawing off grindings and dust. Some of them have a water tank over which the dust-laden air is drawn for filtering. The water level must be maintained according to the instructions for each specific type of machine. The dust traps or filters must be removed and cleaned periodically.

Casting machines

Two kinds of centrifugal casting machines may be found in naval dental prosthetic laboratories. Casting gold is fused by electricity in one type; it is fused by means of a hand-operated blowtorch in the other. The machine which fuses the gold by means of electricity requires regular attention to all lead-in wires and to all contact points which maintain a circuit. The special crucible for this type of machine must be replaced frequently to maintain the heating qualities which its resistance builds up.

Both types of machines are spring-propelled during the casting operation; they throw the melt of gold into the mold by centrifugal force and hold it there until it is solidified. The spring can be strained or broken if wound too tightly. Special knowledge is required to repair both these machines. Repair work should be performed only by qualified repairmen. Persons who are not trained and do not possess the required special tools should not attempt to regulate the pyrometers or the adjusting panels.

Gas equipment

Gas burners of all types—Bunsen burners, hot plates or blow-torches—should be adjusted for operation with the available type of gas. If the gas supply is changed from manufactured gas to natural gas or to one of the several types of bottled gases, it will be necessary to adjust every gas burner in the laboratory for functioning with that particular gas.

Gas lines are not high pressure lines, hence leaks are rare. If leaks are suspected, ALL open flames should be extinguished at once, an adequate air supply should be insured and the person responsible for maintenance of equipment should be called.

Containers for drugs and chemicals

A wide variety of chemicals and drugs are used in the prosthetic laboratory. The inflammable chemicals are often explosive when still some distance from an open flame. The dangers from acids and acid fumes must be guarded against when their use is required in the laboratory. Acids must be stored in a safe container. Unusually large markings should be placed on the bottles. Counteragents and antidotes for all chemicals should be within easy access.

Carbon tetrachloride, a common wax solvent, is a dangerous agent when vaporized by heat. It should be used with caution. Heat treating salt baths are dangerous because of their disarming appearance and extremely high temperatures. Disfiguring and crippling burns can easily result unless this equipment is kept isolated and plainly labeled when in use.

Water traps

One piece of equipment peculiar to a prosthetic laboratory, is the plaster trap found under the sink. Its purpose is to screen all sorts of debris from entering and blocking the main drain lines. These traps have a removable cover to permit opening and removing the series of screens found within. A regular schedule should be established for cleaning out the traps.

Special equipment

Any equipment that is nonstandard and which will require special attention should have attached, either by tag or by label, a list of all points on the machine that will require such attention, and a space for entering a date whenever service has been rendered.

GLOSSARY

ABUTMENT—The support on which one end of a bridge rests or is supported.

ACIDOPHILIC—The property of being easily stained by acid dyes. Also: *Aciduric*—capable of living in an acid medium.

ALKALINE—Having the properties of an alkali, a chemical base.

ALKALOID—A general term applied to any member of a group of basic nitrogenous compounds which are derived from plants or their derivatives. They are physiologically active. Some synthetic compounds, such as procaine, are also classed as alkaloids.

ALLOY—A metallic substance made by fusing or melting together two or more metals. Alloys of mercury need no fusing or melting and are called amalgams.

ALVEOLUS—(Dental) tooth socket: The cavity in the process of the maxillary or mandibular bone in which the root of a tooth is fixed.

AMALGAM—(Dental) Finely divided particles of certain metals held in a crystalline mass by the peculiar property of liquid mercury to harden after being alloyed with the particles' outer surface.

AMOEBOID—Resembling an amoeba, especially in movement.

AMORPHOUS—Shapeless or without form; not crystalline.

AMPHOTERIC—Of opposite chemical characteristics: An amphoteric compound will neutralize either an acid or a base, hence may itself be either an acid or base.

ANNEALING—The heating at a definite temperature of a metal, an alloy, or piece of glass in an oven, for a prescribed period of time to adjust the crystalline structure to a uniform arrangement.

ANTIBODY—A substance produced in the blood of an animal as a reaction to the presence of an antigen. Antibodies affect antigens in numerous ways, attempting to remove the antigens from the blood stream.

ANTIGEN—A foreign substance; when introduced into the blood or tissues, causes the production of antibodies.

ANTISIALOGOGUE—An agent which retards or stops the flow of saliva.

ARTICULATION—The contact relation of the occlusal surfaces of the teeth while in use. Also: the place of union or junction between two bones, usually permitting movement of the two bones to a greater or lesser extent: a joint.

ASPHYXIA—Suffocation. A condition of anoxia or lack of oxygen in the blood.

ASSIMILATE—To convert food into living tissue. (Constructive metabolism.)

ASTRINGENT—An agent which causes contraction of tissue.

AUTOCLAVE—Container for effecting sterilization by steam under pressure.

BALSAM—Any of several resinous vegetable juices, usually semifluid and fragrant.

BIFURCATED—Branched into two parts.

BILIRUBIN—A red pigment commonly found in bile but also contained in small amounts in the blood.

BRACHIAL—Pertaining to the arm.

BUCCAL—Pertaining to the cheek. Toward the cheek.

CARAT—A measure of the fineness of gold, pure gold being 24 carats.

CARDIAC—Pertaining to the heart.

CARMINATIVE—A medicine capable of relieving flatulence.

CARNIVOROUS—Carnivorous animals eat principally flesh; they are called carnivores. Examples are the cats and dogs. Their teeth are fitted for the tearing of meat because of their long, sharp, pointed cusps.

CATABOLIC—Pertaining to that part of body metabolism in which cells or tissues are torn down or destroyed.

CATALYST—An agent which changes the speed with which substances react without itself being changed.

CATHARTIC—A medicine taken internally for speeding up evacuation from the bowels.

CAUSTIC—An agent which causes the destruction of tissue.

CERVICAL—Pertaining to the cervix or neck or constricted portion of an organ or part of the body.

CINGULUM—A small prominence appearing on the lingual surface of upper anterior teeth near the gingival margin.

COLLOID—A substance capable of being permanently suspended in finely divided particles in a liquid, the medium. Colloids do not form true solutions, only colloidal solutions which are recognized by the fact that a beam of light passing through them is visible because the colloid particles reflect it. In a true solution a beam of light is not visible, the molecular size of the solute being too small to reflect light.

CONGENITAL—A characteristic or fault present in a person at, or from the time of birth.

CORROSIVE—Destructive to the texture of a substance or tissue.

COUNTERIRRITANT—An agent or medicine used to allay or counteract the effects of an irritant. Therefore, anything used to lessen or relieve inflammation.

CROWN—That portion of a tooth which is covered with enamel, and which projects from the tissues in which the root is fixed.

CRUSHING STRENGTH—The strength of a substance expressed in terms of the pressure necessary to crush a unit of the substance, usually computed in pounds per square inch.

CULTURE—The propagation of micro-organisms. The growth of micro-organisms.

CUSP—A pronounced elevation, or point, on the surface of a tooth, which during mastication serves a useful purpose.

Deciduous Teeth—The teeth of the child which are shed to give place to the permanent teeth. They are also called temporary, milk, or baby teeth.

Decoction—A watery preparation of a drug prepared by boiling vegetable substances and straining.

Decomposition—The breaking up of a compound into its component parts; decay; putrefaction.

Dehydrate—To deprive of water by the use of a chemical or heat.

Deliquescent—The property of a substance of absorbing moisture from the atmosphere to the extent that a solution is formed.

Dentin—The tissue of which the main body of a tooth is formed.

Developmental Grooves—Fine depressed lines in the enamel of a tooth which mark the junction of its lobes.

Diffusion—The mixing of one fluid (gas or liquid) throughout a second by means of molecular motion. This may take place through a semipermeable membrane. Thus, the movement of plasma through capillary walls and out through the tissues is a process of diffusion.

Distal—Away from the median line of the face. The surface of a tooth most distant from the median line.

Distillation—The process of vaporizing a substance and condensing it at some other place, thus freeing it of impurities less easily vaporized.

Diuretic—An agent which increases the secretion of urine.

Duct—A tube for the passage of excretions or secretions.

Embrasure—An opening that widens outward or inward; as an opening in a wall for a cannon. That portion of the interproximal space that widens from a contact point toward the buccal or labial, or toward the lingual.

Emesis—The act of vomiting.

Emollient—An agent which soothes or softens the skin or soothes an internal irritated surface.

Emulsification—The suspension of an oily substance within a watery vehicle. Example: the emulsification of butter fat in the watery part of milk.

Enamel—Very hard tissue covering the crown of a tooth.

Enzyme—An organic compound, frequently a protein, capable of producing or catalyzing the transformation of some other compound or compounds.

Escharotic—A corrosive or caustic agent.

Ethereal—Pertaining to, prepared with, containing, or resembling ether.

Expectorant—An agent which promotes the ejection of mucus and secretion by spitting.

Fauces—The passage from the mouth to the pharynx.

Fenestra—A window-like opening, especially through bone.

Filtration—A process for the removal of solids from liquids. The *Filter* is a screen which will permit liquid to pass and which has small enough holes to retain the solid. The solid left in the filter is the *Residue*. The liquid passed through the filter is the *Filtrate*.

Fissure—A defect in the surface of a tooth caused by the imperfect fusion of the enamel of the formative parts or lobes. Fissures occur along the lines of the developmental grooves.

Flatulence—Distension of stomach or intestines by gases.

Flora—The vegetative or bacterial life of a given region or locality.

Flow—The lateral spreading or crawling of amalgam when subjected to stress.

Flux—In metallurgy, agents which promote the fusion of metals and/or minerals by cleaning the surfaces, and dissolving and carrying off infusible materials as slag.

Foramen—An opening, usually in bone, through which nerves and blood vessels may emerge or enter.

Fossa—(Pl. Fossae) A round or angular depression in the surface of a tooth. Fossae occur mostly in the occlusal surfaces of the molars and in the lingual surfaces of the incisors.

Friable—Easily fractured or broken into pieces.

Galvanic Action—Direct electric current capable of existing between two metals of different electrical potentials; in the mouth this condition may result in pain when one metallic restoration contacts another of a different metal.

Gangrene—Death of a tissue combined usually with invasion by saprophytic organisms, or organisms which feed on dead tissue.

Gingiva (Pl. Gingivae)—The portion of gum tissue enveloping the necks of the teeth crown-wise from the attachment at the gingival line. The free margin of the gum.

Gingival—Pertaining to the gingival line; as the curvature of the gingival line, gingival margin, etc.

Gingival Line—The line around the neck of a tooth at which the gingiva is attached. The line of junction of the enamel and cementum.

Gingival Margin—The portion of the crown of a tooth next to the gingival line.

Groove—A furrow or long depression on the surface of a tooth.

Hematoma—A swelling or discoloration, or both, due to an abnormal escape or discharge of blood into the tissues.

Hemostatic—Any agent capable of checking or stopping the flow of blood.

Herbivorous—Herbivorous animals eat principally vegetable matter. Herbivores include the cow, sheep and horse. Their teeth have broad, flat chewing or grinding surfaces.

Heterogeneous—Consisting of or composed of dissimilar ingredients which to the eye are not completely mixed. Not homogeneous. Concrete is an example.

Homogeneous—A mixture of uniform consistency or quality throughout. A true solution is homogeneous.

Hormone—A chemical substance which is produced in an endocrine gland and, when transported to some other organ, produces a specific effect.

Horn, Pulpal—A process of the pulp of a tooth extending toward the point of a cusp.

Hygroscopic—Readily absorbing moisture from the atmosphere.

Hypnotic—Inducing sleep.

Incisal Surface—The cutting edges of the incisors and cuspids are regarded as incisal surfaces, but are commonly called incisal edges.

Inclination—Of a tooth: The deviation of the long axis of a tooth from the perpendicular line; as the mesial inclination of the incisors.

Indigenous—Native to a particular place; growing, produced or living naturally in a certain locality.

Ingest—Ingestion: The act of taking food, medicines, etc., into the body.

Interglobular Space—A space of uncalcified tissue in the dentin. It is principally composed of organic matter.

Interproximal Space—The V-shaped space bounded by the proximal surfaces of adjoining teeth, and the border of the septum of the alveolar process between their necks. Normally this space is filled with gingival tissue.

Labial—Pertaining to the lips. Toward the lips.

Lamellae—The concentric circles surrounding haversian canals.

Laxatives—Mild or gentle cathartics.

Legume—The protein-containing fruit of a leguminous plant such as beans and peas.

Line Angles—Of the teeth: Those angles formed by the junction of two surfaces along a line; as the mesiobuccal angle, distobuccal angle, etc.

Lingual—Next to, or toward the tongue; as lingual surface.

Lobe—A division of a tooth formed from a separate point of the beginning of calcification.

Lobule—A small part of an organ indicated by fissures or divisions.

Lumbar—Pertaining to the back or loins.

Lumen—The opening within a tube.

Lysis—The action of a lysin; The destruction of cells by a specific lysin.

Mammalian—Pertaining to the class of vertebrate animals including all that suckle their young.

Mammelons—The three rounded prominences seen on the cutting edges of the incisors when they first come through the gingival tissue.

Marginal Ridge—The ridges, or elevations of enamel on the margins of the occlusal surface of the bicuspids and molars, and on the mesial and distal margins of the lingual surface of the incisors and cuspids. Or—ridges along the margins of the surface of a tooth.

Median Line—The anteroposterior perpendicular central line of the body.

Mesial—Toward the median line. Those surfaces of the teeth which, as they stand in the arch, follow its curve, and are toward the median line, are called mesial surfaces.

Metabolism—The sum total of all chemical and physical processes by which living substance is produced and maintained.

Metazoan—That division of the animal kingdom, the members of which are characterized by segmentation of the ovum. It includes all animals except the protozoa.

Miscible—Capable of being mixed; mutually soluble.

Morphology—The science of the forms and structure of organized beings, or their parts.

Narcotic—Capable of producing stupor or sleep, with relief of pain.

Necrosis—Death of a circumscribed portion of tissue. Necrotic tissue is dead tissue.

Neuralgia—Pain in a nerve or nerves.

Oblique Ridge—A ridge running obliquely across the occlusal surface of the upper molars. It is formed by the union of the triangular ridge of the disto-buccal cusp with the elongated apex of the mesiolingual cusp.

Occlusal Surface—The horizontal chewing surface of a posterior tooth. That surface of a bicuspid or molar tooth that makes contact with a tooth of the opposite jaw when the mouth is closed.

Ointment—A salve or a fatty, medicated preparation for external use or application.

Omnivorous—Man is called omnivorous because his food comprises both meats and vegetables or herbs and he has incisors for cutting, cuspids for tearing, bicuspids for grasping, and molars for grinding.

Opacity—Quality of being opaque, viz., impervious to light rays.

Osmosis—The diffusion which proceeds through a membrane, especially a semipermeable membrane, separating two typically liquid solutions and which tends to equalize their concentrations by flow of the solvent from less concentrated to more concentrated solution.

Oxidation—The process of combining with oxygen or with more oxygen.

Oxidize—To cause oxidation of any materials.

Parasite—A plant or animal which lives upon or within another living organism without contributing to the benefit of the host.

Periodontoclasia—Any destructive disease of the supporting tissues of a tooth. Pyorrhea, periodontosis, peridentitis, Rigg's disease, and other similar conditions are all forms of periodontoclasia.

Permanent Teeth—The teeth of adult age as distinguished from the temporary, or deciduous teeth.

Physiologic—Pertaining to physiology or the functions of the body and organs.

Pickle, Pickling—To clean a metallic surface of oxidation products and impurities by immersion in acid.

Pit—A sharp pointed depression on the surface of a tooth. Pits occur mostly where several developmental grooves join; as in the occlusal surfaces of the bicuspids and molars, and at the endings of the buccal grooves on the buccal surfaces of the molars.

POINT ANGLES—Of the teeth: Those corners or angles formed by the junction of three surfaces of a tooth at a point; as the distobucco-occlusal point angle.

POLYMERIZATION—The chemical union of great numbers of individual molecules of one or more substances to form a new molecule of a compound of very great molecular weight.

PRECIPITATE—A substance formed and forced into the solid state from a solution while in contact with that solution.

PRESCRIPTION—A written direction for the compounding of and administration of a medicinal agent.

PROPHYLAXIS—Any treatment which tends to prevent disease; such as an oral prophylaxis which tends to prevent gingivitis and peridontoclasia.

PROSTHETICS—Pertaining to the fabrication and insertion of artificial substitutes for lost or missing parts of the body.

PROXIMAL SURFACE—The surface of a tooth which lies next to another tooth.

PTOMAINE—A highly toxic chemical compound resulting from the action of certain bacteria on matter containing nitrogen.

PULP—The soft tissue that fills the pulp chambers and root canals of the teeth.

PUTREFACTION—Decomposition of animal or vegetable material by means of micro-organisms resulting in the production of various solid, liquid and gaseous substances.

QUALITATIVE (qualitive)—Pertaining to the identity of the constituents of a substance.

QUANTITATIVE (quantitive)—Pertaining to the quantity or amounts of various constituents of a substance.

RADICAL—A group of atoms of different elements which act together during a chemical reaction. Thus, in sulfuric acid, H_2SO_4, the SO_4 ion is a radical and acts as an individual during a reaction.

REDUCTION—In chemistry, to obtain a metal from one of its salts; to reduce in positive valence. A reducing compound is one which brings about reduction.

REFRIGERANT—A substance which tends to lower temperature.

REGURGITATION—A backward flowing either of undigested food in the alimentary tract or of blood through the left auriculoventricular opening due to improper closure of the mitral valve. The regurgitation of either food or blood is normally prevented by valves.

RESIDUE—That which remains after the removal of other substances.

RESIN—Amorphous vegetable substances or exudates obtained from plants or trees. Amorphous plastic materials are also called resins, as methacrylate resin.

RIDGE—A long-shaped elevation on the surface of a tooth.

ROOT—That portion of the tooth that is fixed in the bony walls of the alveolus, or socket; and is covered with cementum.

ROOT CANAL—The opening through the center of the long axis of the root of a tooth from the crown to the apex.

RUGAE—A series of irregular ridges in the roof of the mouth.

SACRAL—Pertaining to the sacrum or lower portion of the spine, immediately below the lumbar region.

SEDATIVE—An agent which allays activity or has a soothing effect.

SEGMENTATION—Separation of a mass of amalgam into subdivisions. Also subdivision by natural lines, as in the earthworm.

SEPTUM—(Pl. Septa) A partition: (Dental) That portion of the alveolar process which lies between the roots of the teeth separating their alveoli.

SHOCK—A condition, usually caused by injury, in which there is a failure of the peripheral circulatory system due to derangement of the controlling mechanism or loss of body fluid, including blood.

SIALOGOGUE—A medicine which promotes the secretion and flow of saliva.

SPIRIT—Any volatile or distilled liquid; also a solution of a volatile substance in alcohol.

STAGNATION—The stoppage, or retardation of the flow of any normally circulating fluid. (Dental) The accumulation of matter on a tooth whose antagonist in the other jaw has been removed.

STYPTIC—A drug or pertaining to a drug which tends to arrest hemorrhage by contracting the vessels.

SUCCEDANEOUS TEETH—Those of the permanent teeth which succeed, or take the places of, the deciduous or temporary teeth.

SULCUS—(Pl. Sulci) A groove, trench or furrow in the surface of a tooth, the inclines of which meet at an angle. A sulcus has a developmental groove as its bottom.

SUPPLEMENTAL GROOVE—A long, shallow furrow in the surface of a tooth, generally with a smooth rounded bottom, which does not mark the junction of lobes.

SUPPURATION—Development of pus.

SWAGE—To shape metal by using a swage or die. Also: a tool used to shape metal by pressure.

SYNCOPE—Fainting.

THERAPY—Treatment of disease.

THIRDS—Divisions of a crown of a tooth; as to length, into occlusal or incisal third, middle third, and distal third.

TINCTURE—An alcoholic solution of a drug or medicinal substance.

TOPICAL—Local or restricted.

TRANSLUCENT—Permitting the passage of some (not all) light rays.

TRANSVERSE RIDGE—A ridge formed of two triangular ridges which join to form a continuous ridge across the occlusal surface of a tooth.

TRAUMA—An injury or wound.

TRIANGULAR RIDGE—A ridge running from the point of a cusp toward the central portion of the occlusal surface of a tooth.

TRITURATION—The process of producing a plastic amalgam suitable for filling by rubbing alloy and mercury together in a mortar or other device.

TUBERCLE—A slight, rounded elevation on the surface of a tooth which serves no useful purpose. Tubercles occur frequently on the linguogingival ridge of the incisors.
TURBID—Cloudy in appearance, possessing turbidity.

VEHICLE—A substance added to a drug to give it desired consistency or form.
VISCERAL—Pertaining to a large organ in one of the three great cavities of the body or to the region containing such an organ.

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