BSE 102 Bioscience

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The Chemical Basis of Life

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E-mail: sunilboda@iiti.ac.inImage 1:

Caption:The image is the logo of the Indian Institute of Technology Indore. It is a circular

emblem with a blue background and a white border. In the center of the emblem, there is an

open book with aof the emblem, there is an open book with a sunburst design around it. The

book is surrounded by a banner with the words "IIT Indore" written in Hindi. Below the book,

there are two lines of text inBelow the book, there are two lines of text in Hindi, which translates

to "Indian Institute of technology Indore". The text below the book reads "II संस्थान सेवारीय साथिकाली"

(Indian Institute forसंस्थान सेवारीय साथिकाली" (Indian Institute for Technology and Technology) in English.

The emblem is a symbol of knowledge and knowledge in India.Organisms are composed of

elements, usually combined into compounds

Matter – occupies space and has mass

Three physical states of matter – solid, liquid and gasAll forms of matter – rocks, water, air and

biological systems are fundamentally composed

of chemical elements.

An element is a substance that cannot be further broken down to other substances byordinary

chemical means.

A compound is a substance containing two or more elements combined in a fixed ratio.

Eg: $2Na + Cl_2$ 🖂2 NaCl; (Both Na and Cl are corrosive, but NaCl is edible!)$2H_2 + O_2$ 🖂$2H_2O$

Compounds in living organisms comprise of 3 or 4 elements:

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Carbohydrates: Carbon (C), Oxygen (O), Hydrogen (H)

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Proteins: Carbon (C), Oxygen (O), Hydrogen (H), Nitrogen (N), Sulfur (S)

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Nucleic acids: Carbon (C), Oxygen (O), Hydrogen (H), Nitrogen (N), Phosphorus (P)

••

Lipids: Carbon (C), Oxygen (O), Hydrogen (H), Phosphorus (P)

Major elements in the human body: C, O, H, N, Ca, P (make up 99% of body weight)Minor elements (< 1 wt%): K, S, Na, Cl, Mg (for nerve signaling and chemical reactions)

Trace elements (< 0.01 wt%): B, Cr, Cu, F, I, Fe, Mn, Mo, Se, Si, Sn, V, ZnImage 1: Caption:The image is an infographic that shows the elements of the human body as percentage of body weight (including water). It shows a silhouette of a man standing with his back to the viewer, facing thestanding with his back to the viewer, facing the viewer. The man is wearing a red t-shirt, black shorts, and colorful socks. He is standing with one leg slightly bent at the knee and the other legleg slightly bent at the knee and the other leg extended behind him.The infographic is divided into three sections. The first section is titled "Figure 2.1B" and shows the percentage of water in each element. The second section is labeled "Oxygen (O): 65%". The thirdsection is labeled "Oxygen (O): 65%". The third section is labelled "Carbon (C): 18.5%", the fourth section is "Hydrogen (H): 9.5%, the fifth section is listed as "Nitrogen (N): 3.3%", and the sixthis listed as "Nitrogen (N): 3.3%", and the sixth section is colored in shades of blue, green, yellow, and orange. The chart also includes information about the different elements and theirabout the different elements and their properties.Trace elements are common

additives to food and water

Iodine is an essential component of the hormones thyroxine (T4 - inactive) and triiodothyronine (T3 - active)produced by the thyroid glands. Thyroid hormones control body's metabolism (food to energy conversion) rate.Iodine deficiency leads to abnormal swelling of the thyroid gland leading to a condition called goiter. Mostserious effects of iodine deficiency occur during fetal development and childhood, leading to miscarriages,

poor growth and mental impairment.poor growth and mental impairment.

Iodine sources include seafood, kelp, dairy products and dark leafy greens. Iodized salt contains 45 μg/g or ppm of table salt. Daily requirement is 150 µg.ppm of table salt. Daily requirement is 150 µg.

Iron (Fe) makes up only 0.004 wt% of body weight, but it is vital for energy

processing and transport of oxygen.processing and transport of oxygen.

Iron deficiency anemia occurs due to lack of iron to produce hemoglobin. In

pregnant women, iron deficiency puts the baby at the risk of developmental delays.Iron rich foods include meat, fish, poultry, eggs, green, legumes, raisins, etc.

Fluoride is added to toothpaste and mouthwash at ~1500 ppm to prevent dental cavities and tooth loss.Excess fluoride in drinking water can cause fluorosis, a condition of brown stained teeth.

Excess/ overload of trace elements can lead to accidental fatal poisoning. Recommended dietaryallowances (RDA) of trace elements are based on gender (male/ female) and age (infants/ adults)Image 1:

Caption:The image is a portrait of an elderly woman from Burma. She is wearing a blue and white headscarf with a pink scarf around her neck. The woman has a serious expression on her face and is lookinga serious expression on her face and is looking directly at the camera. She appears to be in her late 60s or early 70s. The background is plain white. The text on the image reads "Figure 2.2A Goiter,The text on the image reads "Figure 2.2A Goiter, a symptom of iodine deficiency, in a Burma woman."Image 2:

Caption:The image shows a variety of food items that are rich in iron. On the left side of the image, there are two eggs, a bunch of green beans, and a small bowl of nuts. Next to the eggs, there is a pilebowl of nuts. Next to the eggs, there is a pile of dried raisins. In the center of the table, there appears to be a large piece of raw meat, possibly pork or beef, with a pink onion and parsley onpork or beef, with a pink onion and parsley on top. The meat is pink in color and looks to be seasoned with herbs and spices. The background is white.Image 3:

Caption:The image shows a toothbrush and a glass of toothpaste. The toothbrush has a green handle and white bristles, and the toothpaste is a light blue color. The glass is filled with a clear liquid, whichThe glass is filled with a clear liquid, which appears to be toothpaste with added fluoride. The background is white, and there is text on the image that reads "Figure 2.2C Mouthwash and toothpaste".Importance of trace elements

PN: Parenteral nutrition –

feeding nutrients through

intravenous/ non-

gastrointestinal routeImage 1:

Caption:

The image is a table that lists the different types of dietary deficiencies and their properties. The table is divided into three columns and three rows.The first column is titled "Physical Functions" and lists the physical functions of the dietary deficiencies. The physical functions are:

- Selenium (S)

- Zinc (Zn)As a component of the body's immune system, the body is responsible for regulating the flow of nutrients and nutrients in the body.- Copper (C) is a component that helps to regulate the metabolism and metabolism of the human body. It helps to reduce inflammation and improve the overall health and wellbeing of the person.There are also several other physical functions listed in the table, such as the body, the brain, and the brainstem. These functions are essential for maintaining a healthy and well-being, and canfor maintaining a healthy and well-being, and can help to maintain a balanced diet and maintain a healthy lifestyle. The image also includes a brief description of each type of deficiency and howdescription of each type of deficiency and how they can affect the overall overall health of the individual.Radioactive isotopes in biology

Atom means ‘indivisible’. But physicists split atom into sub-atomic particles.

Atom = proton (p+) + neutron (n) + electron (e-)

Atomic Number = No. of protonsAtomic Number = No. of protons

Mass Number = No. of protons + No. of neutrons

Atomic Mass = Mass of protons + Mass of neutrons + Mass of electrons

Mass of proton = Mass of neutron ~ 1 DaMass of proton = Mass of neutron ~ 1 Da

Mass of electron = 1/2000 Mass of proton; m (e-) << m (p+)

So, Atomic Mass ≈ Mass of protons + Mass of neutronsIsotopes = same atomic number, but different mass number. Eg: 6

12C,

6

13C,

6

14C

A radioactive isotope is one in which nucleus decays spontaneously, emitting particles and energy.Radiation from decaying isotope can damage cellular molecules and thus can pose serious risks to living organisms.But radioactive isotopes can be helpful, as in their use in dating fossils by C-14 decay (t1/2 = 5730 years).Living organisms cannot distinguish between isotopes. So, they uptake both normal and radioactive compounds similarly.Basic research involving radioisotopes: Biologists often use radioactive tracers to follow molecules as they undergo chemicalchanges in an organism. Eg: Monitoring 14CO2 transforming into different metabolites during photosynthesis of carbohydrates

Atomic structureImage 1:

Caption:The image is a diagram that shows two models of a helium atom. The model on the left is a nucleus, which is a type of atom with two protons and two neutrons. The nucleus is represented by a pinkneutrons. The nucleus is represented by a pink circle with a plus sign in the center, representing the nucleus.On the right side of the image, there is an electron cloud, which represents the nucleus of the atom. Inside the nucleus, there are two electrons, one pink and one black, representing protons. Theone pink and one black, representing protons. The protons are represented by the plus sign, while the neutrons represent the electrons.There is also a note on the image that reads "Note that these models are not to scale; they greatly overestimate the size of the nucleus in relation to the electron cloud." This suggests that theto the electron cloud." This suggests that the image is meant to illustrate the relationship between the two models.DNA, not protein contains the genetic code – proven by radioisotope labeling

Griffith’s experiment (1928) – bacterial transformation

Two strains of the bacterium Streptococcus pneumoniae:

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R-strain (rough colonies) – not virulent; did not kill mice

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S-strain (smooth colonies) – virulent; killed infected mice

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Heat-treated S-strain – non-virulent; did not kill mice

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Heat-treated S-strain + R-strain – killed mice; horizontal gene

transfer from heat-treated S transformed R-strain to virulent

strain

Hershey & Chase experiment (1952) - transductionHershey & Chase experiment (1952) -

transduction

Viral DNA was labelled with 32P and protein with 35S. After

E.coli infection by 32P-labeled phage, radioactivity was foundonly in the transduced bacteria

(after the phage are removed

by agitation and centrifugation). In contrast, after infection

with 35S-labeled phage, radioactivity is found only in thesupernatant that remains after the

bacteria are removed.Image 1:

Caption:Image 1:

Caption:

The image is a diagram that shows the process of heat-treated S and S+R. It shows the different stages of the process, from the initial stage of heat treatment to the final stage.In the first stage, there are six rats, each with a different color - R, S, and R. The rats are shown in a light brown color and are arranged in a grid-like pattern. The first stage is labeled "R"grid-like pattern. The first stage is labeled "R" and shows a yellow circle with a black arrow pointing to it, indicating the direction of the heat treatment process. The second stage is labelledtreatment process. The second stage is labelled "S", indicating that the rats are being treated with a heat treatment. The third stage is titled "heat-treated" and has a yellow sphere with a red"heat-treated" and has a yellow sphere with a red arrow pointing towards it. The fourth stage is described as "heat treated S" and is labeled as "R".There are also several smaller yellow spheres scattered throughout the image, representing the different types of heat treatments that can be used to treat the rats. These are likely to be used into treat the rats. These are likely to be used in the treatment process, such as heat treatment, treatment, and treatment.Image 2:

Caption:

The image is a diagram that shows the process of DNA, heat-treated S, and protease. The diagram is divided into four sections, each representing a different stage of the process.The first section shows the DNA molecule, which is represented by a yellow circle with the letters "DNA" and "heat-treated" written on it. The molecule is surrounded by a black circle with a yellowis surrounded by a black circle with a yellow arrow pointing to it, indicating that it is being treated with the DNA. The second section shows a group of yellow spheres, which are likely thea group of yellow spheres, which are likely the nucleotides of the molecule. The third section shows two brown mice, one on each side of the image, with their heads facing towards the right side. Thetheir heads facing towards the right side. The fourth section shows another brown mouse with a black arrow pointing towards the left side, representing the nucleotide. The fifth section shows thatthe nucleotide. The fifth section shows that the molecule is protease, and the sixth section shows how it is treated with a heat-treated S. The image also shows the interaction between the twoimage also shows the interaction between the two molecules, with the first molecule on the left and the second on the right.Image 3:

Caption:

The image is a diagram that shows the process of centrifugation of bacteria in cells. It is divided into two sections.The first section on the left shows a sulfur-labeled protein capsule (red) with a cell inside it. The capsule is labeled as "bacteriophages" and the cell inside the capsule is labelled as "phosphorusinside the capsule is labelled as "phosphorus labeled DNA (green).In the second section, there is an infection of the bacteria. The infection is represented by a green line that runs from the cell to the cell. The cell is shown in the center of the image.There are three steps in the diagram:

1. Infection
2. Blending
3. Centrifugation
4. After centrifugating no sulfur in cellsAt the bottom of the diagram, there are two circles, one labeled "cell" and another labeled "centrifugal". The circles are connected by arrows, indicating the direction of the infection. The arrowsthe direction of the infection. The arrows are pointing towards the cells, indicating that the infection is in the process. The diagram also has a label that reads "1."Overall, the image shows how bacteria can be used to differentiate between different types of bacteria and how they interact with each other.Radioactive isotopes in medical diagnosis and treatment

Radioactive isotopes may also be used to tag chemicals that accumulate in specific areas of the body. Eg: Phosphorus (30P) in

bones.bones.

[18F-FDG]Fluorodeoxyglucose is used to detect cancer. After injection of tiny amount of such a tracer, a special camera

produces an image of where the radiation collects.Some radioactive isotopes are used for treatment. Eg: The body uses iodine to make a thyroid hormone. Because radioactiveiodine accumulates in the thyroid, it can be used to kill thyroid cancer cells.Substances that the body metabolizes, such as glucose or oxygen, may also be labeled with a radioactive isotope. PET (positron-emission tomography) scan can produce images of areas of the body with high metabolic activity.

PET is useful for diagnosing certain heart disorders and cancers and for basic

research on the brain.research on the brain.

Alzheimer is a neurodegenerative disease, wherein the brain becomes riddled

with deposits (plaques) of a protein called beta-amyloid. Researchers havesynthesized a radioactively labeled protein molecule called PIB (Carbon-11-

labeled Pittsburgh Compound B) that binds to beta-amyloid plaques and can be

detected on a PET scan.detected on a PET scan.

Brain of the Alzheimer’s patient has high levels of PIB (red and yellow areas),

whereas the unaffected person’s brain has lower levels (blue).Image 1:

Caption:The image shows two MRI images of the brain, one in blue and the other in yellow. The blue image shows the brain in detail, while the yellow image shows it in color. Both images are labeled with theit in color. Both images are labeled with the text "Healthy person" and "Alzheimer's patient".The image also includes a text that reads "Figure 2.4B PET images of brains of a healthy person (left) and a person with Alzheimer's disease (right), Red and yellow colors indicate high levels of PIBRed and yellow colors indicate high levels of PIB bound to beta-amyloid plaques." This suggests that the image is related to the study of the human brain and the study's findings.Dangers of radioactive isotopes

Although radioactive isotopes have many beneficial uses, uncontrolled exposure to high levels of radiation can be lethal. Theparticles and energy thrown off by radioactive atoms can damage molecules, especially DNA.Chernobyl nuclear disaster: Explosion of a nuclear reactor in Chernobyl, Ukraine, in 1986 released large amounts of radioactiveisotopes into the environment, which drifted over large areas of Russia, Belarus, and Europe. A few dozen people died fromacute radiation poisoning within a few weeks of the accident, and more than 100,000 people were evacuated from the area.Increased rates of thyroid cancer in children exposed to the radiation have been reported. 2011 post-tsunami Fukushima nuclear disaster in Japan is another similar incident.disaster in Japan is another similar incident.

Natural sources of radiation can also pose a threat. Radon, a radioactive gas, is

the second-leading cause of lung cancer in the United States.Radon can contaminate buildings in regions where underlying rocks naturally

contain uranium, a radioactive element. Homeowners can buy a radon detectoror hire a company to test their home to ensure that radon levels are safe. If

levels are found to be unsafe, technology exists to remove radon from home.Marie Curie (twice awarded Nobel Prize) died of aplastic pernicious anemia

(body stops producing blood cells) due to her years of exposure to radiation

during her work.Image 1:

Caption:The image is a diagram of the Uranium-238 Decay Chain, which is a periodic table that shows the atomic number of the elements in the periodic table. The diagram is divided into two columns, with theThe diagram is divided into two columns, with the left column representing the element name and the right column representing half-life units.The first column is labeled "Only main decays are shown Gamma emitters are not indicated" and shows the number of gamma emitters in each element. The second column is titled "Element Names" and listssecond column is titled "Element Names" and lists the elements that are represented in the diagram. The elements are arranged in a grid-like pattern, with each element represented by a square box.At the top of the diagram, there is a title that reads "The Uranium -238 Decay Chain" and below it, there are numbers that indicate the atomic decay chain. The atomic number is 82, 83, 84, 85, 86,chain. The atomic number is 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, and 92.Chemical bonds in biomolecules

Distribution of electrons determine an atom’s chemical properties.

Chemical bond: When two atoms with incomplete outer shell electronsinteract, they loose, accept or share electrons to form a chemical bond.

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Ionic bond: Complete electron transfer between two atoms. Eg: NaCl

••

Covalent bond: Sharing of electrons between two atoms. Eg: H_2, O_2, CH_4,

H_2O

•

Hydrogen bonds: weak bonds between polar molecules; important in the

chemistry of lifechemistry of life

Chemical reactions make and break chemical bonds

$2H_2 + O_2$ ✉$2H_2O$

Above reaction is an explosive reaction (fortunately does not occur in cells)Chemical reactions

essential for life on earth:

Photosynthesis: $6CO_2 + 6H_2O$

hv$C_6H_{12}O_6 + 6O_2$

Aerobic respiration: $C_6H_{12}O_6 + 6O_2$ ✉$6CO_2 + 6H_2O$ + ATPImage 1:

Caption:The image is a diagram that explains the overall equation for photosynthesis in plants.

It shows the oxidation-reduction reaction in which H_2O donates electrons (as hydrogen) for the

reduction of CO_2electrons (as hydrogen) for the reduction of CO_2 to carbonhydrate (CH_2O).The

diagram is a flowchart that shows the process of photosynthesis, which is a process where

photosynthesis takes place in the atmosphere of a plant. The diagram shows a sun with a

carbon dioxideThe diagram shows a sun with a carbon dioxide molecule in the center,

representing the energy of the sun. The molecule is represented by a yellow circle with a red

line connecting it to the carbonwith a red line connecting it to the carbon dioxide molecules.At

the bottom of the diagram, there is a text that explains that photosynthesis is the ultimate source

of all biological en-ergy, photosynthetic organisms use the energy to sunlight to manufactureuse

the energy to sunlight to manufacture glucose and other organic products, which heterotrophic

cells use as energy and carbon sources.How did life originate on earth?

Theory of spontaneous generation: If food was left to rot, it would generate living organisms like microbes,maggots (larvae of flies) and subsequently higher organisms like rats. But this was disproved by Louis Pasteur

saying ‘life only comes from life’.saying ‘life only comes from life’.

Darwin’s theory of evolution suggested that simpler life forms gave rise to complex organisms.

Oparin-Haldane theory of abiogenesis (1929):Oparin-Haldane theory of abiogenesis (1929):

Organic molecules needed for life could be formed from abiotic

materials in the presence of energy (lightning, heat and UV-light)under reducing conditions of early earth’s atmosphere (low levels of

O_2; major composition of CH_4, NH_3 and H_2).

Oparin’s primordial soup: abiogenic factors above in water gave riseto biomolecules (amino acids, lipids, nucleic acids, carbohydrates)

needed to form cells, the primary constituents of life.

All above theories were only speculations without proof.Image 1:

Caption:

The image is a diagram of a tree with different types of plants and animals. The tree is divided into different sections, each representing a different type of plant.The top section of the tree has a list of different types, including birds, reptiles, mammals, amphibians, land plants, and seaweed. There are also illustrations of animals such as a bird, a zebra, aof animals such as a bird, a zebra, a ladybug, and a turtle. The animals are arranged in a circular pattern around the tree, with the birds at the top and the reptiles at the bottom.On the left side of the image, there are illustrations of reptiles, reptiles and amphibians. On the right side, there is an illustration of a seaweed plant, which is a type of seaweed that is nativeplant, which is a type of seaweed that is native to the ocean floor. The seaweed is a reddish-brown color and has a long, thin trunk that extends from the top to the bottom of the trunk. There isfrom the top to the bottom of the trunk. There is also an illustration that shows a snail, a crab, a jellyfish, a starfish, and an octopus. The image is labeled with the names of the plants and theiris labeled with the names of the plants and their habitats.Miller – Urey experiment (1953)

Miller simulated the origins of life on earth by using –

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Water representing the oceans

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Reducing earth's atmosphere consisting majorly of gases likeCH_4, NH_3 , H_2 and H_2O (water vapor)

•

Energy source – sunlight, geothermal heat, electric spark for
lightning/ thunder

After a week, the water turned brown and containedcoacervates of organic biomolecules such as

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Amino acids – building blocks for proteins

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Lipids – vesicles that can trap proteins and minerals in them
to form cells

•to form cells

•

Sugars – building blocks for polysaccharides, glycoproteins,
etc.

Prebiotic chemistry – amino acids, lipids and sugar are found onother planets, asteroids in our solar system and even beyond
within our galaxy.

In one set of experiments, Miller included H_2S from atmosphericvolcanoes, which accounted for formation of sulfur containing
amino acids and subsequent disulfide links in proteins.Image 1:

Caption:The image is a diagram of an electrical spark (Lightning) system. It consists of a white sphere with a red arrow pointing towards it, representing the electrical spark. The sphere is connected to aelectrical spark. The sphere is connected to a blue line that runs from the top left corner of the image to the bottom right corner.There are two pipes connected to the sphere, one on the left side and the other on the right side. The pipes are connected to each other by a series of wires. The wires are labeled with the lettersof wires. The wires are labeled with the letters "H2O, CH4, NH3, H2O" and "Lightning".In the center of the diagram, there is a red circle with a blue wave-like pattern, representing a light source. On the bottom left corner, there are two purple pipes, one of which is connected with apurple pipes, one of which is connected with a purple pipe. The red circle represents the light source, while the blue circle represents a blue sphere.The diagram appears to be a representation of the process of electrical spark lightning, which is a type of lightning that is used to generate electricity from a source of light.Miller – Urey experiment proved the Oparin-Haldane chemical origin of life

Step1

* Free atoms of C, H, O, N

* Abiotic synthesis of monomers from simple inorganic gases like H_2, CH_4, NH_3 and H_2O.• Monomers included amino acids, purines, pyrimidines, monosaccharides, fatty acids and glycerol

Step2

* Monomers combine to form polymers

* Proteins, nucleic acids, lipids and polysaccharides

Step3Step3

* Formation of coacervates

* Biomolecules surrounded by a lipid membrane

Step4

* Origin of nucleic acid and protein controlled metabolism inside a lipid membrane

* Protocells or protobiontsWhich came first – DNA or Protein?

Figure 1-36, A Possible RNA scenario world

First cell probably used inorganic fuels produced by chemosynthesis for ATP generation: $FeS + H_2S$ ---✉$FeS_2 + H_2$generation: $FeS + H_2S$ ---✉$FeS_2 + H_2$

Figure 1-37, Landmarks in the evolution of life on earth

Lehninger, Principles

of Biochemistry, 6th Ed

Development of life stages on earth:

•Development of life stages on earth:

•

Chemical evolution: geological molecules to complex organic polymers

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Acquisition of replicative ability:

transition from lifeless chemicallytransition from lifeless chemically

interacting entities to self replicating

systems

•

Biological evolution: eukaryotes,

multicellularity, plants and animals,

metabolic evolutionImage 1:

Caption:

The image is a flowchart that explains the process of DNA replication. It is divided into six sections, each representing a different step in the process.The first section is titled "Prebiotic formation of simple compounds, including nucleotides, from components of Earth's primitive atmosphere or gases in undersea volcanic vents". The second sectionin undersea volcanic vents". The second section is labeled "Production of short RNA molecules with random sequences". The third section is "Selective replication of self-duplicating catalytic RNAreplication of self-duplicating catalytic RNA segments". The fourth section is labelled "Synthesis of specific peptides, catalyzed by RNA". The fifth section is described as "Increasing role offifth section is described as "Increasing role of peptides in RNA replication, coevolution of RNA and protein". The sixth section is called "Primitive translation system develops, with RNA genome andtranslation system develops, with RNA genome and RNA-protein catalysts".At the bottom of the flowchart, there is a label that reads "Genomic RNA begins to be copied into DNA". This indicates that the process is related to DNA genome translation and protein catalysts.Image 2:

Caption:The image is a table that shows the different types of eukaryotes and their properties. The table is divided into two columns, with the left column representing the number of different species ofrepresenting the number of different species of organisms and the right column representing their characteristics.The first column is labeled "Diversification of multicellular eukariesotes (plants, fungi, animals)". The second column is titled "Appearance of red and green algae" and lists the characteristics ofand green algae" and lists the characteristics of the species. The characteristics include:1,500, 2,000, and 3,000. The appearance of protists, the first euaryotes, and the development of O2-rich atmosphere

There are also three types of photosynthetic O2 producing cyanobacteriaAt the bottom of the table, there is a section titled "Formation of oceans and continents" which provides further information about the formation of Earth.Figure 1-38, Evolution of eukaryotes through endosymbiosis

Lehninger, Principles of Biochemistry, 6th Ed

Evolution of eukaryotes through endosymbiosis

•Evolution of eukaryotes through endosymbiosis

•

Few aerobic bacteria evolved into mitochondria of modern eukaryotes

••

Photosynthetic cyanobacteria became plastids, chloroplasts of green algae, the ancestors of modern plant cells.Image 1:

Caption:

The image is a diagram that shows the different types of chromosomes and their functions. It is divided into four sections, each representing a different type of chromosome.The first section on the left shows an anaerobic metabolism, which is a type of bacteria that is responsible for the formation of nuclei and nuclei. The nuclei are responsible for storing nuclei inThe nuclei are responsible for storing nuclei in the nucleus of the cell. The nucleus is then released into the cell, which then releases nuclei into the mitochondria. The mitochondria is theninto the mitochondria. The mitochondria is then converted into a nuclei, which helps to store and transport the nuclei to the nucleus. The image also shows the mitochondrion, which acts as a catalystshows the mitochondrion, which acts as a catalyst for the cell's growth and development.In the center of the image, there are four chromosomes, each with a different color - blue, green, and white. These chromosomes are arranged in a circular pattern, representing the different stagespattern, representing the different stages of the cycle. The blue chromosomes represent the nucleis, while the green chromosomes represent photosynthetic chromosomes. The white chromosomes representchromosomes. The white chromosomes represent chloroplast, which are the cells that make up the cell membrane. The diagram also includes text that explains the process of photosynthesis and howexplains the process of photosynthesis and how photosynthesis can be used to convert photosynthesis into photosynthesis