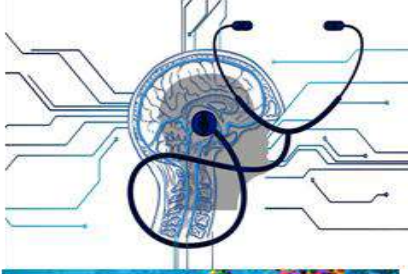
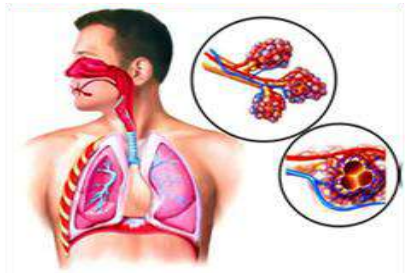
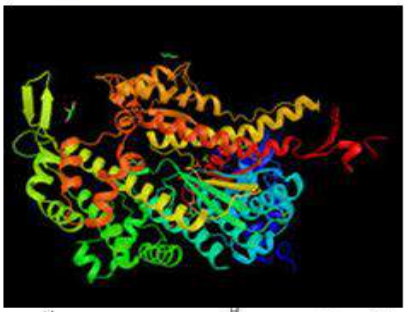
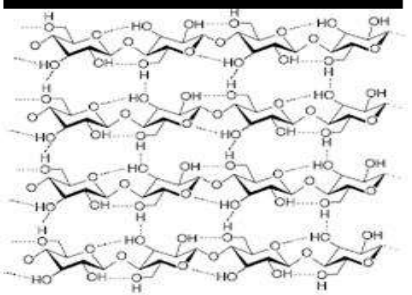


UNIVERSIDADE ESTADUAL DE RORAIMA

CURSO DE MEDICINA

Disciplina: Bioquímica

MÓDULO 1: Biomoléculas

AULA 5

CARBOIDRATOS: ESTRUTURA E FUNÇÕES

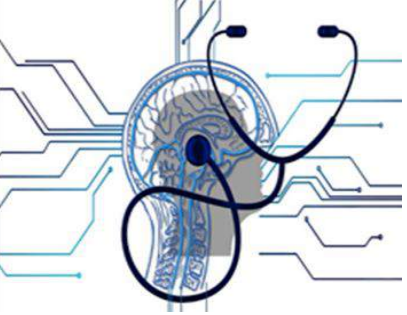
Prof. Higo Nasser S. Moreira

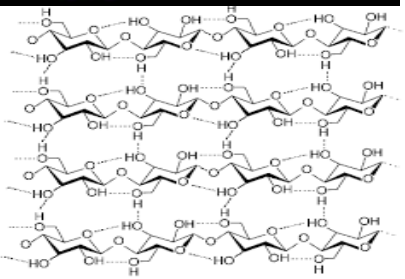
Doctor Scientiae em Bioquímica Aplicada

Universidade Federal de Viçosa – Brasil

Docente do Curso de Medicina da Universidade Estadual de Roraima

Boa Vista – Roraima





VISÃO GERAL SOBRE AS BIOMOLÉCULAS E O METABOLISMO

BIOQUÍMICA é o ramo da ciência que estuda a química das biomoléculas e suas reações nos sistemas biológicos e nos seres vivos.

BIOQUÍMICA

ESTRUTURA

REAÇÕES

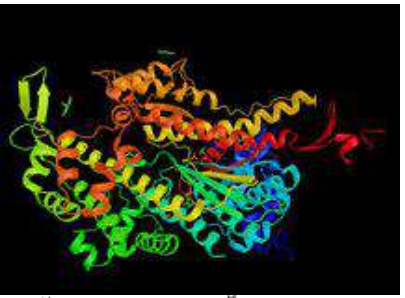
BIOMOLÉCULAS/ BIOPOLÍMEROS

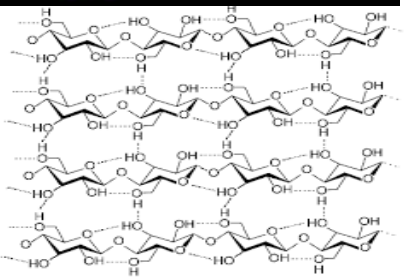
- **Proteínas**
- **Ácidos nucléicos**
- **Lipídeos**
- **Carboidratos**

METABOLISMO

CATABOLISMO → **Produção de energia (+ATP)**

ANABOLISMO → **Síntese de biomoléculas (-ATP)**





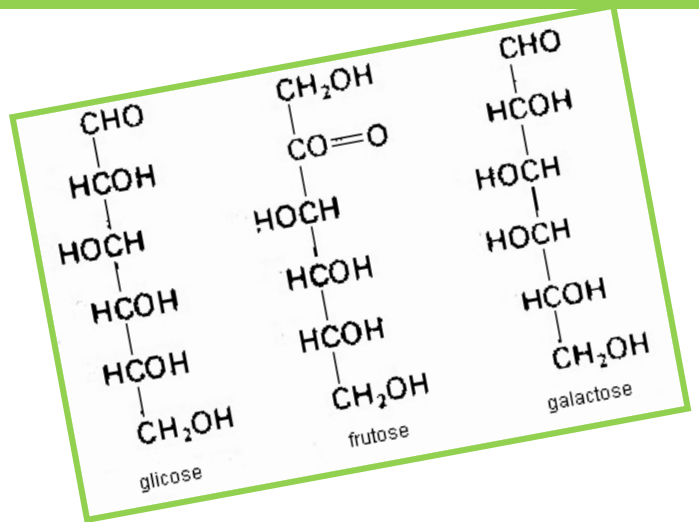
- ✓ **Carboidratos, açúcares, sacarídeos ou glicídios;**
- ✓ **Biomoléculas mais abundantes na natureza;**

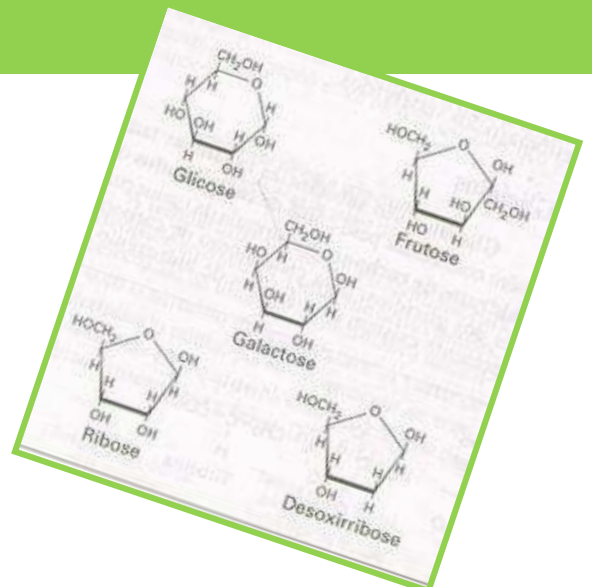
CONCEITO

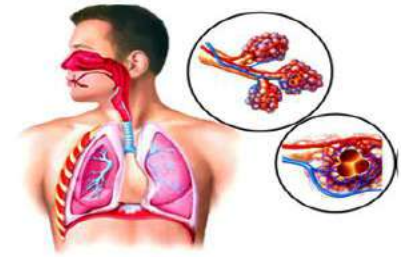
- ➢ **Aldeídos ou cetonas poliidroxilados;**
- ➢ **No geral, possuem a relação**

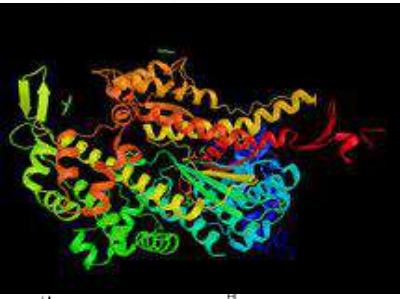
C:H:O de 1:2:1 = $(CH_2O)_n$;

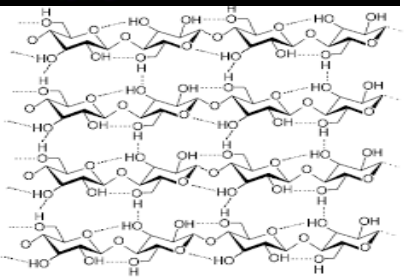
Ex.: Glicose = $C_6H_{12}O_6$ ou $(CH_2O)_6$





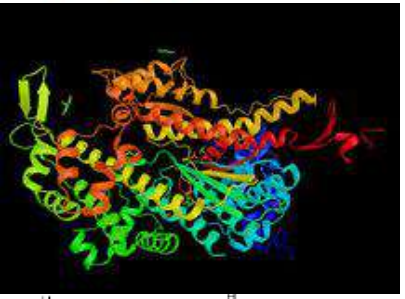


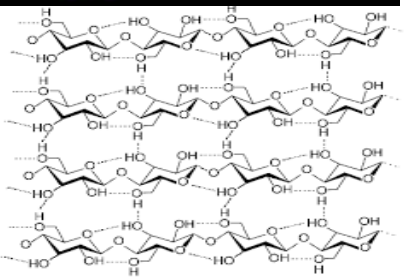




FUNÇÕES

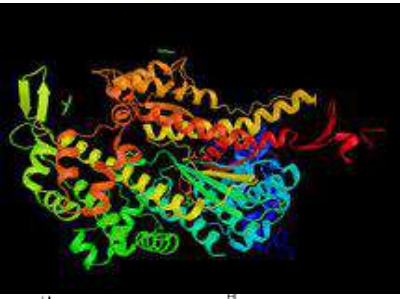
- ✓ **Energética;**
- ✓ **Armazenamento (amido, glicogênio);**
- ✓ **Estrutural e proteção (celulose, pectina, quitina, peptídeoglicano);**
- ✓ **Reconhecimento celular (glicolipídeos ou glicoproteínas);**
- ✓ **Outras: difusão de nutrientes e lubrificação de articulações, anticoagulante (heparina).**

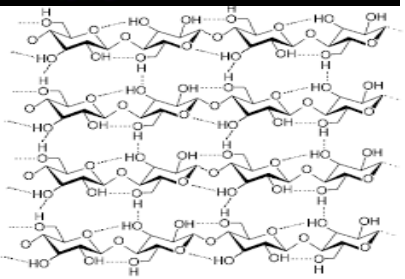




TRÊS CLASSES PRINCIPAIS

- ✓ **Monossacarídeos - poliidroxialdeído ou cetona**
- ✓ **Oligossacarídeos - cadeias curtas de unidades de monossacarídeos (2 a 10 mono)**
- ✓ **Polissacarídeos - centenas ou milhares de unidades de monossacarídeos (>10)**





1. **MONOSSACARÍDEOS: Carboidratos com uma só unidade de poliidroxialdeído ou – cetona**

✓ **CLASSIFICAÇÃO DOS MONOSSACARÍDEOS:**

a) DE ACORDO COM A POSIÇÃO DA CARBONILA:

- **ALDOSES: na extremidade da cadeia (ex.: gliceraldeído);**
- **CETOSES: no interior da cadeia (ex.: diidroxicetona).**

b) DE ACORDO COM O NÚMERO DE ÁTOMOS DE CARBONO:

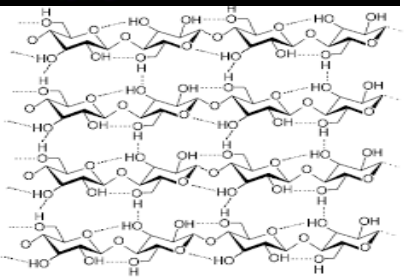
3C – TRIOSES (aldotriose ou cetotriose);

4C – TETROSE (aldotetrose ou cetotetrose);

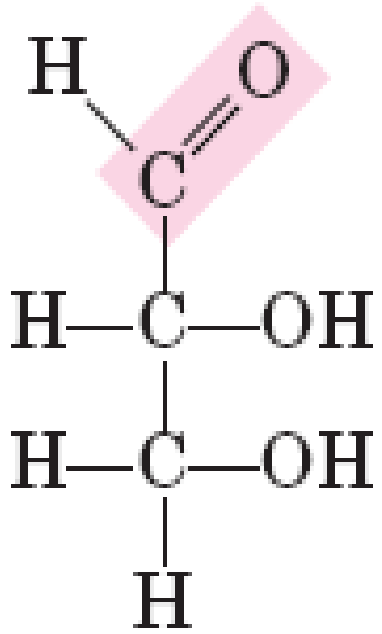
5C – PENTOSE (aldo ou cetopentose);

6C – HEXOSE (aldo ou cetoexose);

7C – HEPTOSE (aldo ou cetoheptose).

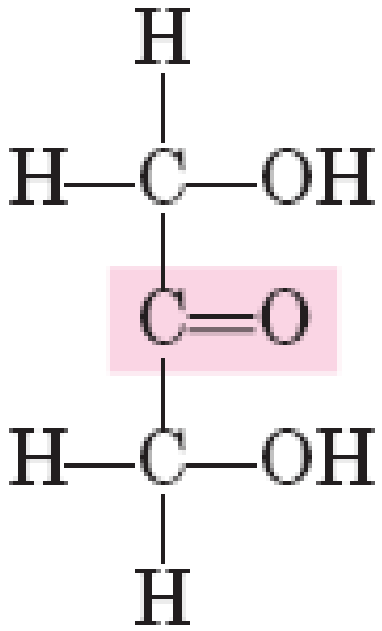


TRIOSES: MONOSSACARÍDEOS COM 3 ÁTOMOS DE CARBONO



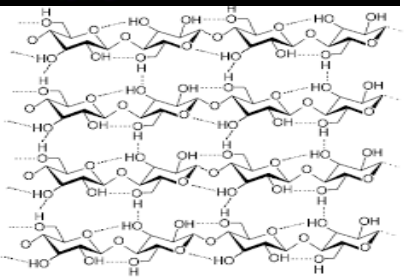
D-Gliceraldeído

(aldotriose)

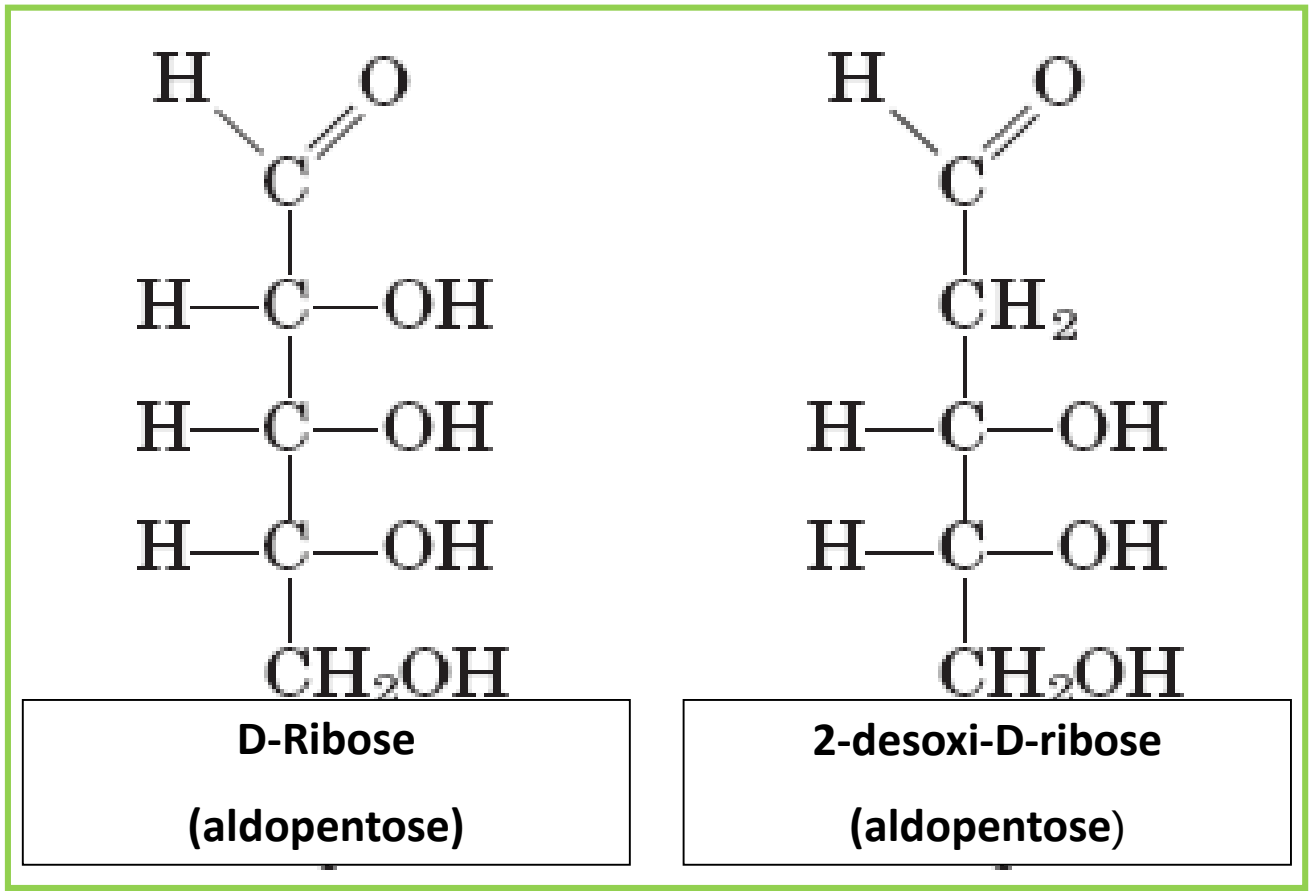


Diidroxiacetona

(cetotriose)



PENTOSES: MONOSSACARÍDEOS COM 5 ÁTOMOS CARBONOS. COMPONENTES DOS ÁCIDOS NUCLÉICOS:

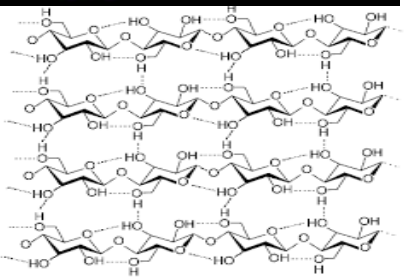


D-Ribose

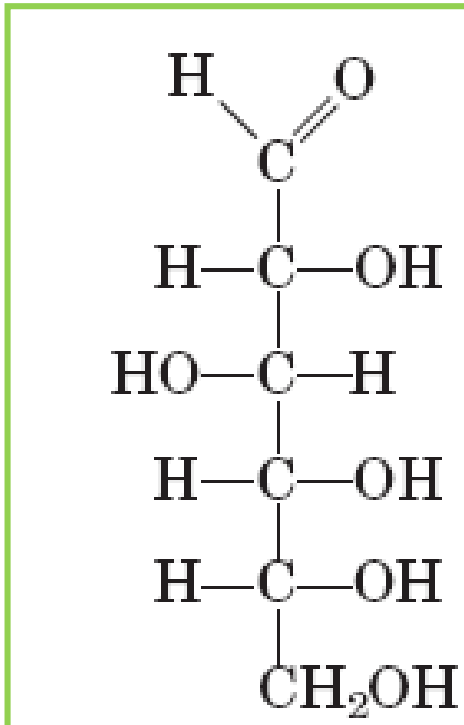
(aldopentose)

2-desoxi-D-ribose

(aldopentose)

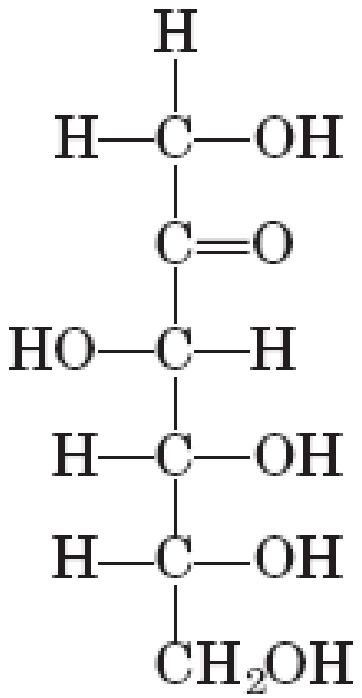


HEXOSES: MONOSSACARÍDEOS COM 6 ÁTOMOS CARBONOS. PRINCIPAL FONTE DE CARBONO/ENERGIA DOS SERES VIVOS



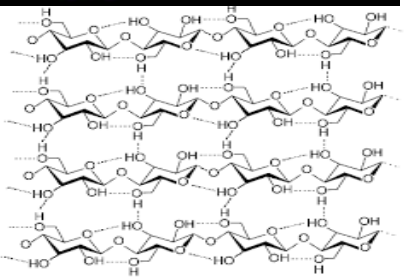
D-Glicose

(aldohexose)



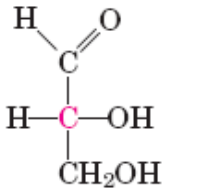
D-Frutose

(cetohexose)



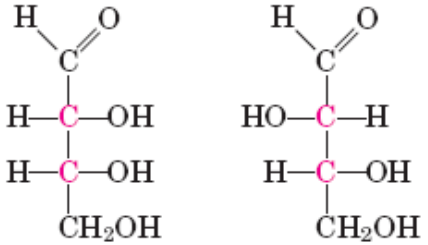
FAMÍLIA DAS ALDOSES

Três carbonos



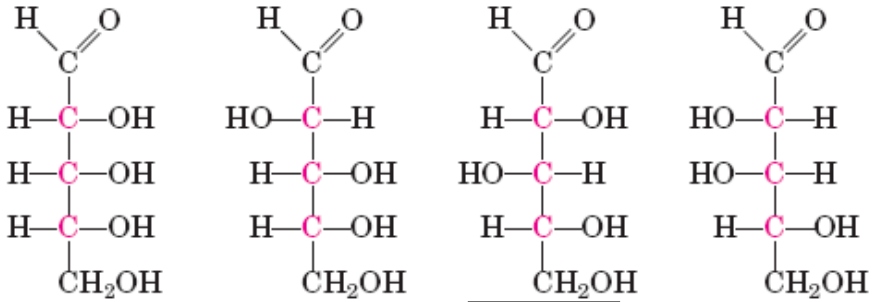
D-Gliceraldeído

Quatro carbonos



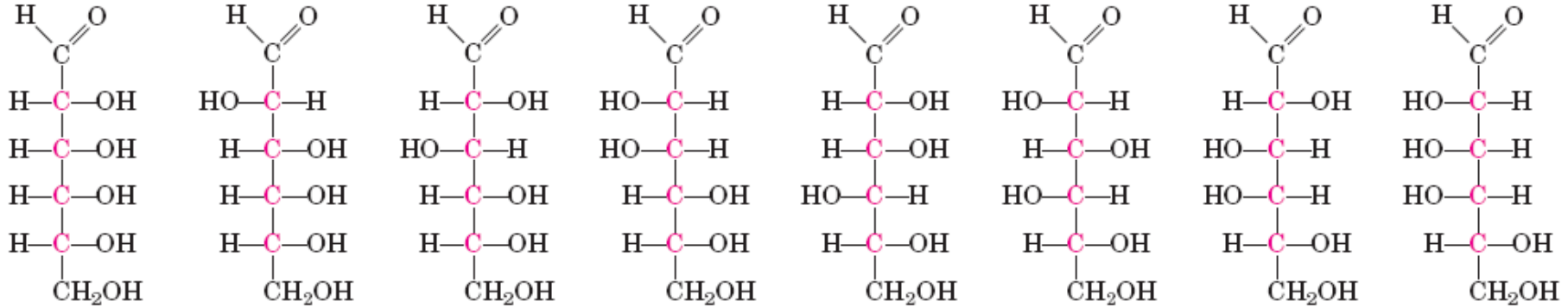
D-Eritrose D-Treose

Cinco carbonos



D-Ribose D-Arabinose D-Xilose D-Lixose

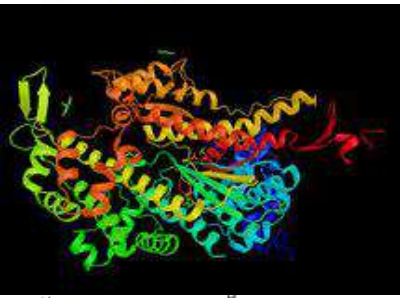
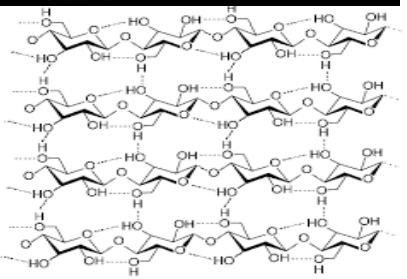
Seis carbonos



D-Allose D-Altrose D-Glicose D-Mannose D-Gulose D-Idose D-Galactose D-Talose

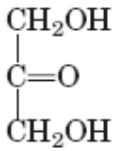
D-Aldoses



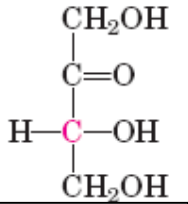
FAMÍLIA DAS CETOSES

Três carbonos



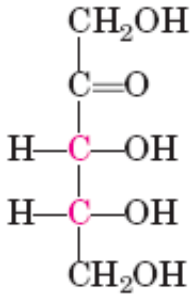
Diidroxiacetona

Quatro carbonos

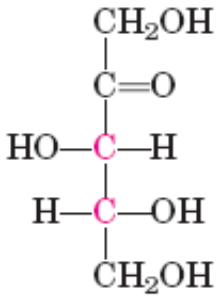


D-Eritrulose

Cinco carbonos

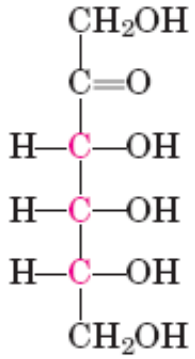


D-Ribulose

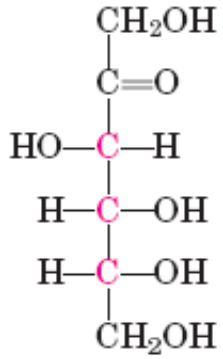


D-Xylulose

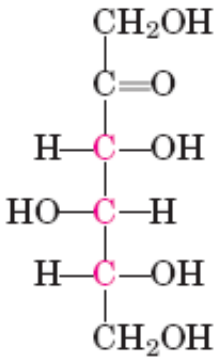
Seis carbonos



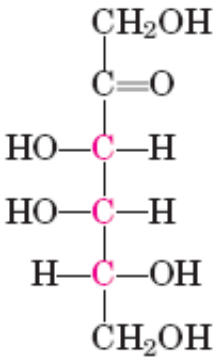
D-Psicose



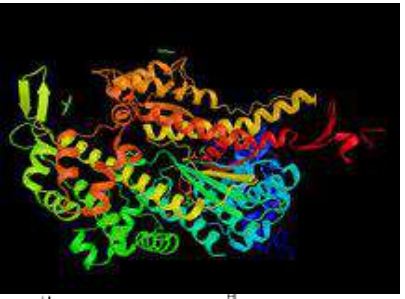
D-Frutose

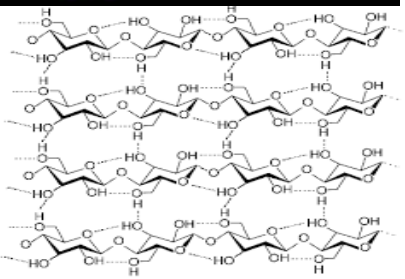


D-Sorbose

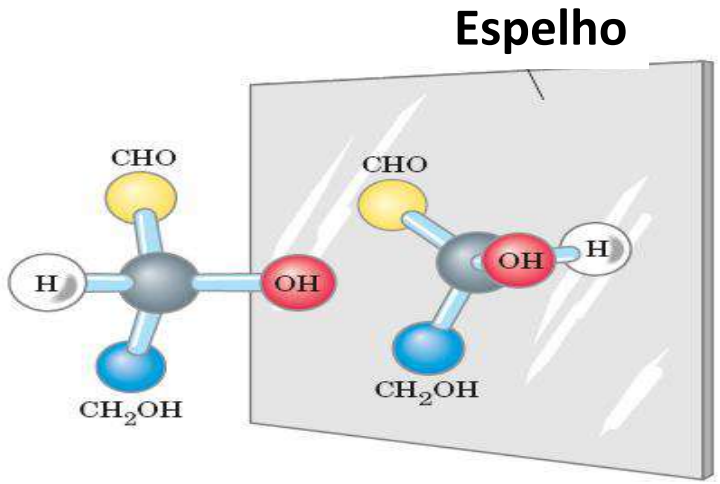


D-Tagatose



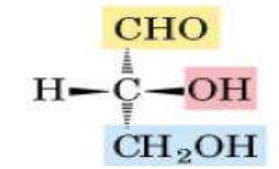


ESTEREOISÔMEROS: Compostos com mesma composição e mesma ordem de conexão de átomos, mas com arranjos moleculares diferentes

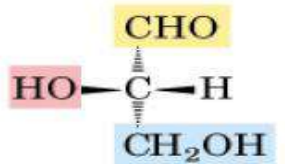


D-Gliceraldeído **L-Gliceraldeído**

Modelo tipo bola bastão



D-Gliceraldeído



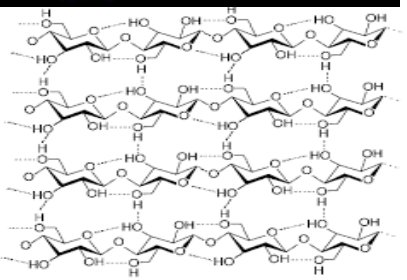
L-Gliceraldeído

Fórmulas de projeção de Fischer

Carbono quiral ou centro quiral (C*)

Quatro ligantes diferentes (carbono assimétrico)

2^n estereoisômeros (n=nº centro quirais ou nº C*)



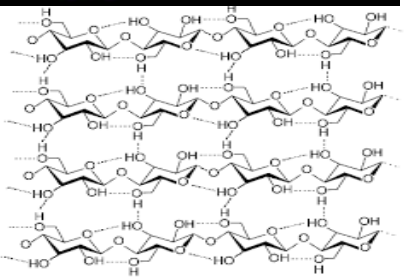
NO TOCANTE AO CARBONO QUIRAL, OS MONOSSACARÍDEOS SE APRESENTAM EM 2 GRUPOS

1) **Mesma configuração do C* do D-Gliceraldeido: Isômeros D**
2) **Mesma configuração do C* do L-Gliceraldeido: Isômeros L**

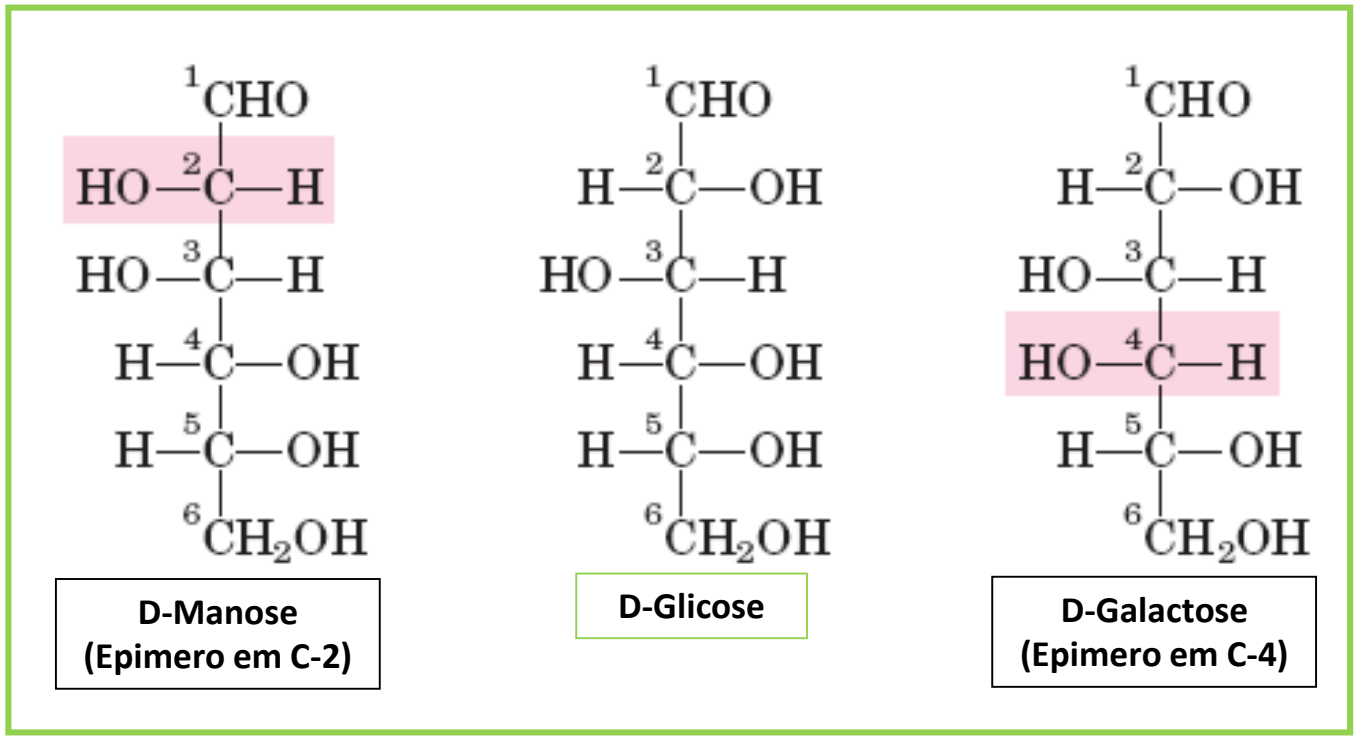
<u>A MAIORIA DOS ORGANISMOS VIVOS = FORMA D</u>

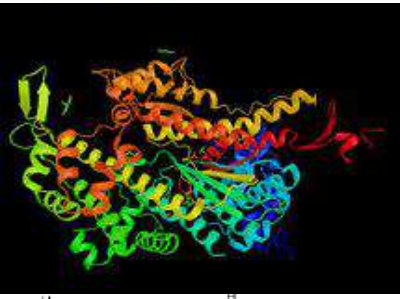
DETERMINAÇÃO DA FORMA QUIRAL (D ou L):

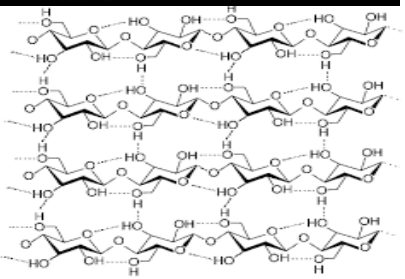
- ✓ **A configuração do C assimétrico mais distante da carbonila**

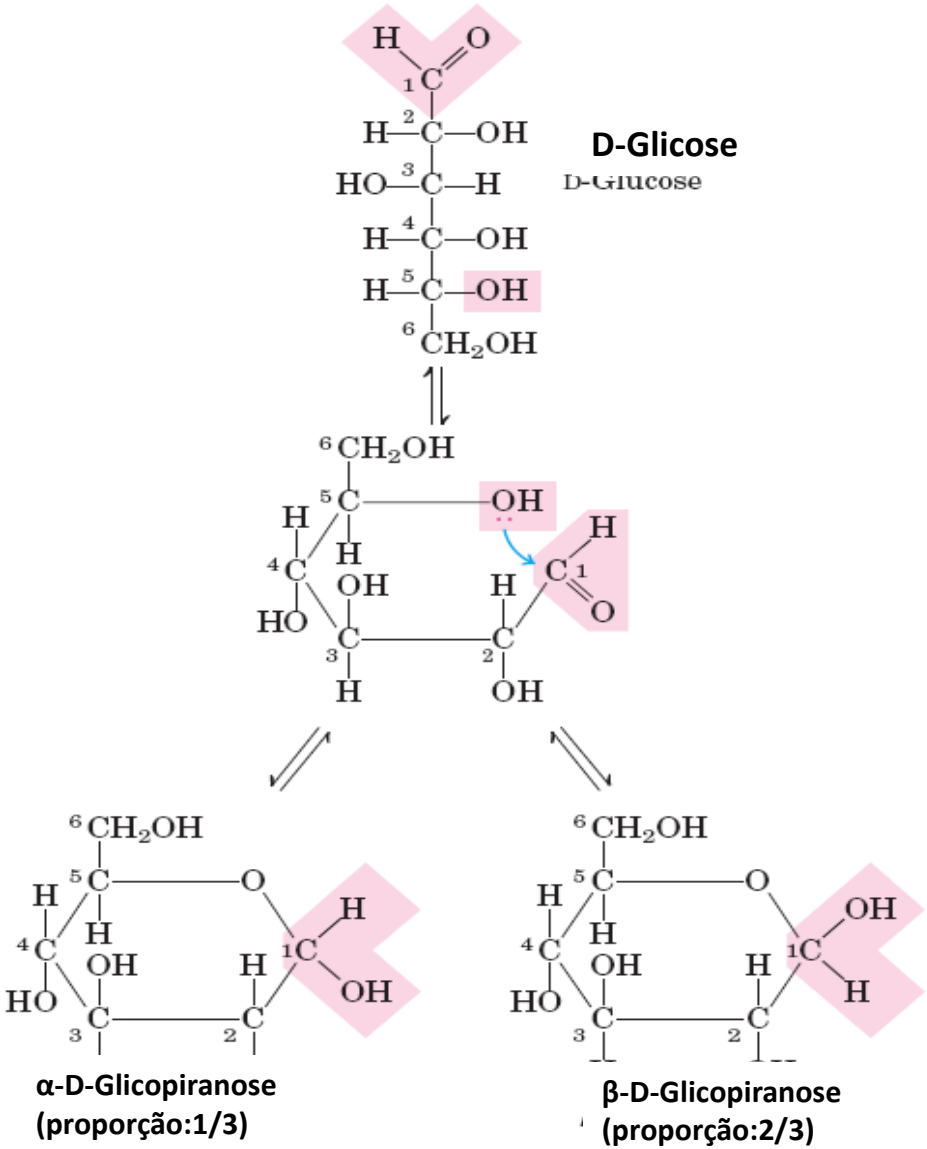


EPÍMEROS: SÃO MONOSSACARÍDEOS (QUE POSSUEM MESMO NÚMERO DE CARBONOS) MAS QUE DIFEREM EM APENAS 1 CARBONO ASSIMÉTRICO.







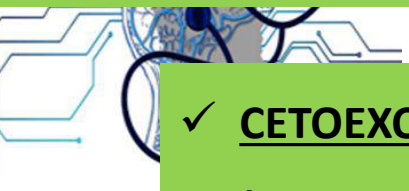


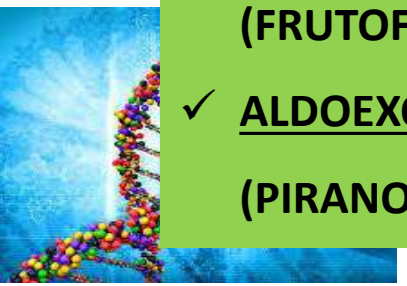
Anômeros

CICLIZAÇÃO DA D-GLICOSE
Mutarrotação: anômeros α e β

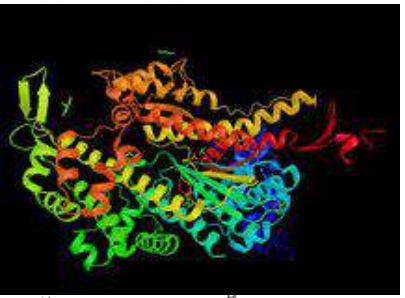
- ✓ **Quase sempre os monossacarídeos se apresentam na forma cíclica.**
- ✓ **A forma cíclica pode se apresentar de 2 formas distintas, dependendo da configuração do carbono da carbonila (anomérico)**
- ✓ **As diferentes formas formam os anômeros α e β**

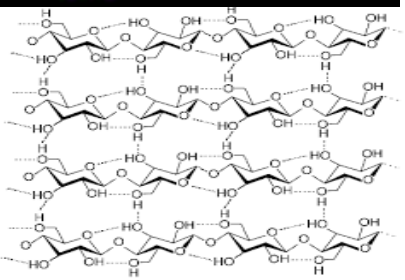
FORMAS PIRANOSÍDICAS (GLICOSE) E FURANOSÍDICAS (FRUTOSE)

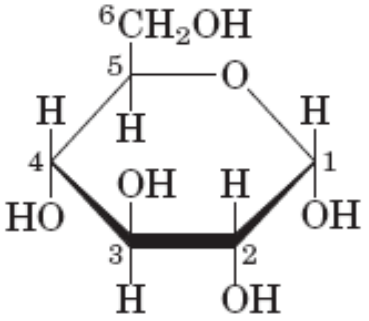




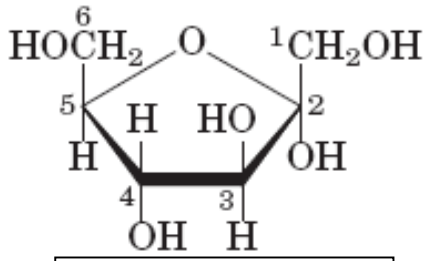
- ✓ **<u>CETOEXOSES</u> forma anéis de 5 membros (FRUTOFURANOSE)**
- ✓ **<u>ALDOEXOSES</u> formam anéis de 6 membros (PIRANOSE)**



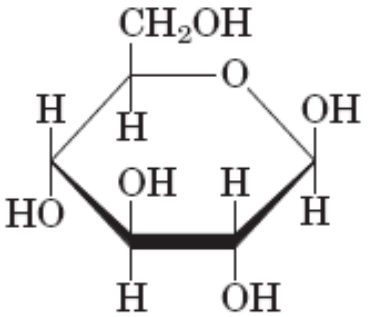




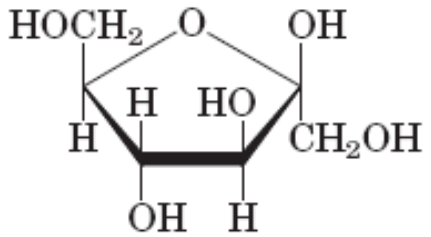
α-D-Glicopiranose



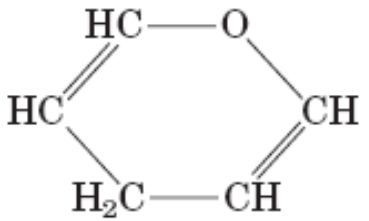
α-D-Frutofuranose



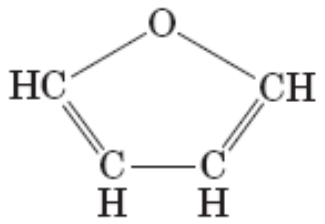
β-D-Glicopiranose



β-D-Frutofuranose

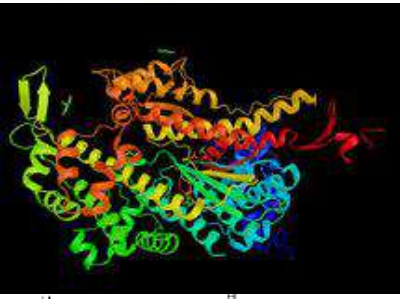


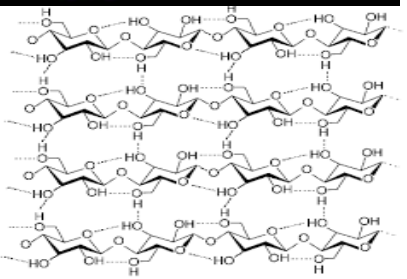
Pirano



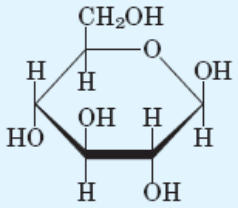
Furano

GLICOCONJUGADOS DERIVADOS DOS MONOSSACARÍDEOS

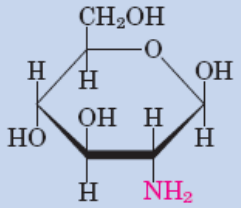




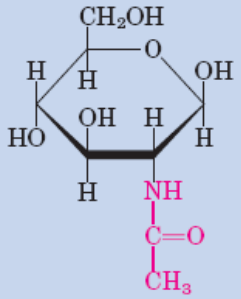
Família Glicose



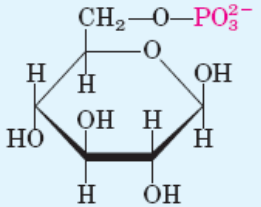
β-D-Glucose



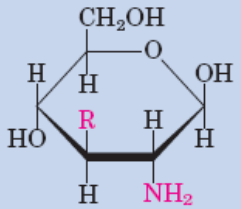
β-D-Glucosamine



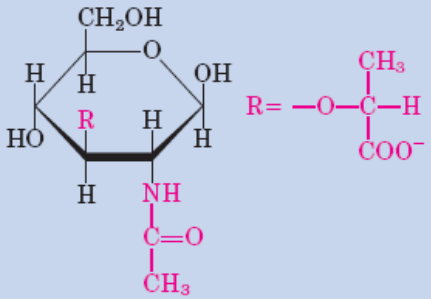
N-Acetyl-β-D-glucosamine



β-D-Glucose 6-phosphate

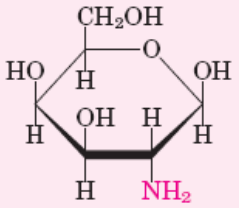


Muramic acid

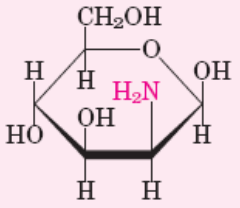


N-Acetylmuramic acid

Amino acúcares

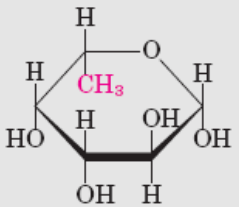


β-D-Galactosamine

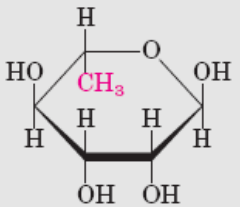


β-D-Mannosamine

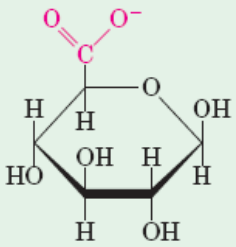
Deoxi açúcares



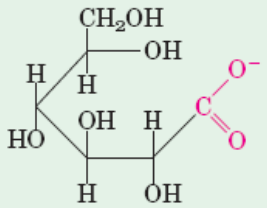
β-L-Fucose



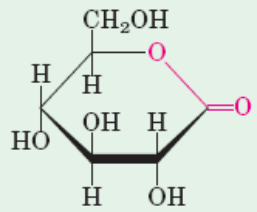
α-L-Rhamnose



β-D-Glucuronate

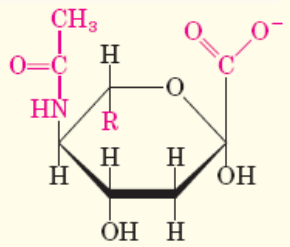


D-Gluconate

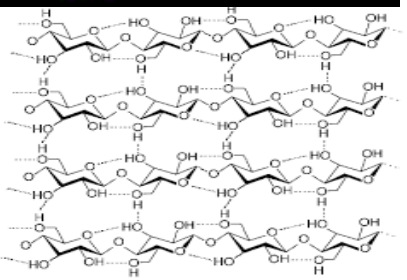


D-Glucono-δ-lactone

Açúcares ácidos



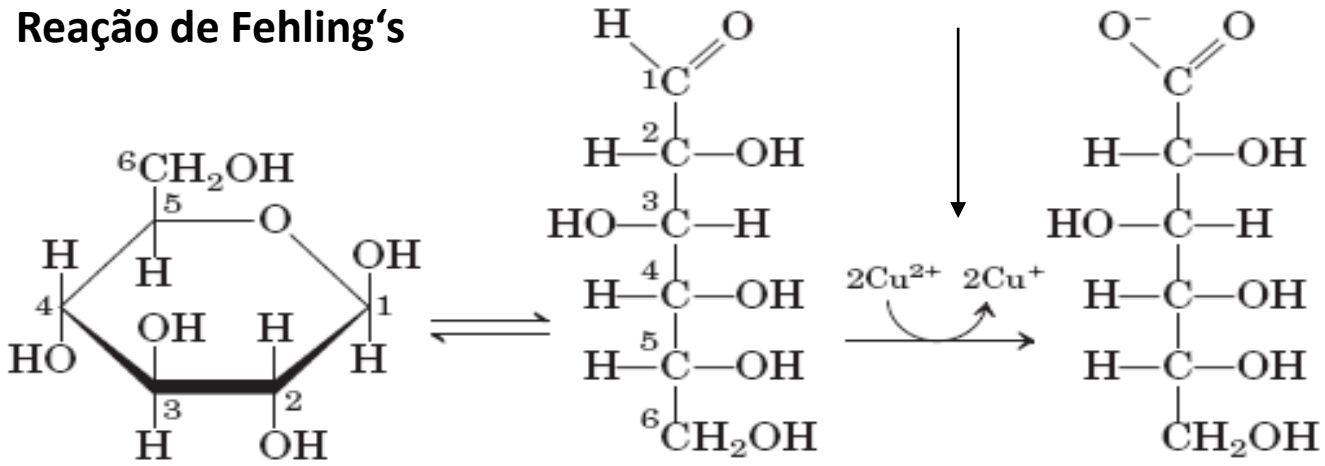
N-Acetylneuraminic acid
(a sialic acid)



ALDOSES E CARBOIDRATOS QUE APRESENTAM CARBONO ANOMÉRICO LIVRE PODEM SOFRER OXIDAÇÃO

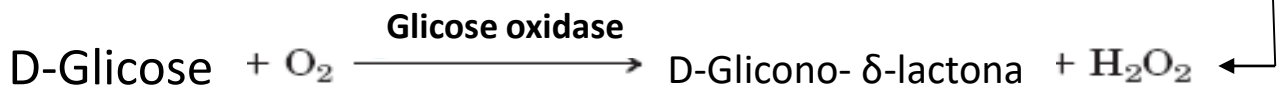
Reação de Fehling's

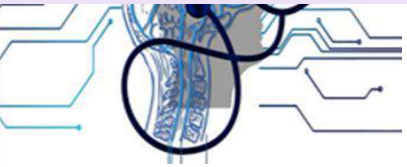
Forma óxido cuproso (precipitado vermelho)

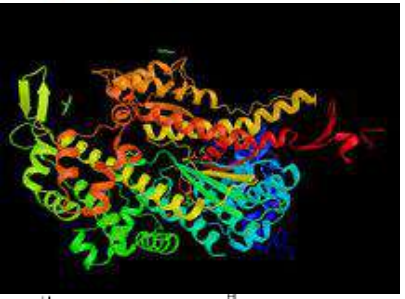


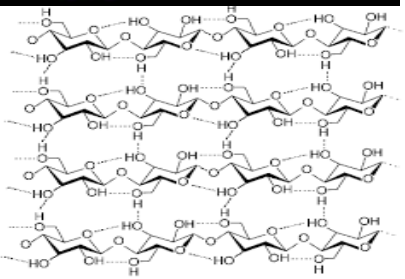
α-D-Glicose ⇌ **D-Glicose** (forma linear) → **D-Gliconato**

Peroxidase



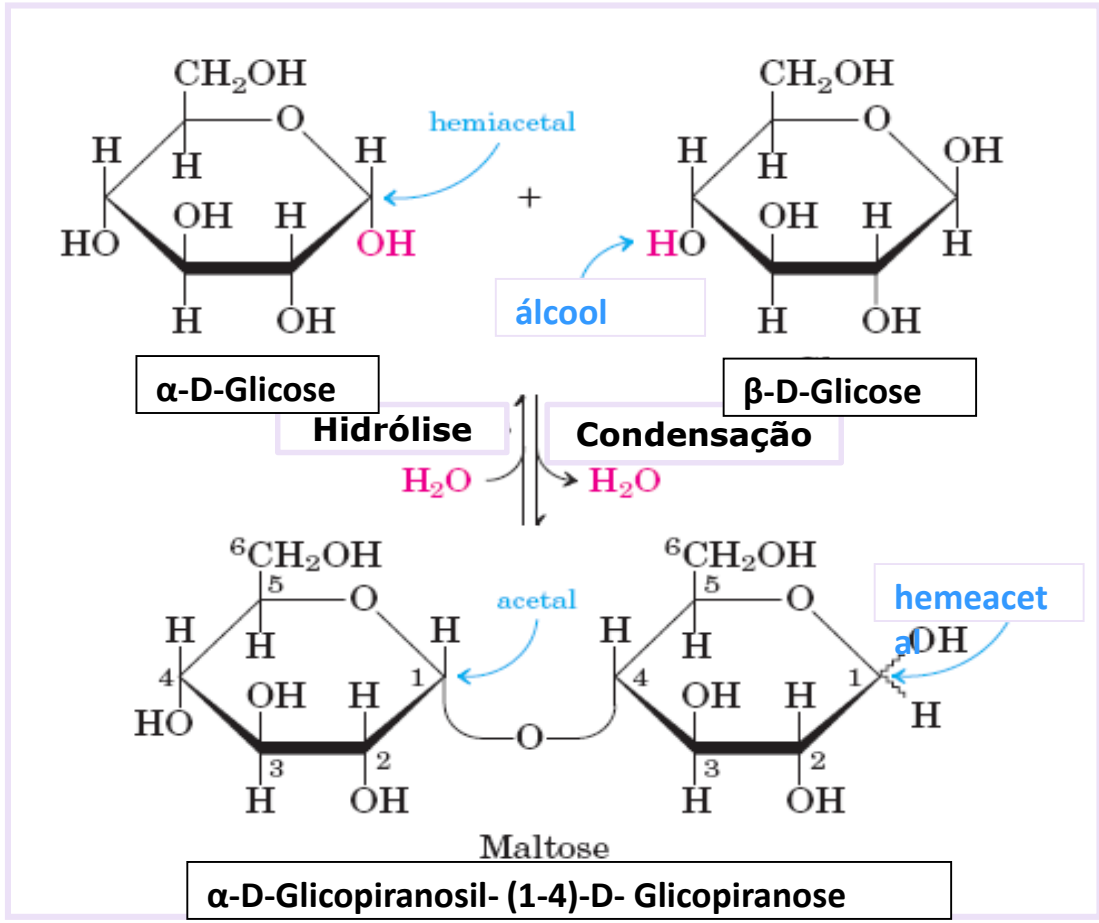


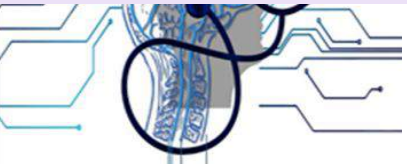


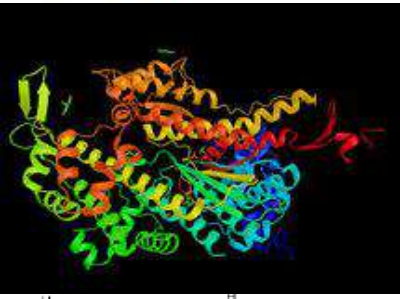


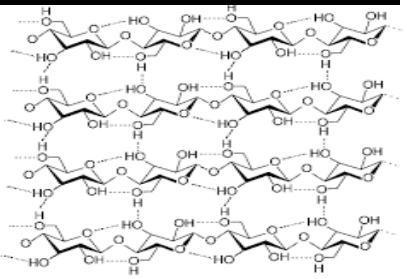
OLIGOSSACARÍDEOS São formados pela ligação glicosídica entre 2 até 10 monossacarídeos.

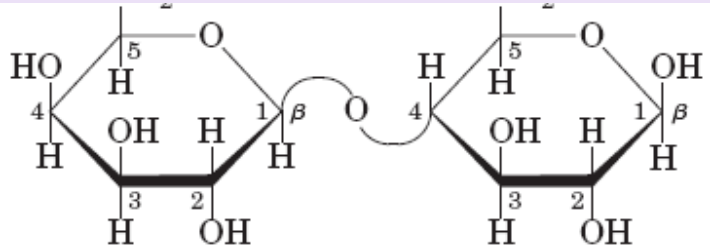
Formação da MALTOSE à partir de 2 moléculas de D-glicose







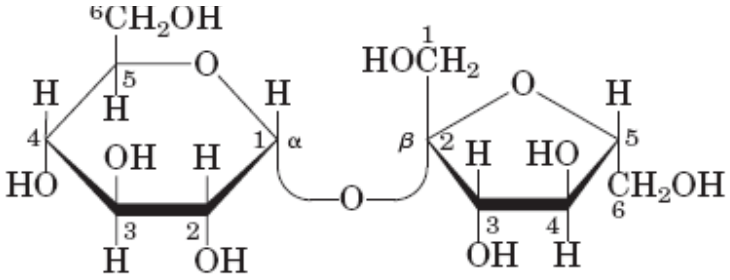




Lactose (forma β)
β-D-galactopiranosil-(1→4)-β-D-glicopiranose
Gal(β1→4)Glc

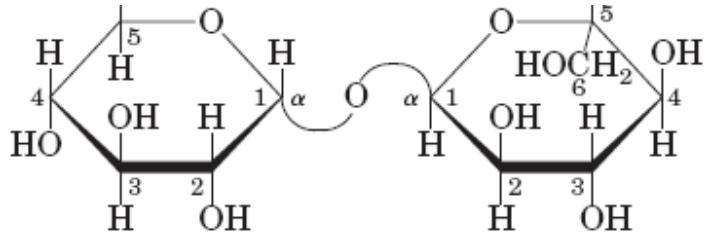
Redutor

DISSACARÍDEOS:
Oligosscarídeos formados pela união de 2 monossacarídeos



Sacarose
α-D-Glicopiranosil-(1→2) β -D-frutofuranosideo
Glc(α1-2 β)Fru

Não redutor



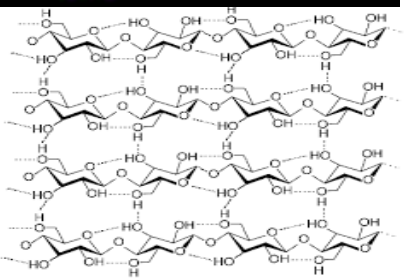
Trealose
α-D-Glicopiranosil-(1→1)α –D-glicopiranosideo
Glc(α1--1α)Glc

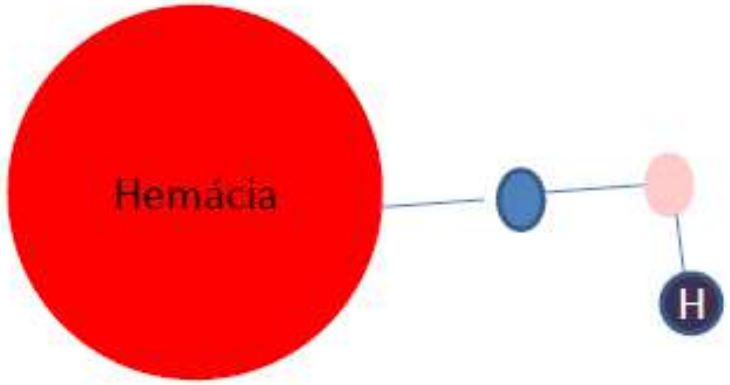
Não redutor

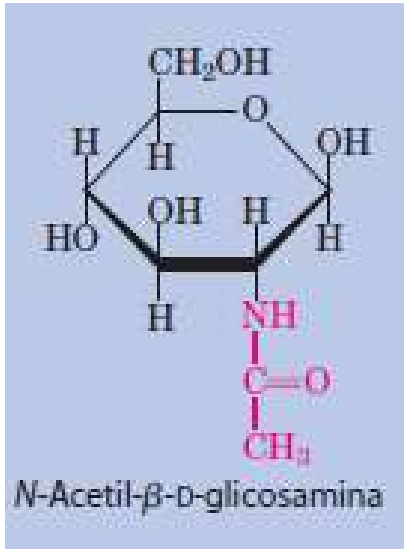
SISTEMA ABO: PADRÕES DE GLICOSILAÇÃO DE PROTEÍNAS DE MEMBRANA DE ERITROBLASTO

Antígeno H: Membrana dos eritrócitos

- ✓ **Efeito Bombain: Individuo portador do antígeno H apenas.**
- ✓ **Só pode receber transfusões sanguíneas de outro indivíduo que apresenta a mesma condição**





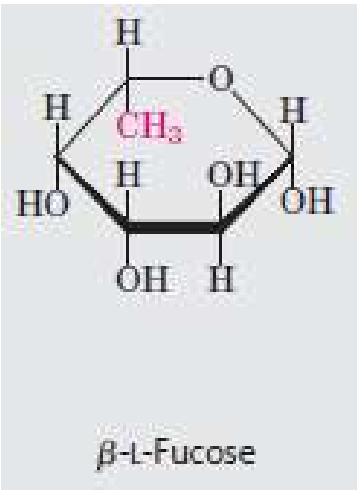


N-Acetil-β-D-glicosamina

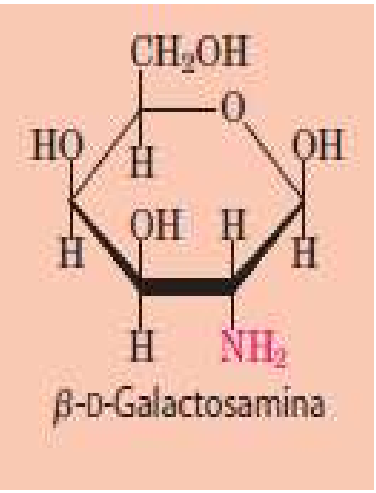
N-acetil glucosamina

D- galactose

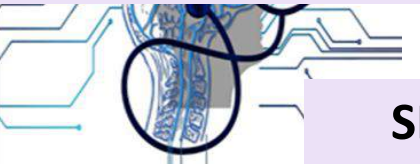
L- Fucose



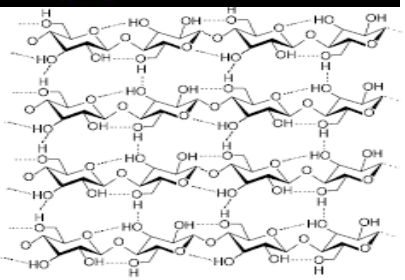
β-L-Fucose



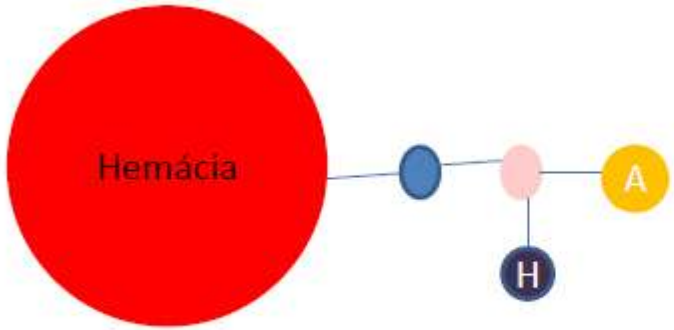
β-D-Galactosamina



SISTEMA ABO: PADRÕES DE GLICOSILAÇÃO DE PROTEÍNAS DE MEMBRANA DE ERITROBLASTO

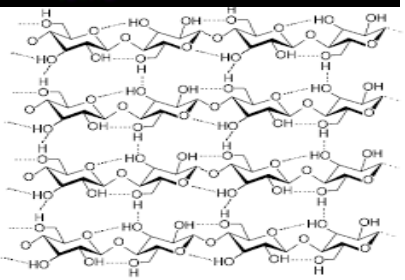


Grupo A

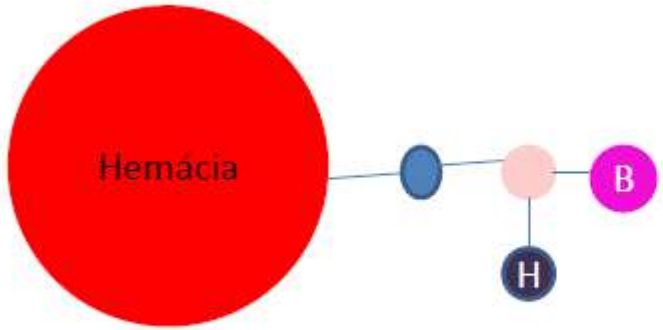


GENE A. Codifica a enzima N-acetilgalactosaminiltranferase que coloca o açúcar N-acetil galactosamina ao antígeno H expresso na membrana do eritrócito, formando o antígeno A

SISTEMA ABO: PADRÕES DE GLICOSILAÇÃO DE PROTEÍNAS DE MEMBRANA DE ERITROBLASTO

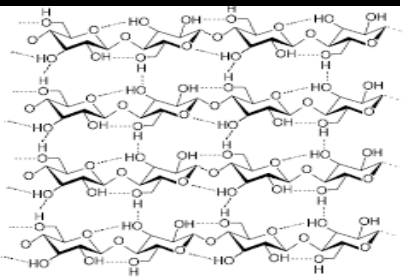


Grupo B

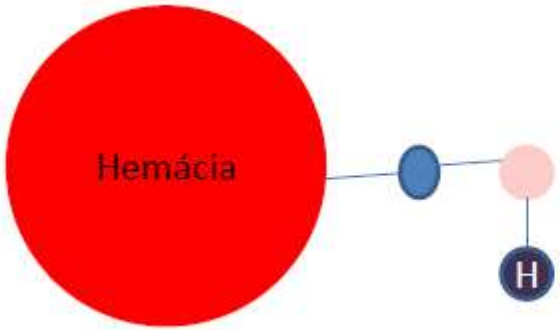


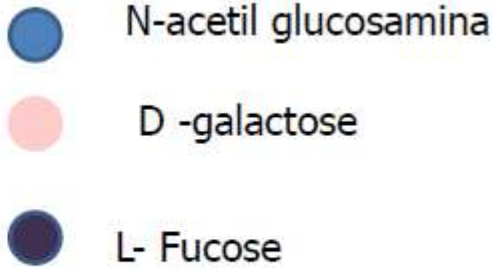
GENE B. Expressa a enzima galactosiltransferase que coloca o açúcar galactose ao antígeno H, produzindo o antígeno B

SISTEMA ABO: PADRÕES DE GLICOSILAÇÃO DE PROTEÍNAS DE MEMBRANA DE ERITROBLASTO

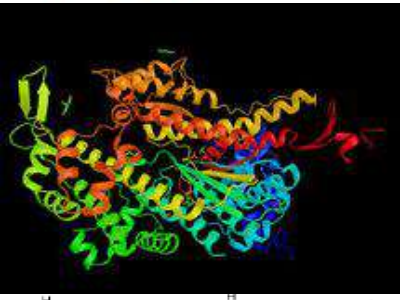


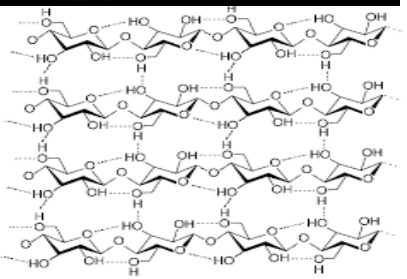
Grupo O



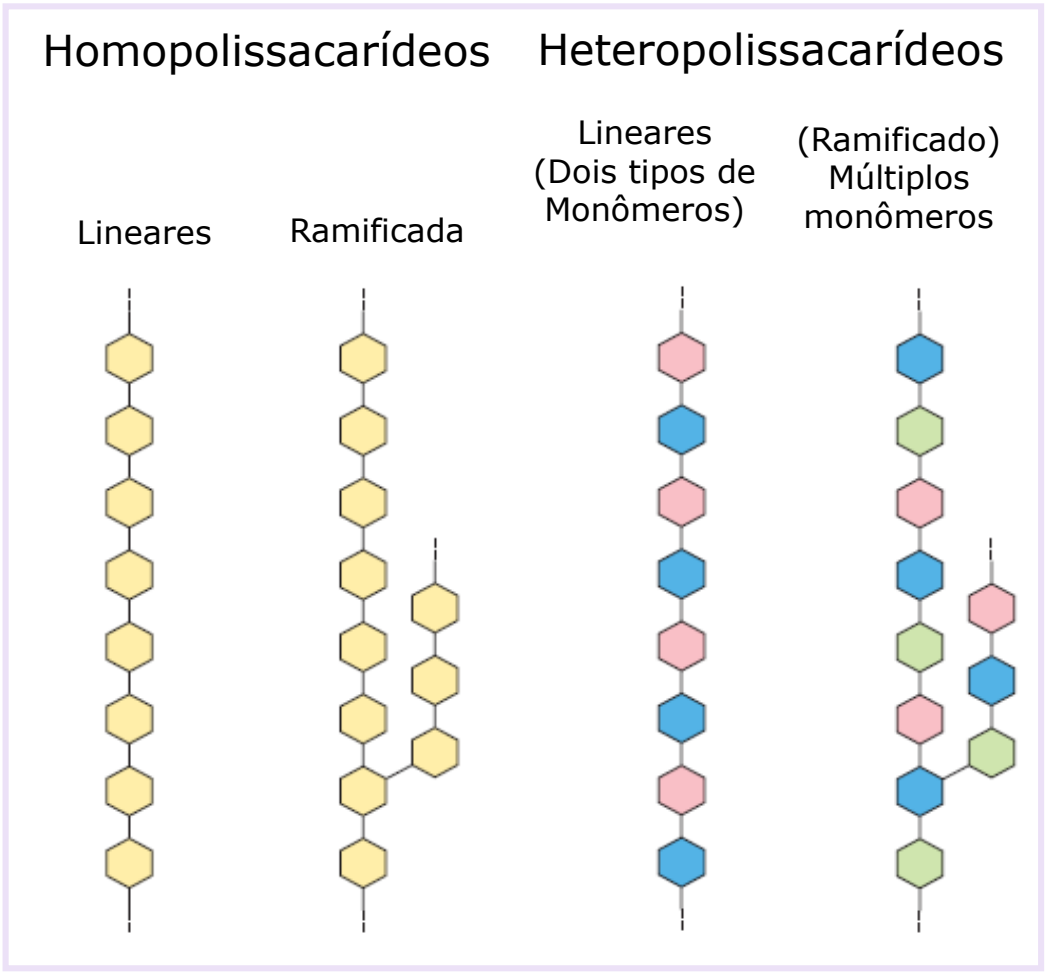


GENE O: Produz uma enzima afuncional que não coloca nenhum açúcar no antígeno H

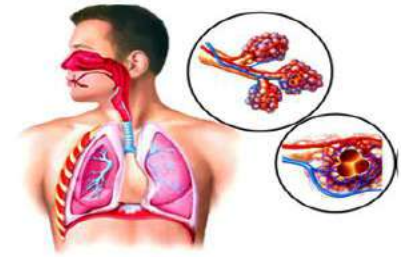


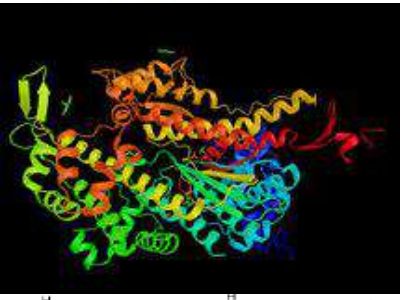


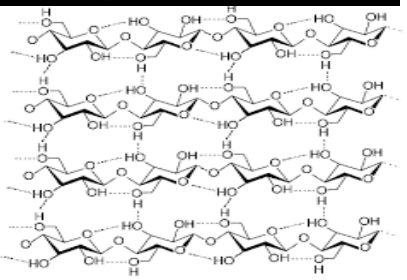
SÃO FORMADOS PELA UNIÃO DE VÁRIOS MONOSSACARÍDEOS (MAIS DE 300 UNIDADES) ATRAVÉS DA LIGAÇÃO GLICOSÍDICA.



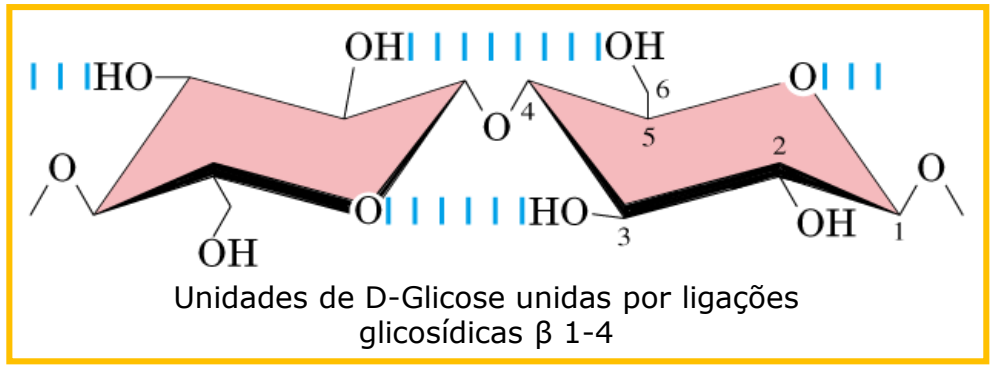
3-POLISSACARÍDEOS
Celulose



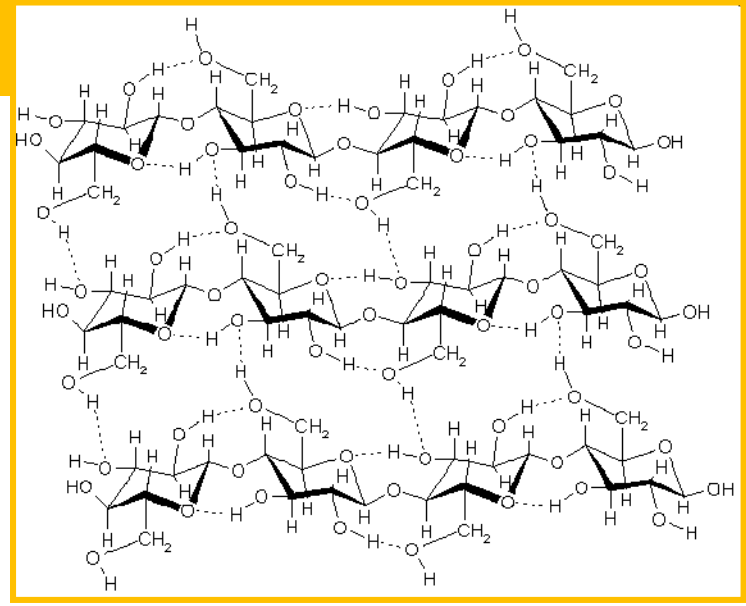


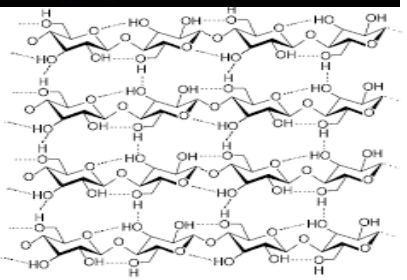


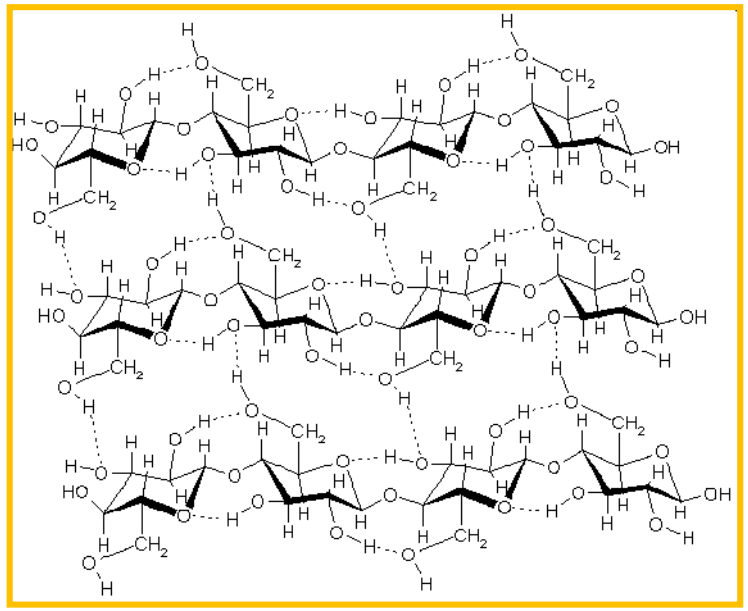
- ✓ **Polissacarídeo mais abundante na natureza;**
- ✓ **fibrosa, resistente e insolúvel em H_2O;**
- ✓ **Função estrutural nos vegetais (parede celular);**
- ✓ **Fonte de energia para microrganismos e animais (cupins, térmitas, ruminantes) que apresentam no trato digestivo de microrganismos que secretam a enzima celulase a qual hidrolisa as ligações β(1→4);**
- ✓ **Ligações β(1→4).**



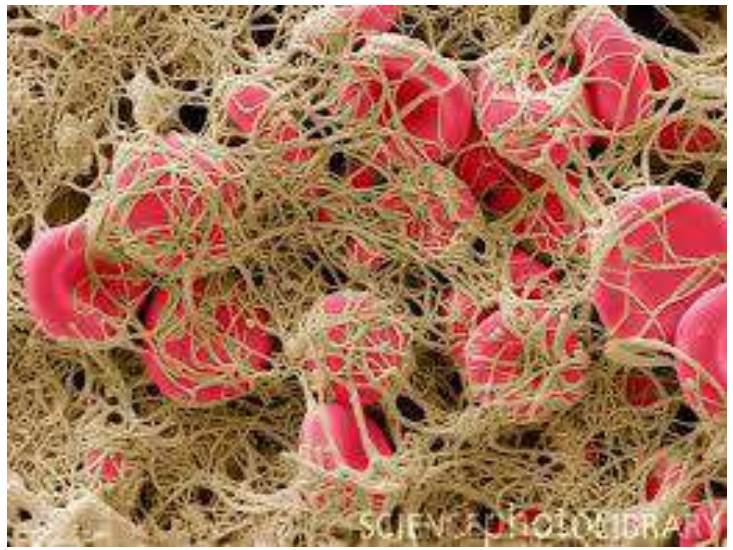
Unidades de D-Glicose unidas por ligações glicosídicas β 1-4





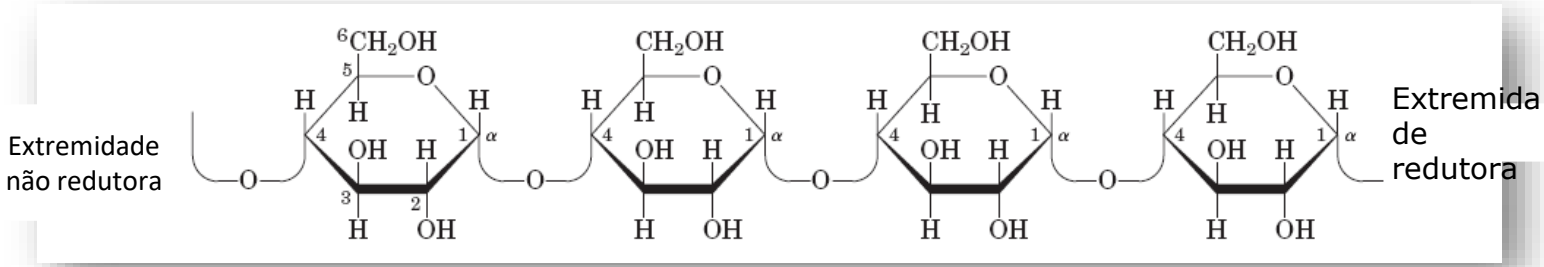


APLICAÇÕES BIOTECNOLÓGICAS NA MEDICINA:
Biocurativo

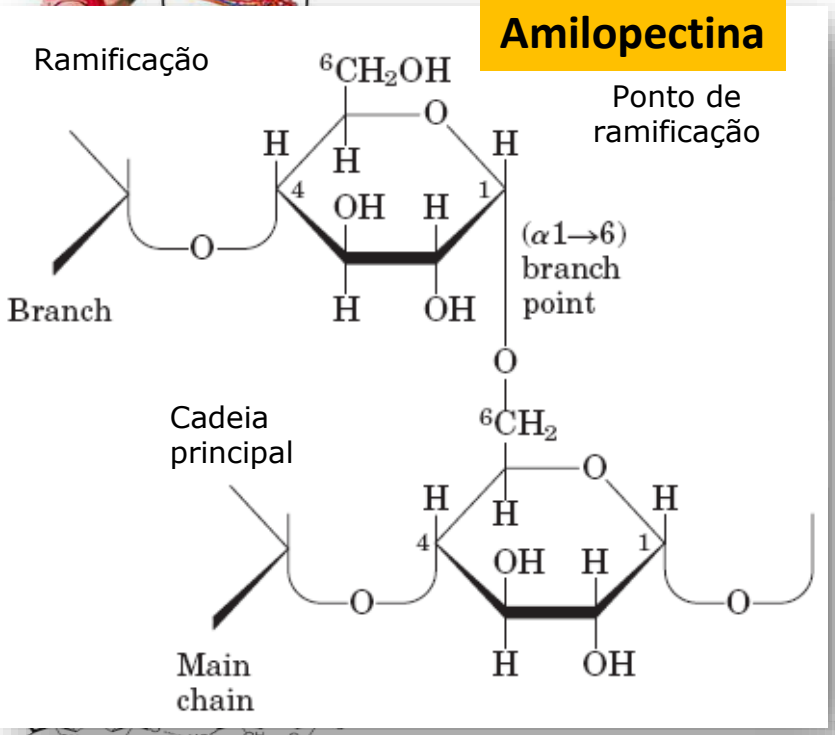


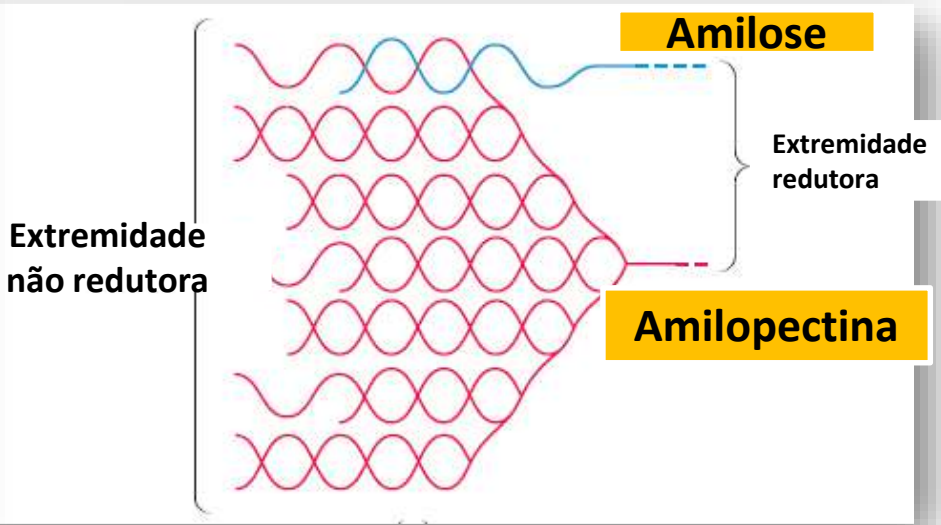
- ✓ **Polissacarídeo de reserva de energia em vegetais.**
- ✓ **Ocorrem intracelularmente como grandes agregados ou grânulos.**
- ✓ **Formado por dois tipos de polímeros de glicose:**

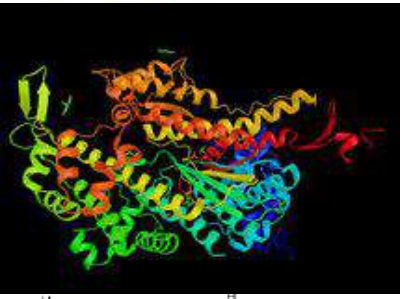
Amilose:

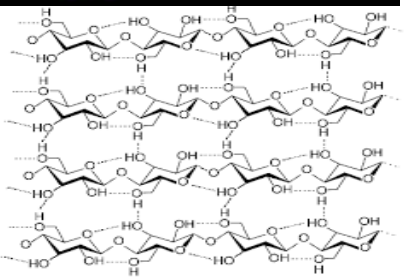


Amilopectina

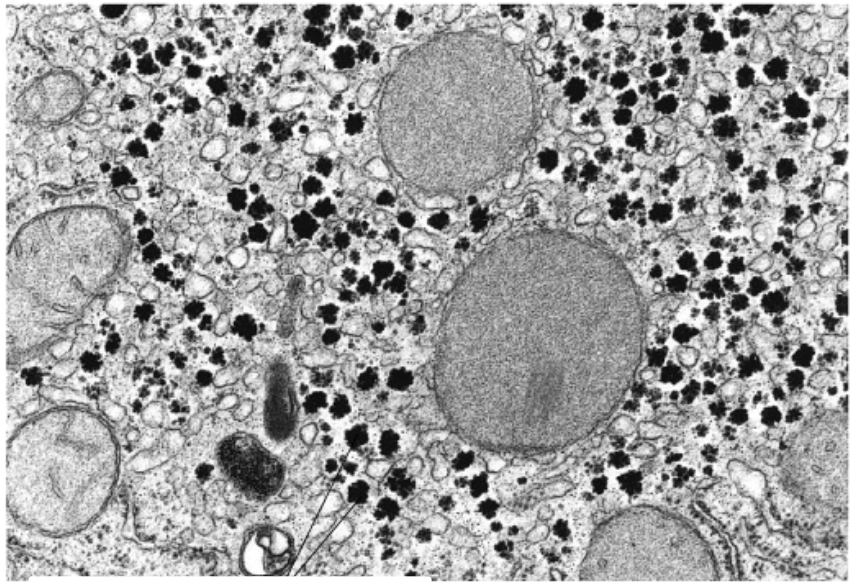




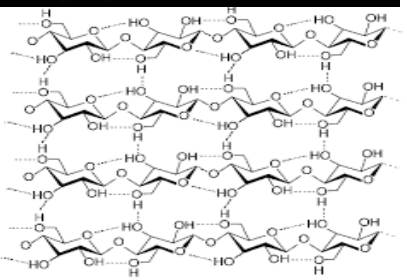


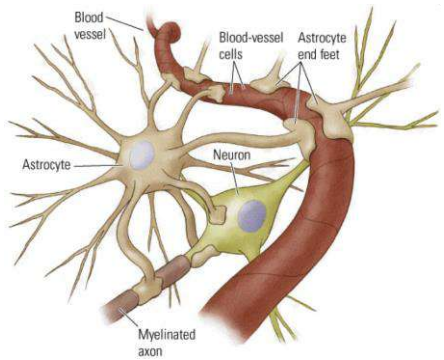


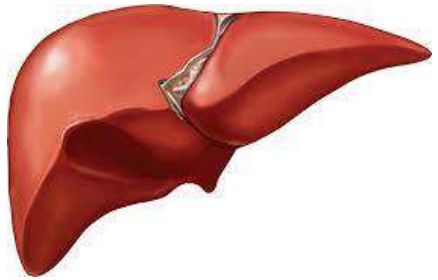
- ✓ Polissacarídeo de reserva nos animais;
- ✓ Ocorre principalmente no fígado e músculos esqueléticos;
- ✓ Formado por mais de 500 α-D-glicopiranoses;
- ✓ Ligações α (1→4) nas cadeias e α (1→6) nas ramificações;
- ✓ Estrutura com ramificações a cada 8 ou 12 resíduos;

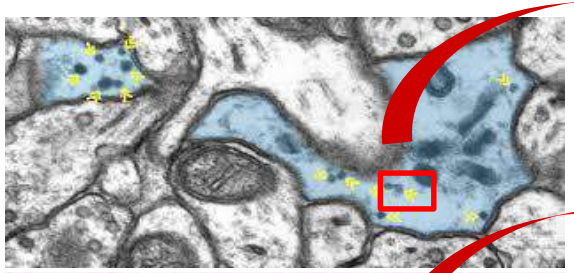


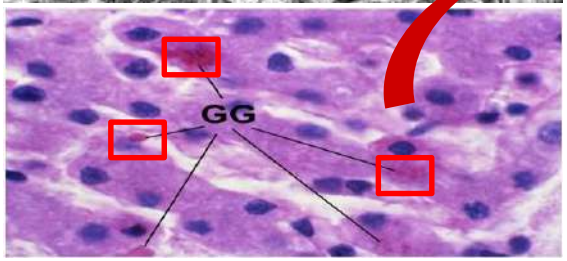
Grânulos de Glicogênio

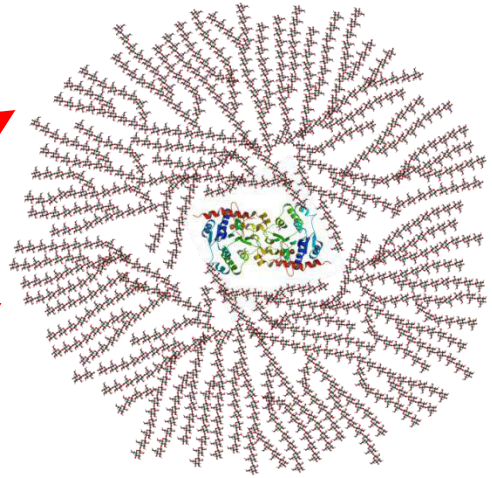



Blood vessel
Blood-vessel cells
Astrocyte end feet
Astrocyte
Neuron
Myelinated axon

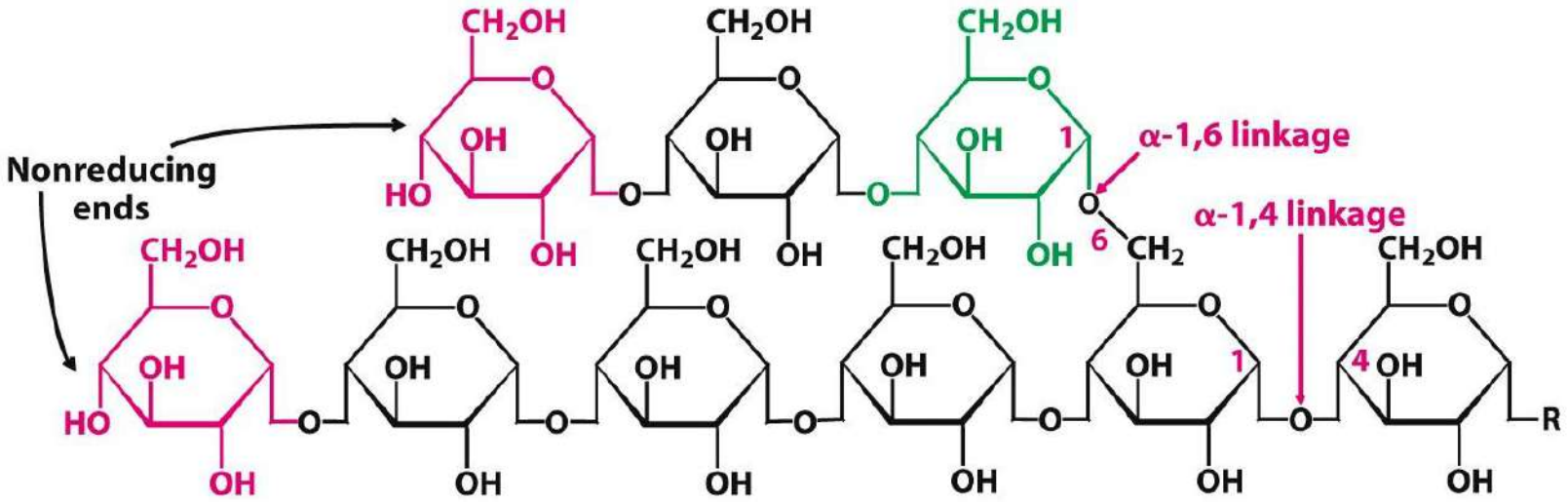




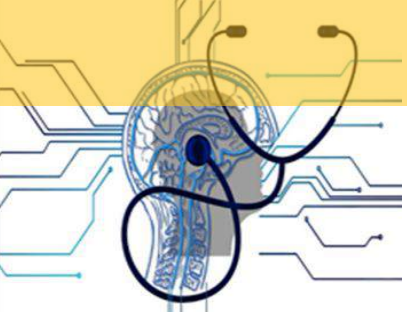

GG

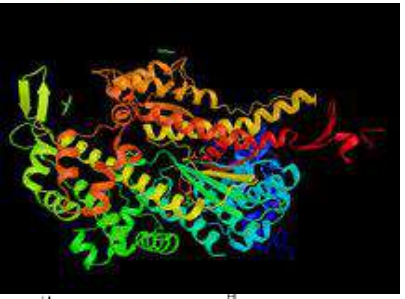


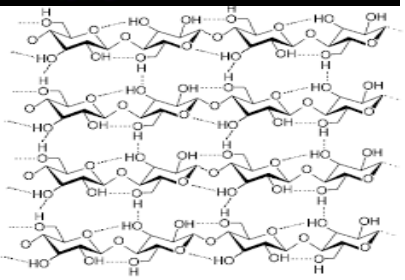
Glicogênio

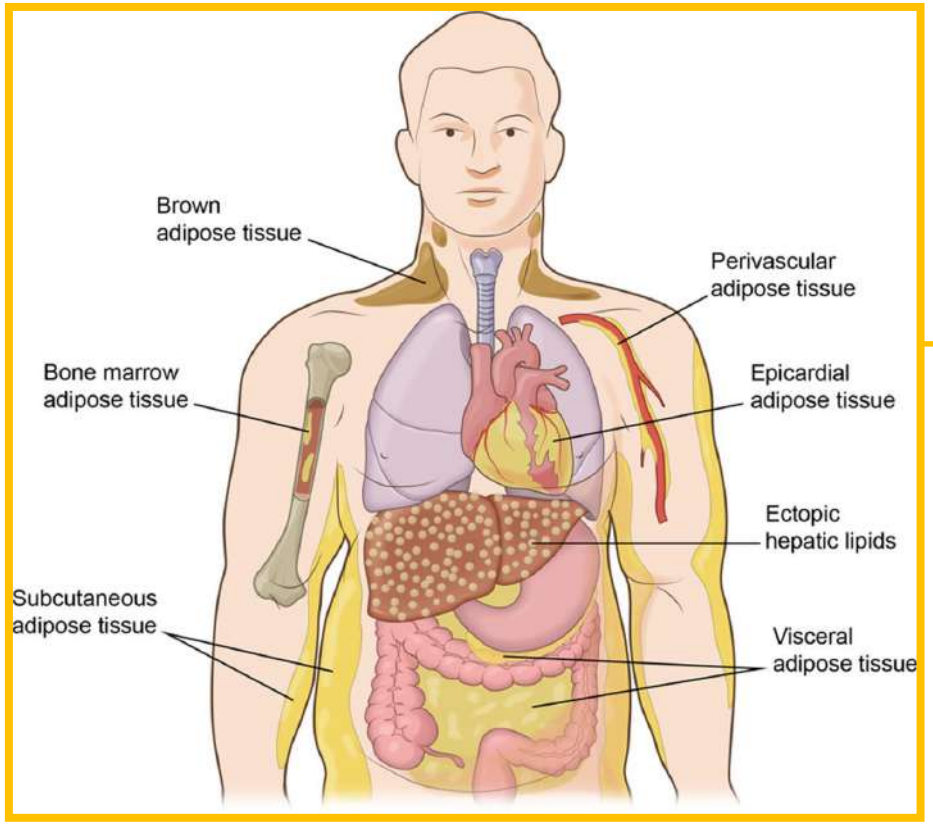

Nonreducing ends
α-1,6 linkage
α-1,4 linkage
R

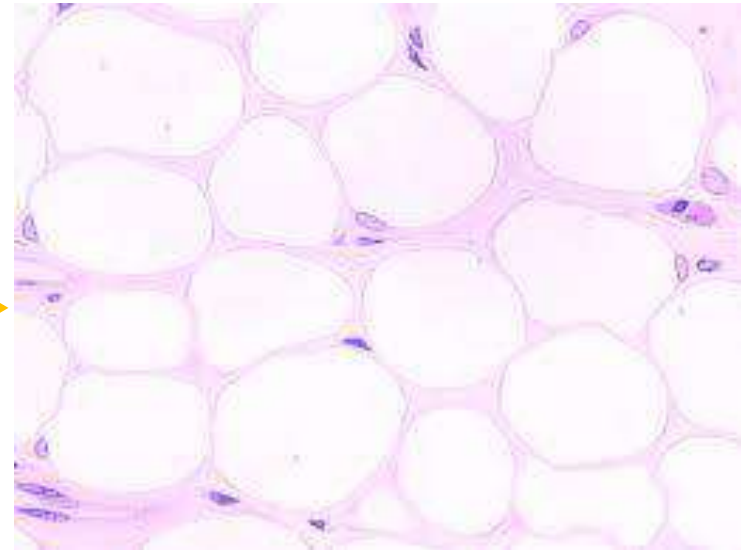
TRIACILGLICERÓIS: PRINCIPAL FORMA DE RESRVA ENERGÉTICA



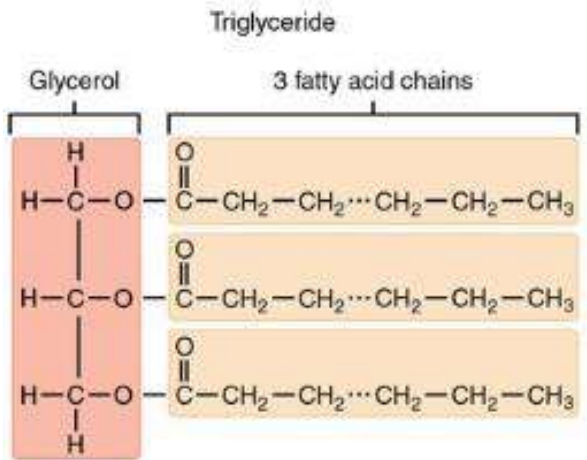


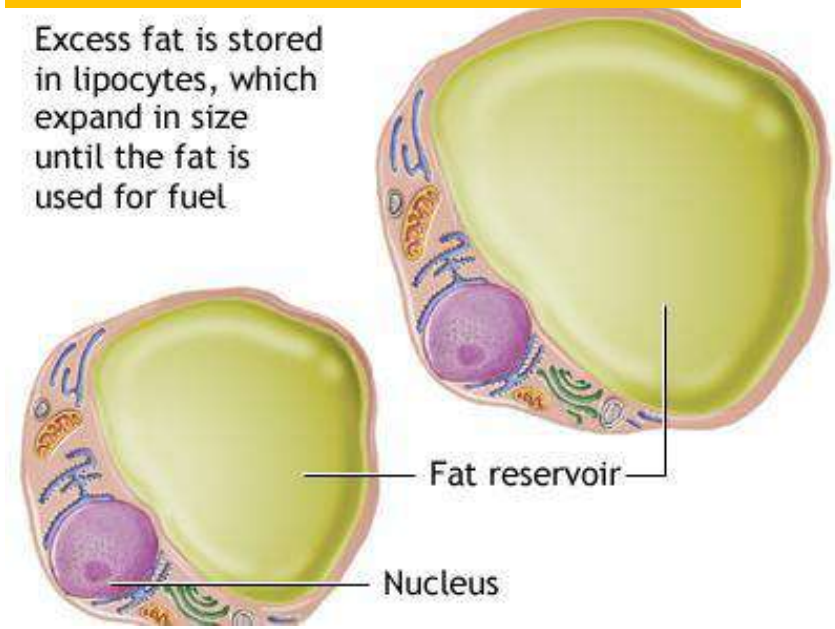


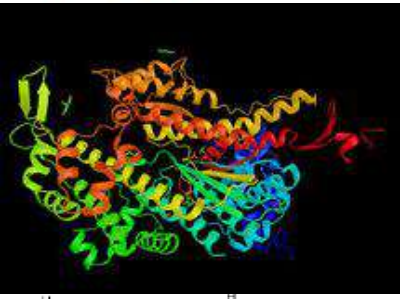


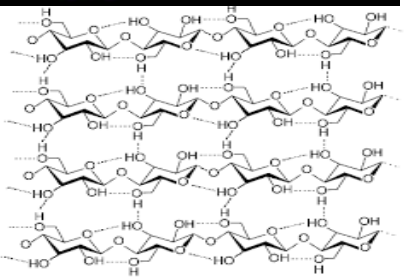


ADIPÓCITOS

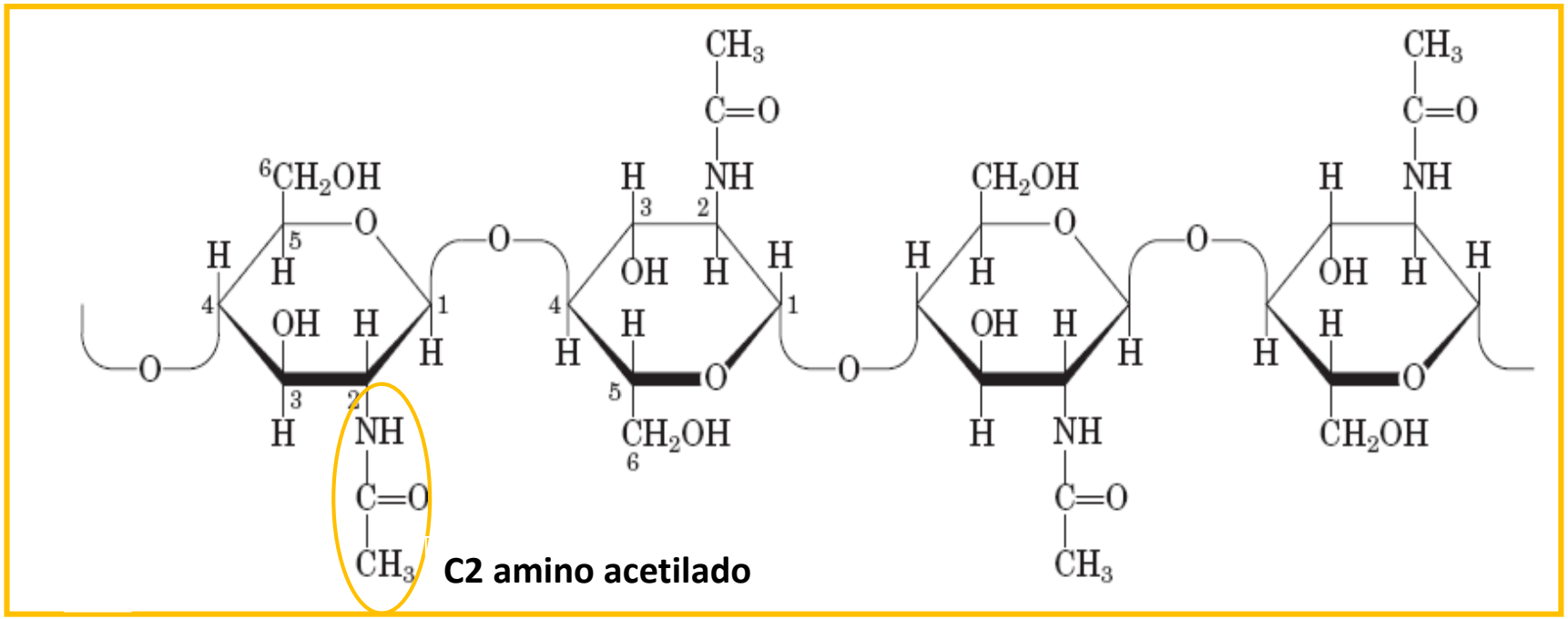


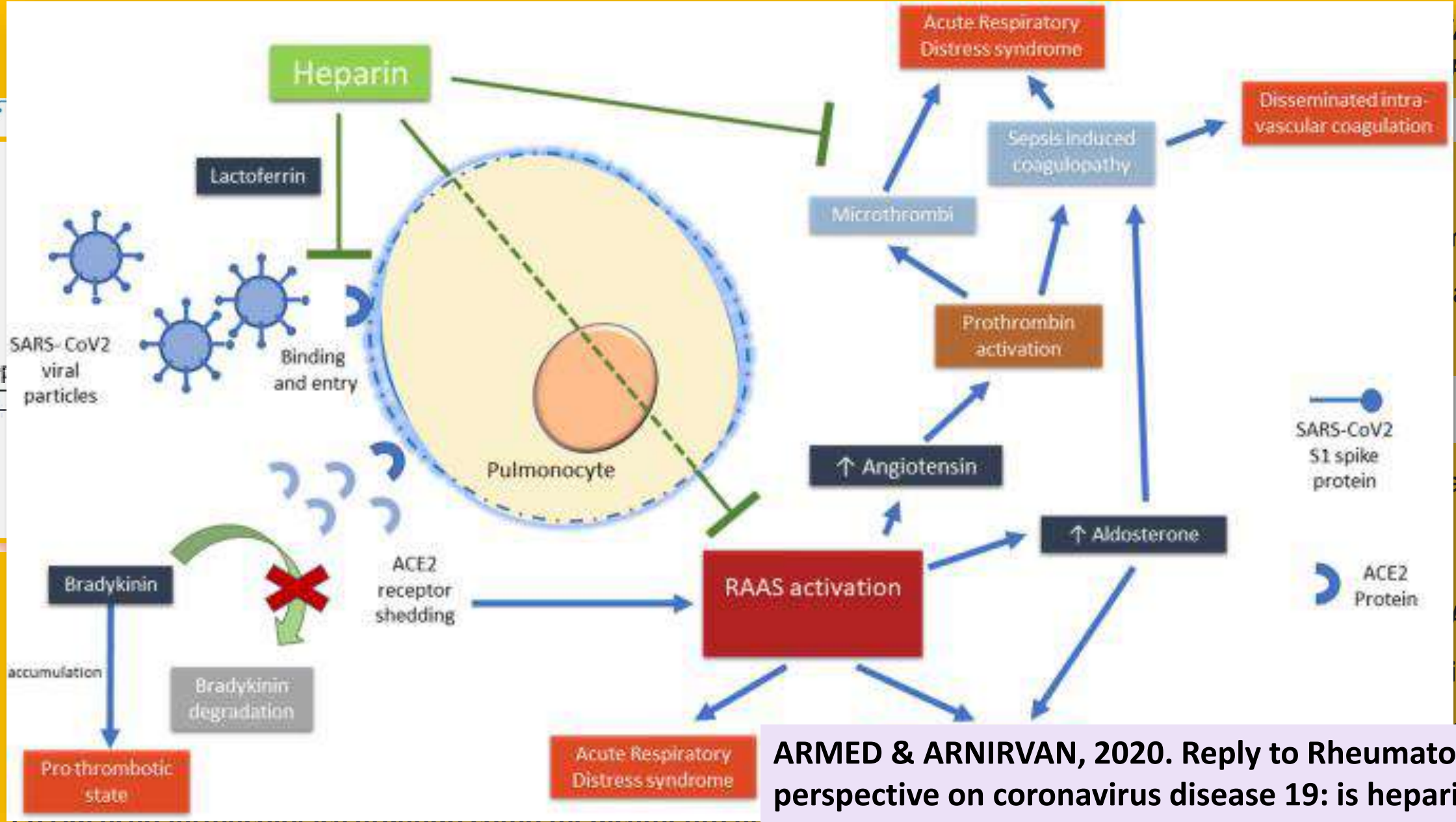






- ✓ **Polissacarídeo estrutural dos invertebrados;**
- ✓ **Também encontrado na parede celular de certos fungos;**
- ✓ **Formada por unidades de N-ACETILGLICOSAMINA;**
- ✓ **Ligações β (1→4);**
- ✓ **Cadeia distendida como a celulose.**





ARÍDEOS
Heparina

pode
n 70%
as do

a do

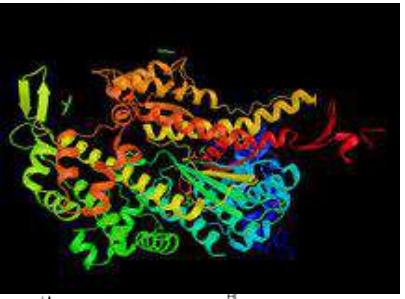
Altos
id-19

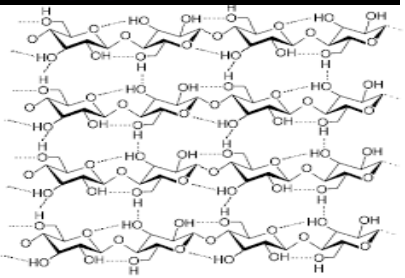
✓

✓

utilizado em várias patologias.

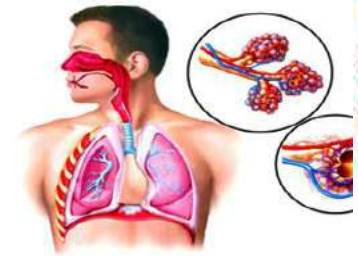
ARMED & ARNIRVAN, 2020. Reply to Rheumatologists' perspective on coronavirus disease 19: is heparin the dark horse for COVID-19? Clinical Rheumatology volume 39, pages2099–2100(2020)

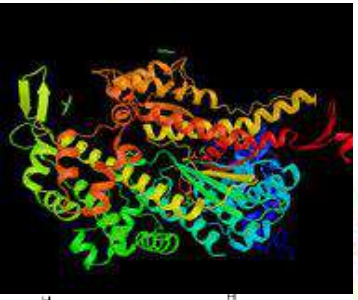


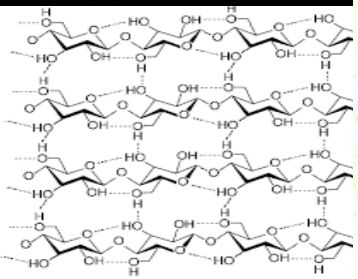


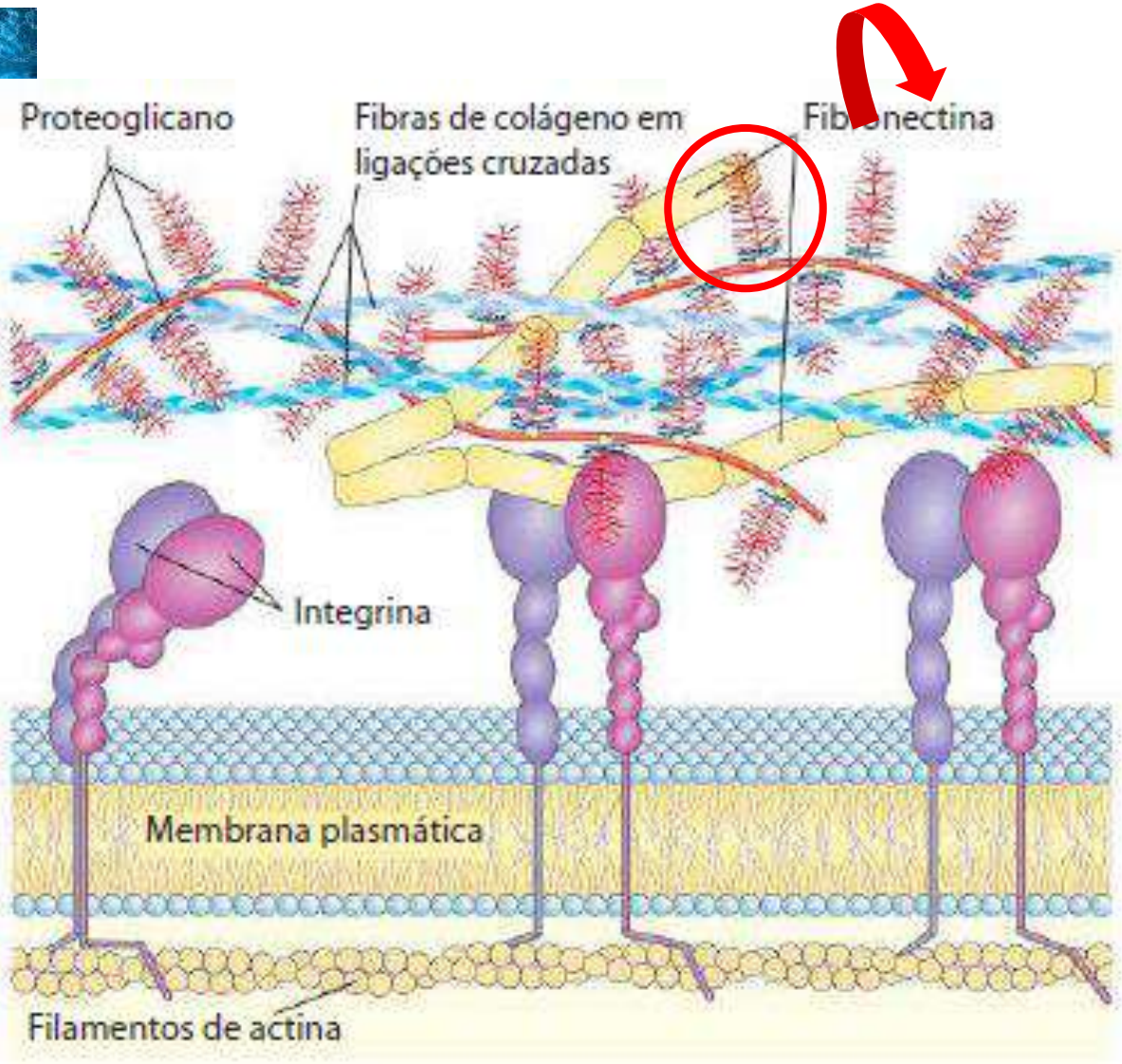
Glicosaminoglicano	Número de dissacarídeos por cadeia	Dissacarídeo repetido
Acido hialurônico	~50,000	GlcA (β1→3) GlcNAc (β1→4)
Condroitina-4-sulfato	20–60	GlcA (β1→3) GalNAc4S (β1→4)

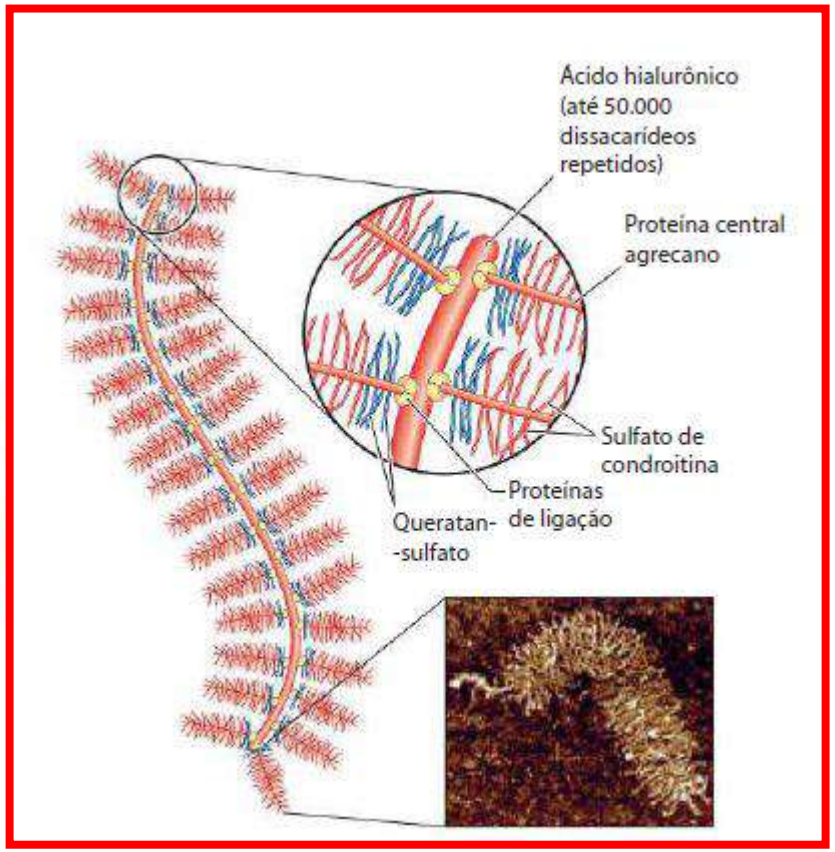
GLICOSAMINOGLICANOS DA MATRIZ EXTRACELULAR

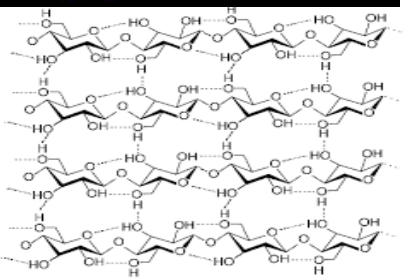


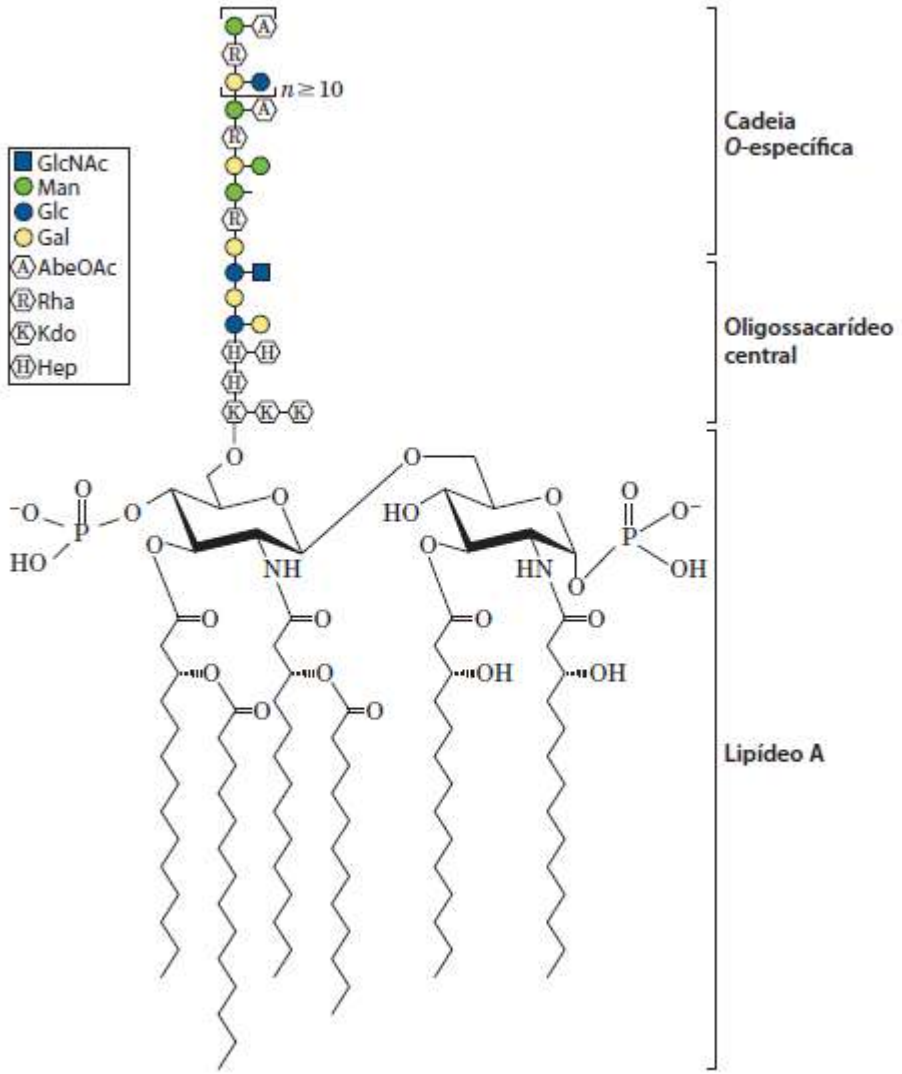












LIPOPOLISSACARÍDEOS BACTERIANOS

PAMPs: Padrões Moleculares

associados à patógenos