LS1101: Module II

Molecules of life

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Topics covered

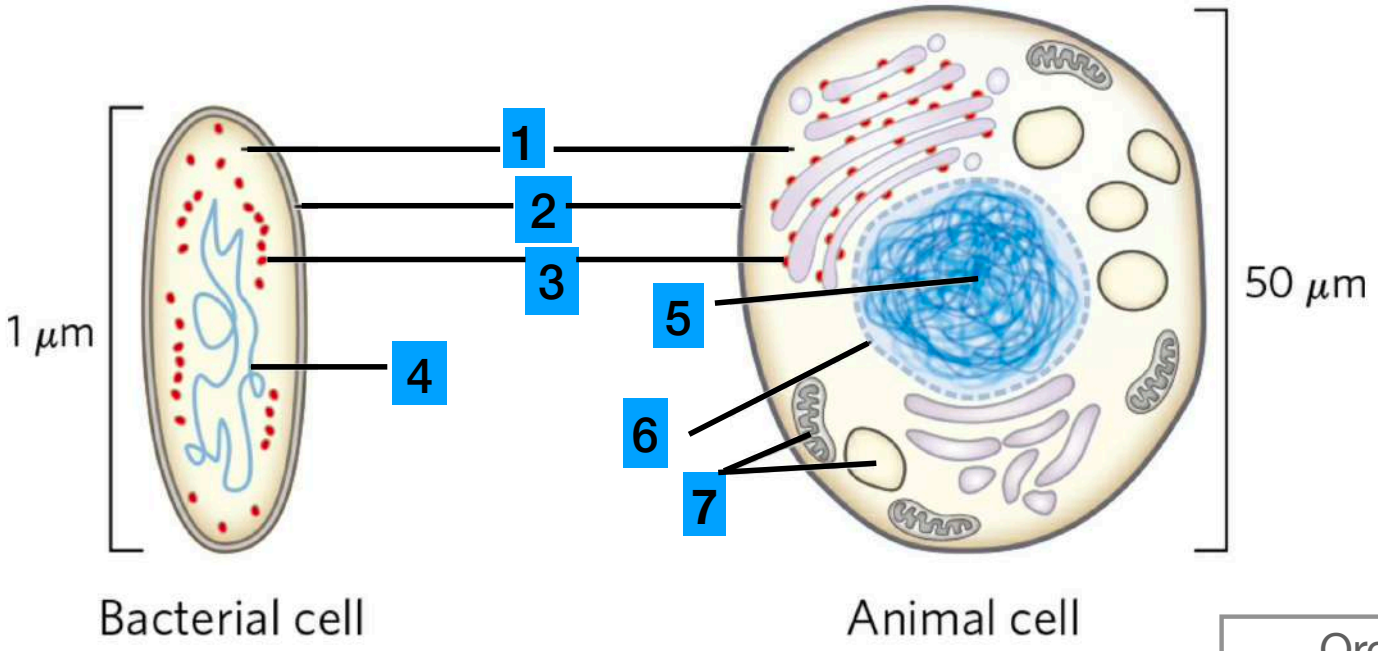
- Cellular architecture, molecules of life
- Water
- Amino acids as building blocks of peptides and proteins
- Peptides and proteins
- Nucleotides as building blocks of nucleic acids.
- Nucleic acids
- Enzymes and catalysis

Reference books

- My slides
- Lehninger Principles of Biochemistry (Nelson and Cox.) (library)
- Biochemistry, Jeremy M Berg, John L Tymoczko, and Lubert Stryer. Available online at: https://www.ncbi.nlm.nih.gov/books/NBK21154/ **(note: this book is topic searchable using the "search this book" feature)**

Cellular structure

The upper limit of cell size is set by the rate of diffusion of solute molecules in aqueous systems (eg. O_2)



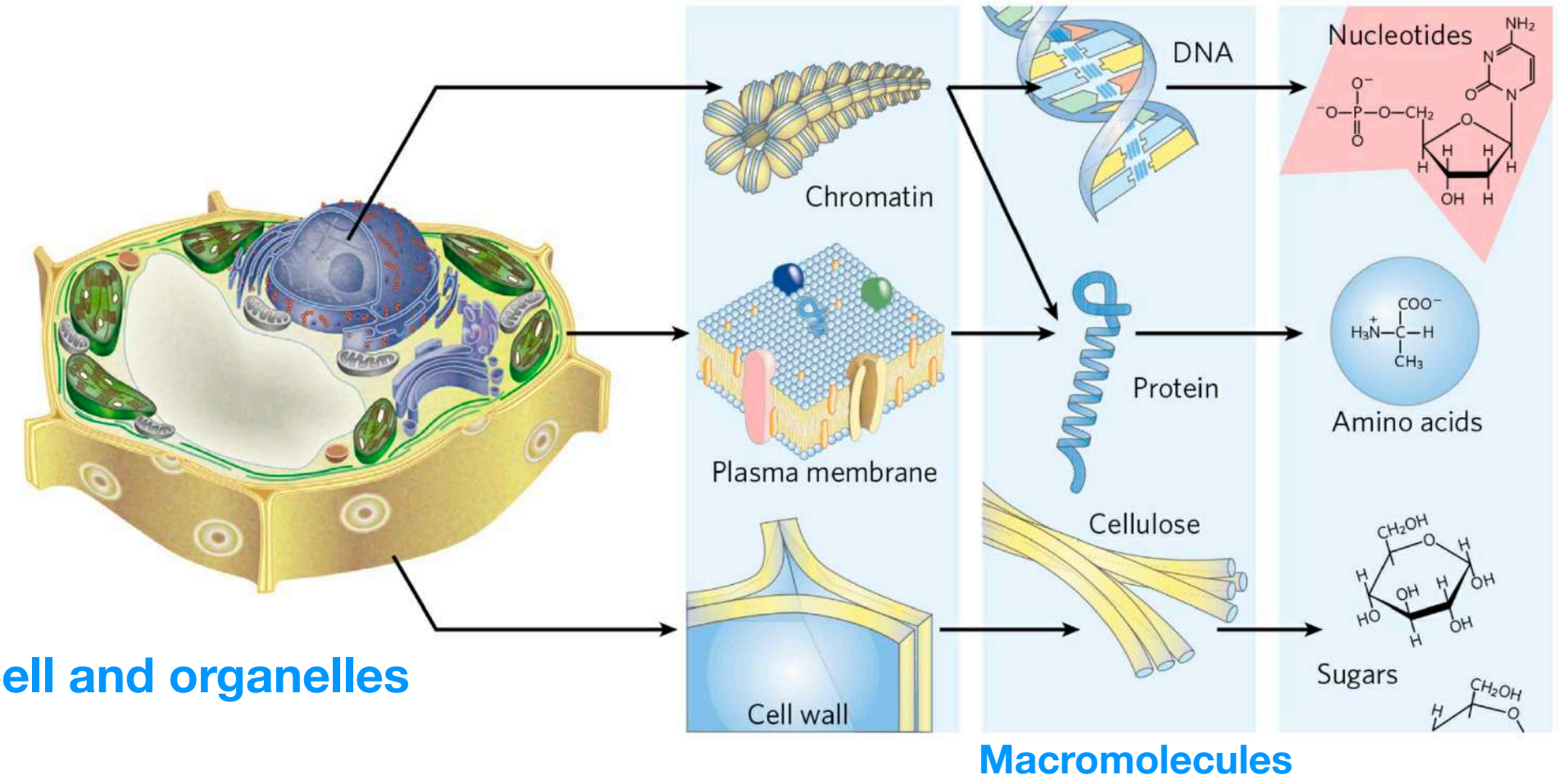
1. Cytosol or cytoplasm
2. Plasma membrane
3. Ribosome
4. Nucleoid
5. Nucleus

Contains organism's genome

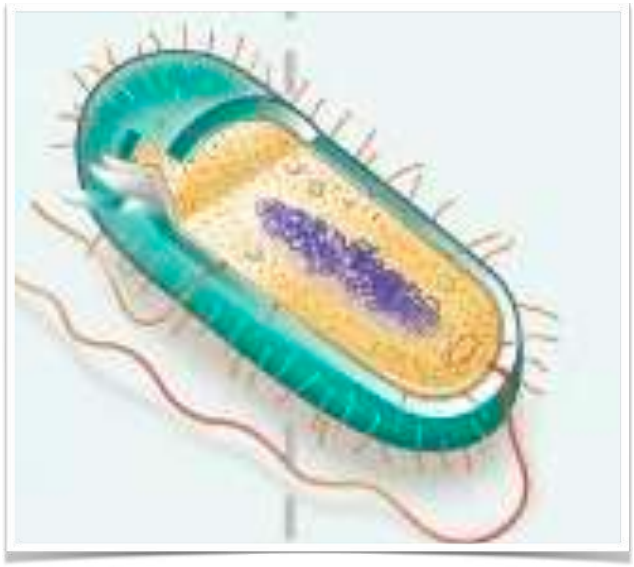
6. Nuclear membrane
7. Organelles

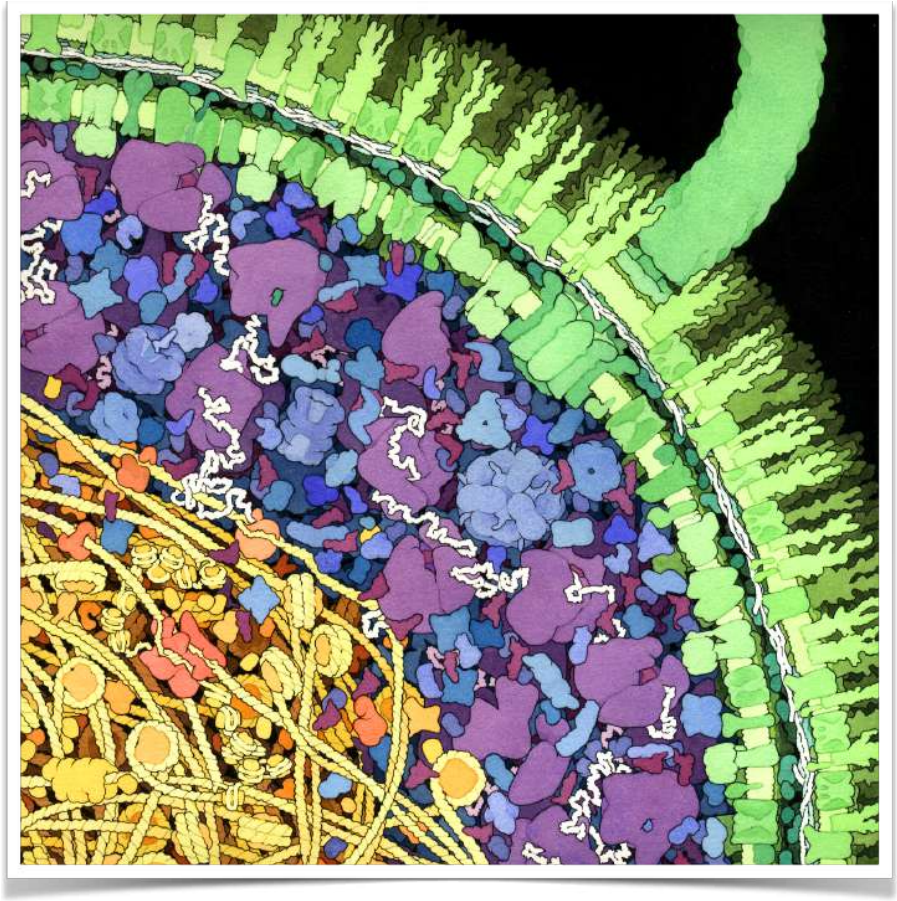
Organelles are membrane bound structures such as mitochondria (found in animals), chloroplast (found in plants) etc.

Cellular organization



Glancing inside the cell: “crowded” cell

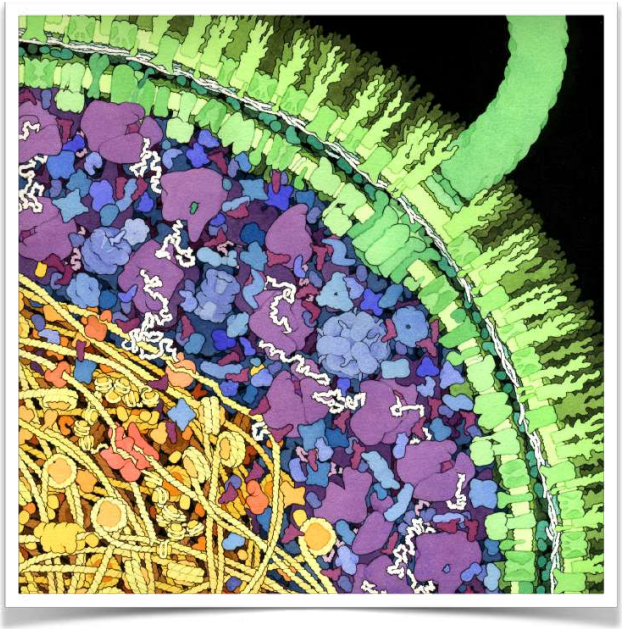




Cellular macromolecules do not rely only on diffusion to carry out their functions

Courtesy: David Goodsell

Glancing inside the cell: “crowded” cell



- When all of the known macromolecules in a cell are represented in their known dimensions and concentrations, it is clear that the cytosol is very crowded and that diffusion of macromolecules within the cytosol must be slowed by collisions with other large structures.
- In the cell, a macromolecule is dissolved or suspended in the gel-like cytosol with thousands of other molecules, some of which bind and influence its activity.
- A given molecule may behave quite differently in the cell and *in vitro*.

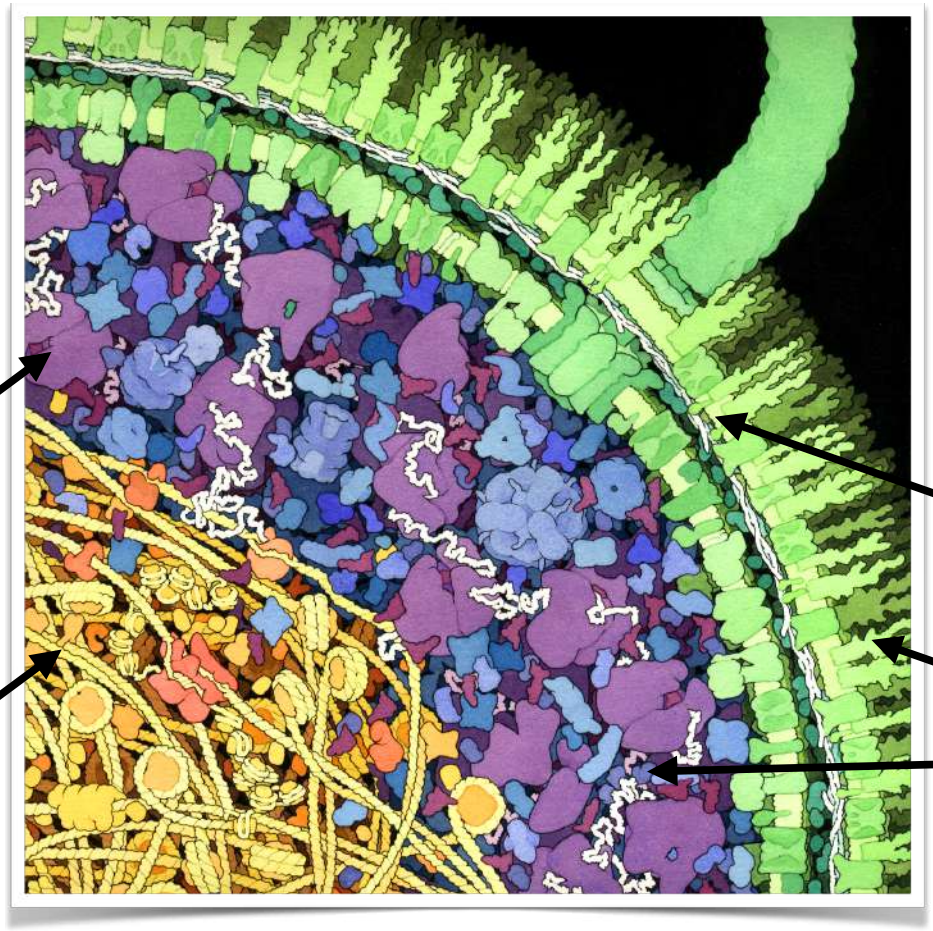
Courtesy: Nelson and Cox

A central challenge of biochemistry is
to understand the influences of cellular organization and macromolecular associations on the function of individual biomolecules and their relationship to other biomolecules
—to understand function in vivo as well as in vitro.

Courtesy: Nelson and Cox

Introduction to the molecules of life

What are the molecules of life?

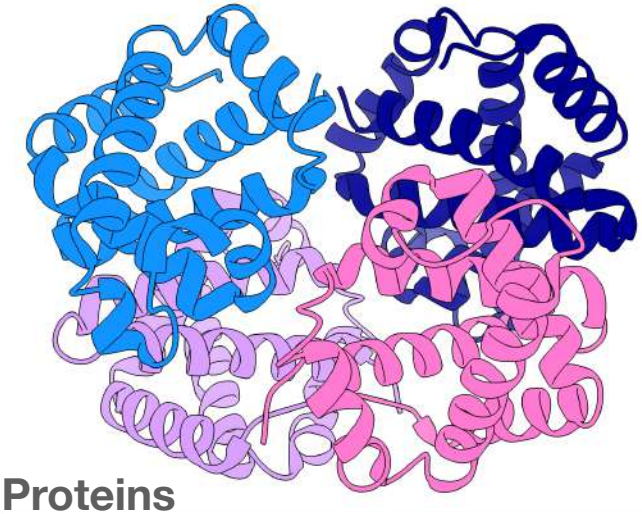


Courtesy: David Goodsell

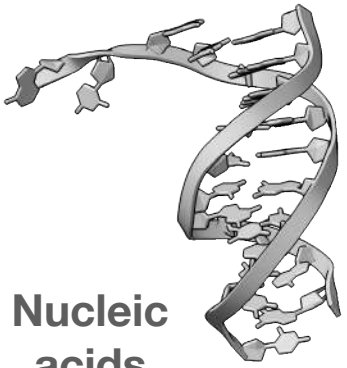
Biology at the molecular level: macromolecules and their monomers

Polymers

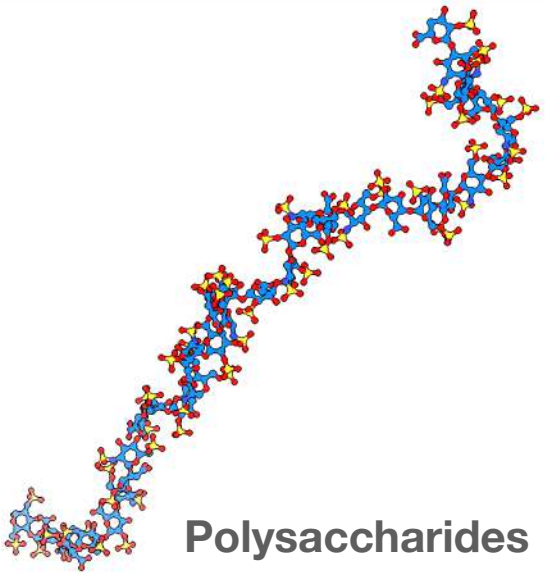
Monomers



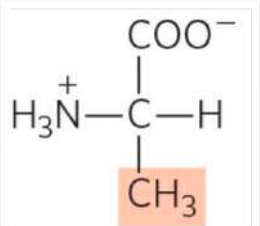
Proteins



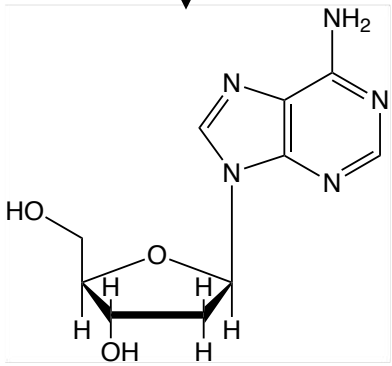
Nucleic acids



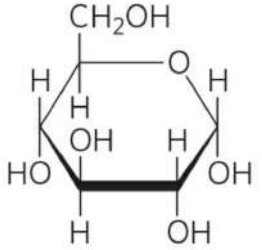
Polysaccharides



Amino acids



Nucleotides



Monosaccharides

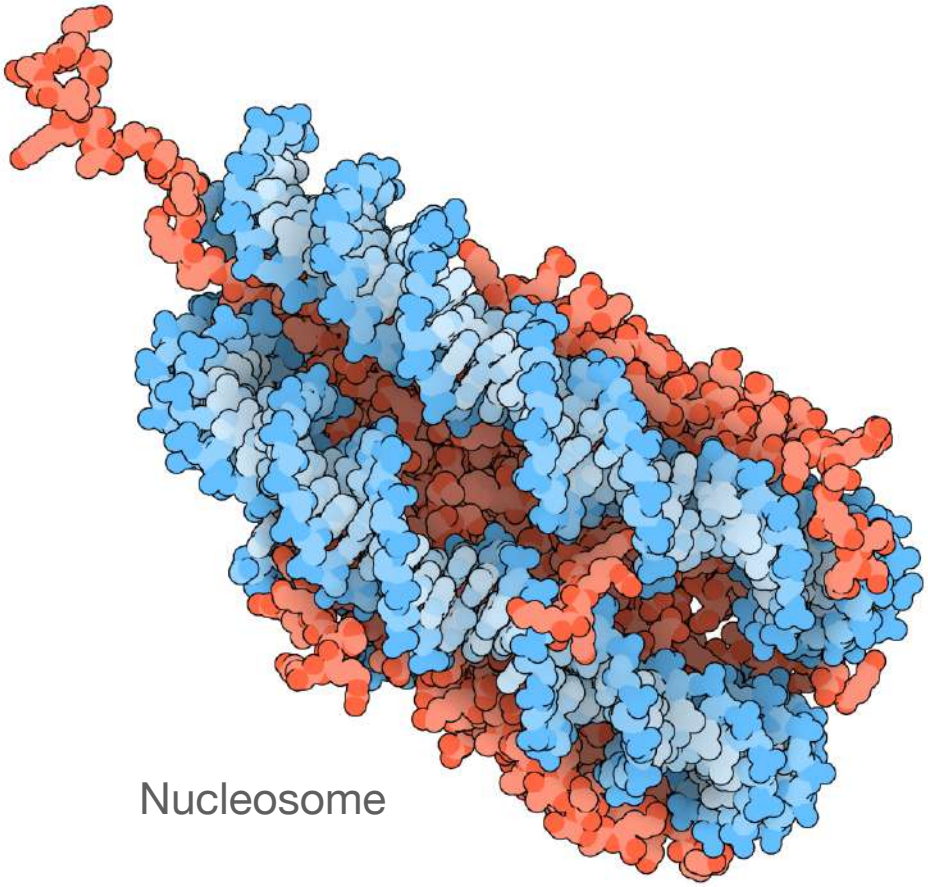
Biology at the molecular level: macromolecules

- Many biological molecules are **macromolecules**: polymers with molecular weights above ~5,000 Da that are assembled from relatively simple precursors.
- Shorter polymers are called oligomers.
- **Proteins**, **nucleic acids**, and **polysaccharides** are macromolecules composed of monomers with molecular weights of 500 Da or less.
    - The monomeric units of:
        - proteins are amino acids
        - nucleic acids are nucleotides
        - polysaccharides are monosaccharides
- Synthesis of macromolecules is a major energy-consuming activity of cells.

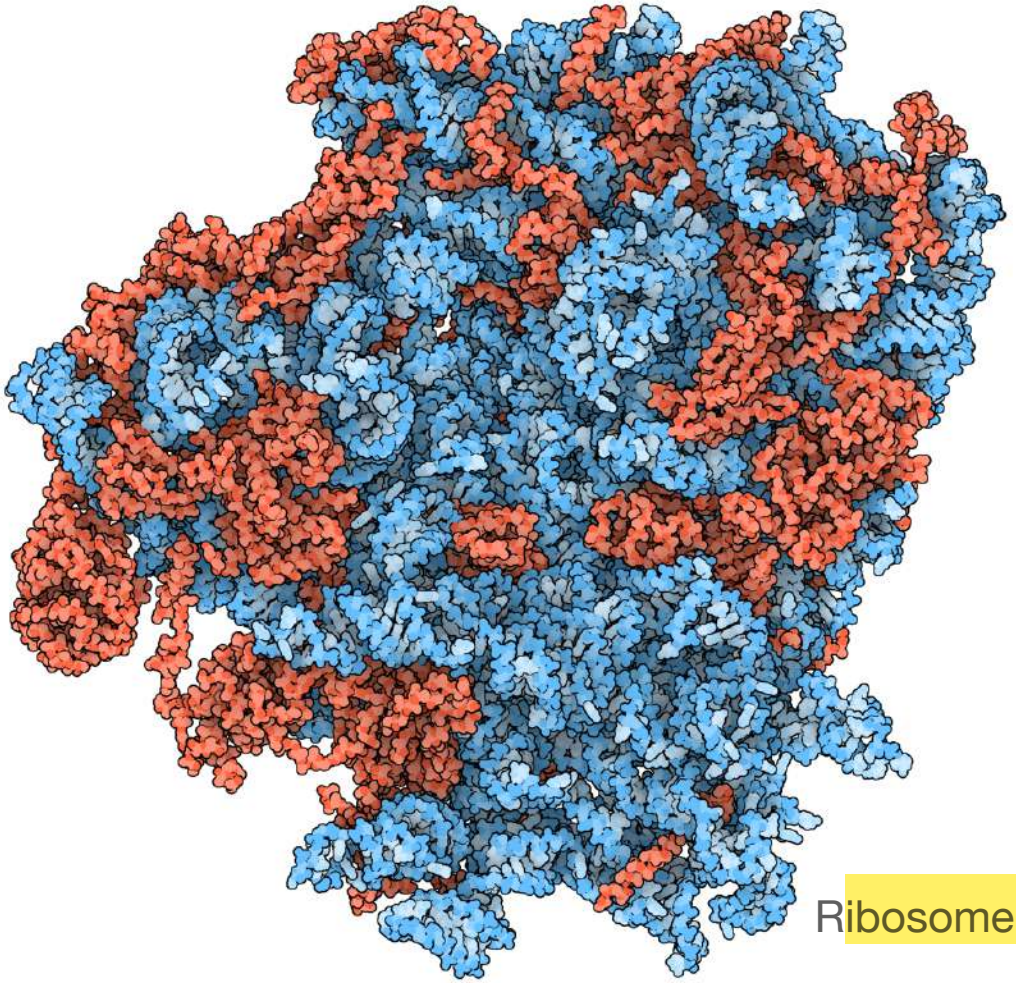
Biology at the molecular level: macromolecules

- Proteins, nucleic acids, and polysaccharides have high molecular weights and thus a large number of monomeric subunits—
  - 5,000 to >1 million for proteins
  - up to several billion for nucleic acids
  - several millions for polysaccharides such as starch
- Individual lipid molecules are much smaller (Mw 750 to 1,500) and are not classified as macromolecules, but they can associate noncovalently into very large structures.
  - Cellular membranes are built of enormous noncovalent aggregates of lipid and protein molecules.
- Proteins and nucleic acids are often referred to as informational macromolecules. Some oligosaccharides may also serve this function.

Biology at the molecular level: molecular machines

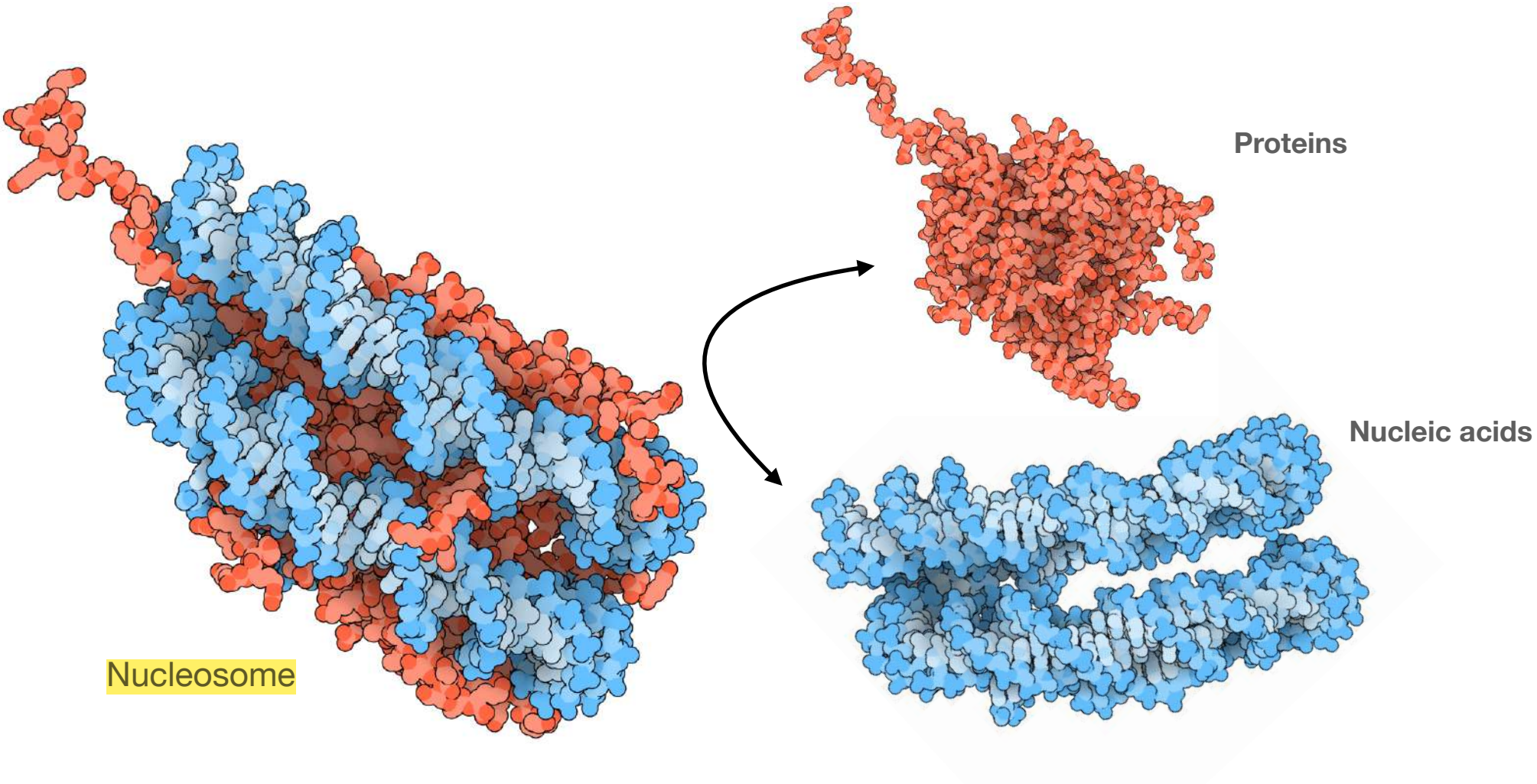


Nucleosome

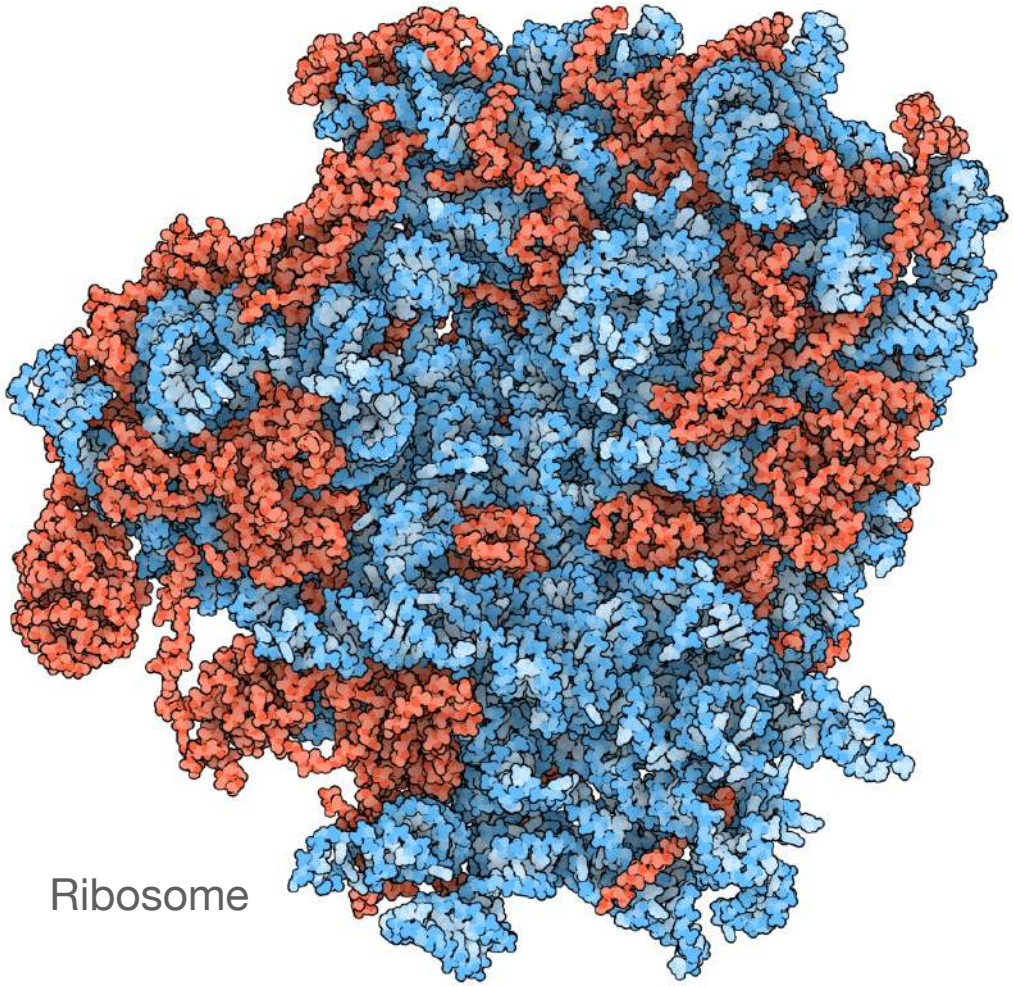


Ribosome

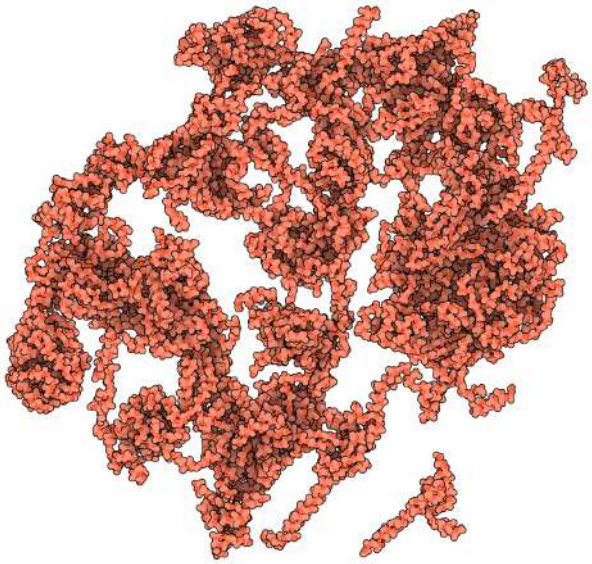
Biology at the molecular level: molecular machines



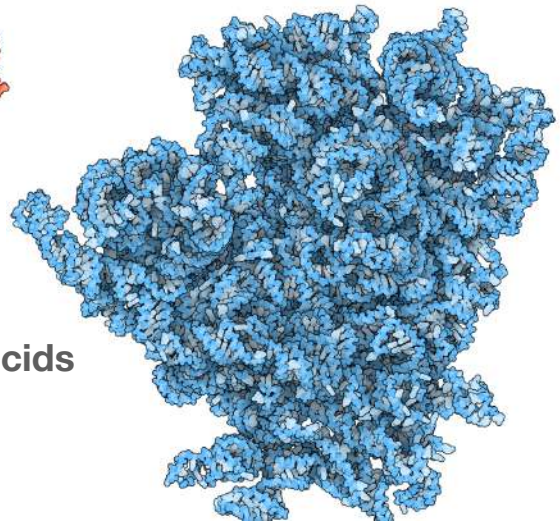
Biology at the molecular level: Molecular machines



Ribosome



Proteins



Nucleic acids