

A blue-toned background featuring a stethoscope and several white pills. Overlaid on this are various medical and scientific icons, including a heart, a brain, and a DNA helix. A semi-transparent anatomical diagram of a human torso is visible in the upper right, with labels for 'Inferior vena cava' and 'Right ventricle'.

Biology

Prokaryotes and Eukaryotes

A colorful background of molecular structures. It features a central horizontal chain of spheres in red, orange, yellow, and green, connected by thin lines. To the left and right are smaller, more complex molecular models with spheres in blue, pink, and green. The background is light green with faint white circles.

Assis. Prof. Dr. Labeed Al - Saad

Objectives

- Introduction to Cell Biology.
- Prokaryotic Cells.
- Eukaryotic Cells.
- Comparison between Prokaryotes and Eukaryotes.
- Prokaryotes in Health and Disease.
- Eukaryotes in Health and Disease.
- Prokaryotes and Eukaryotes in Medical Biotechnology.
- Current Research and Advances in Prokaryotic and Eukaryotic Biology.

Introduction to Cell Biology - Basic concepts in cell biology

- **Cell:** The cell is the basic structural and functional unit of all living organisms. It is the smallest unit of life and is capable of carrying out all the functions necessary for survival. Cells can be prokaryotic or eukaryotic, and they vary in size, shape, and function.
- **Cell Theory:** The cell theory states that all living organisms are composed of one or more cells, and that the cell is the basic unit of structure and function in all living things. **This theory was formulated by scientists Schleiden, Schwann, and Virchow in the 19th century.**

Introduction to Cell Biology - Basic concepts in cell biology

- **Prokaryotic and Eukaryotic Cells:** Prokaryotic cells are simple, single-celled organisms that lack a distinct nucleus and membrane-bound organelles. They are found in bacteria and archaea. Eukaryotic cells, on the other hand, are more complex, containing a distinct nucleus and membrane-bound organelles. They are found in plants, animals, fungi, and protists.

Introduction to Cell Biology - Basic concepts in cell biology

- **Cell Membrane:** The cell membrane, also known as the plasma membrane, is a semi-permeable barrier that surrounds the cell. It regulates the passage of substances in and out of the cell and plays a crucial role in maintaining the cell's internal environment.
- **Organelles:** Organelles are specialized structures within the cell that carry out specific functions. Examples of organelles include the nucleus, endoplasmic reticulum, Golgi apparatus, mitochondria, chloroplasts (in plant cells), lysosomes, and peroxisomes.

Introduction to Cell Biology - Basic concepts in cell biology

- **DNA:** DNA, or deoxyribonucleic acid, is the genetic material of the cell. It contains the instructions for building and maintaining the cell and is passed on from one generation to the next. DNA is located in the nucleus of eukaryotic cells and in the nucleoid region of prokaryotic cells.
- **Cell Division:** Cell division is the process by which a cell divides into two daughter cells. This process is essential for growth, repair, and reproduction. In eukaryotic cells, cell division occurs through mitosis and meiosis.

Introduction to Cell Biology - Basic concepts in cell biology

- **Cellular Metabolism:** Cells carry out various metabolic processes to obtain energy and build molecules necessary for their survival. These processes include cellular respiration, photosynthesis (in plants and algae), and other biochemical reactions.
- **Cell Communication:** Cells communicate with each other through chemical signals, allowing them to coordinate their activities and respond to changes in their environment. This communication can occur through direct contact or through the release and reception of signaling molecules.

Prokaryotic Cells

Prokaryotes are simple, unicellular organisms that lack a nucleus and other membrane-bound organelles. They are found in the domains Bacteria and Archaea.

The characteristics of prokaryotic cells:

- Lack of nucleus: Prokaryotic cells lack a true nucleus and have free-floating genetic material instead
- Small size: Prokaryotic cells are typically smaller in size, ranging from 0.1–5.0 μm in diameter.
- Nucleoid region: Prokaryotic DNA is found in a central part of the cell called the nucleoid.

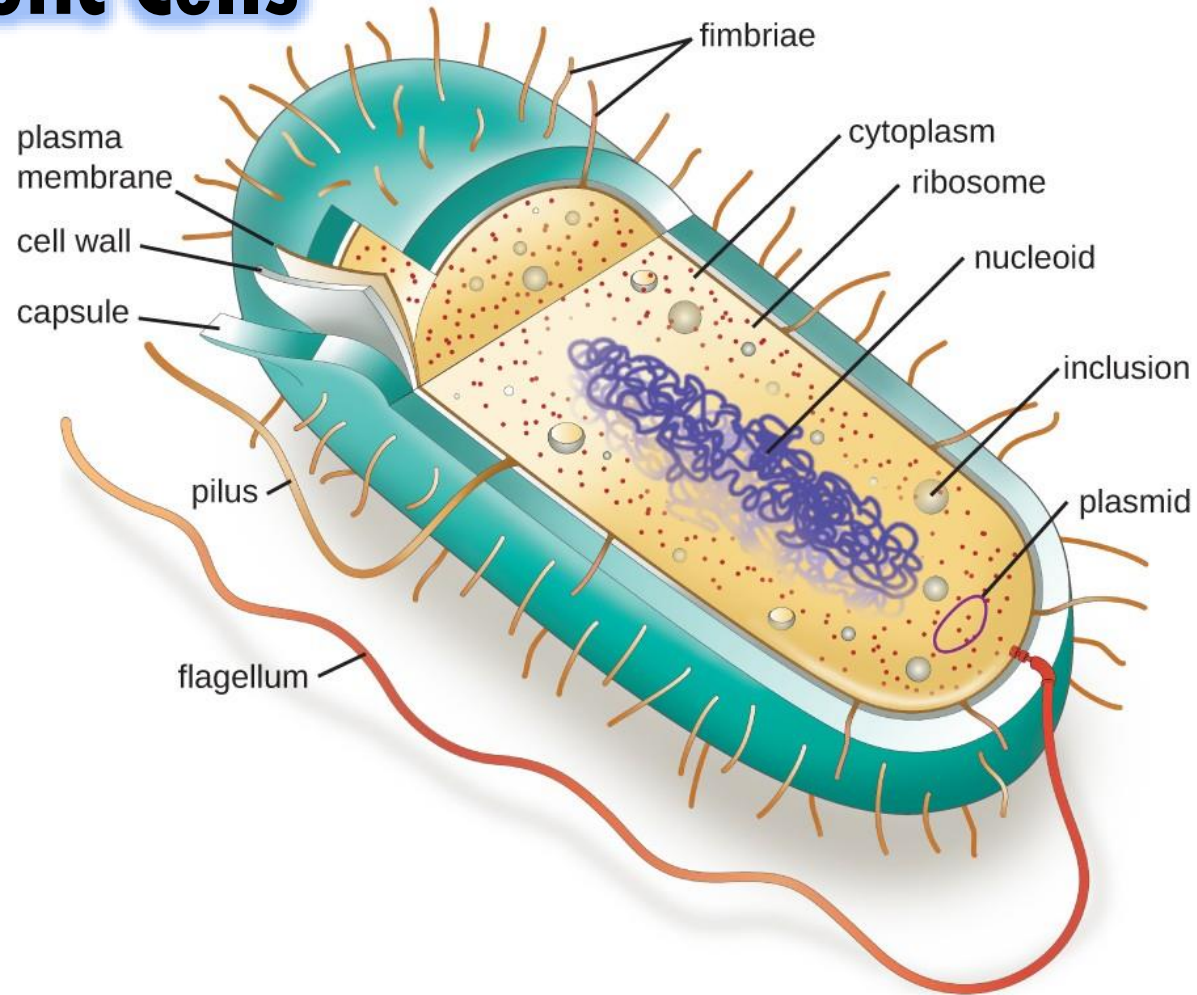
Prokaryotic Cells

- Cell wall: Most prokaryotes have a peptidoglycan cell wall and many have a polysaccharide capsule. The cell wall acts as an extra layer of protection, helps the cell maintain its shape, and prevents dehydration.
- Lack of Membrane-Bound Organelles: Prokaryotic cells lack membrane-bound organelles such as mitochondria, endoplasmic reticulum, and Golgi apparatus, which are present in eukaryotic cells. However, they may have other specialized structures, such as ribosomes, flagella, and pili.
- Asexual reproduction: Prokaryotic cells divide asexually by binary fission.

Prokaryotic Cells

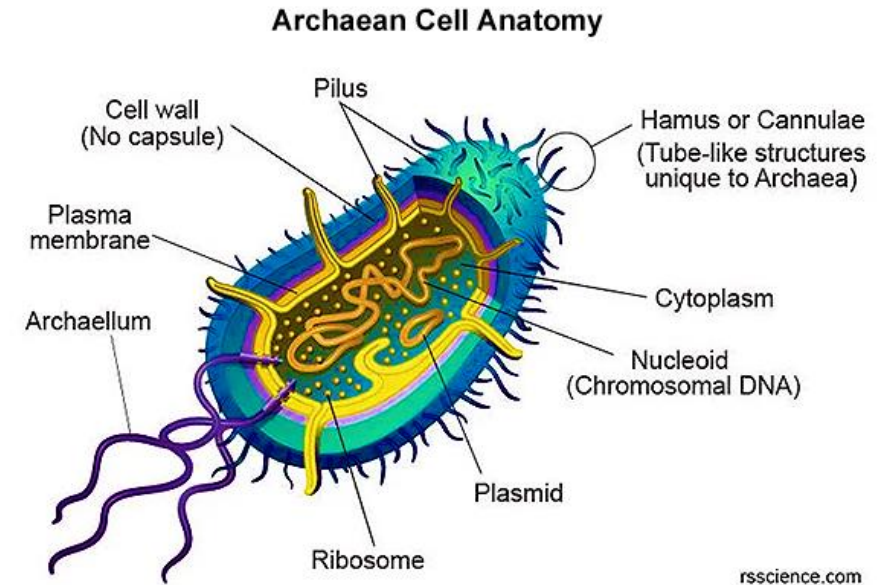
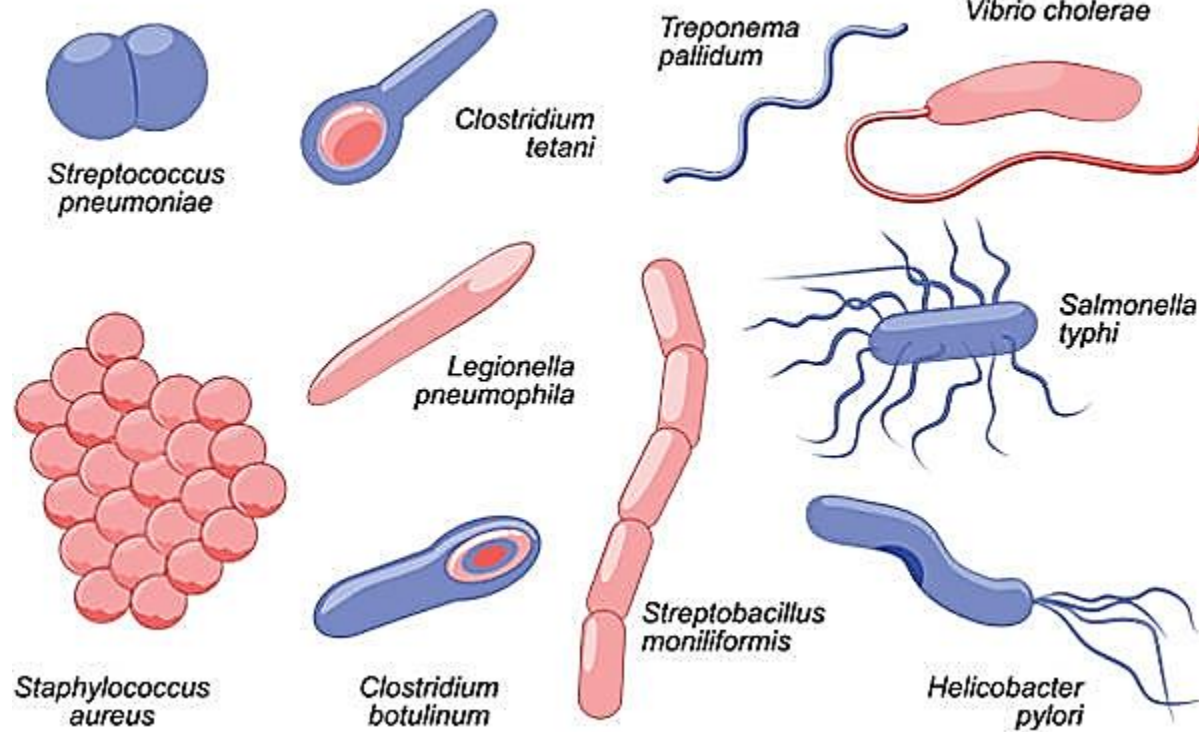
- **Metabolism:** Prokaryotic cells exhibit diverse metabolic capabilities. They can be aerobic (requiring oxygen), anaerobic (not requiring oxygen), or facultative anaerobes (capable of surviving in the presence or absence of oxygen). Prokaryotes play vital roles in various biogeochemical cycles due to their metabolic diversity.
- **Genetic Variation:** Prokaryotic cells exhibit high genetic diversity due to their ability to quickly adapt to changing environmental conditions. This genetic variation contributes to their ability to thrive in a wide range of habitats.

Prokaryotic Cells



<https://open.oregonstate.edu/app/uploads/sites/8/2019/06/fig-2.12.png>

Examples of Prokaryotic Cells



Archaea and Bacteria are two kinds of microorganisms that fall under the category of prokaryotes. Earlier, archaea were classified as bacteria, but now it is outdated as it has been found that they both have different biochemistry and different evolutionary history.

Archea is a domain of living organisms containing unicellular prokaryotic organisms. Cell wall in arechea is made up of Pseudopeptidoglycan, whereas in bacteria, it is made up of either Lipopolysaccharide or Peptidoglycan.

Prokaryotic Cells

These prokaryotes characteristics are fundamental to understanding the biology and ecology of bacteria and archaea. Prokaryotes are essential components of ecosystems and have significant impacts on human health, industry, and the environment.

<https://open.oregonstate.edu/app/uploads/sites/8/2019/06/Fig-2.12.png>

Eukaryotic Cells

Eukaryotes are organisms whose cells contain a true nucleus and membrane-bound organelles. They are more complex than prokaryotic cells and are found in various forms, including single-celled protists, multicellular plants, animals, and fungi. Some of the key characteristics of eukaryotic cells include:

- **Nucleus:** Eukaryotic cells have a distinct nucleus that houses the cell's genetic material (DNA). The nucleus is enclosed by a double membrane and contains the genetic material organized into linear chromosomes.

Eukaryotic Cells

- **Membrane-Bound Organelles:** Eukaryotic cells contain various membrane-bound organelles such as mitochondria, endoplasmic reticulum, Golgi apparatus, lysosomes, and chloroplasts (in plant cells). These organelles perform specialized functions within the cell.
- **Cytoplasm:** Eukaryotic cells have a complex internal structure, with a cytoplasm that contains various organelles and structures, including the cytoskeleton, which provides structural support and is involved in cell movement and division.

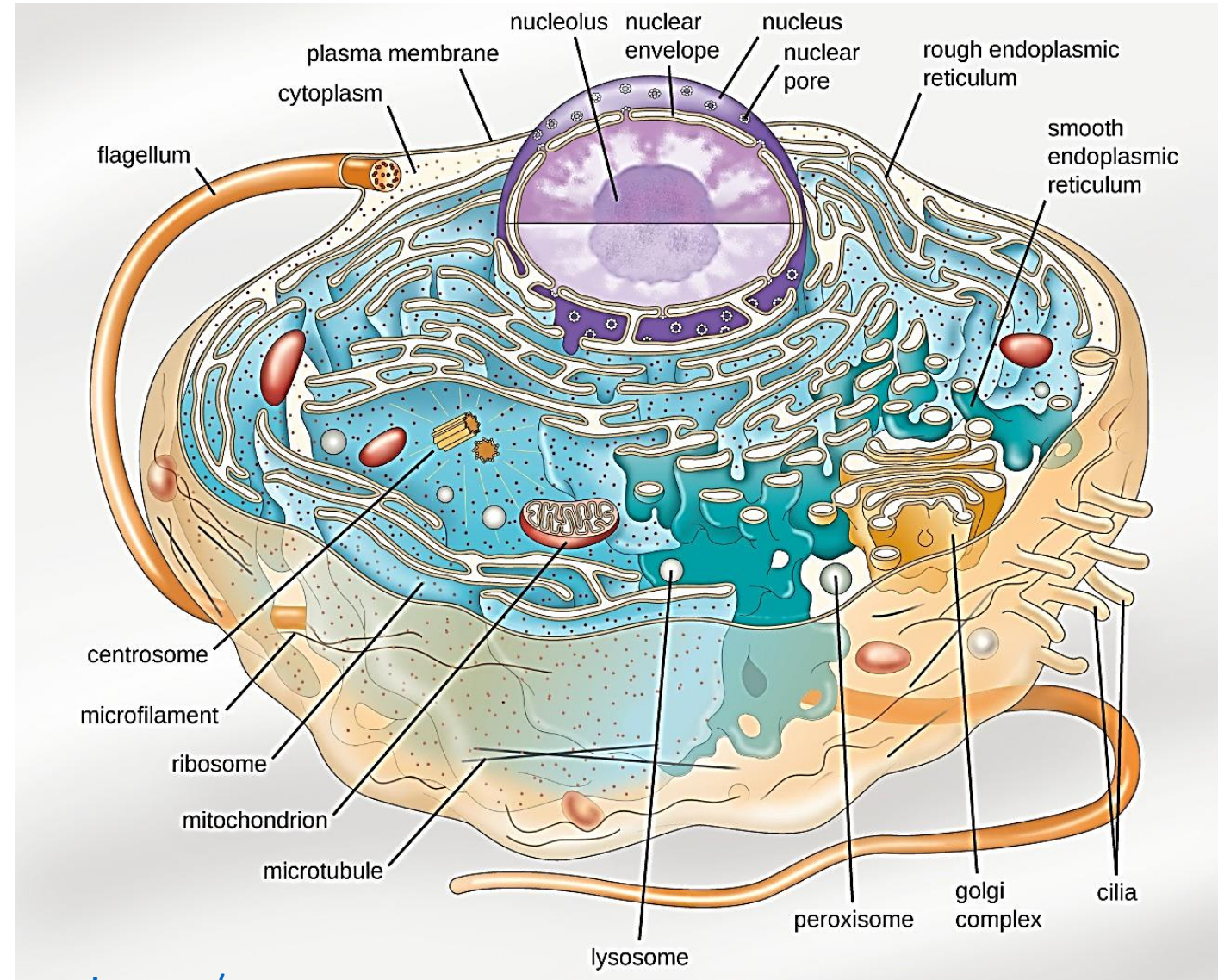
Eukaryotic Cells

- Cell Size: Eukaryotic cells are generally larger and more complex than prokaryotic cells, with sizes ranging from 10 to 100 micrometers in diameter.
- Asexual reproduction (Cell Division): Eukaryotic cells divide through a process called mitosis, where the nucleus divides and distributes the genetic material equally to two daughter cells.
- Sexual Reproduction: Many eukaryotic organisms reproduce sexually by a process called meiosis , involving the fusion of gametes from two parents to produce offspring with genetic variation.

Eukaryotic Cells

- **Complex Cytoskeleton:** Eukaryotes have a complex cytoskeleton composed of microtubules, microfilaments, and intermediate filaments. The cytoskeleton provides structural support, facilitates cell movement, and helps in cell division.
- **Multicellularity:** Many eukaryotes are multicellular organisms, meaning they are composed of multiple cells that work together to form tissues, organs, and organ systems. This allows for specialization and division of labor among different cell types.
- **Metabolic Diversity:** Eukaryotes exhibit a wide range of metabolic capabilities. They can be autotrophs, obtaining energy through photosynthesis, or heterotrophs, obtaining energy by consuming organic matter. Eukaryotes have diverse metabolic pathways and can carry out complex biochemical reactions.

Eukaryotic Cells



[https://s3-us-west-2.amazonaws.com/courses-images/wp-content/uploads/sites/1094/2016/11/03153931/OSC Microbio 03 04 eukcell.jpg](https://s3-us-west-2.amazonaws.com/courses-images/wp-content/uploads/sites/1094/2016/11/03153931/OSC_Microbio_03_04_eukcell.jpg)

Eukaryotic Cells



eukaryotic



animals



protists



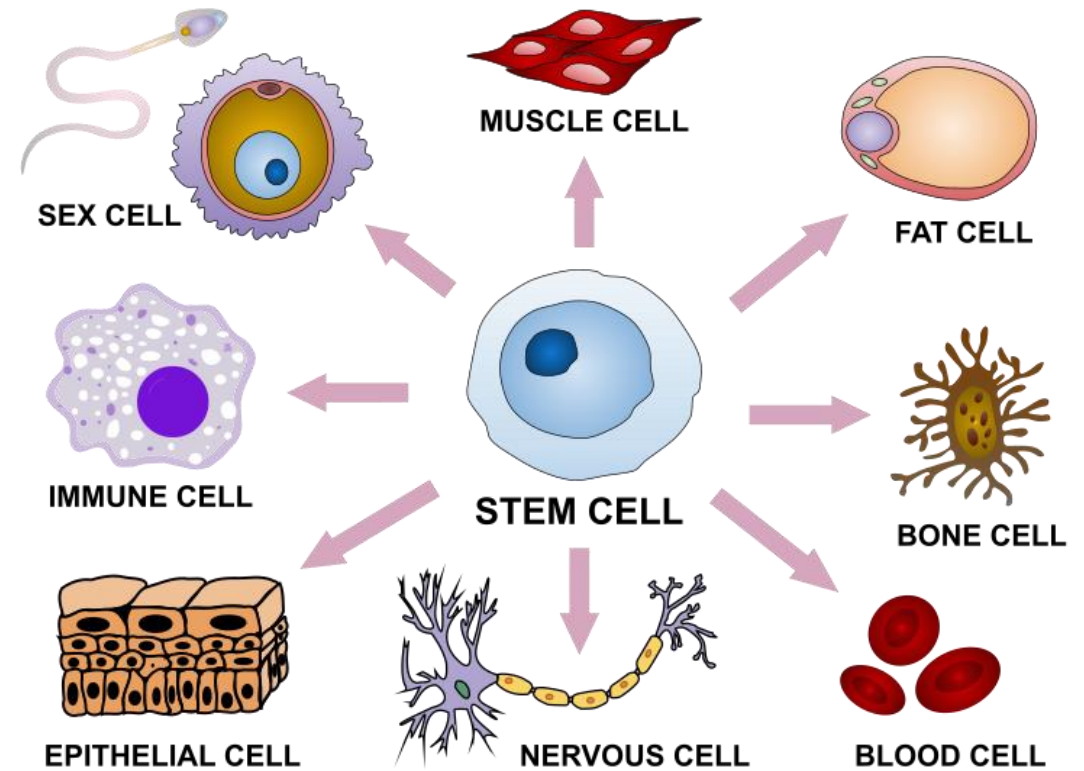
fungus



plants

©Study.com

Human Cells



<https://study.com/cimages/videopreview/videopreview-full/q9fbhu6y00.jpg>

https://upload.wikimedia.org/wikipedia/commons/thumb/d/d3/Final_stem_cell_differentiation_%281%29.svg/800px-Final_stem_cell_differentiation_%281%29.svg.png

Comparison between Prokaryotes and Eukaryotes

	Prokaryotes	Eukaryotes
1	Prokaryotes are generally smaller and simpler in structure compared to eukaryotes. Prokaryotes lack a nucleus and membrane-bound organelles.	eukaryotes have a nucleus and various membrane-bound organelles.
2	Prokaryotes have a single circular DNA molecule located in the nucleoid region.	eukaryotes have multiple linear chromosomes enclosed within a nucleus.
3	Prokaryotes divide by binary fission, a simple form of cell division.	Eukaryotes undergo mitosis (for growth and tissue repair) or meiosis (for sexual reproduction) as more complex forms of cell division.
4	Prokaryotes are generally smaller, ranging from 1 to 10 micrometers.	eukaryotes are larger, ranging from 10 to 100 micrometers.
5	Prokaryotes exhibit diverse metabolic capabilities, including autotrophic and heterotrophic modes of nutrition.	Eukaryotes also have diverse metabolic pathways but are generally more specialized in their metabolic processes.

Comparison between Prokaryotes and Eukaryotes

	Prokaryotes	Eukaryotes
6	Prokaryotes are not complex.	Eukaryotes are generally more complex in terms of cellular organization and structure. They have membrane-bound organelles that allow for compartmentalization and specialization of cellular functions.
7	Prokaryotes reproduce asexually through binary fission.	Eukaryotes can reproduce both asexually and sexually. Sexual reproduction in eukaryotes involves the fusion of gametes from two parents, leading to genetic variation
8	Prokaryotes are believed to be the earliest forms of life on Earth.	Eukaryotes likely evolved from prokaryotes through a process called endosymbiosis, where one organism engulfed another, leading to the development of organelles

Comparison between Prokaryotes and Eukaryotes

Despite their differences, prokaryotes and eukaryotes share fundamental characteristics, such as the ability to carry out metabolic processes, respond to stimuli, and reproduce. Understanding the similarities and differences between these two types of cells is essential for studying cellular biology, evolution, and the diversity of life on Earth.

Prokaryotes in Health and Disease

Prokaryotes play a significant role in human health and disease. Some prokaryotes can cause various illnesses, while others can provide benefits to humans.

Beneficial prokaryotes:

- Antibiotic production: Some prokaryotes, such as Streptomyces, produce antibiotics like penicillin that are used to treat various bacterial infections.
- Bioremediation: Some prokaryotes can help clean up pollution by breaking down toxic compounds in the environment

Prokaryotes in Health and Disease

Prokaryotes play a significant role in human health and disease. Some prokaryotes can cause various illnesses, while others can provide benefits to humans.

Disease-causing prokaryotes:

- *Escherichia coli* (*E. coli*): Some strains of *E. coli* can cause foodborne illnesses, leading to symptoms such as diarrhea, abdominal pain, and vomiting.
- *Salmonella*: *Salmonella* bacteria can cause salmonellosis, a type of food poisoning that leads to symptoms like diarrhea, fever, and abdominal cramps.
- *Streptococcus pneumoniae*: This bacterium can cause pneumonia, as well as other infections such as ear infections, sinusitis, and meningitis.
- *Mycobacterium tuberculosis*: This bacterium is responsible for tuberculosis, a potentially serious infectious disease that primarily affects the lungs.

Prokaryotes in Health and Disease

- *Vibrio cholerae*. This bacterium causes cholera, a diarrheal disease that can be severe and life-threatening if not treated promptly.
- *Clostridium tetani*. The bacterium responsible for tetanus, a serious disease that affects the nervous system and can lead to muscle stiffness and spasms.

These are just a few examples of disease-causing prokaryotes, and there are many other bacterial species that can cause illness in humans and animals. Understanding these pathogens and developing strategies to prevent and treat their infections is an important aspect of public health and medicine.

Eukaryotes in Health and Disease

Eukaryotes play a significant role in human health and disease. Here are some examples of how eukaryotes impact human health:

Beneficial eukaryotes:

- **Food production:** Many eukaryotic organisms, such as plants and fungi, are used in food production. For example, yeast is used in baking and brewing, and various plants are cultivated for their nutritional value
- **Biotechnology:** Eukaryotic cells are used in biotechnology to produce various products, such as insulin and vaccines.
- **Environmental benefits:** Eukaryotic organisms play a crucial role in maintaining the balance of ecosystems. For example, plants produce oxygen and absorb carbon dioxide, while fungi help break down organic matter and recycle nutrients.

Eukaryotes in Health and Disease

Disease-causing eukaryotes:

- Protozoan parasites: Protozoan parasites, such as Plasmodium, Trypanosoma, and Leishmania, can cause serious diseases in humans, including malaria, sleeping sickness, and leishmaniasis.
- Fungal infections: Fungal infections can affect various parts of the body, including the skin, nails, and lungs. Some common fungal infections include athlete's foot, ringworm, and thrush.
- Certain types of algae can produce toxins that can cause illness in humans who consume contaminated seafood or water.

Eukaryotes in Health and Disease

Disease-causing eukaryotes:

- Helminths: Helminths are parasitic worms that can cause a range of diseases in humans, including schistosomiasis, filariasis, and tapeworm infections.
- Amoebic infections: Amoebic infections, such as amoebic dysentery and amoebic keratitis, can be caused by organisms like *Entamoeba histolytica* and *Acanthamoeba*.

Eukaryotes in Health and Disease

In conclusion, eukaryotes can have both positive and negative impacts on human health. While some eukaryotes can cause diseases, others can provide benefits to humans through food production, biotechnology, and environmental benefits

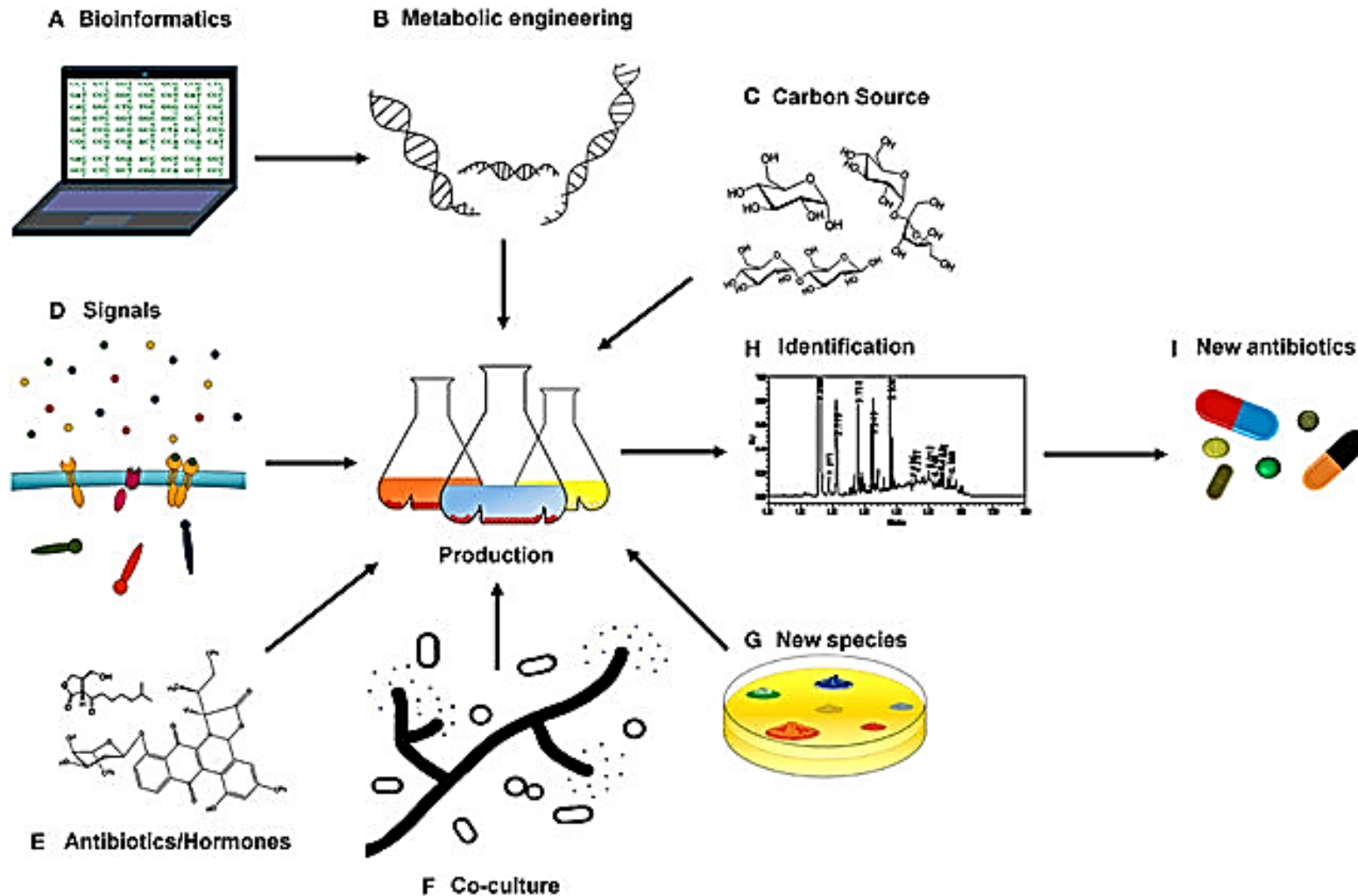
Prokaryotes and Eukaryotes in medical Biotechnology

Prokaryotes and eukaryotes play crucial roles in medical biotechnology, contributing to various processes and applications.

Prokaryotes in Medical Biotechnology:

- **Antibiotic Production:** Prokaryotes, particularly bacteria, are a vital source of antibiotics used in medicine. For example, *Streptomyces* bacteria produce antibiotics such as streptomycin and tetracycline, which are used to treat various bacterial infections.
- **Bioremediation:** Certain prokaryotes are employed in bioremediation to clean up environmental pollutants by breaking down toxic compounds. This has implications for environmental health and human well-being

Antibiotic Production



Schematic overview of new approaches for antibiotic discovery in *Streptomyces*. (A,B) Biosynthetic clusters and regulatory elements can be predicted with bioinformatic tools, opening up new possibilities to metabolic engineering. (C) Modification of the culture medium that is crucial in antibiotic production such as different carbon sources. (D) Searching for the signals that activate different regulatory systems triggering antibiotic production. (E) Communication molecules like antibiotics and hormones may also boost secondary metabolism. (F) Co-culture of *Streptomyces* species with fungi and bacteria might simulate interspecies interactions and thus induce antibiotic production. (G) The discovery of new *Streptomyces* species could also reveal new compounds with antibiotic activities. (H) The compounds produced have to be identified and isolated. (I) All these approaches contribute to the elucidation of the nature and activity of new antibiotics.

<https://www.researchgate.net/publication/276655269> Towards a new focus in antibiotic and drug discovery from *Streptomyces* arsenal

Prokaryotes and Eukaryotes in medical Biotechnology

Eukaryotes in Medical Biotechnology:

- **Pharmaceutical Production:** Eukaryotic cells, such as yeast and mammalian cells, are used to produce pharmaceuticals, including vaccines, insulin, and monoclonal antibodies. These products are essential for the prevention and treatment of various diseases.
- **Bioprocessing:** Eukaryotic cells are utilized in bioprocessing for the production of recombinant proteins, enzymes, and other biopharmaceuticals. These products have diverse medical applications, including in diagnostics and therapeutics.

Prokaryotes and Eukaryotes in medical Biotechnology

In summary, both prokaryotes and eukaryotes are extensively utilized in medical biotechnology, contributing to the production of pharmaceuticals, antibiotics, and other biopharmaceuticals. Their unique characteristics and capabilities make them valuable assets in the field of medical biotechnology, impacting human health and disease management

Current Research and Advances in Prokaryotic and Eukaryotic Biology

Current research and advances in prokaryotic and eukaryotic biology have explored various aspects of their structure, function, and evolution. Some notable recent findings and developments include:

- **Microbiome Research:** The study of the microbiome, the collection of microorganisms living in and on organisms, is a rapidly growing area of research. Scientists are investigating the composition and function of microbial communities in various environments, including the human gut, soil, oceans, and plants. This research has implications for human health, agriculture, and environmental conservation.
- **CRISPR-Cas9 Technology:** The development of CRISPR-Cas9 gene editing technology has revolutionized genetic research in both prokaryotes and eukaryotes. This tool allows for precise and efficient manipulation of genes, enabling researchers to study gene functions, develop disease models, and explore potential therapeutic applications.

Current Research and Advances in Prokaryotic and Eukaryotic Biology

- **Synthetic Biology:** Synthetic biology combines engineering principles with biology to design and construct new biological systems or modify existing ones. Researchers are using synthetic biology approaches to create novel metabolic pathways, engineer microbes for industrial applications, and develop biosensors for environmental monitoring and medical diagnostics.
- **Single-Cell Analysis:** Advances in single-cell analysis techniques have enabled researchers to study individual cells and their heterogeneity within a population. This approach provides insights into cellular diversity, developmental processes, disease mechanisms, and the identification of rare cell types.

Current Research and Advances in Prokaryotic and Eukaryotic Biology

- **Omics Technologies:** Omics technologies, such as genomics, transcriptomics, proteomics, and metabolomics, allow for comprehensive analysis of biological molecules and their interactions within cells and organisms. These technologies provide a systems-level understanding of cellular processes, disease mechanisms, and the identification of potential therapeutic targets.
- **Evolutionary Biology:** Research in evolutionary biology continues to uncover the mechanisms and patterns of evolution in prokaryotes and eukaryotes. Scientists are studying the role of natural selection, genetic drift, gene flow, and horizontal gene transfer in shaping the diversity and adaptation of organisms..

Current Research and Advances in Prokaryotic and Eukaryotic Biology

- **Cell Signaling and Communication:** Understanding the intricate signaling networks and communication processes within cells and between cells is an active area of research. This research helps elucidate cellular responses to environmental cues, cell differentiation, tissue development, and disease progression..
- **Bioinformatics and Computational Biology:** The growing field of bioinformatics and computational biology plays a crucial role in analyzing large-scale biological data, predicting protein structures and functions, and modeling complex biological systems. These computational approaches aid in understanding the vast amount of biological information generated through various omics technologies.

Current Research and Advances in Prokaryotic and Eukaryotic Biology

These are just a few examples of the current research and advances in prokaryotic and eukaryotic biology. The ongoing exploration of these areas contributes to our understanding of fundamental biological processes, human health, environmental sustainability, and the development of novel biotechnological applications.



THANK YOU!