Unit 1 - How is life Organized:

Cells:

1. **All living things are made of cells**: Just like how a building is made of bricks, living things are made of cells. Whether it's a tiny bacterium or a giant oak tree, they're all made up of these tiny building blocks called cells.
2. **Cells are like the little workers of life**: Think of cells as tiny factories inside living things. They're the ones doing all the jobs needed to keep living things alive and working. From making energy to repairing damaged parts, cells are the ones getting things done.
3. **New cells come from existing cells**: Imagine if you had a LEGO set, and every time you needed a new LEGO piece, it magically appeared by splitting one of the existing pieces into two. That's kind of how cells work. Instead of popping up out of nowhere, new cells are made by splitting from existing ones.

So, in simple terms, cell theory tells us that everything alive is made of cells, cells do all the important jobs to keep living things going, and new cells come from existing ones. It's like the rulebook for how life is put together!

Key characteristics of all Living beings:

1. **Movement**: Living things can move on their own, whether it's a cheetah sprinting across the savannah or a plant turning its leaves towards the

sunlight. Movement can be big, like running, or small, like cells moving around inside our bodies.

2. **Respiration**: Living things need energy to do stuff, just like you need food to keep going. Respiration is how living things get that energy. They take in oxygen (usually from the air) and use it to break down food molecules to release energy.
3. **Sensitivity**: Living things can respond to changes in their environment. For example, if you touch a hot stove, you quickly pull your hand away. Plants do this too, like when they grow towards the light or close their leaves when touched.
4. **Growth**: Living things grow and develop over time. From a tiny seed growing into a giant tree to a baby growing into an adult, growth is a key characteristic of life. It's not just about getting bigger, but also about changing and developing.
5. **Reproduction**: Living things can make more of themselves. This can happen in different ways, like animals having babies or plants producing seeds. Reproduction ensures that life continues from one generation to the next.
6. **Excretion**: Living things produce waste as they go about their lives. Excretion is the process of getting rid of this waste to keep the body healthy. Animals do this through urine and feces, while plants often release waste gases through tiny openings in their leaves.
7. **Nutrition**: Living things need food to survive. Nutrition is the process of obtaining and using food. Animals eat other living things or organic matter, while plants make their food through photosynthesis using sunlight, water, and carbon dioxide.

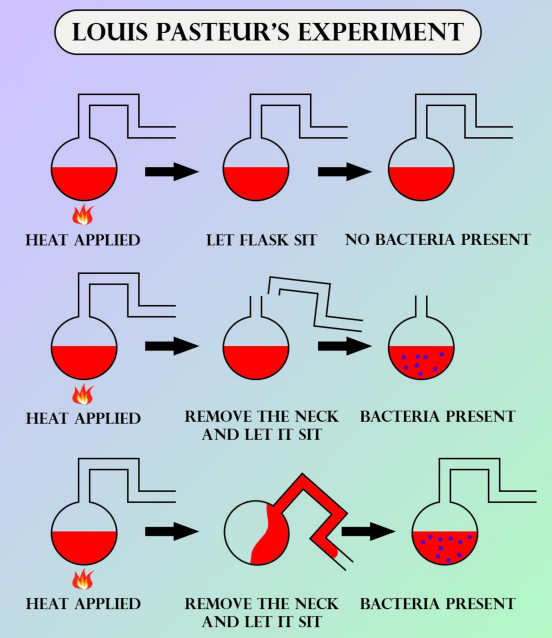
Special Cases:

1. **Viruses**: Not considered living beings. They can't replicate on their own and need a host cell to reproduce.
2. **Fungi**: Living beings as they exhibit all seven characteristics. They can grow, reproduce, and respond to their environment. They get their nutrients by

absorbing organic matter.

3. **Bacteria**: Also living beings since they exhibit all 7 characteristics. Single-celled microorganisms that can grow, reproduce, and adapt to different environments. They play important roles in ecosystems.

Pasteur's Experiment:



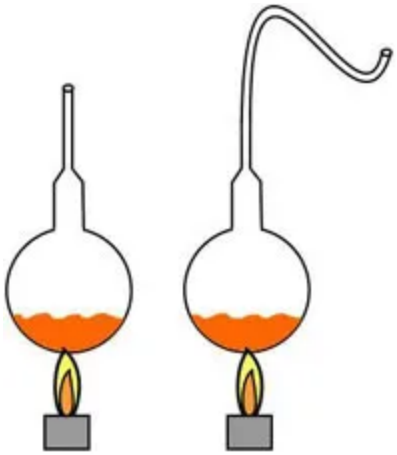
For a simple video explanation: https://rb.gy/tr0cgl

The steps of Pasteur's experiment are outlined below:

First, Pasteur prepared a nutrient broth similar to the broth one would use in soup.

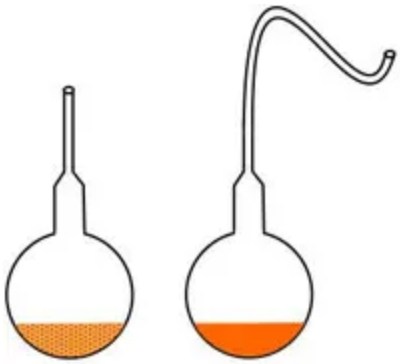
Next, he placed equal amounts of the broth into two long-necked flasks. He left one flask with a straight neck. The other he bent to form an "S" shape.

Then he boiled the broth in each flask to kill any living matter in the liquid. The sterile broths were then left to sit, at room temperature and exposed to the air, in their open-mouthed flasks. The broth in both flasks is boiled.



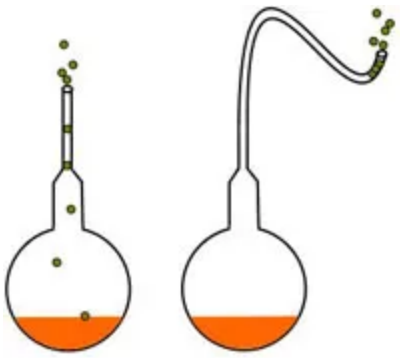
After several weeks, Pasteur observed that the broth in the straight-neck flask was discolored and cloudy, while the broth in the curved-neck flask had not changed.

The broth in the straight-neck flask becomes discolored.



He concluded that germs in the air were able to fall unobstructed down the straight-necked flask and contaminate the broth. The other flask, however, trapped germs in its curved neck, preventing them from reaching the broth, which never changed color or became cloudy.

Conclusion: germs come from other germs and do not spontaneously generate.

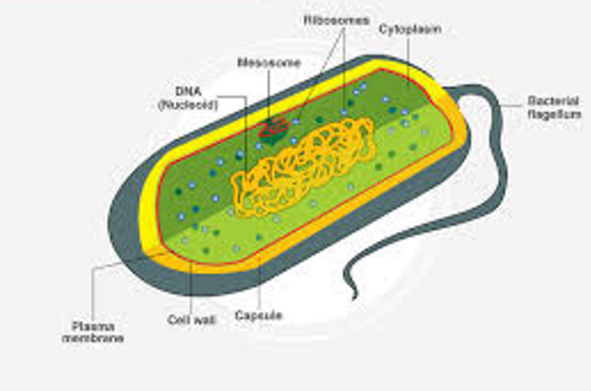


If spontaneous generation had been a real phenomenon, Pasteur argued, the broth in the curved-neck flask would have eventually become reinfected because the germs would have spontaneously generated. But the curved-neck flask never became infected, indicating that the germs could only come from other germs.

> Credit : https://science.howstuffworks.com/innovation/scientific-experiments/scientific-method5.htm

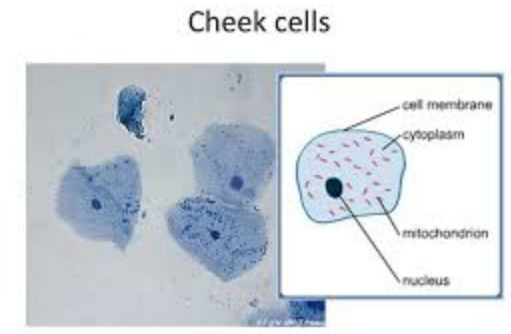
Types of Cells :

	Prokaryotic Cell	Eukaryotic Cell
Type of Cell	Always unicellular	Unicellular and multi-cellular
Cell size	Ranges in size from 0.2 µm – 2.0 µm in diameter	Size ranges from 10 µm – 100 µm in diameter
Cell wall	Usually present; chemically complex in nature	When present, chemically simple in nature
Nucleus	Absent. Instead, they have a nucleoid region in the cell	Present
Cell division	Through binary fission	Through mitosis
Reproduction	Asexual	Both asexual and sexual
Example	Bacteria and Archaea	Plant and Animal cell



Cells Under Microscopes:

Human Cheek cells:



Materials

- Glass microscope slides
- Plastic cover slips
- Paper towels or tissue
- Methylene Blue solution (0.5% to 1% (mix approximately 1 part stock solution with 4 parts of water))

- Plastic pipette or dropper
- Sterile, individually packed cotton swabs

See information on suppliers here.

Methods

1. Take a clean cotton swab and gently scrape the inside of your mouth.
2. Smear the cotton swab on the center of the microscope slide for 2 to 3 seconds.
3. Add a drop of methylene blue solution and place a coverslip on top. Concentrated methylene blue is toxic if ingested. Wear gloves and do NOT allow children to handle methylene blue solution or have access to the bottle of solution.
4. Remove any excess solution by allowing a paper towel to touch one side of the coverslip.
5. Place the slide on the microscope, with 4 x or 10 x objective in position and find a cell. Then view at higher magnification.

Onion Cells:

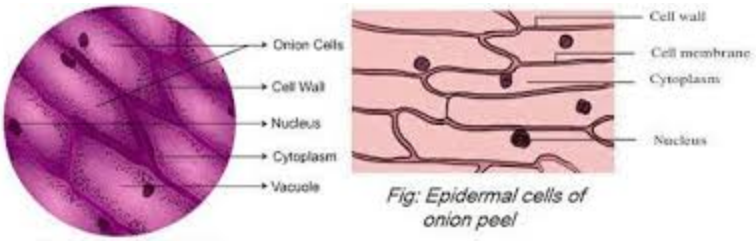


Fig: Onion Peel Cell

Fig: Epidermal cells of onion peel

Material required:

Onion, forceps, watch
glass, water, dropper, iodine solution, cover slip, filter paper, and microscope.

Procedure :

1. Remove a fleshy leaf from the onion bulb.

2. Strip a thin layer with forceps.
3. Place a piece of it in a drop of water on a clean side.
4. *W*ith a dropper, add a drop of iodine to it.
5. Gently cover with a cover slip.
6. Use a piece of filter paper to remove excess liquid from the slide. This type of slide is known as wet mount.
7. Place the slide on the microscope and observe.

Cells Organelles:

1. **Mitochondria**: Organelles responsible for generating energy in the form of ATP through cellular respiration. Often called the powerhouse of the cell.
2. **Nucleus**: The central organelle that houses the cell's genetic material (DNA) and controls cellular activities such as growth, metabolism, and reproduction.
3. **Ribosomes**: Cellular structures responsible for protein synthesis. They translate genetic information from the nucleus into proteins.
4. **Vacuoles**: Membrane-bound organelles responsible for storage, waste disposal, and maintaining turgor pressure in plant cells.
5. **Cell wall**: A rigid structure surrounding the cell membrane of plant cells, fungi, and some bacteria. It provides structural support and protection.
6. **Cytoplasm**: The gel-like substance filling the cell, where organelles are suspended. It contains various molecules necessary for cellular processes.
7. **Plasma membrane**: A phospholipid bilayer that surrounds the cell, regulating the passage of substances in and out of the cell and maintaining cell integrity.
8. **Pili**: Short, hair-like structures on the surface of some bacteria used for attachment to surfaces or other cells, as well as for conjugation (the transfer of genetic material).
9. **Flagella**: Whip-like appendages that protrude from certain cells, enabling movement. They propel the cell through their whip-like motion.

10. **Nucleoid**: The region within a prokaryotic cell (like bacteria) where the DNA is located. It's not enclosed by a membrane as in the nucleus of eukaryotic cells.
11. **Chloroplast**: Organelles found in plant cells and some protists, responsible for photosynthesis, converting light energy into chemical energy in the form of glucose. They contain chlorophyll, giving them their green color.

Differences between Plant and Animal Cells:

Point of comparison	Plant cell	Animal cell
Location	They make up the body of the plants and algae.	They make up the body of the animals.
Shape	They are roughly rectangular or cuboid in shape.	They can be branched-like neurons, cuboid-like glandular cells, flat-like squamous epithelial cells, spindle-like muscle cells, etc.
Inter-cellular spaces	The inter-cellular spaces are less or absent.	The inter-cellular spaces are more, compared to the plant cells.
Cell wall	Cellulose cell wall is present.	The cell wall is absent.
Vacuole	There is one large vacuole that maintains the shape and turgidity of the cell.	There are several small vacuoles.
Plastids	Plastids are present. Chlorophyll-containing green plastids called chloroplasts are also present.	Plastids and chloroplasts are altogether absent.
Centrosomes	Centrosomes and centrioles are absent.	Centrosomes containing two units of centrioles are present.
Nucleus position	The nucleus is generally situated at the periphery due to the presence of a large vacuole.	The nucleus is generally present at the center of the cell.
Cell division	The cell division does not involves the polar centrioles for the formation of spindle fribres and the cytokinesis takes place	Cell division takes place by the formation of the spindle fibers from the polar centrioles and cytokinesis takes place by the formation of

	by the formation of cell plates from middle to the periphery.	membrane furrow from the periphery towards centre of the dividing cell.

Organs:

Systems:

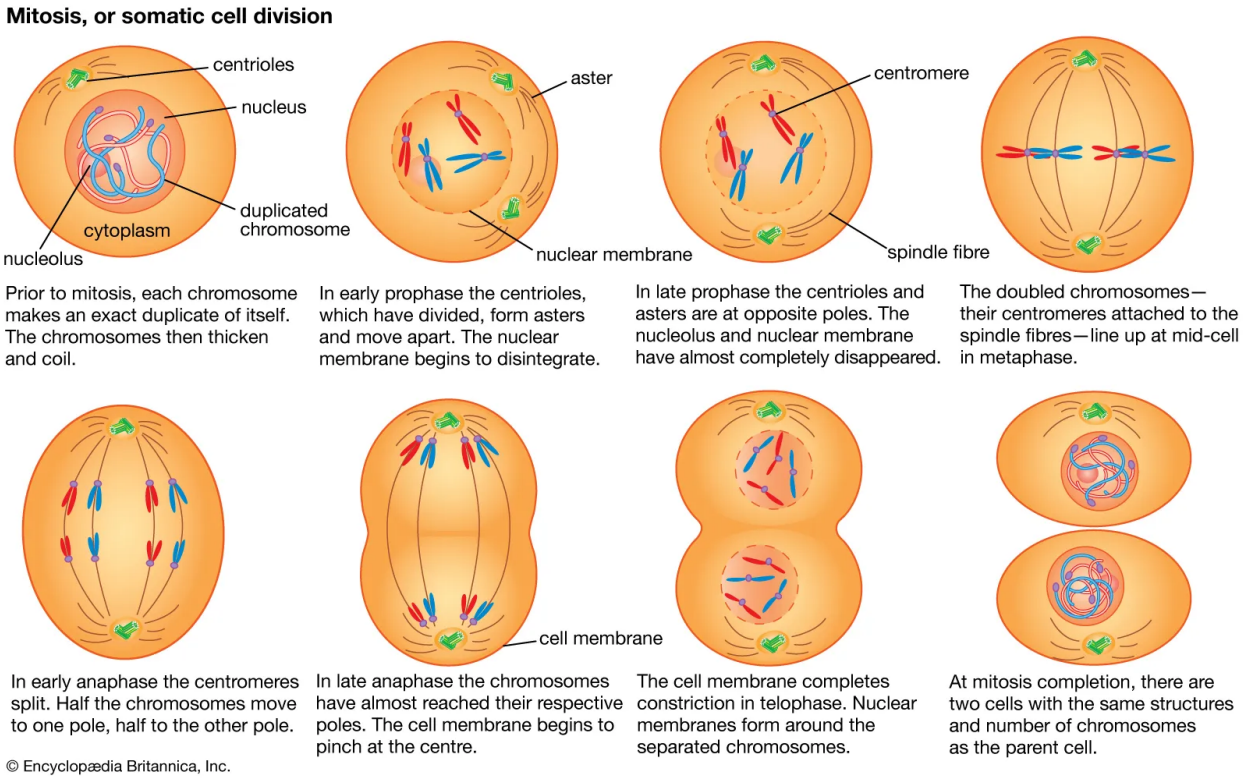
Components/Key Terms:

1. **Embryonic stem cells**: These are pluripotent cells derived from the inner cell mass of a blastocyst, an early-stage embryo. Embryonic stem cells have the ability to differentiate into any cell type in the body, making them valuable for research and potential medical applications.
2. **Hierarchy**: Hierarchy refers to a system or organization in which individuals or components are ranked or arranged according to their relative importance, authority, or level.
3. **Multicellular**: Multicellular organisms are composed of more than one cell. These cells often organize into tissues, organs, and organ systems, allowing for specialized functions and greater complexity compared to unicellular organisms.
4. **Organization**: Organization refers to the arrangement or structure of parts within a system. In biology, it often refers to the structural arrangement of cells, tissues, organs, and organ systems within multicellular organisms.
5. **Unicellular**: Unicellular organisms are composed of a single cell. Despite their simplicity, unicellular organisms can carry out all necessary life functions within this single cell.
6. **Physical differentiation**: Physical differentiation refers to the process by which cells become specialized in structure and function during development. This specialization allows cells to perform specific tasks within a multicellular organism.

Relationship between these terms:

Embryonic stem cells represent the earliest stage of cellular differentiation in multicellular organisms. They have the potential to give rise to all cell types in the body, making them the most undifferentiated cells in the hierarchy of cellular differentiation. As development progresses, embryonic stem cells undergo physical differentiation, where they become specialized into various cell types with specific functions. This process of differentiation contributes to the organization of cells into tissues, organs, and organ systems within multicellular organisms. In contrast, unicellular organisms do not undergo physical differentiation to the same extent since they consist of only one cell, which must perform all necessary functions for survival. Thus, the relationship between these terms highlights the importance of cellular differentiation and organization in the development and function of multicellular organisms.

Life Cycle of a Cell:



Specialized Cells:

1. **Neurons (Nerve Cells)**:
    - Neurons are specialized cells of the nervous system responsible for transmitting electrical impulses.
    - Structure: Neurons have a cell body (soma), dendrites (which receive signals from other neurons), and an axon (which transmits signals away from the cell body).
    - Function: Neurons function in transmitting signals throughout the nervous system, allowing for communication between different parts of the body, sensory perception, and motor control.
    - Difference: Neurons are uniquely adapted for rapid signal transmission over long distances. Their elongated structure and ability to generate and propagate electrical impulses enable them to communicate quickly between different parts of the body, facilitating complex processes such as thought, sensation, and movement.
2. **Red Blood Cells (Erythrocytes)**:
    - Red blood cells are specialized cells found in the bloodstream responsible for transporting oxygen from the lungs to tissues throughout the body.
    - Structure: Red blood cells lack a nucleus and most organelles, maximizing space for hemoglobin, a protein that binds and transports oxygen.
    - Function: Red blood cells function primarily in oxygen transport. They pick up oxygen in the lungs and release it to tissues throughout the body, while also transporting carbon dioxide back to the lungs for exhalation.
    - Difference: Red blood cells are specialized for oxygen transport. Their biconcave shape increases surface area for gas exchange, and their lack of a nucleus allows for more space to carry hemoglobin. This specialization enables them to efficiently transport oxygen to tissues and maintain proper oxygen levels in the body.
3. **Muscle Cells (Myocytes)**:
    - Muscle cells are specialized cells responsible for generating force and movement in the body.

- Structure: Muscle cells contain specialized proteins (actin and myosin) arranged in repeating units called sarcomeres, which contract and relax to produce muscle movement.
- Function: Muscle cells contract in response to electrical signals from neurons, generating force that allows for movement of body parts, including voluntary movements (skeletal muscle), involuntary movements (smooth muscle), and rhythmic contractions (cardiac muscle).
- Difference: Muscle cells are specialized for generating force and movement. Their unique structure and ability to contract efficiently enable them to perform various types of movement, including voluntary actions such as walking and running, involuntary actions such as digestion and breathing, and rhythmic contractions such as heartbeat.

Different Organ System:

Video: https://www.youtube.com/watch?v=cQlU0yJ8RBg

1. **Circulatory System**:
    - Function: Transport oxygen, nutrients, hormones, and waste products throughout the body.
    - Components: Heart, blood vessels (arteries, veins, capillaries), and blood.
2. **Respiratory System**:
    - Function: Facilitate the exchange of oxygen and carbon dioxide between the body and the environment.
    - Components: Lungs, trachea, bronchi, bronchioles, and diaphragm.
3. **Digestive System**:
    - Function: Break down food into nutrients for absorption and eliminate waste.
    - Components: Mouth, esophagus, stomach, small intestine, large intestine, liver, pancreas, and gallbladder.

4. **Nervous System**:
    - Function: Control body activities through electrical impulses and neurotransmitters.
    - Components: Brain, spinal cord, nerves, and sensory organs (eyes, ears, etc.).
5. **Muscular System**:
    - Function: Enable movement, support the body, and generate heat.
    - Components: Skeletal muscles, smooth muscles, and cardiac muscle.

These five organ systems work together to maintain bodily functions, support survival, and adapt to environmental changes.

Organization of life:

1. **Organisms**: These are individual living things, like plants, animals, and humans.

2.
Organ Systems: Inside organisms, there are organ systems that work together to keep them alive and healthy. For example, in humans, the digestive system helps break down food, while the nervous system helps us think and move.

3.
Organs: Organs are specific parts of the body that do special jobs. For example, the heart pumps blood, and the brain controls thoughts and actions.

4.
Tissues: Organs are made up of tissues, which are groups of similar cells working together to perform a specific function. For example, muscle tissue helps with movement, and nerve tissue sends messages around the body.

5.

Cells: Cells are the smallest units of life. They are the building blocks of organisms and come in many different types, each with its specific job. For example, muscle cells contract to move, and nerve cells transmit signals for communication.

Classification:

Classification is sorting things into groups based on similarities. It helps us understand relationships and organize information. In biology, it's especially useful for grouping living things based on shared characteristics, like species of animals or plants.

Kingdoms and Characteristics:

1. **Animalia (Animals)**:
    - **Characteristics**: Multicellular, heterotrophic (they eat other organisms for food), and most can move from place to place.
    - **Examples**: Dogs, cats, birds, insects, and humans.
2. **Plantae (Plants)**:
    - **Characteristics**: Multicellular, autotrophic (they make their own food through photosynthesis), and usually stationary (they don't move around).
    - **Examples**: Trees, flowers, grasses, ferns, and mosses.
3. **Fungi**:
    - **Characteristics**: Mostly multicellular (some are unicellular like yeast), heterotrophic (they absorb nutrients from dead or decaying matter), and typically have cell walls made of chitin.
    - **Examples**: Mushrooms, molds, yeasts, and mildews.
4. **Protista (Protists)**:

- **Characteristics**: Mostly unicellular (though some are multicellular), diverse in structure and function, and many live in water.
- **Examples**: Amoebas, algae, protozoa, and slime molds.

5. **Monera (Bacteria and Archaea)**:
    - **Characteristics**: Mostly unicellular (though some form colonies), prokaryotic (lacking a true nucleus and membrane-bound organelles), and extremely diverse in habitat and function.
    - **Examples**: Bacteria, cyanobacteria (blue-green algae), and archaea.

Structures:

Analogous Structures:

- Analogous structures are features of different organisms that have similar functions but different origins.
- They arise from convergent evolution, where unrelated species evolve similar traits due to similar environmental pressures.
- Analogous structures do not share a common evolutionary origin or developmental pathway.
- Example: The wings of birds and insects. They both serve the function of flight, but they evolved independently in each group.

Homologous Structures:

- Homologous structures are features that are similar in different organisms because they are inherited from a common ancestor.
- They may have different functions in different organisms, but they share a similar underlying structure.
- Homologous structures provide evidence of common ancestry and divergent evolution.
- Example: The forelimbs of mammals (like humans, cats, and bats). Despite having different functions (walking, grasping, flying), they

share a common bone structure, indicating a shared evolutionary origin.

In summary, analogous structures have similar functions but different evolutionary origins, while homologous structures have similar structures and may have different functions but share a common evolutionary origin.

Binomial Nomenclature and Naming of Animals:

1. **Binomial Nomenclature**:
    - Every species is given a unique two-part scientific name, also known as a binomial.
    - The first part of the name is the genus, which represents a group of closely related species.
    - The second part is the species epithet, which is unique to each species within the genus.
2. **Example**:
    - Let's take the domestic dog as an example. Its scientific name is Canis lupus familiaris.
    - "Canis" is the genus, representing a group of carnivorous mammals including wolves, coyotes, and domestic dogs.
    - "Lupus" is the species epithet, specifically referring to the wolf species.
    - "Familiaris" indicates that it's the domesticated form of the species.
3. **Rules**:
    - Scientific names are typically written in Latin or Latinized forms.
    - The genus name is always capitalized, while the species epithet is lowercase.
    - The entire scientific name is italicized when typed or underlined when handwritten.

4. **Importance**:
    - Using scientific names helps scientists communicate accurately about species without confusion, as common names can vary between regions and languages.
    - It also reflects the evolutionary relationships between species, as closely related species are grouped within the same genus.

In summary, biological nomenclature provides a standardized way to name and classify organisms, ensuring clarity and accuracy in scientific communication.

Hierarchy of Life and Characteristics:

1. **Kingdom**: Represents the highest level of classification, grouping organisms into broad categories based on shared characteristics.
2. **Phylum (plural: Phyla)**: Subdivides each kingdom into smaller groups based on more specific characteristics.
3. **Class**: Further subdivides each phylum into smaller groups based on shared characteristics.
4. **Order**: Divide each class into smaller groups based on similarities in anatomy, behavior, or other characteristics.
5. **Family**: Further divides each order into smaller groups based on similarities in anatomy, behavior, or genetic relationships.
6. **Genus (plural: Genera)**: Groups closely related species together based on shared ancestry and common characteristics.
7. **Species**: Represents the smallest and most specific level of classification, referring to a group of organisms capable of interbreeding and producing fertile offspring.

So, the complete hierarchy of life from broadest to most specific is: Kingdom > Phylum > Class > Order > Family > Genus > Species. Each level becomes increasingly specific and represents a deeper level of classification.

Artificial Life:

Video: https://www.youtube.com/watch?v=jYC7ECDA1jk

Creating artificial life involves designing synthetic biological systems or computational models that mimic living organisms. Synthetic biology manipulates DNA to engineer desired functions or behaviors, potentially leading to the creation of artificial cells or organisms. Computer simulations create virtual environments for studying evolutionary processes and complex behaviors.

Challenges include understanding complex biological processes, engineering functional components, and addressing ethical concerns like biosecurity risks and the ethical implications of playing "creator."

Applications include biotechnology for drug development, biofuel production, and materials engineering. Artificial life research also contributes to understanding the origin of life and evolutionary processes.

Future prospects include the development of synthetic organisms for medical, environmental, and industrial applications. However, ethical and safety considerations remain paramount.