Lecture 3
Organic molecules

Proteins: protos = “to come first”
- Function: Cellular “machinery” & structure
  - Crucial for regulation of cell processes & maintenance
- Monomer: Amino Acid

Basic Structure:
- Carbon center (C)
- Amino group (NH₂)
- Carboxylic Acid (COOH)
- Hydrogen (H)
- R - functional group (residue)
R group: Variable portion of Amino Acid

- 20 different functional groups: 20 AAs
  - Possessing different chemical properties
    - Charge, polar, hydrophobic & hydrophilic

- Dehydration Synthesis forms:
  - PEPTIDE BONDS
2 amino acids linked form: **Dipeptide**

3 amino acids linked form: **Tripeptide**

4–9 amino acids linked form: **Oligopeptide**

Greater than 10 amino acids link to form: **Polypeptides (50 – 2,000)**

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**Protein: Functional Polypeptide**

- Greater than 100 Amino Acids
- Possess a specific 3-D shape
- Normal function depends upon protein structure

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**Protein Structure: 4 Levels**

1. **PRIMARY STRUCTURE:**
   - Sequence of Amino Acids
   - Linked with: **Covalent Peptide Bonds**
2. **SECONDARY STRUCTURE:**
   * Similar Monomers linked produce a very Consistent Pattern
     a. Coiled Pattern: Helix
     b. Folded Pattern: Pleated Sheet

3. **TERTIARY STRUCTURE:**
   * Depicts complete 3-D shape
     ~ Consists of non-uniform contortions & bends
     ~ Provides uniqueness to the protein

~ Repetition of H-bonds provides strength to 2D Structure
Results from R-groups interactions

1. Hydrophobic
2. Hydrogen Bonding: Van der Waals Forces
3. Ionic Bonds
4. Covalent Bonds: Disulfide bond

Specific amino acid sequence determine specific protein shape

Sickle Cells Anemia

Result: Incorrect structure and function
4. QUATERNARY STRUCTURE

* Proteins consisting of **2 or more** polypeptide chains

![Hemoglobin Structure](image)

Protein Structure

![PDB-101](image)
Protein Denaturation:
- Process of unfolding protein structure
- Due to physical or chemical stress
- Result: Change in folding can result in change in function

\[ \text{pH, temperature, salt, hydrophobic, hydrophilic} \]

Lipids: Most diverse organic molecule
- Common feature: Insoluble in polar solvents
  - “Do not dissolve in water”
  - Hydrophobic / non-polar
4 Major subgroups:
1. **Triglycerides**: Body energy storage
2. **Phospholipids**: Cell & organelle membranes
3. **Steroids**: Hormones: Cell Regulation
4. **Prostaglandins**: Hormone like: Local cell regulation

**Triglyceride: Fats & Oils**
- 80 – 85% stored body energy
- Monomers:
  1. **Glycerol**: 3 carbon molecule
  2. **3 Fatty Acids**: Hydrocarbon chains

**Dehydration Synthesis:**
- Bond: **Ester bond**
  - Glycerol’s –Hydroxyl end
  - Fatty acids –Carboxyl end

= Neutral fat
Differ according to 3 Fatty acid features
1. Number of carbons in chain: 4 – 24 carbons
2. Number of carbon = carbon double bonds
   - Determines: degree of fatty acid saturation

Fats & oils:
- Double bonds: Decrease hydrogen saturation
  - Increases the degree of Unsaturation

Hydrogen Saturation: Amount of Hydrogen
A. **Saturated fats**: Contain NO double bonds

B. **Monounsaturated fats**: Contain ONE double bond

C. **Polyunsaturated fats**: Contain 2 or more double bonds

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3. The fatty acid chain shape: *Bent or straight*

   - Double bonds: *create bends in the fatty acid*

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- **Bends**: *increase fatty acid fluidity*
  - **Solid**: Fatty acids “stack” easily on each other
  - **Fluid**: Fatty acids are difficult to “stack”
Saturated fats:
- Contain NO double bonds
- Contain maximum hydrogen bonds
- Straight hydrocarbon chains
- Solid at room temperature: Stack easily

Unsaturated fats:
- Contain one or more double bonds
- Do NOT contain maximum hydrogen bonds
- Bent hydrocarbon chains
- Liquid at room temperature: Especially with high unsaturation
Hydrogenation:

- **Chemically adding hydrogen to unsaturated fats:**
  - **Goals:**
    - a. Increase **stability**: "self life": Reduced oxidation
    - b. Increase **convenience**: More solid
    - c. Better taste and texture
    - d. Melt **better for cooking**

Cis Double bonds: Naturally occurring
- Hydrogens on **same side** of double bond
- Allows movement: Bending

Trans Double bonds: Not common naturally
- Hydrogens on **opposite side** of double bond
- Restricts movement: Less bending

Trans Fats linked to heart disease
- On shelves: Popular because of easy use, extended shelf life, desirable taste and texture, it goes to food.
- Up and down: Increase risks for heart disease by both raising bad cholesterol levels and lowering good cholesterol.
- Reduces heart attacks: Change could potentially prevent 20,000 heart attacks and 7,000 deaths a year.
- Other options: Butter, vegetable oils, such as palm or coconut, involving man-made fat without ill health effects.

Worst foods:
- Fried, battered food
- Microwave popcorn
- Frozen desserts
- Baking mixes
- Ready-to-eat frosting
- Frozen pizza
- Pie crusts, cookies

The Food and Drug Administration is taking steps to eliminate trans fats in American diets.
Saturated or Unsaturated?

Unsaturated  Saturated

2. Phospholipids: “Membrane lipid”

Extracted Space

Lumen of Cell

Phospholipid
**Building Blocks**

a. **Glycerol**: 3 carbon "Anchor"

b. **2 Fatty Acids**: *Uncharged* hydrocarbon chains

c. **Phosphate Group**: *Charged* entity

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**Phospholipids: Amphipathic**

- Possess a dual affinity for water:
  - **Hydrophobic**: "fearing water"
    - Hydrocarbons chains: Non-polar covalent bonds
    - Water orients away hydrocarbons
  - **Hydrophilic**: "water loving"
    - Phosphate group: Charged entity
    - Water orients toward phosphate

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**Phospholipids in water**

- Self assemble due to water affinity into:
  - **Micelles**
  - **Lipid bi layers**
3. **Steroids**: “Chemical Messengers”

- **Structure**: 4 Fused carbon rings
  - 3 six carbon member rings
  - 1 five carbon ring

![Steroid structures](image)

- **Lipid characteristic**: Insoluble in water
  - Enables steroids to diffuse through membranes

![Lipid diffusion](image)

4. **Prostaglandins**: “Cell activity moderators”

- **Structure**: 20 carbon fatty acid with cyclical pentacarbon ring

![Prostaglandin structure](image)
• Lipid characteristic: **Insoluble in water**
• Function: **Produced by essentially ALL tissues:**
  * Produced by tissue at site of activity:
    > Paracrine & autocrine regulatory molecules
    > Act LOCALLY
  * Mediate:
    a. **Inflammatory response:** pain, swelling, fever
    b. **Normal tissue function:** blood clotting, gastric secretion, vasodilation, bronchus, uterine function

**Biosynthesis:**
- **Precursor: Phospholipid** (membrane)
  - Enzyme: Phospholipase A2
  - Product: Arachidonic Acid
- **Primary Precursor: Arachidonic Acid**
  - Enzyme: Cyclooxygenase Enzyme (COX1 and COX2)
  - Product: Tissue specific Prostaglandins
Clinical Significance: NSAID

- NSAID: Non-steroidal anti-inflammatory
- Mechanism of Action: Inhibit COX enzyme
- Function:
  1. Reduce Pain and inflammation
  2. Inhibit clotting
- Examples:
  1. Aspirin
  2. Ibuprofen
  3. Tylenol (acetaminophen)

Prostaglandin: Aspirin

Diagram showing the biosynthesis of prostaglandins with Aspirin as an example.