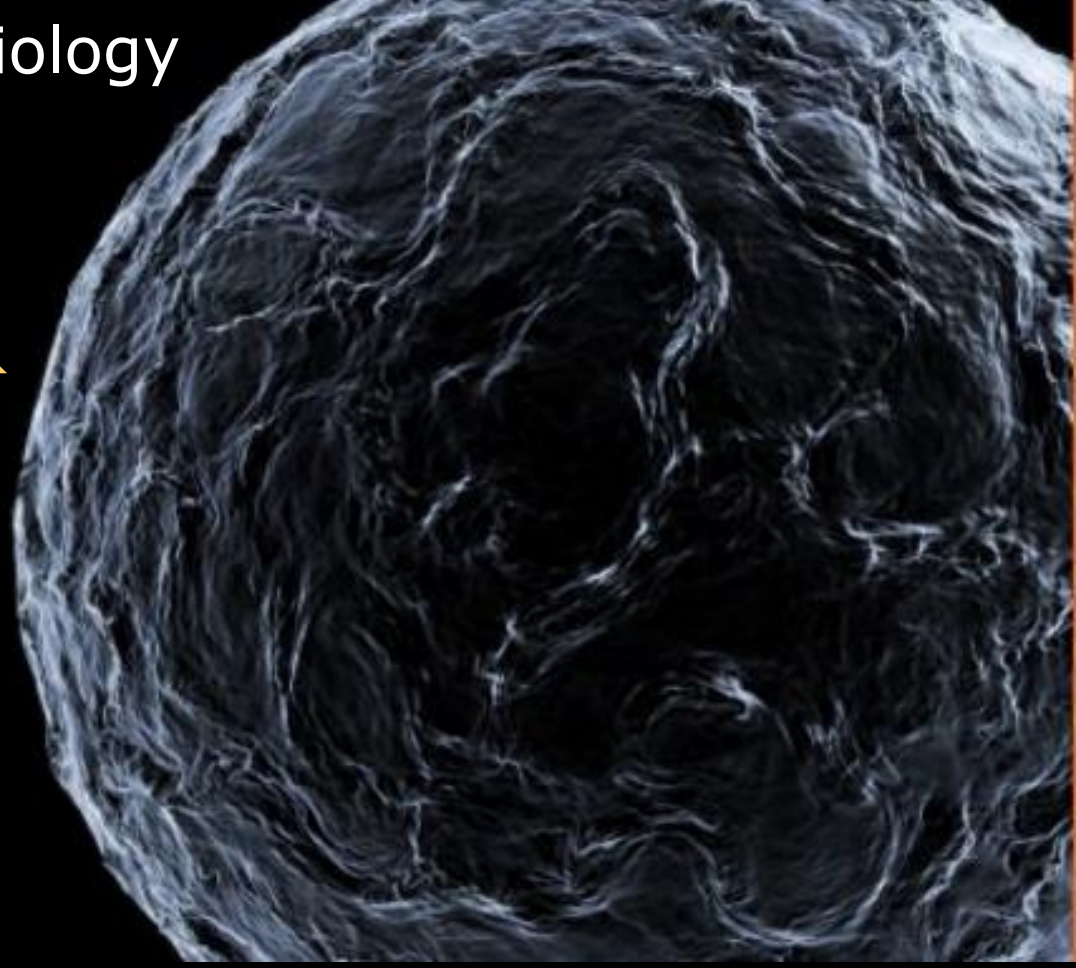
MD567712 Cells and Molecular Biology

Introduction to Cells & Molecular Biology



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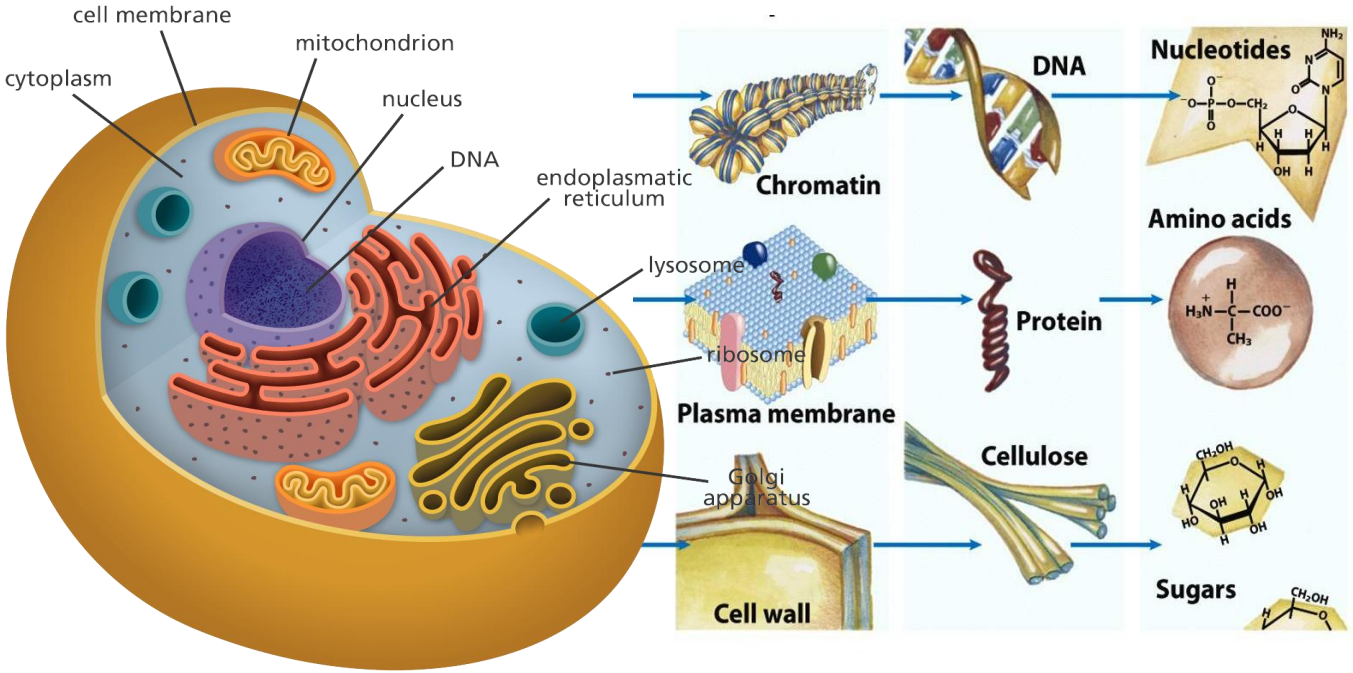
Cells and molecular biology



Cell biology: the characteristics of cells, *e.g.*, their physiological properties, structure, organelles, interactions with the environment, life cycle, division and death. **Understanding cells is crucial in comprehending life itself.**

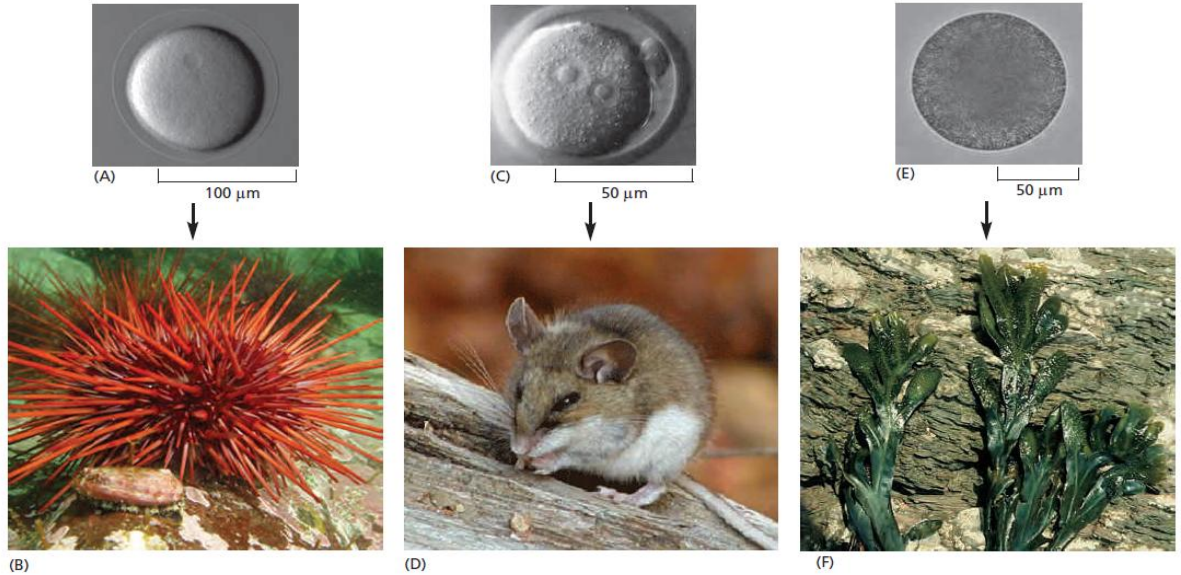
Molecular & cellular biology are interrelated,

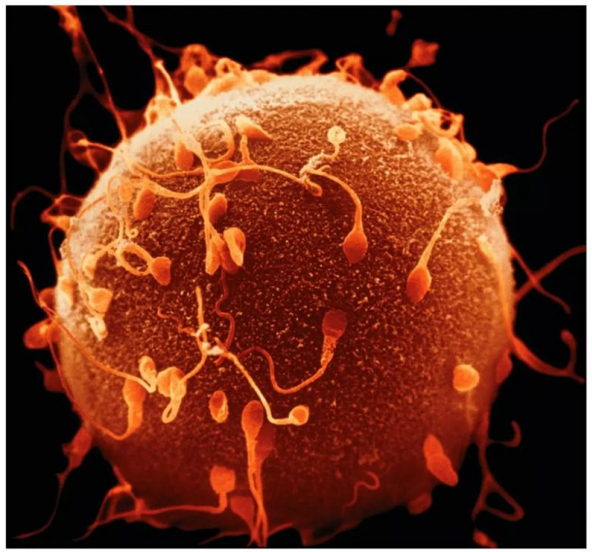
Most of cell properties & functions described at the molecular level. Various branches of biology, including biotechnology, developmental biology, physiology, pathology, genetics, microbiology, etc.

Molecular biology: the study of biology at the molecular level. Chiefly concerns itself with understanding & interactions between **DNA, RNA & proteins,** and learning **how these interactions are regulated**.

Life begins with cells

- The **individual cells** that form our bodies can **grow, reproduce, process information, respond to stimuli, and carry out an amazing array of chemical reactions. These ability define life.**




Chapter 1 Opener
Molecular Cell Biology, Sixth Edition
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- We & other multicellular microorganisms contain **billions or trillion of cells** organized into **a complex structure.**
- **Even simple unicellular organisms exhibit all the hallmark properties of life, indicating that the cell is the fundamental unit of life.**

Alberts, Bruce, et al. (2014) Molecular biology of the cell Sixth edition

Overview of cells video

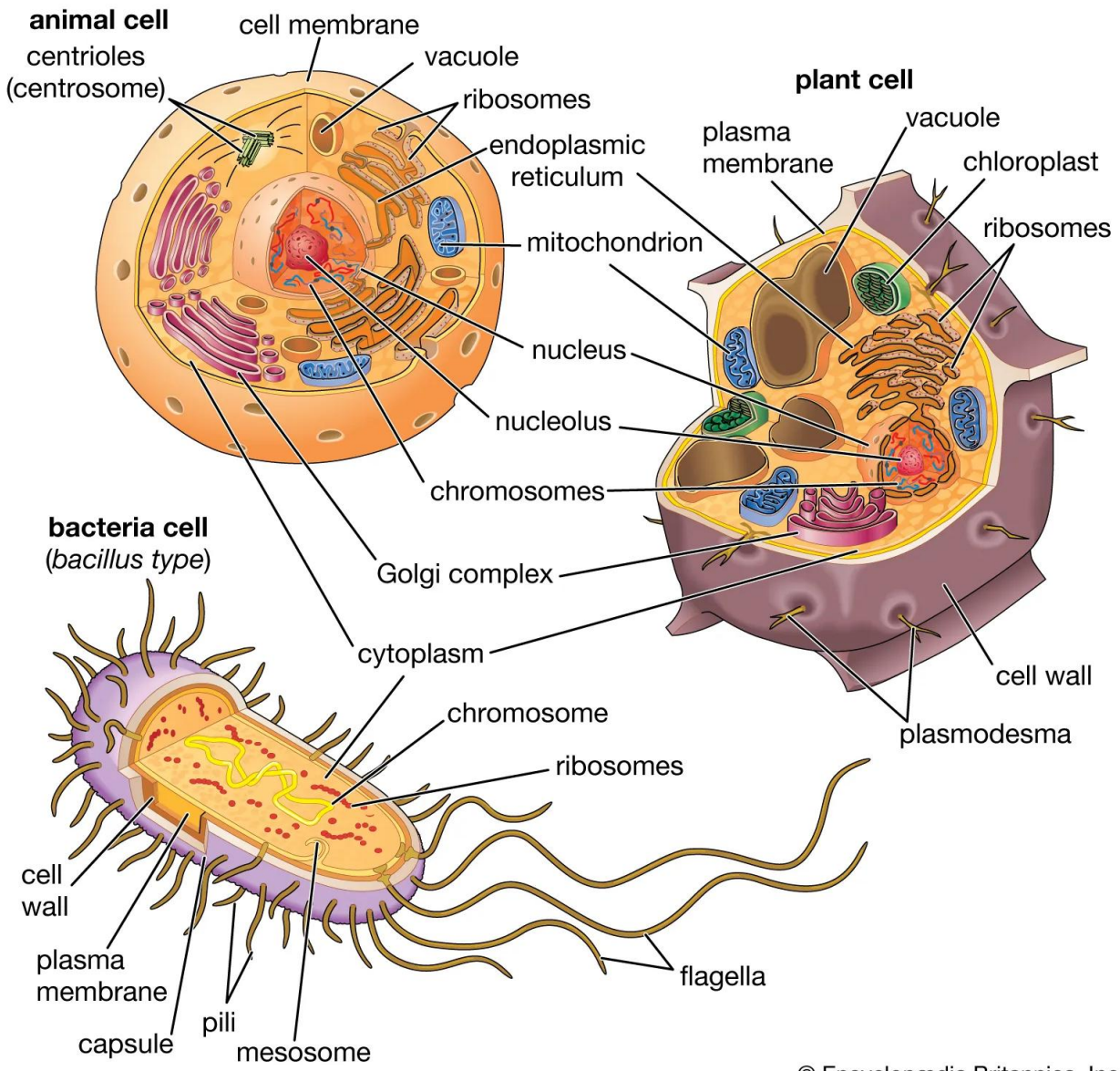
Overview of cells video	Question	Answer
1		
2		
3		
4		

All cells are prokaryotes and eukaryotes

Prokaryotic cells

"before nucleus"

(Bacteria, archaea)



Eukaryotic cells

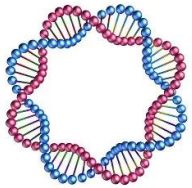
"true nucleus"

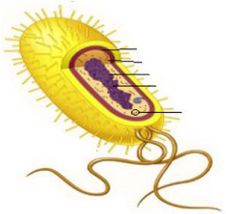
(Plants, animals, fungi, protists)

Eukaryotic and Prokaryotic Cells: Similarities & Differences

Prokaryotes

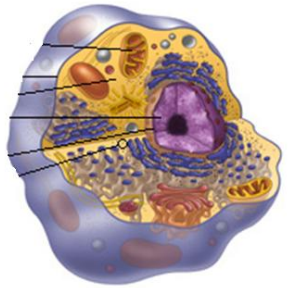
- Oldest cell type
- Small & simple
- Lacks a defined nucleus
- Has a relatively simple
- Internal organization
- Lacks organelles
- **Unicellular**
- Circular DNA





Both

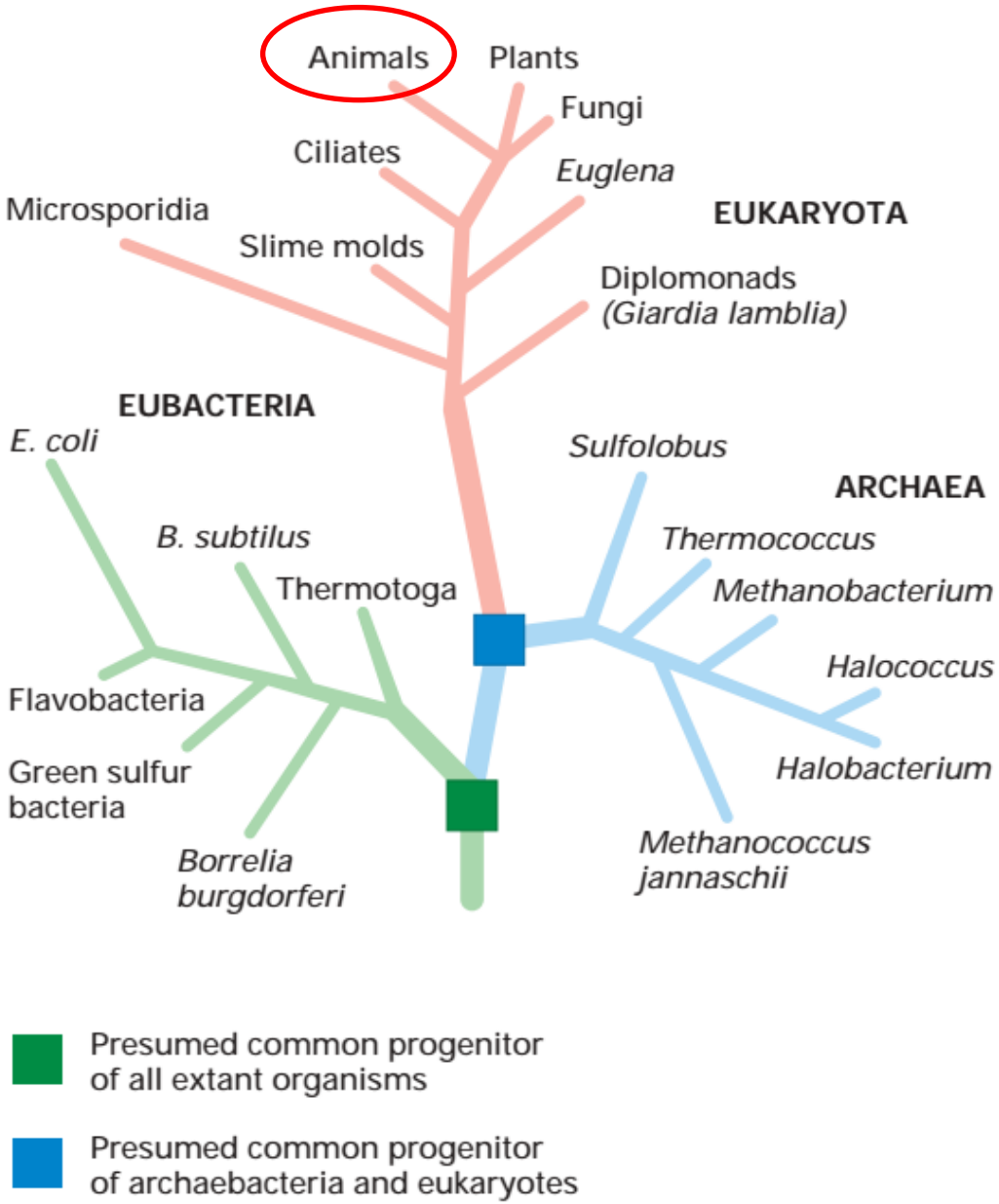
- ✓ DNA
- ✓ Ribosome
- ✓ Cytoplasm
- ✓ Plasma membrane



Eukaryotes

- Evolved from
- prokaryotes
- Larger and more complex
- Have nucleus
- Have membrane bound organelles
- Unicellular (yeast) or **multicellular** (animals)
- Linear DNA

Phylogeny of the three domains of life

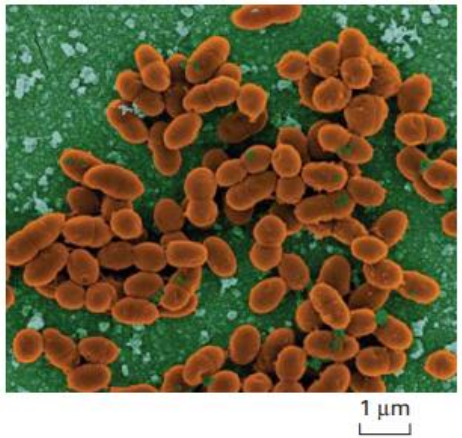


All organisms from simple bacteria to complex mammals probably evolved from a common, **single celled progenitor**.

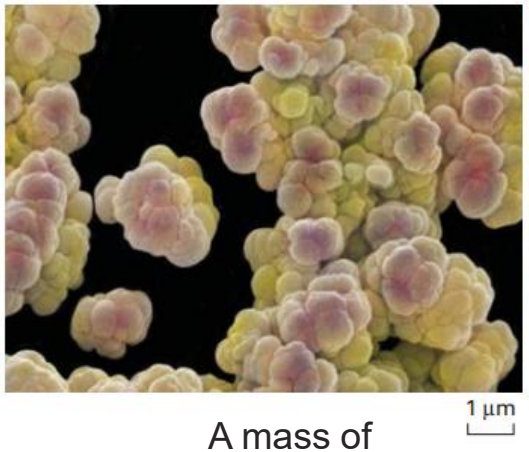
This **family tree** depicts **the evolutionary relations** among the three major lineages of organisms or domains namely **Archaea, Bacteria, Eukaryota.**

All animals, plants, fungi, and many unicellular

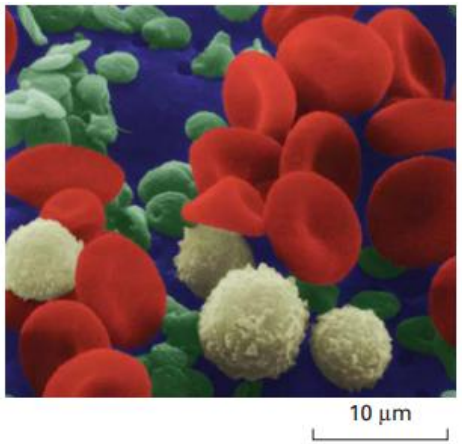
Cells come in an amazing variety of shapes and sizes.



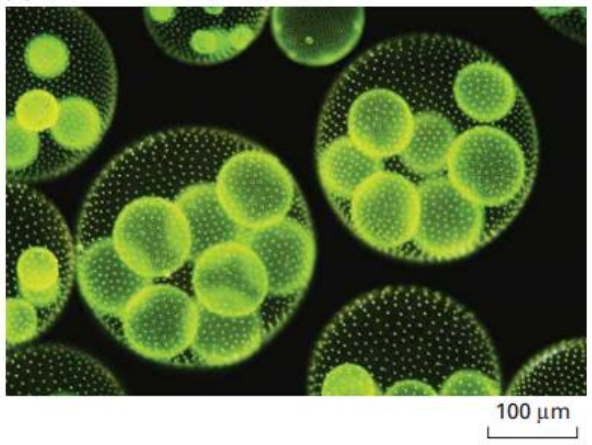
Eubacteria;
Lactococcus lactis,



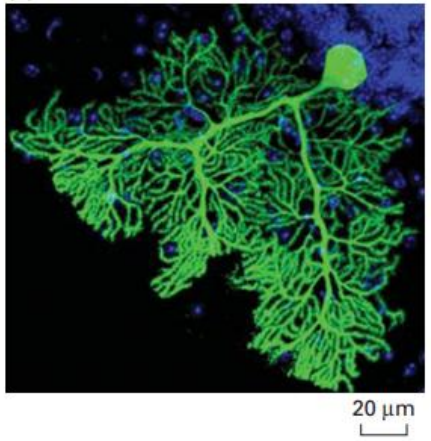
A mass of archaebacteria (*Methanosarcina*)



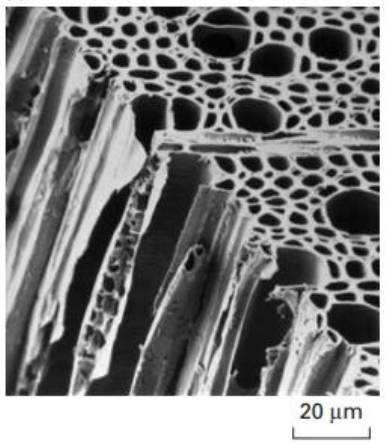
Blood cells



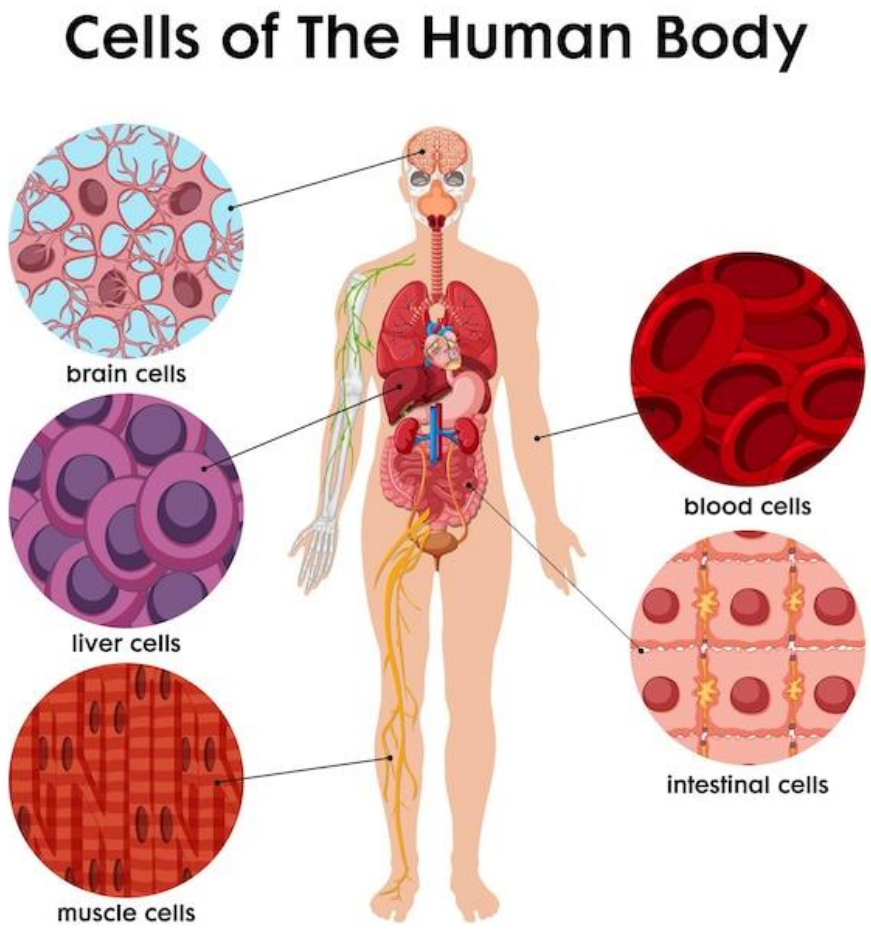
A colonial single-celled green alga



A single Purkinje neuron of the cerebellum



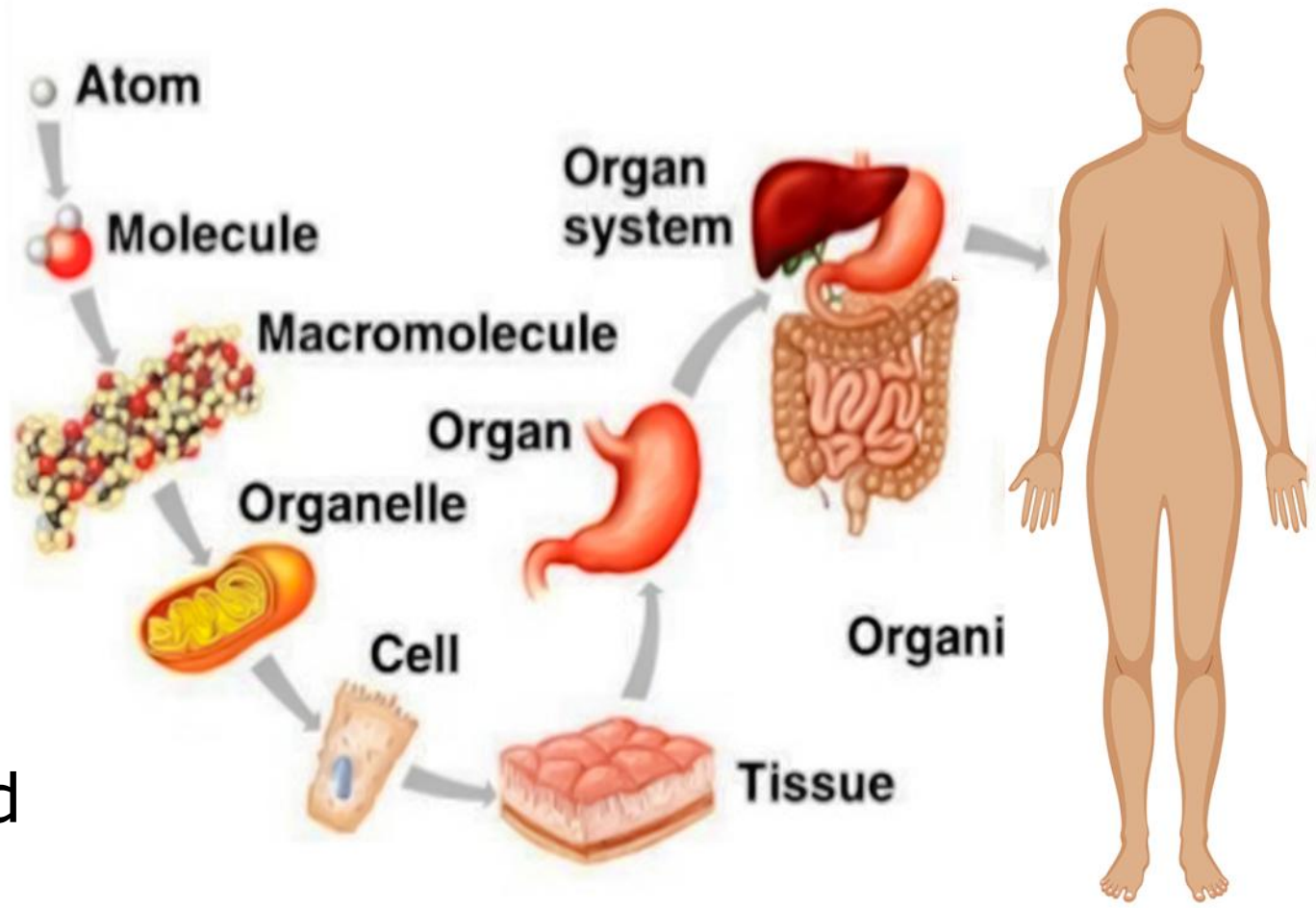
Plant cells are fixed firmly in place in vascular plants



https://www.freepik.com/free-photos-vectors/human-body-cells

Levels of organization of the human body

- The major levels of organization in the body, from the simplest to the most complex are: atoms, molecules, organelles, cells, tissues, organs, organ systems, and
- Molecules (Small molecules, precursors, intermediates, building blocks)
- Macromolecules (Biological molecules or Biomolecules): proteins, carbohydrates, lipids, nucleic acids
- Cells are basic structural and functional units of all living organisms



Molecules of a cell

Structural hierarchy in the molecular organization of cells

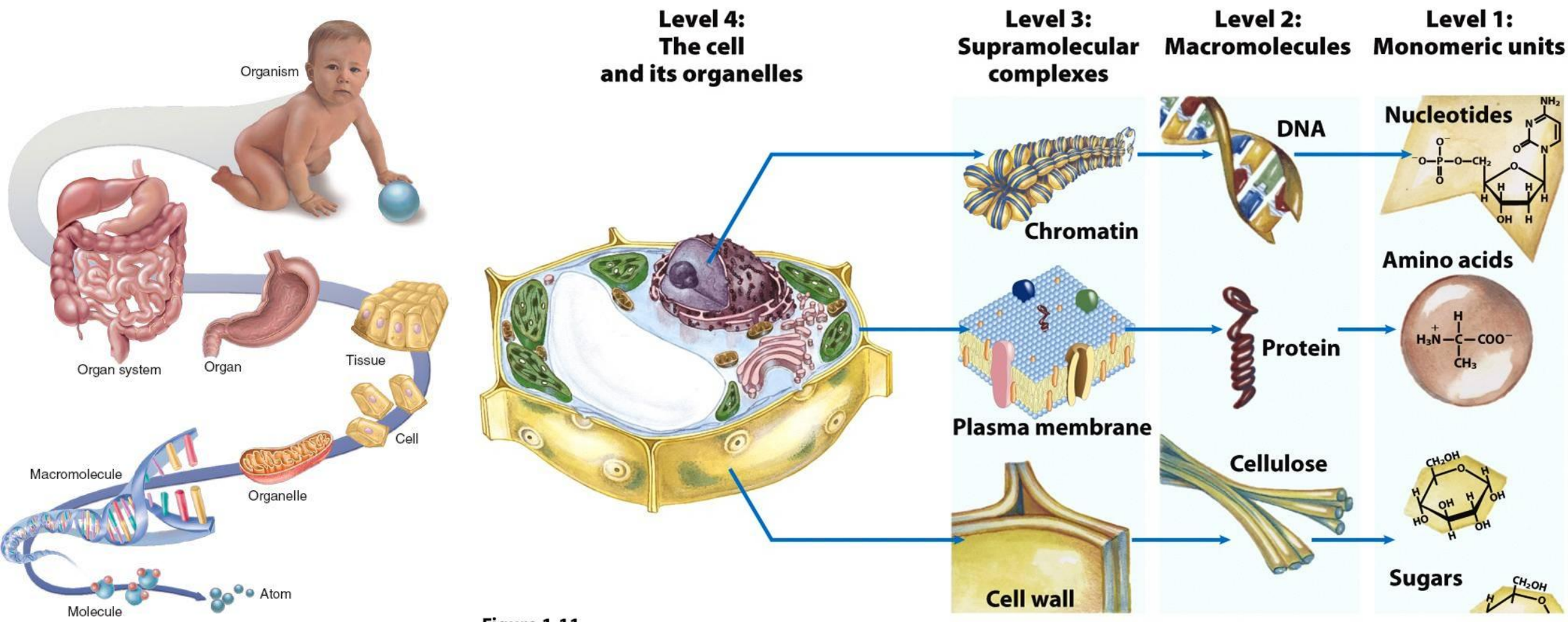
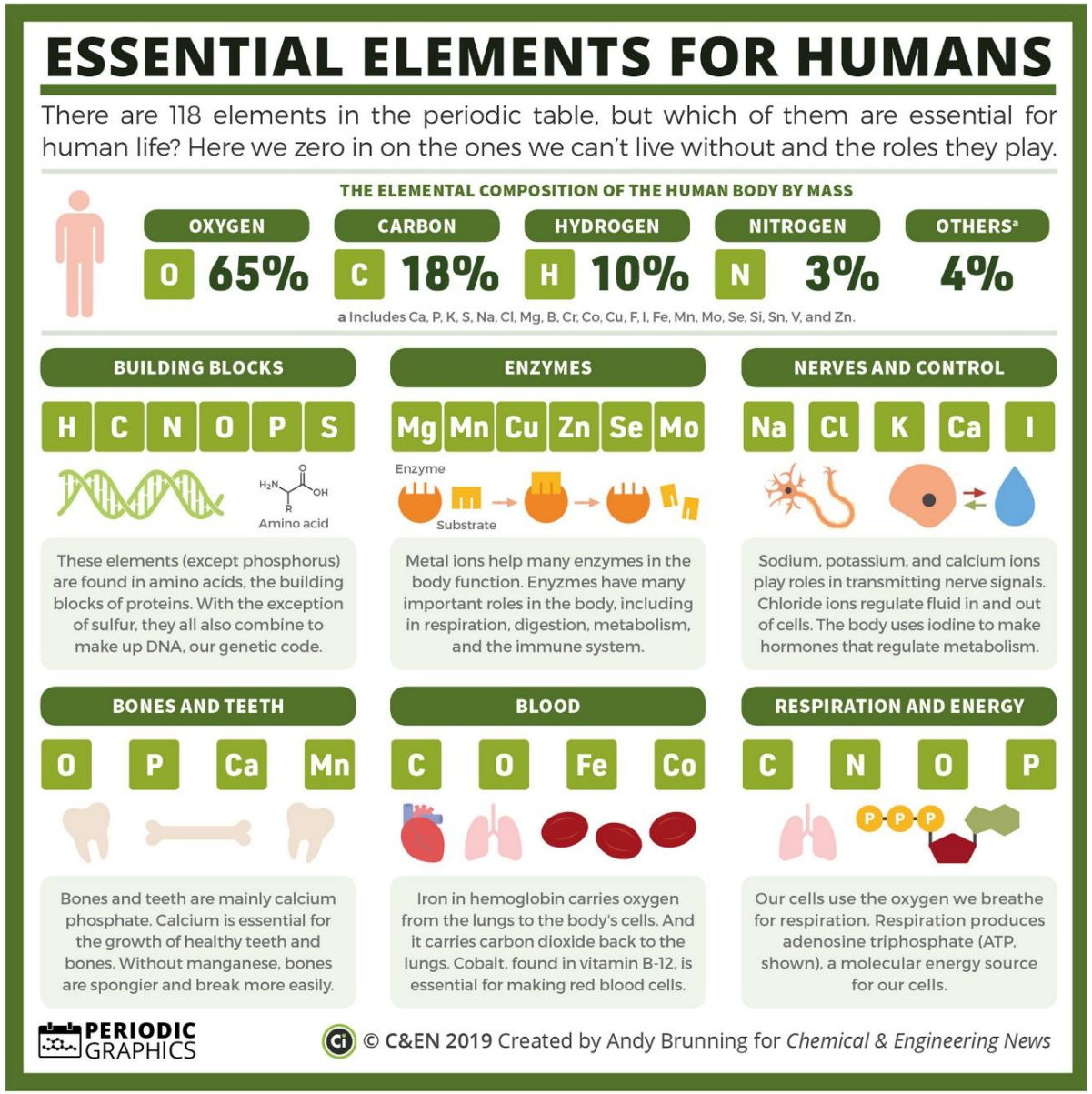
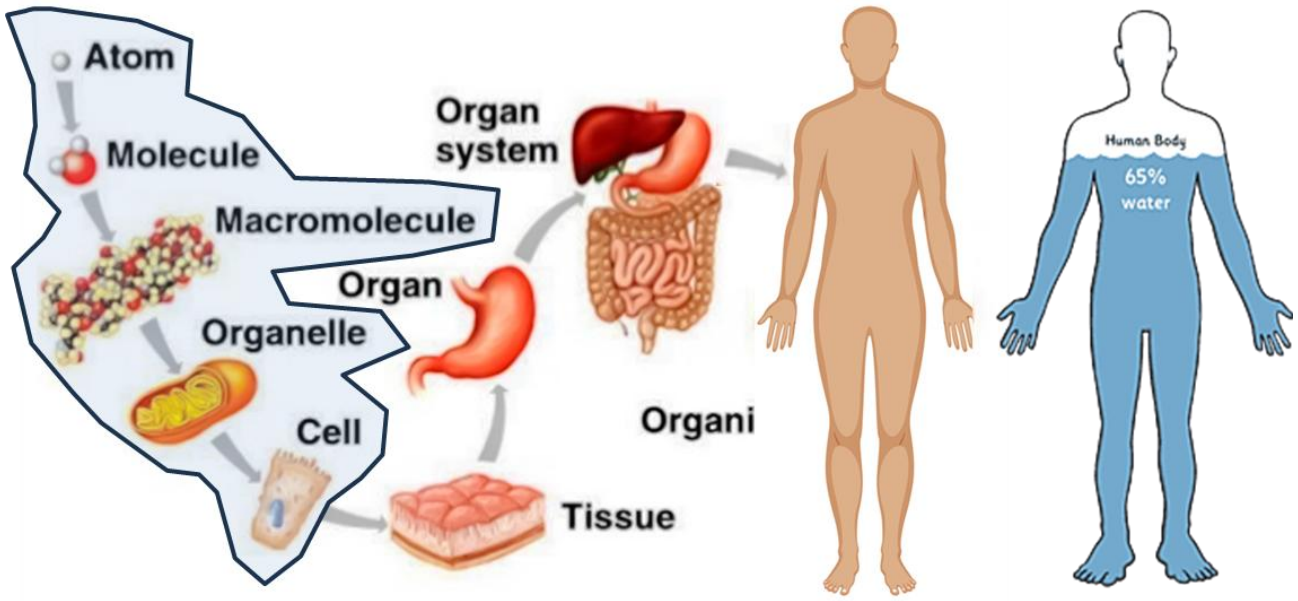


Figure 1-11
Lehninger Principles of Biochemistry, Fifth Edition

Essential elements for humans

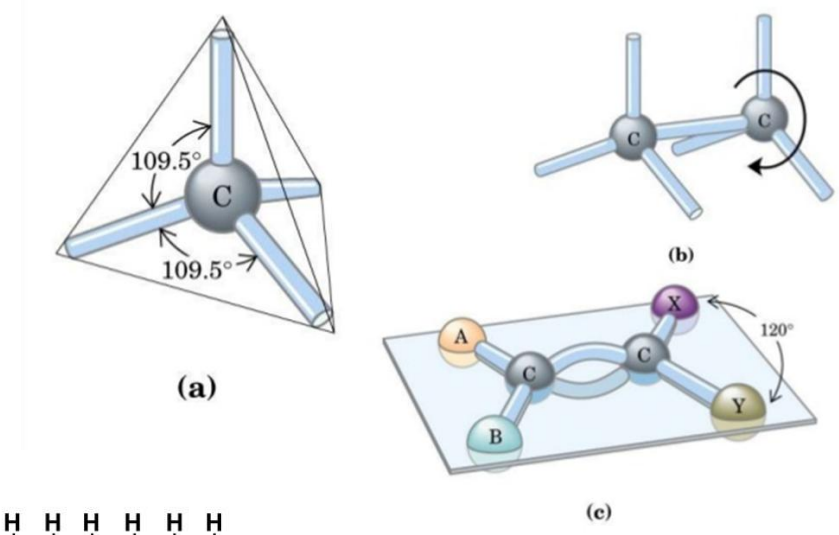




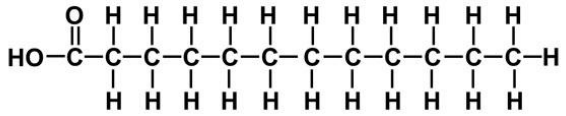
The human body is comprised of several major elements, including carbon, hydrogen, oxygen, nitrogen, calcium, phosphorus and potassium.

Big 4 – 96%

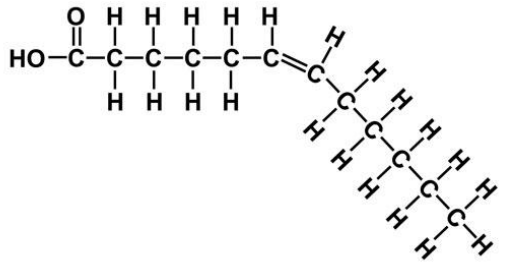
Carbon – the backbone of life

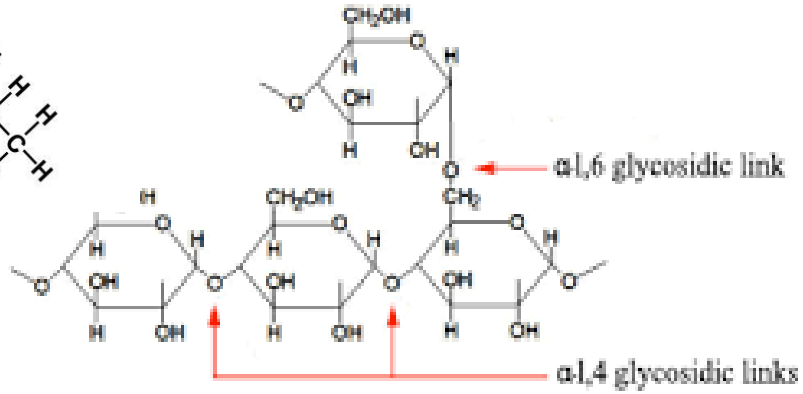


Saturated Fatty Acid



Unsaturated Fatty Acid



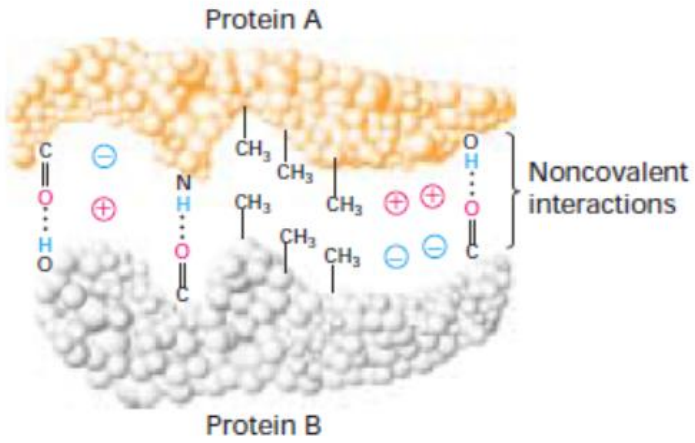


Molecular diversity arising from carbon skeleton variation

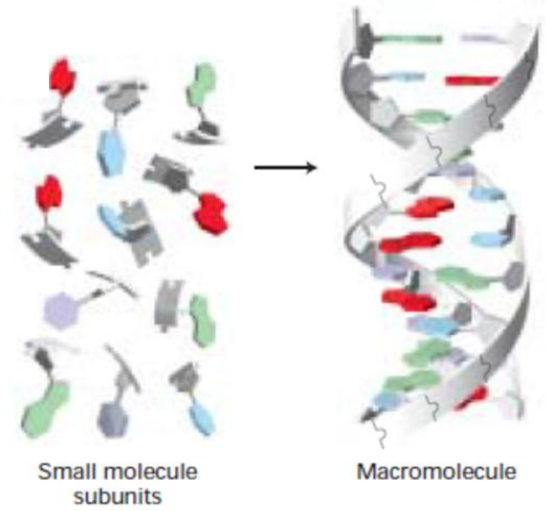
- Chain length
- Branching
- Double bonds
- Ring formations

Isomers – compounds that have the same number of atoms of the same elements, but different structures, hence different properties

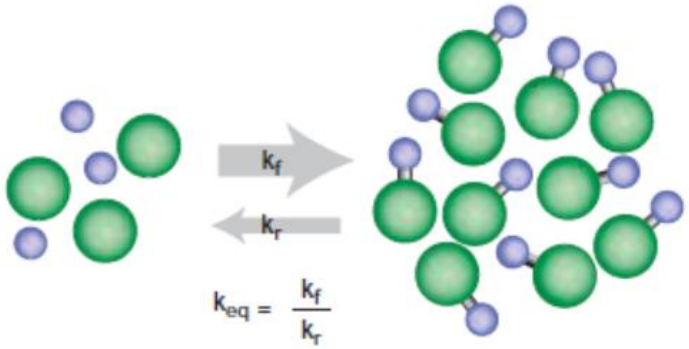
Chemistry of life: key concepts



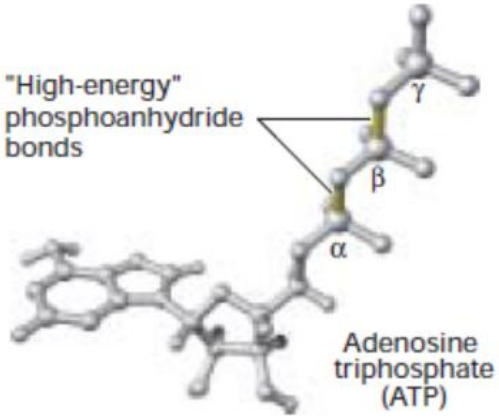
Covalent and non-covalent interactions



Small molecules serve as building blocks for larger structures.



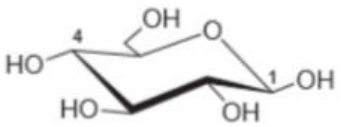
Chemical reactions

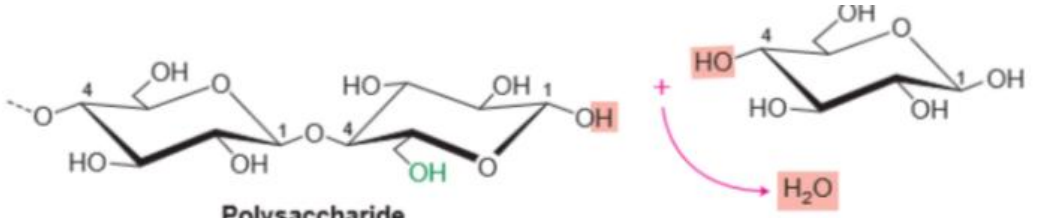


ATP the universal "currency" of chemical energy

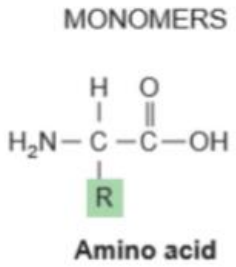
Biomolecules - An overview

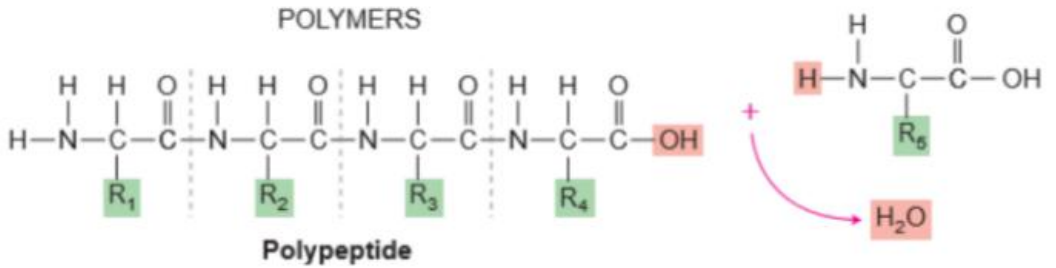
Carbohydrates



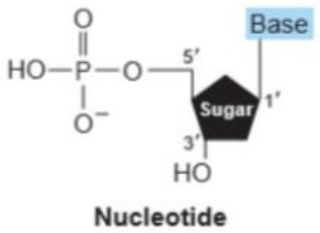


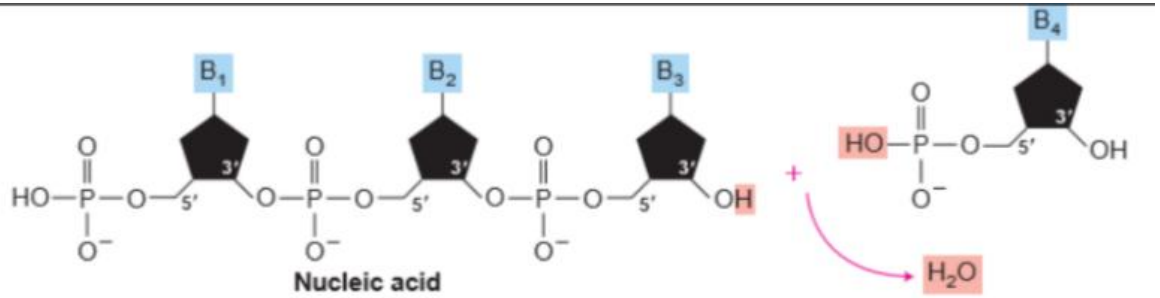
Proteins



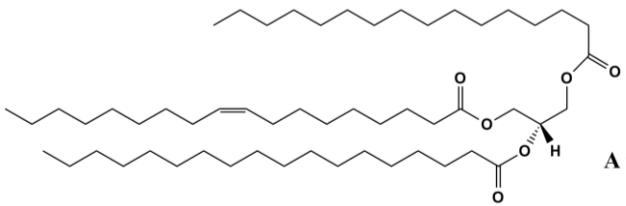


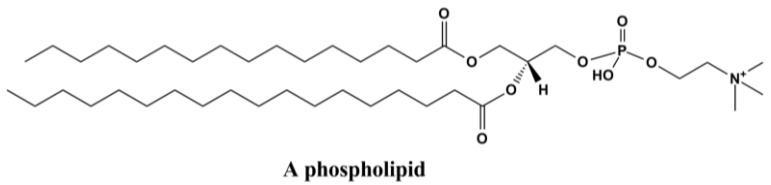
Nucleic acids





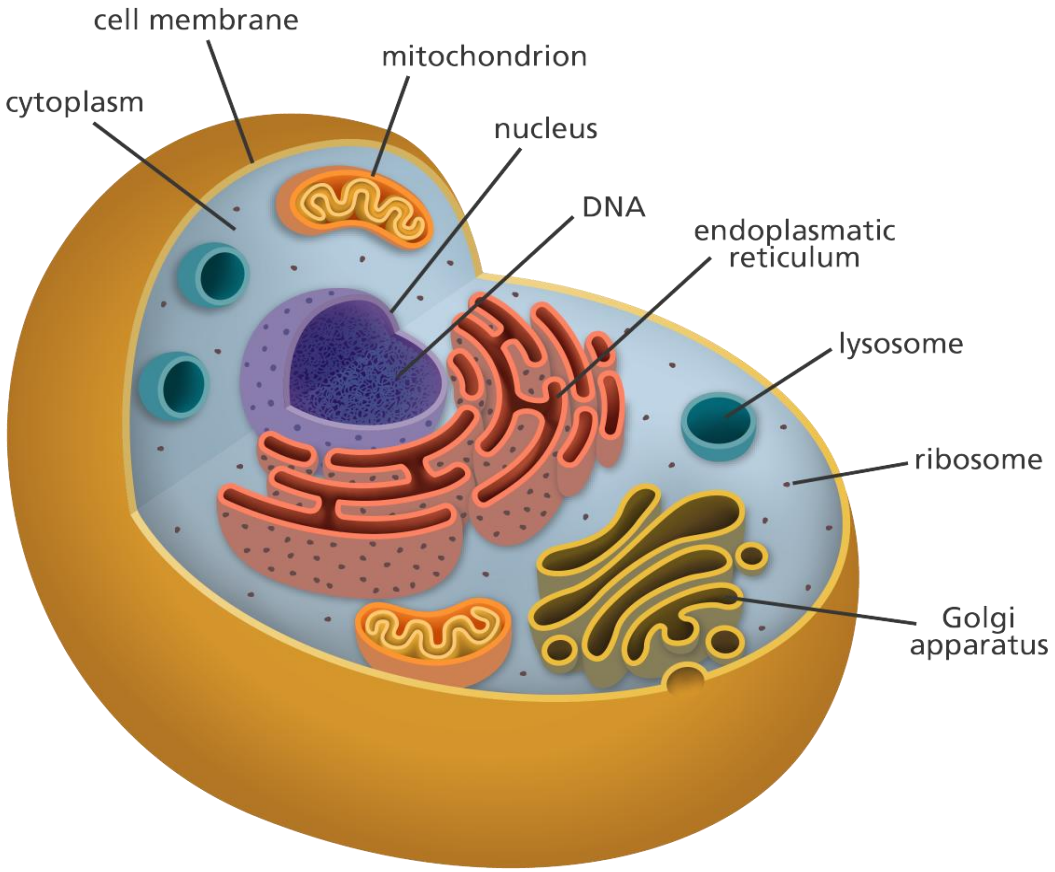
Lipids





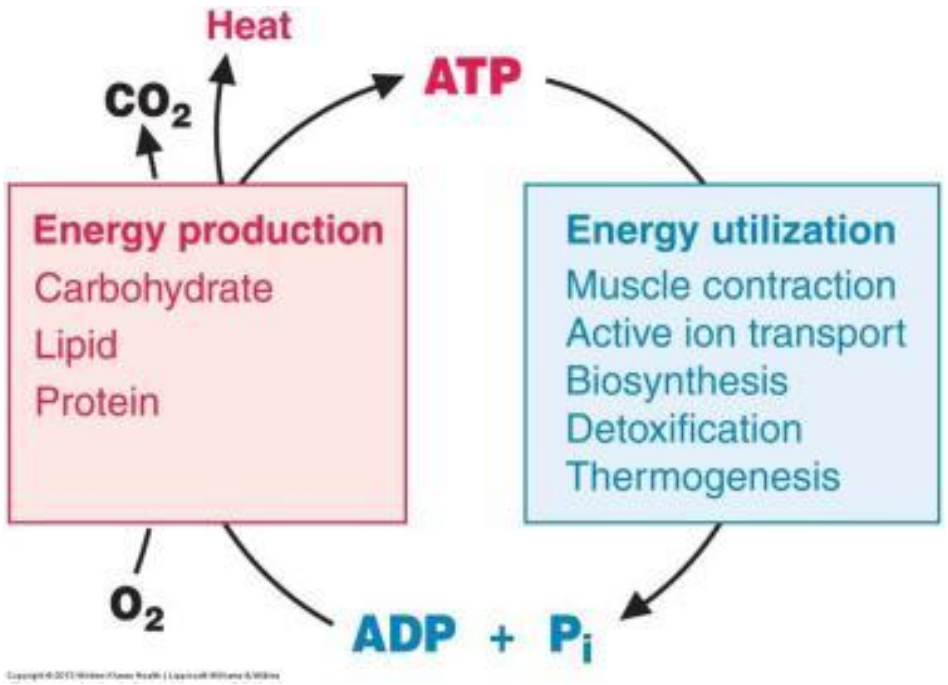
Organelles

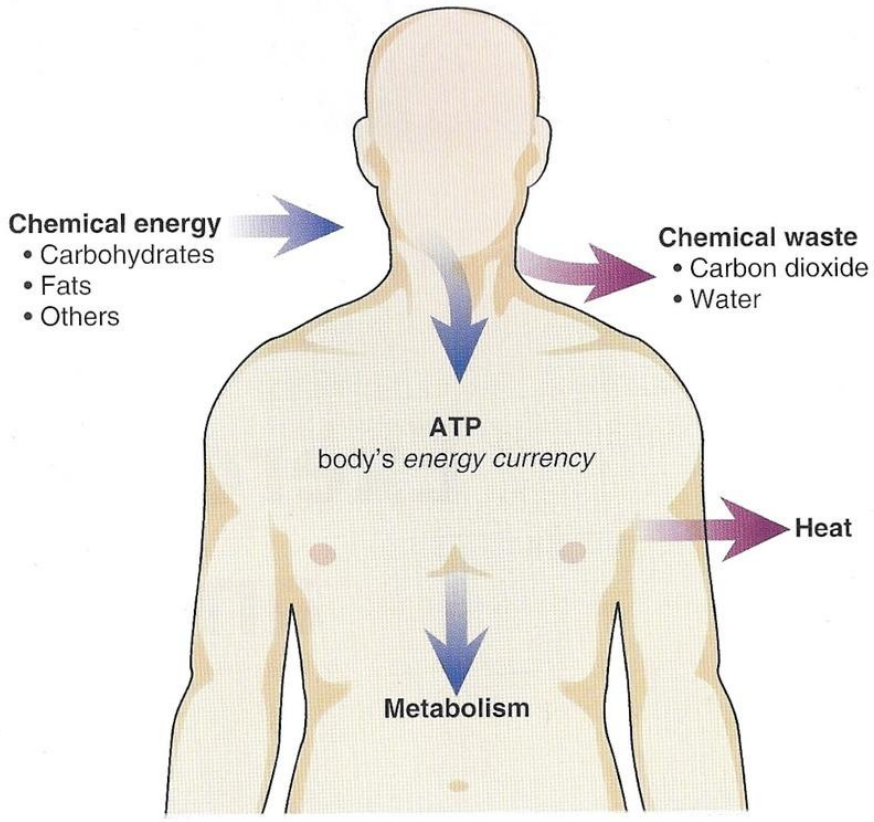
Organelles are specialized structures that perform various jobs inside cells.



Nucleus	**DNA Storage**
Mitochondrion	**Energy production**
Golgi apparatus	**Protein modification and export**
Peroxisome	**Lipid destruction; contains oxidative enzymes**
Lysosome	**Protein destruction**
Cell membrane	**Regulates the transport of materials entering and exiting the cell**
Ribosome	**Protein synthesis**

Bioenergetics





- To obtain energy for making ATP, cells break down food molecules.
- ATP is the most common molecule used by cells to capture and transfer energy.

Metabolism

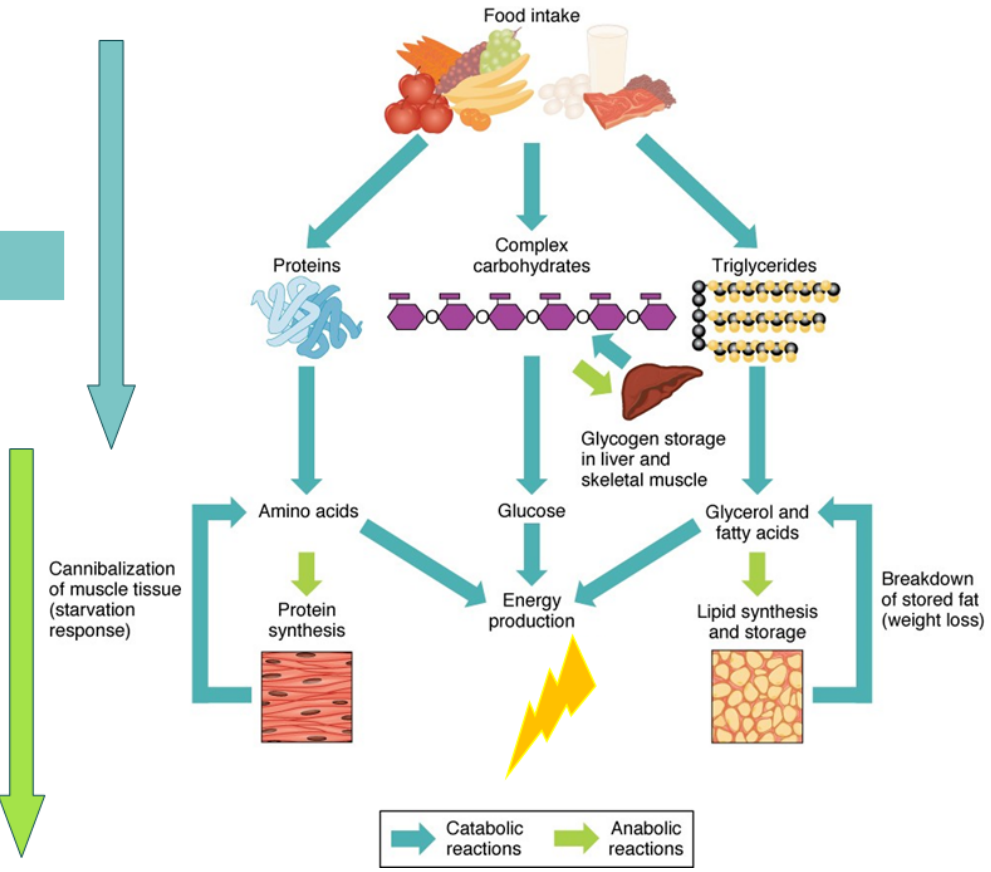
"The sum of all the reactions in a cell or the body"

Catabolism

Break down
Releases energy

Anabolism

Build
Requires energy



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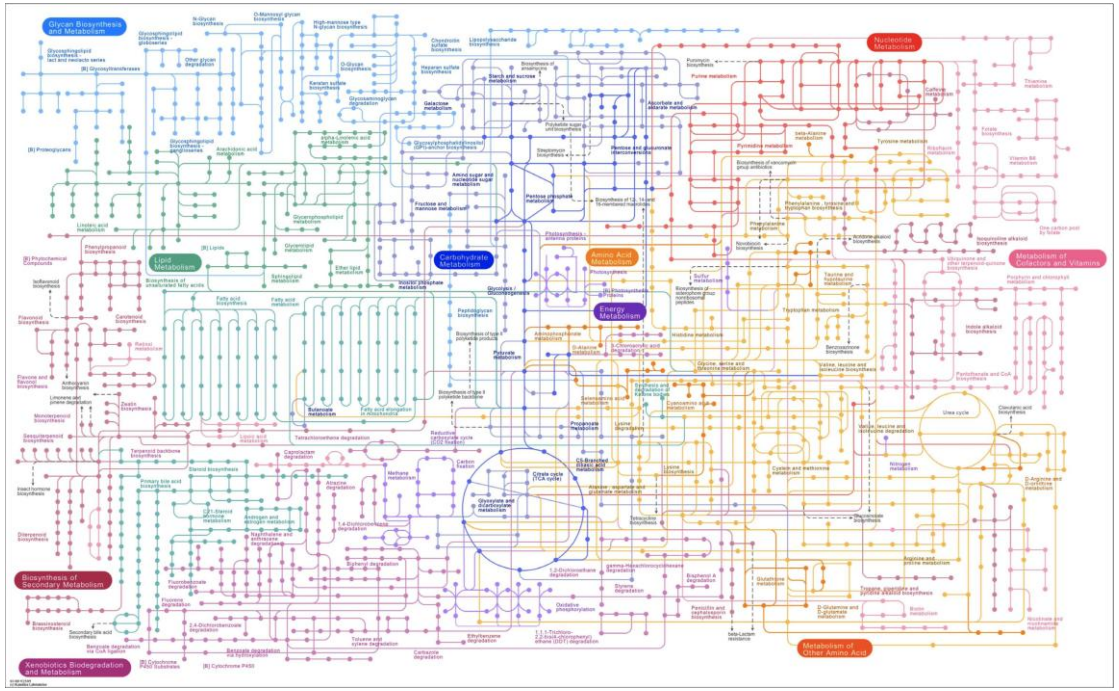
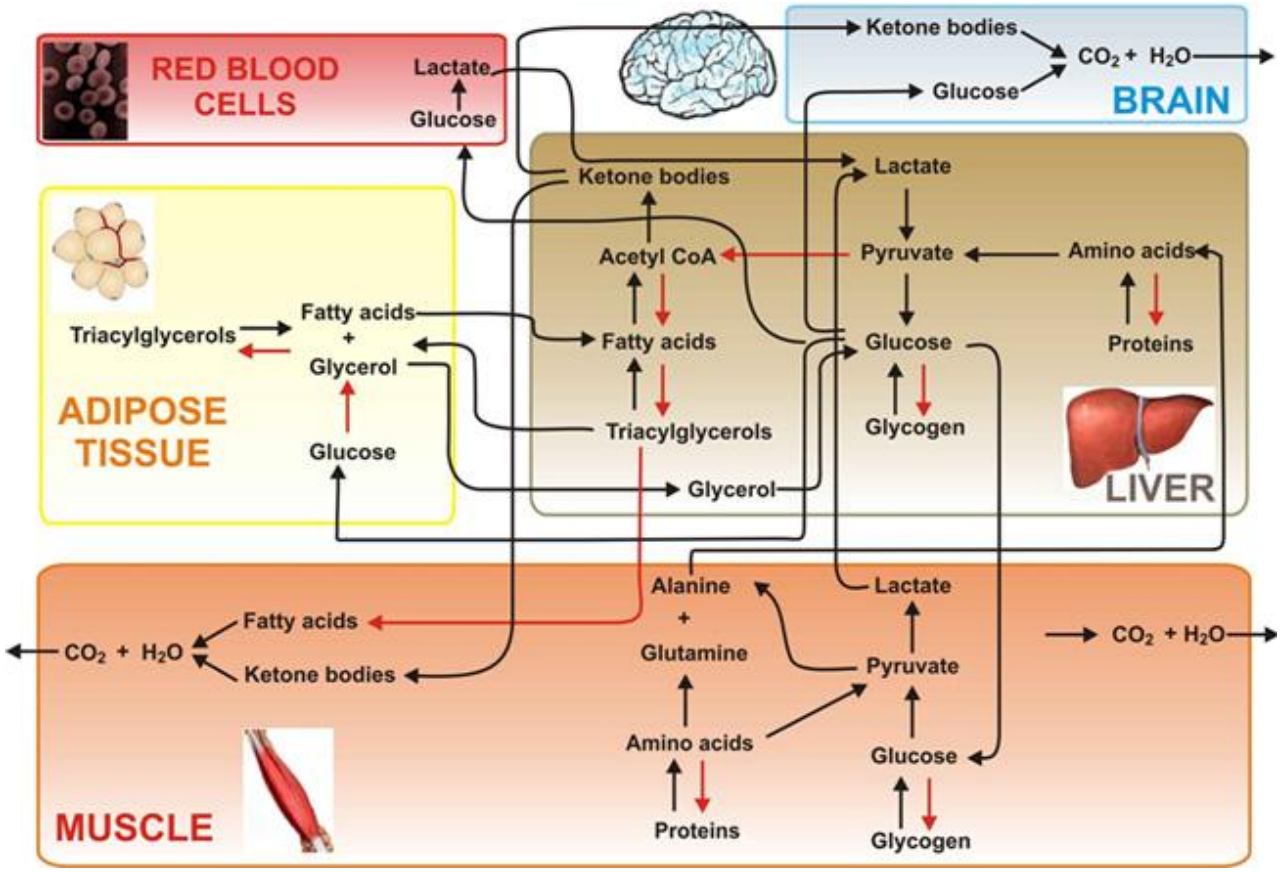


Map of the human metabolic pathway

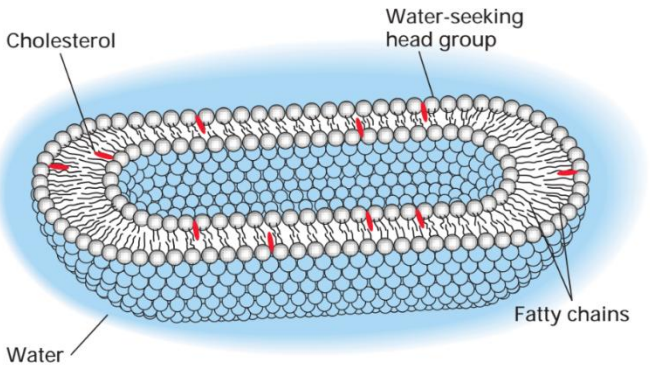
Different cell types (e.g. RBC and brain) require different fuel molecules

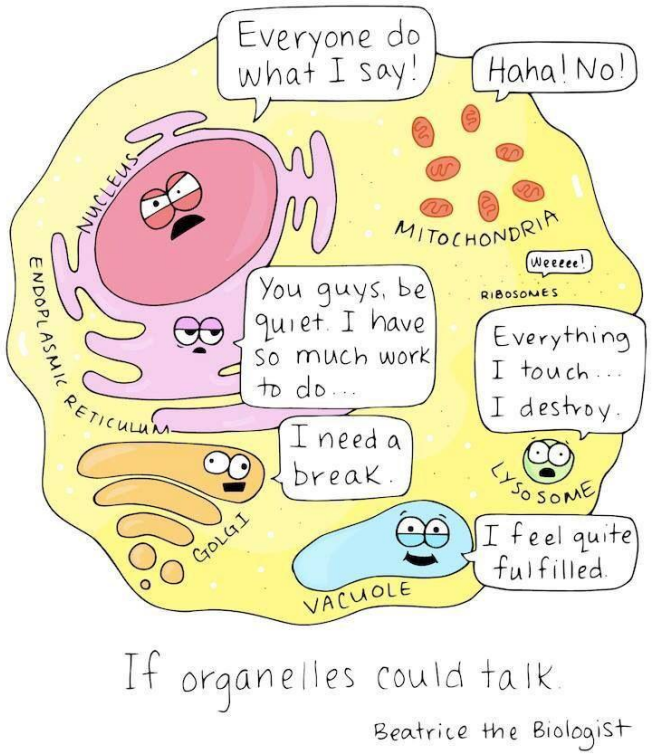


Red blood cells **rely on** **glucose** for energy and convert glucose to lactate. The **brain** uses **glucose** & **ketone bodies** for energy.

How does the cell's organization of metabolism and regulation of signaling pathways, facilitated by membrane-bound compartments and receptors, contribute to cellular function?

The work of cells





Cell compartmentalization

Eukaryotes have a compartmentalized cell structure.

Plasma membranes separate the interior of all cells from the outside environment that prevents the free flow of molecules in and out.

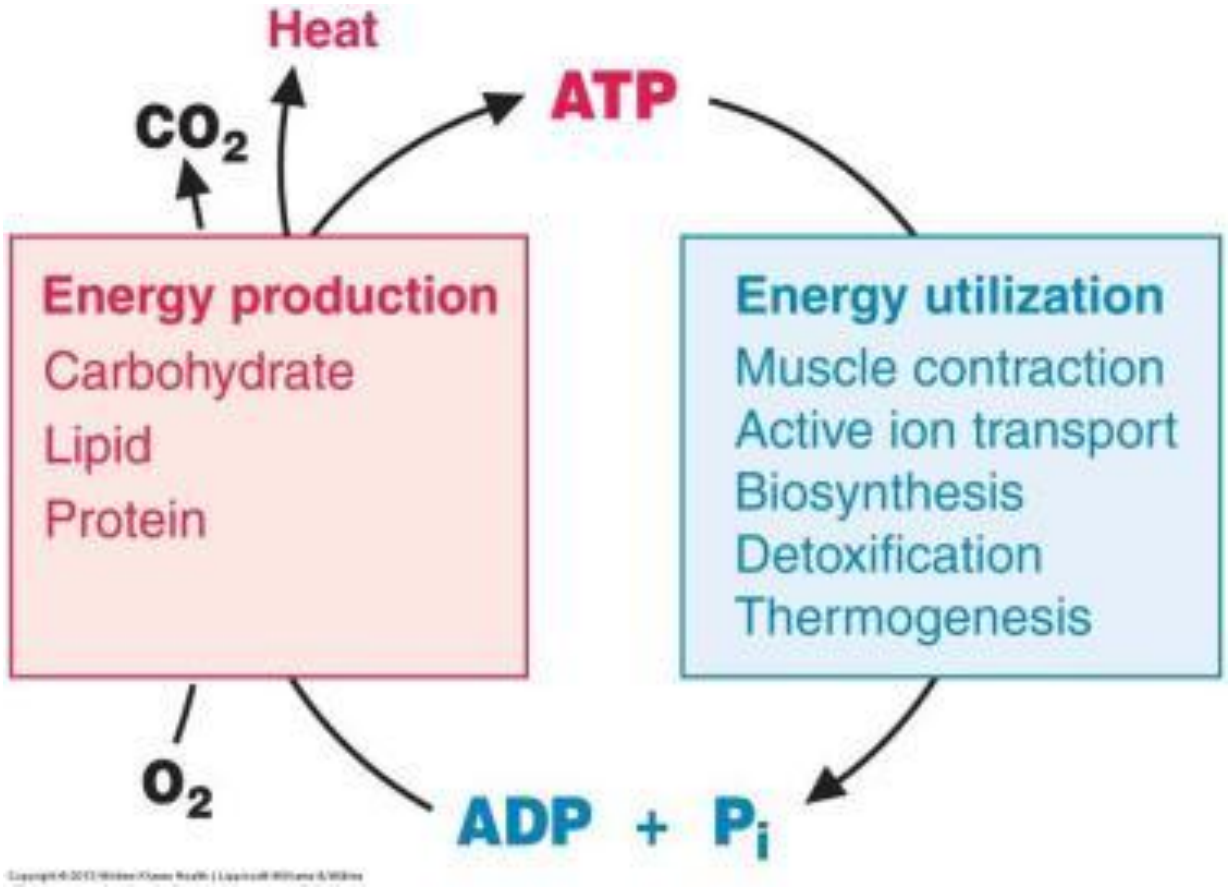
Membrane-bound organelles sub-divide into compartments allows for the creation of specific microenvironments within a cell.

Each organelle **can have all the advantages it needs to perform to the best of its ability,** e.g., specialized proteins/enzymes, a certain pH, each organelle has its own **assigned tasks in the overall work of the cell.**

The work of cells

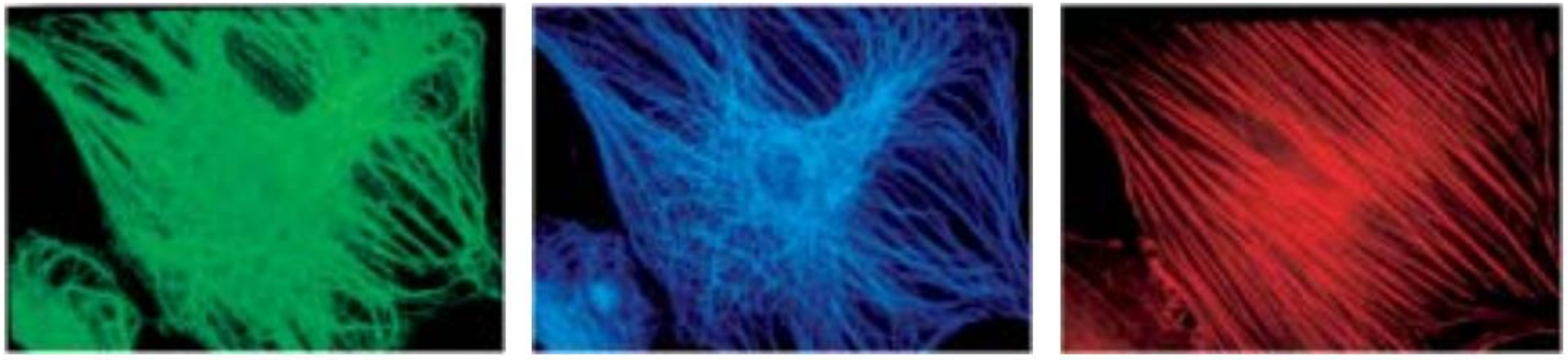
Cells build & degrade numerous molecules & structures.

- Producing an enormous number of complex molecules from simple building blocks.
- Cells also need to breakdown biomolecules into small molecules.
- ATP is the most common molecule used by cells to capture and transfer energy.



The work of cells

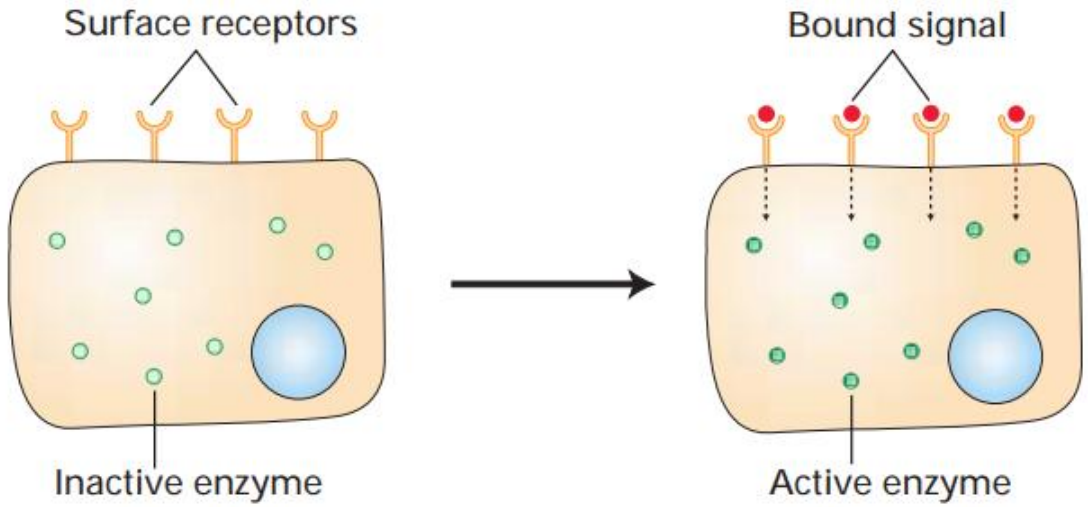
- **Animal cells produce their own external environment and glues.** Extracellular cellular matrix such as collagen, cell adhesion molecules (CAMs) etc.
- **Cells change shape and move.** Cytoskeleton structure: network of fibers extending throughout cytoplasm. Cytoskeleton function: structural support, maintain cell shape, cell locomotion, transport of vesicles etc.

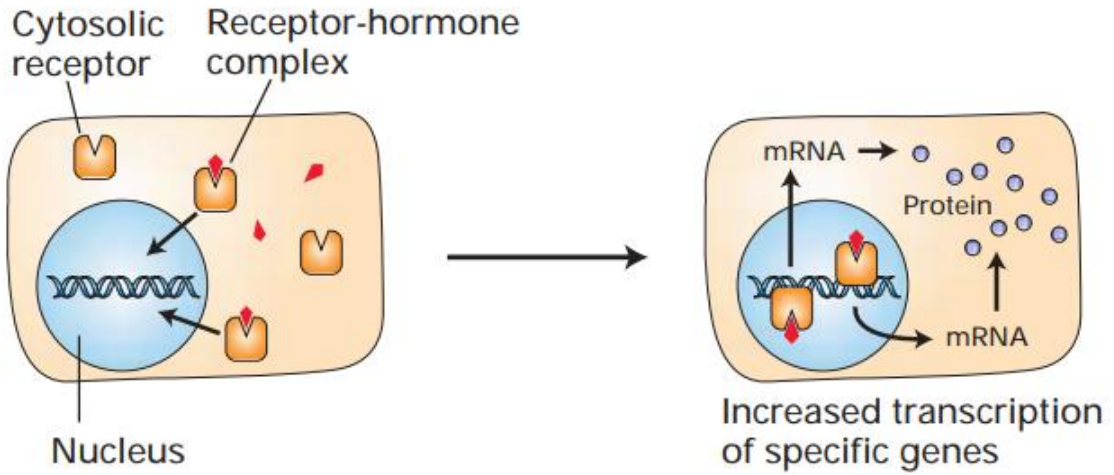


The three types of cytoskeletal filaments have characteristic distributions within cells.

The work of cells

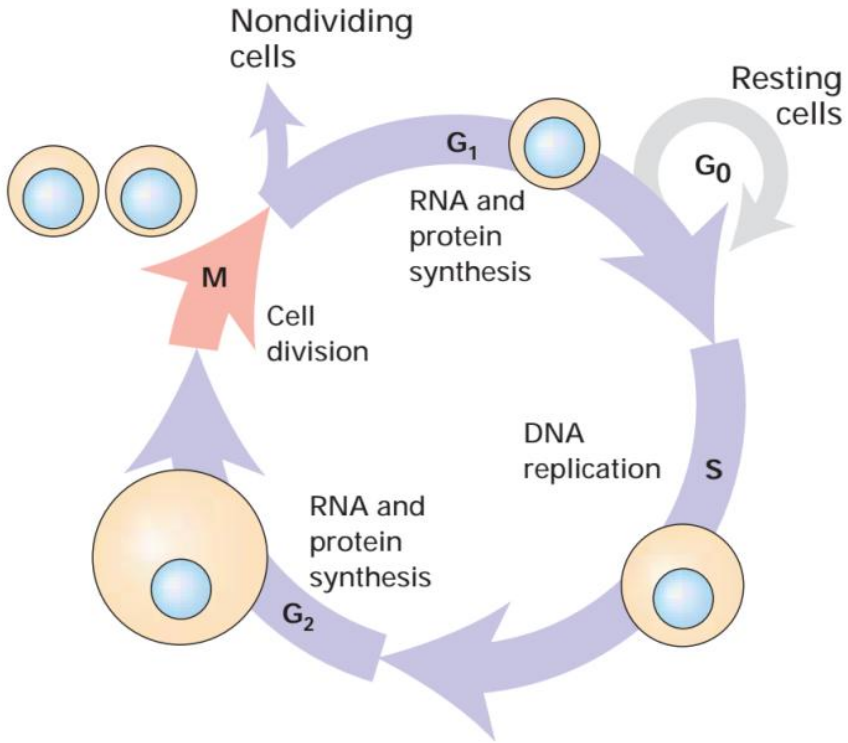
Cells sense & send information.

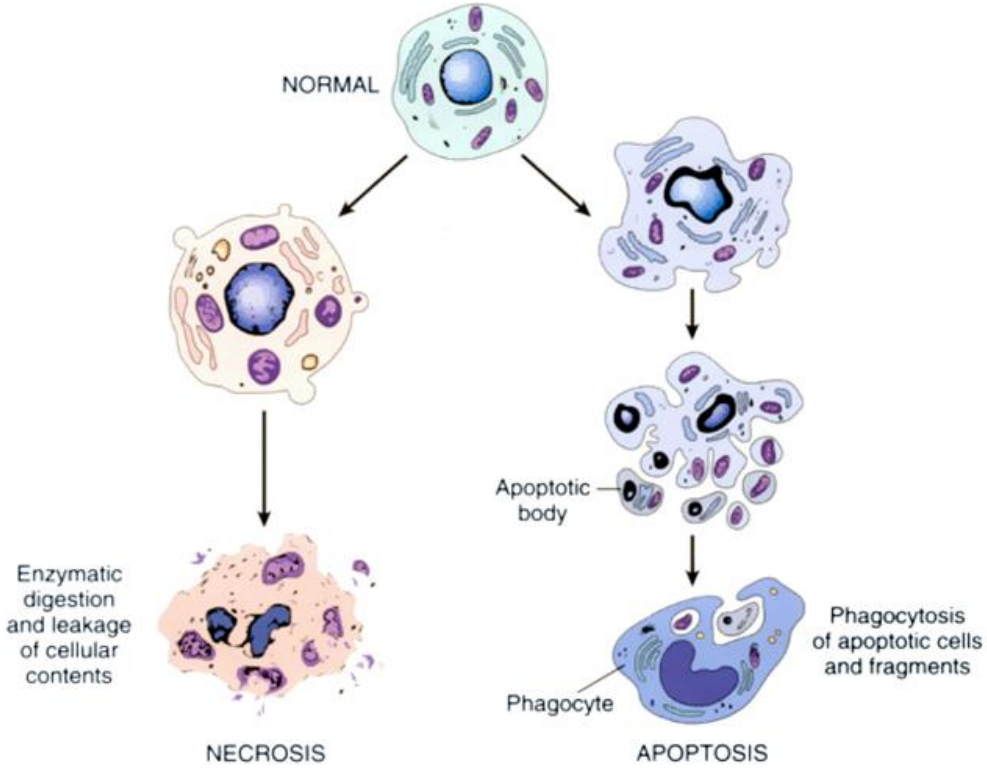




The work of cells

- Cells regulate their gene expression to meet changing needs. Gene expression and regulation.
- Cells grow and divide.
- Cells die form aggravated assault or internal program (apoptosis).

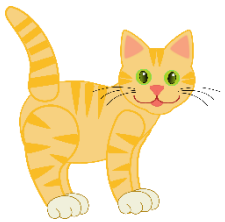




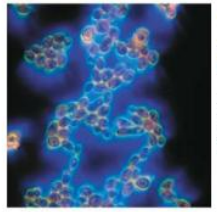
Investigating cells & their parts

- Science is the way to understand nature
- Choice of experimental organism matters

Human?
Cell culture?
Animal?



(a)



Yeast (*Saccharomyces cerevisiae*)

Control of cell cycle and cell division
Protein secretion and membrane biogenesis
Function of the cytoskeleton
Cell differentiation
Aging
Gene regulation and chromosome structure

(b)

Alga (*Chlamydomonas reinhardtii*)

Structure and function of flagella
Chloroplasts and photosynthesis
Organelle movement
Phototaxis

(c)

Roundworm (*Caenorhabditis elegans*)

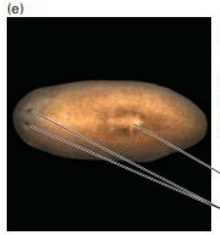
Development of the body plan
Cell lineage
Formation and function of the nervous system
Control of programmed cell death
Cell proliferation and cancer genes
Aging
Behavior
Gene regulation and chromosome structure

(d)

Fruit fly (*Drosophila melanogaster*)

Development of the body plan
Generation of differentiated cell lineages
Formation of the nervous system, heart, and musculature
Programmed cell death
Genetic control of behavior
Cancer genes and control of cell proliferation
Control of cell polarization
Effects of drugs, alcohol, pesticides

(e)



Planarian (*Schmidtea mediterranea*)

Stem cells
Turnover of adult tissues
Wound healing
Regeneration

(f)

Zebrafish (*Danio rerio*)

Development of vertebrate body tissues
Formation and function of brain and nervous system
Birth defects
Cancer

(g)

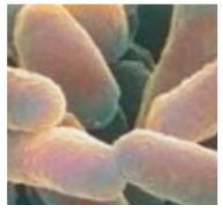
Mouse (*Mus musculus*), including cultured cells

Development of body tissues
Function of mammalian immune system
Formation and function of brain and nervous system
Models of cancers and other human diseases
Gene regulation and inheritance
Infectious disease
Behavior

(h)

Plant (*Arabidopsis thaliana*)

Development and patterning of tissues
Genetics of cell biology
Agricultural applications
Physiology
Gene regulation
Immunity
Infectious disease



Bacteria

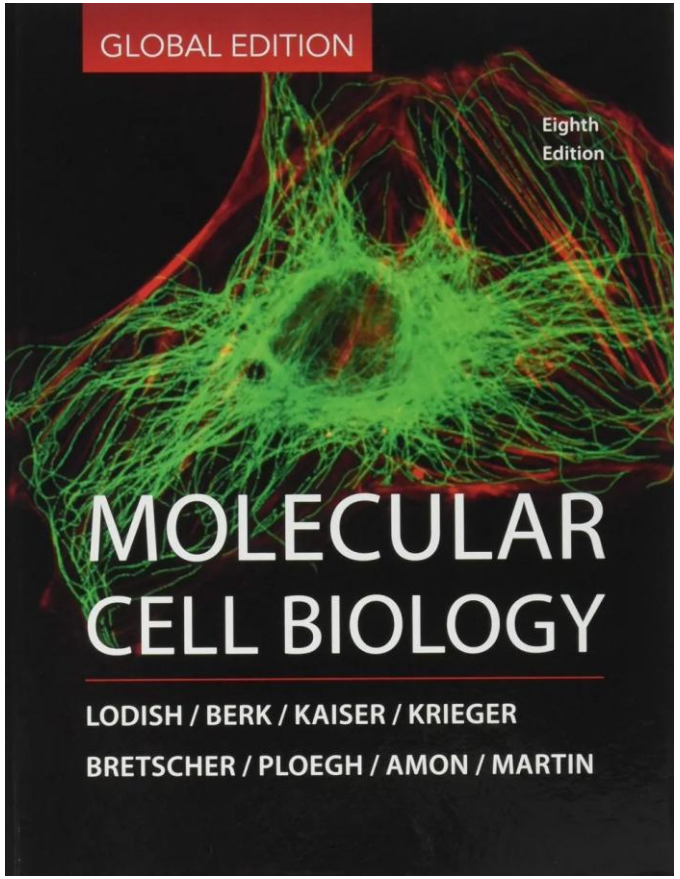
Proteins involved in DNA, RNA, protein synthesis, metabolism
Gene regulation
Targets for new antibiotics
Cell cycle
Signaling

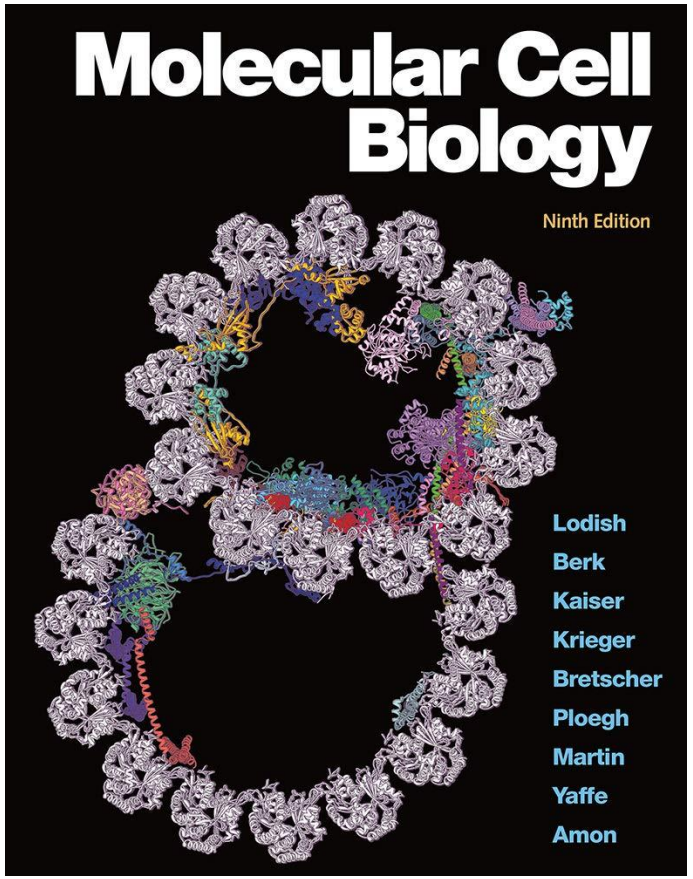
Viruses

Proteins involved in DNA, RNA, protein synthesis
Gene regulation
Cancer and control of cell proliferation
Transport of proteins and organelles inside cells
Infection and immunity
Possible gene therapy approaches

Each eukaryotic organism used in cell biology has advantages for certain types of studies.

References





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