

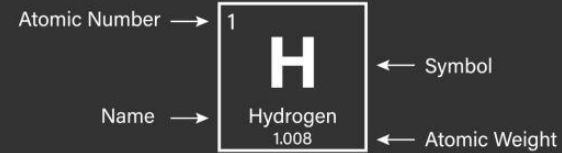
InterceptAge

Conversion of biowaste
into metals using
microorganisms



InterceptAge

Periodic Table of the Elements



										13 IIIA	14 IVA	15 VA	16 VIA
										5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999
										13 Al Aluminium 26.9815385	14 Si Silicon 28.085	15 P Phosphorus 30.973761998	16 S Sulfur 32.06
3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.921595	34 Se Selenium 78.971
Sc Scandium 44.955908	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938044	26 Fe Iron 55.845	27 Co Cobalt 58.933194	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60
Y Yttrium 88.90584	40 Zr Zirconium 91.224	41 Nb Niobium 92.90637	42 Mo Molybdenum 95.95	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.414	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98040	84 Po Polonium (209)
57 - 71 Lanthanoids	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.592	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (289)	116 Lv Livermorium (293)
89 - 103 Actinoids	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (269)	107 Bh Bohrium (270)	108 Hs Hassium (269)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (282)	112 Cn Copernicium (285)				
La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90766	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93033	68 Er Erbium 167.259	69 Tm Thulium 168.93422	70 Yb Ytterbium 173.045
Ac Actinium (227)	90 Th Thorium 232.0377	91 Pa Protactinium 231.03588	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)

Annotation

- This presentation examines the process of biomineralization of organic waste using microorganisms to obtain valuable metals. It explores the mechanisms of transforming biowaste into metallic compounds, as well as the prospects for the practical application of this process.



Introduction

- The problem of biowaste disposal is one of the key environmental challenges of our time. The search for efficient methods of processing organic waste is becoming particularly relevant in the context of increasing anthropogenic impact on the environment. One promising approach is the use of microorganisms to transform biowaste into valuable metallic compounds.

Periodic Table of the Elements

Theoretical basis

- Biomineralization is a natural process of the formation of inorganic compounds by living organisms. Microorganisms are capable of accumulating and transforming various elements, including metals, through biochemical reactions.

										13 IIIA	14 IVA	15 VA	16 VIA
										5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999
										13 Al Aluminium 26.9815385	14 Si Silicon 28.085	15 P Phosphorus 30.973761998	16 S Sulfur 32.06
3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.921595	34 Se Selenium 78.971
Sc Scandium 44.955908	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938044	26 Fe Iron 55.845	27 Co Cobalt 58.933194	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60
Y Yttrium 88.90584	40 Zr Zirconium 91.224	41 Nb Niobium 92.90637	42 Mo Molybdenum 95.95	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.414	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98040	84 Po Polonium (209)
57 - 71 Lanthanoids	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.592	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (289)	116 Lv Livermorium (293)
89 - 103 Actinoids	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (269)	107 Bh Bohrium (270)	108 Hs Hassium (269)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (282)	112 Cn Copernicium (285)	117 Ts Tennessine (294)	118 Og Oganesson (294)	119 Uue Ununennium (295)	120 Uub Unbinilium (296)
La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90766	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93033	68 Er Erbium 167.259	69 Tm Thulium 168.93422	70 Yb Ytterbium 173.045
Ac Actinium (227)	90 Th Thorium 232.0377	91 Pa Protactinium 231.03588	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)

The main mechanisms of biomineralization include:

- Precipitation of metals as insoluble compounds.
- Formation of organometallic complexes
- Biosorption of metal ions
Biocatalytic
- Biosorption of metal ions
Biocatalytic reduction of metals
- The objects of the study were various types of biowaste (plant residues, food waste, livestock waste). Strains of bacteria from the genera *Pseudomonas* and *Bacillus*, other bacterial strains, and several species of fungi were used as biological agents.

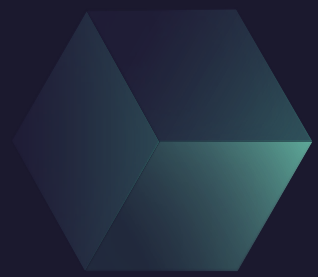


The research methodology included:

- Preparation of biowaste samples
- Incubation with microbial cultures
- Monitoring of the mineralization process
- Analysis of the obtained metallic compounds

Research Results In the course of the experiment, it was established that microorganisms are capable of effectively transforming organic substances with the formation of the following metallic compounds:

- Iron and manganese oxides
- Copper and zinc sulfides
- Calcium carbonates
- Complex organometallic compounds



Efficiency of the process depends on:

- The chemical composition of the raw material
- Temperature and humidity conditions pH of the medium



Discussion of the Results



Perfect. Here is the translation:

- The obtained results demonstrate the promise of using microorganisms for processing biowaste to obtain valuable metallic compounds. This approach makes it possible to solve two important tasks: waste disposal and the production of useful products.



- The study showed that the biomineralization process is an effective method for transforming biowaste into valuable metallic compounds. The further development of this approach can contribute to the creation of environmentally friendly technologies for processing organic waste and producing in-demand metallic products.

Research Prospects

- Optimization of the biomineralization process conditions
- Search for new strains of microorganisms
- Development of industrial technologies
- Economic assessment of the process





Methods for obtaining precious metals using microorganisms

- Current research demonstrates the promise of using microorganisms to extract valuable metals from various sources, including industrial waste.
- Particular attention is paid to bacterial leaching methods, which make it possible to efficiently extract gold and copper.



Mechanism of metal extraction

The extraction process is based on the ability of specific bacterial strains to:

- Oxidize sulfide minerals
- Transform metals into a soluble form
- Catalyze chemical reactions

The most effective microorganisms for the process:

- Bacteria of the genus *Acidithiobacillus*
- Bacteria of the genus *Leptospirillum*
- Bacteria of the genus *Sulfobacillus*
- Strains of *C. Metallidurans*
- Others

Periodic Table of the Elements

Technological features of the process

The process is carried out under the following conditions:

- Acidic medium (pH 1-2.5)
- Temperature range of 2-80°C
- Aeration control
- Maintenance of optimal humidity

Atomic Number → 1 ← Symbol Name → Hydrogen ← Atomic Weight 1.008										13 IIIA	14 IVA	15 VA	16 VIA
										5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999
3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	13 Aluminium 26.9815385	14 Silicon 28.085	15 Phosphorus 30.973761998	16 Sulfur 32.06
Sc Scandium 44.955908	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938044	26 Fe Iron 55.845	27 Co Cobalt 58.933194	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.921595	34 Se Selenium 78.971
Y Yttrium 88.90584	40 Zr Zirconium 91.224	41 Nb Niobium 92.90637	42 Mo Molybdenum 95.95	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60
57 - 71 Lanthanoids	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.592	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98040	84 Po Polonium (209)
89 - 103 Actinoids	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (269)	107 Bh Bohrium (270)	108 Hs Hassium (269)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (282)	112 Cn Copernicium (285)	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (289)	116 Lv Livermorium (293)
La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90766	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93033	68 Er Erbium 167.259	69 Tm Thulium 168.93422	70 Yb Ytterbium 173.045
Ac Actinium (227)	90 Th Thorium 232.0377	91 Pa Protactinium 231.03588	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)

Practical application

Russian research has demonstrated the possibility of extracting metals from:

- Electronic waste (printed circuit boards)
- Ash waste
- Technogenic waste
- Refractory ores

When processing 1 million electronic devices, it is possible to obtain:

- 16 tons of copper
- 34 kg of gold
- 350 kg of silver
- 15 kg of palladium

The unique properties of certain bacteria are based on:

- Ability to absorb toxic metals
- Controlled removal of toxic compounds
- Formation of gold nanoparticles

Periodic Table of the Elements

Atomic Number →

1

← Symbol

Name →

Hydrogen

← Atomic Weight

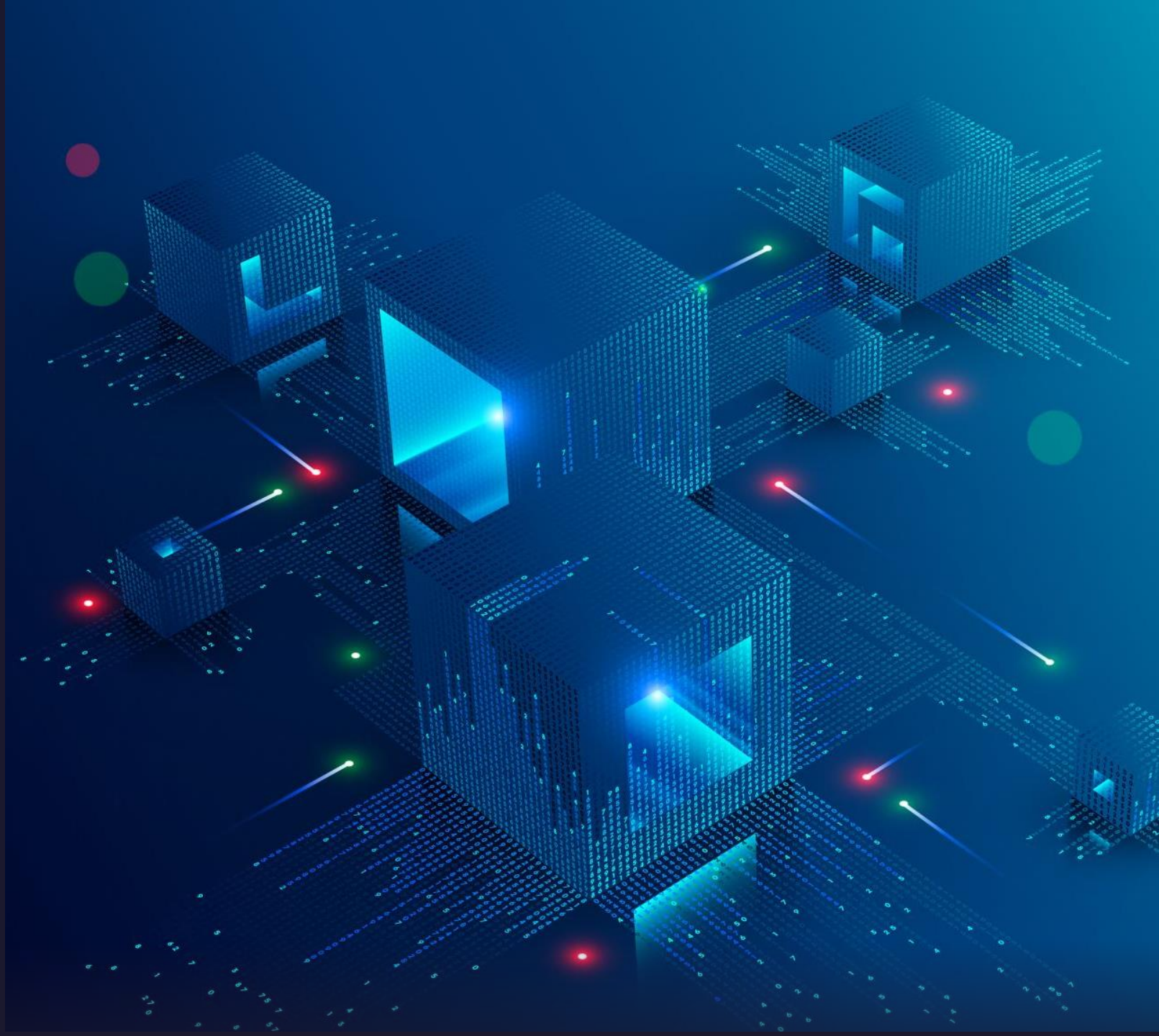
1.008

																		13 IIIA		14 IVA		15 VA		16 VIA	
																		5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999				
																		13 Al Aluminum 26.9815385	14 Si Silicon 28.0855	15 P Phosphorus 30.973761998	16 S Sulfur 32.06				
3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII B	9 VIII B	10 VIII B	11 IB	12 IIB																
Sc Scandium 44.955908	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938044	26 Fe Iron 55.845	27 Co Cobalt 58.933194	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 68.723	32 Ge Germanium 72.630	33 As Arsenic 74.921595	34 Se Selenium 78.971												
39 Y Yttrium 88.90584	40 Zr Zirconium 91.224	41 Nb Niobium 92.90637	42 Mo Molybdenum 95.95	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60												
57-71 Lanthanoids	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.221	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.592	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98040	84 Po Polonium (209)												
109-113 Actinoids	104 Rf Rutherfordium (261)	105 Db Dubnium (268)	106 Sg Seaborgium (269)	107 Bh Bohrium (270)	108 Hs Hassium (281)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (285)	111 Rg Roentgenium (282)	112 Cn Copernicium (285)	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (289)	116 Lv Livermorium (293)												

Technology Development Prospects

Key improvement directions:

- Selection of new microbial strains
- Optimization of technological parameters
- Development of combined methods
- Creation of industrial installations



Economic significance

Advantages of the method:

- Environmental safety
- Reduced processing costs
- Utilization of new raw material sources
- Rational resource use





- The technology of metal extraction using microorganisms represents a promising direction in the field of technogenic waste processing. The further development of this method will make it possible to solve waste disposal problems and ensure the production of valuable metals from non-traditional sources.



Recommendations for scaling up

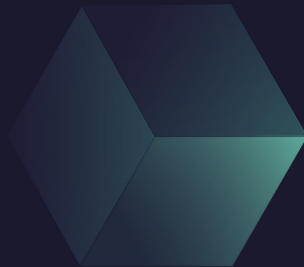
For industrial implementation, it is necessary to:

- Conduct pilot tests
- Develop control systems
- Create automated production lines
- Assess economic efficiency

Mechanisms of Transmutation of Chemical Elements in Microorganisms

Theoretical Foundations of the Process

Nuclear transmutation in microorganisms represents a unique biological process of converting one chemical element into another.



This phenomenon is carried out with the participation of specific strains of microorganisms and is characterized by the following features:

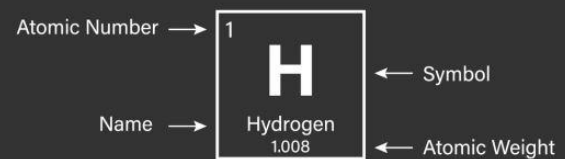
- Process occurring at relatively low temperatures
- No need for complex equipment
- Environmental safety of the procedure

Periodic Table of the Elements

The following
microorganisms play a
crucial role in transmutation:

Объяснение перевода / Explanation of the translation:

- Deinococcus radiodurans is capable of transmutation when exposed to ionizing radiation.
- Thiobacillus initiates and accelerates various types of radioactive decay.
- Special associations of 3000 microorganisms (according to A. Kornilova's technology).



										13 IIIA	14 IVA	15 VA	16 VIA
										5 B Boron 10.81	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999
										13 Al Aluminium 26.9815385	14 Si Silicon 28.085	15 P Phosphorus 30.973761998	16 S Sulfur 32.06
3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	31 Ga Gallium 69.723	32 Ge Germanium 72.630	33 As Arsenic 74.921595	34 Se Selenium 78.971
Sc Scandium 44.955908	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938044	26 Fe Iron 55.845	27 Co Cobalt 58.933194	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.38	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60
Y Yttrium 88.90584	40 Zr Zirconium 91.224	41 Nb Niobium 92.90637	42 Mo Molybdenum 95.95	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.414	81 Tl Thallium 204.38	82 Pb Lead 207.2	83 Bi Bismuth 208.98040	84 Po Polonium (209)
57 - 71 Lanthanoids	72 Hf Hafnium 178.49	73 Ta Tantalum 180.94788	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.084	79 Au Gold 196.966569	80 Hg Mercury 200.592	113 Nh Nihonium (286)	114 Fl Flerovium (289)	115 Mc Moscovium (289)	116 Lv Livermorium (293)
89 - 103 Actinoids	104 Rf Rutherfordium (267)	105 Db Dubnium (268)	106 Sg Seaborgium (269)	107 Bh Bohrium (270)	108 Hs Hassium (269)	109 Mt Meitnerium (278)	110 Ds Darmstadtium (281)	111 Rg Roentgenium (282)	112 Cn Copernicium (285)				
La Lanthanum 138.90547	58 Ce Cerium 140.116	59 Pr Praseodymium 140.90766	60 Nd Neodymium 144.242	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92535	66 Dy Dysprosium 162.500	67 Ho Holmium 164.93033	68 Er Erbium 167.259	69 Tm Thulium 168.93422	70 Yb Ytterbium 173.045
Ac Actinium (227)	90 Th Thorium 232.0377	91 Pa Protactinium 231.03588	92 U Uranium 238.02891	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)

The process is realized through the following biochemical pathways:

**Объяснение перевода /
Explanation of the translation:**

- Beta decay – a process of electron emission initiated and accelerated by bacteria.
- Electron capture – the transfer of electrons between atomic nuclei.
- Oxidation-reduction reactions on the cell wall surface.
- Nuclear fusion under specially created conditions





Practical Application

The technology
enables:

Convert radioactive waste into
stable elements

Obtain valuable metals from
non-traditional sources

PRODUCTION _____

DIRECTOR _____

CAMERA _____

SCENE _____

TAKE _____

Obtain rare isotopes for:



- Medicine
- Nuclear Power
- Aerospace Instrumentation
- Decontaminate liquid nuclear waste

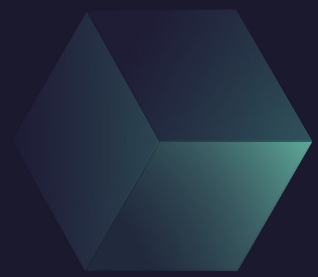
Promising Directions

- Optimization of microbial consortium composition
- Investigation of new microorganism strains
- Development of scalable technologies
- Creation of specialized bioreactors

Economic Significance

The technology opens up opportunities for:

- Disposal of hazardous waste
- Production of valuable isotopes
- Reduction of nuclear processing costs
- Creation of new industrial sectors
- Obtaining valuable metals from non-traditional sources



Microbiological transmutation represents a revolutionary approach to the transformation of chemical elements.

Further study of the mechanisms of this process could lead to the creation of new technologies in the fields of nuclear physics, ecology, and industry.

