Quick Review: Cellular Biology

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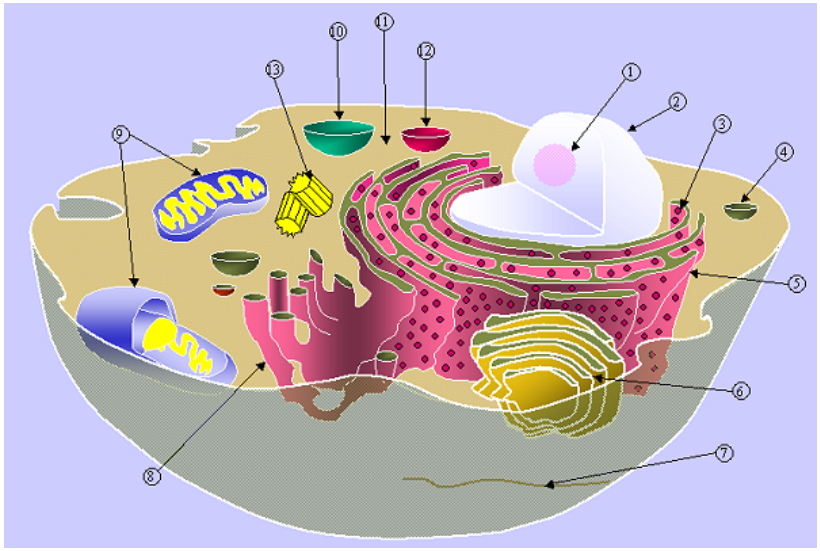
Cellular Biology

Full appreciation of proteins, or more specifically heat shock proteins, and the complex chemical pathways in which they are involved begins with the study of basic undergraduate level cellular biology.

Eukaryotic Cell

Cell: minuscule membrane-bound corpuscles filled with a concentrated aqueous solution of chemicals and endowed with an extraordinary ability to create copies of themselves by growing and dividing in two.

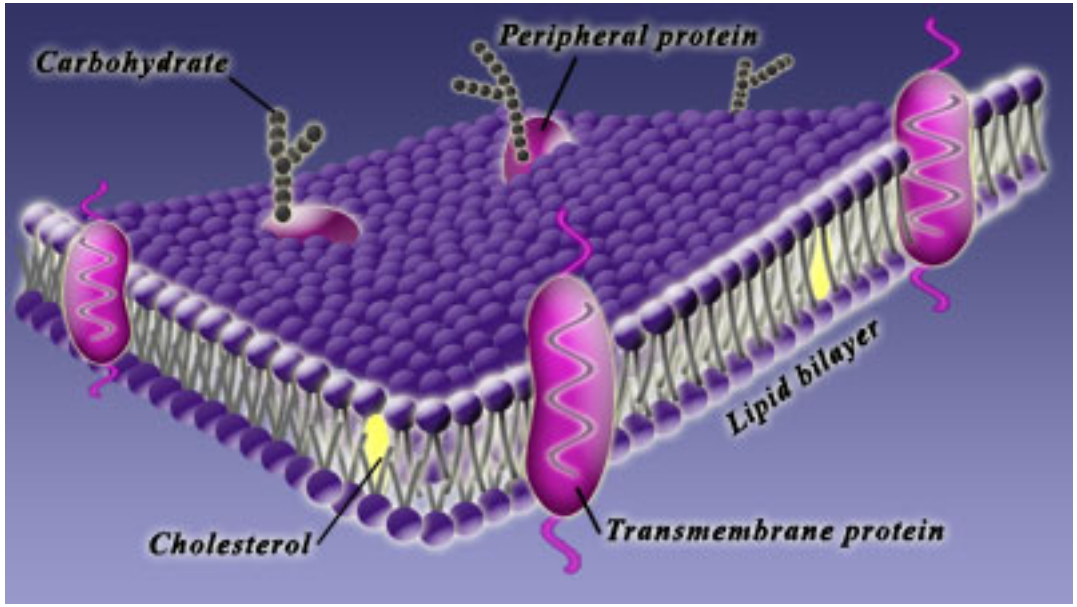


1. nucleolus
2. nucleus
3. ribosome
4. vesicle
5. rough ER
6. Golgi apparatus
7. cytoskeleton
8. smooth ER
9. mitochondria
10. vacuole
11. cytoplasm
12. lyosome
13. centrioles

Cellular Constituents

Plasma Membrane

- 5 nm thick
- two fatty acids* create barrier between cell and surroundings



*fatty acid: characterized by a large hydrocarbon tail covalently bonded to a carbonyl group

Cellular Constituents

- Within the cell exists an ordered chaos
- Organelles*, embedded in the cytoskeleton!, each contain their own soup of molecules in constant thermal motion
- Using the language of chemical reactions, organelles perform their own tasks and collectively work together to create life

*organelles: membrane bound entities contained within the cell each with its own set of chemical specific to its function

!cytoskeleton: may be considered the muscles and bones of the cell giving structural support and allowing movement

Cell Length Scales

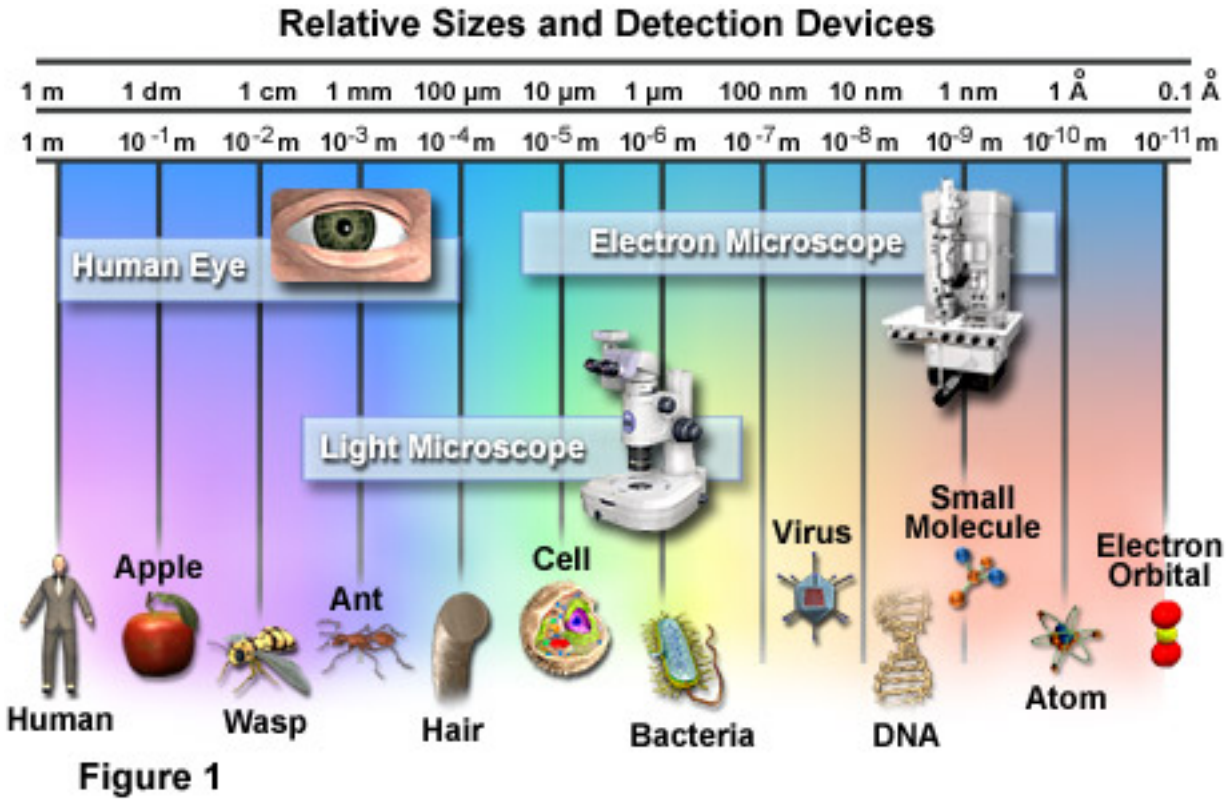


Figure 1

Cellular Constituents

Cell constituents:

- 70% water
- 26% macromolecules (proteins, nucleic acids, and polysaccharides)
- 4% inorganic molecules, amino acids, nucleotides, fatty acids, other small molecules

Proteins constitute the majority of the dry mass

Proteins

Functions of Proteins:

- structural support
- movement
- trans-membrane transport
- message carriers
- enzymes
- antibodies, toxins, hormones, etc.

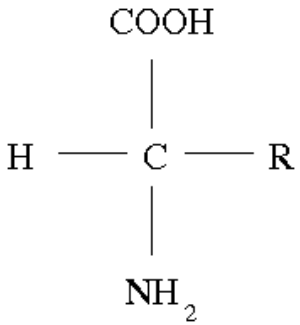
Proteins: A Sequence of Amino Acids

Proteins built from Amino Acids

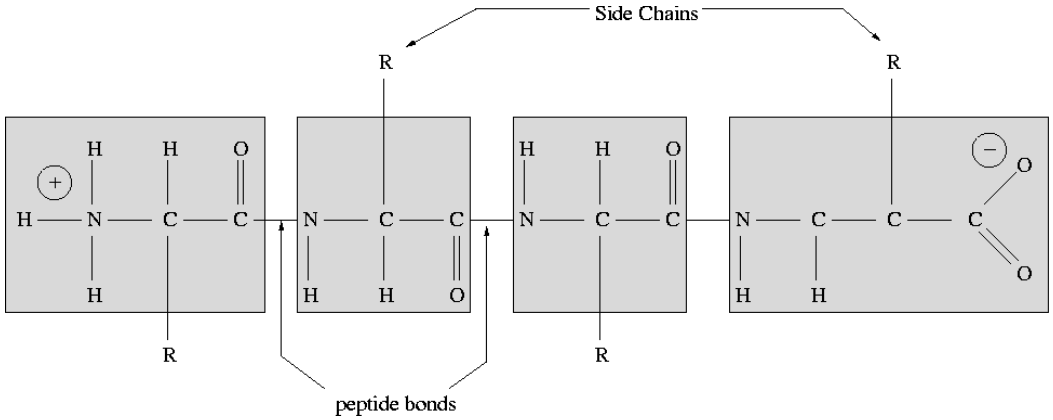
- amino acid: molecules named according to chemistry naming convention

- amino: signals presence of amide functional group*
- acid: signals presence of carbonyl functional group*

Generic Amino Acid



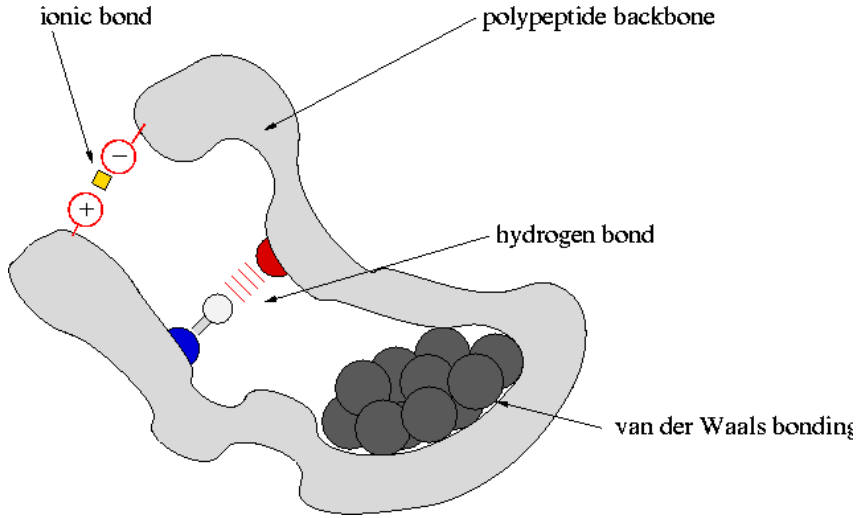
Simple protein

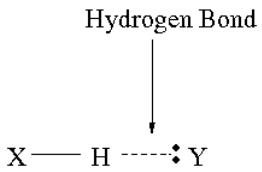


*functional group: groups of atoms occurring repeatedly in organic molecules, each with a distinct chemical and physical properties that influence the behavior of the molecule in which they appear

Proteins: A Sequence of Amino Acids

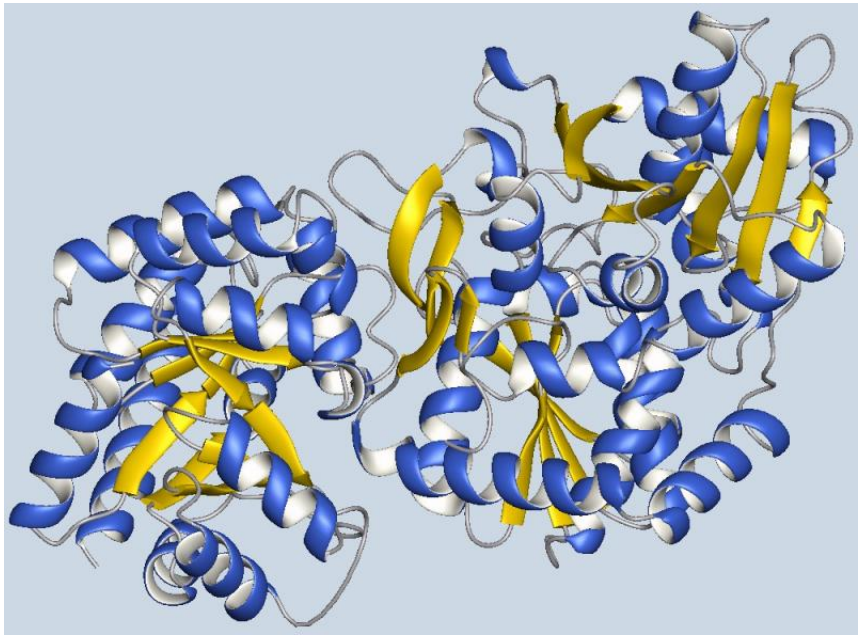
- total of 20 amino acids occurring in nature
- 30-10000 covalently bonded amino acids
- majority of proteins consist of 50-2000 amino acids
- non-covalent bonds determine conformal shape of protein





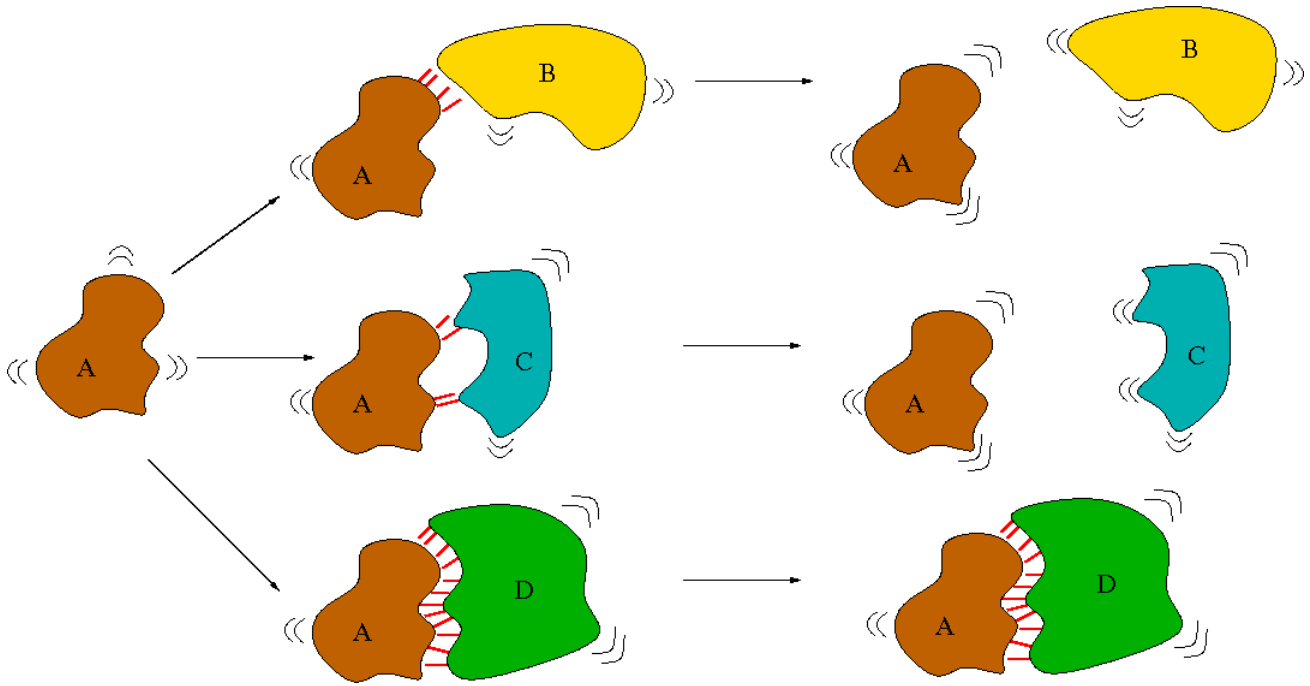
Proteins: Conformal Shape

- α Helix and β Sheets common folding patterns
- first the structure of the folded protein may seem random



Protein: Conformal Shape

The folded shape essential to function of protein. Combined strength of multiple non-covalent bonds allow proteins to perform their tasks.



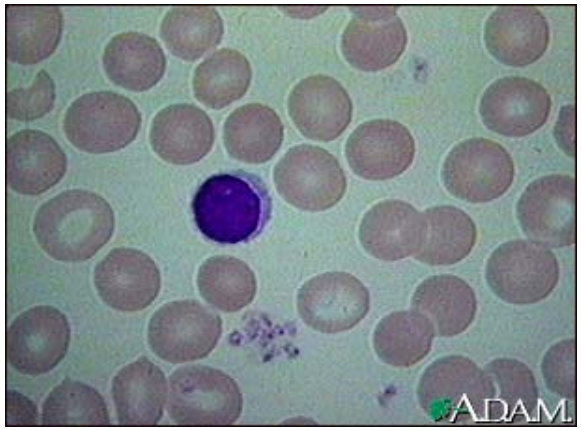
Bond Strength

bond type	length (nm)	strength in vacuum (kcal/mole*)	strength in water (kcal/mole*)
covalent	0.15	90	90
non-covalent: ionic	0.25	80	3
non-covalent: hydrogen	0.30	4	1
non-covalent: van der Waals	0.35	0.1	0.1

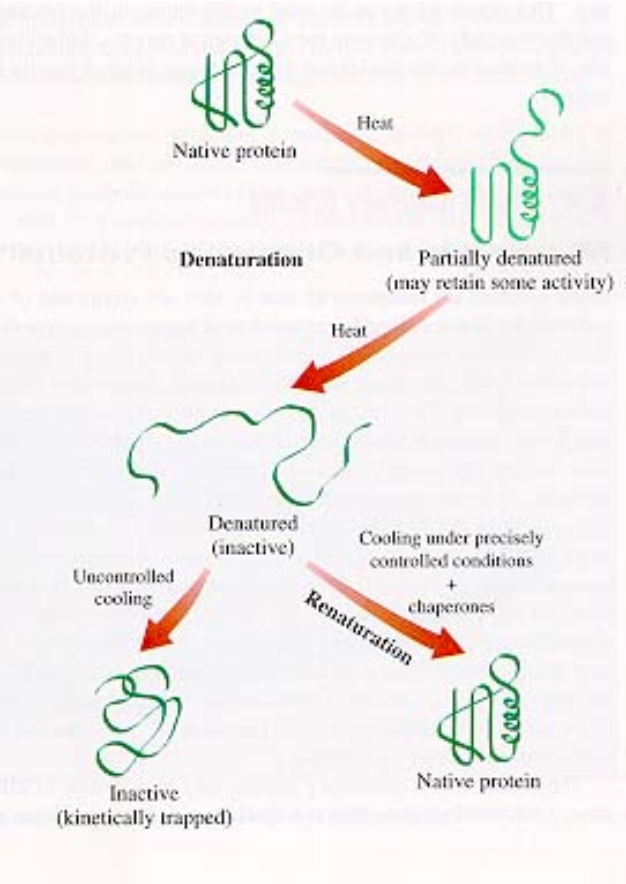
Where a bond strength of 1 kcal/mole implies that 1 kilocalorie of energy must be supplied to break 6×10^{23} of these bonds.

Protein: Sensitivity

- A typical red blood cell contains about 270 million hemoglobin molecules
- alteration of a single amino acid in the β-globin chain of hemoglobin mutates the hemoglobin, hemoglobin S
- hemoglobin S polymerizes under low oxygen conditions giving the cells their sickle shape



Heat Shock Proteins



- molecular chaperones
- disassembly of abnormal proteins
- inhibition of improper protein aggregation
- direction of newly formed proteins to target organelles for final packaging, degradation, or repair
- activation of the immunological system in response to the presence of viral proteins