Biomolecules

The building blocks of life.
The 4 Major Organic Biomolecules

“Looks aren’t everything. It’s what’s inside you that really matters. A biology teacher told me that.”
The large molecules (biomolecules OR polymers) are formed when smaller building blocks (monomers) bond covalently. ←via anabolism

Small molecules are formed when those covalent bonds are broken ←via catabolism
metabolism

Anabolism – building

Catabolism – breaking down
How are polymers formed?
Condensation – a.k.a. polymerization, dehydration, synthesis

- removal of water to make polymers out of monomers
- requires an input of Energy
- Enzymes are required in biological systems (no enzyme = no polymerization)
- anabolism – building!
Condensation reactions

A dehydration synthesis – requires ENERGY to make the bond

A covalent bond forms

Water is removed
hydrolysis

- converts polymers to monomers
- Releases Energy
- Enzymes used for most reactions
- Catabolism – breaking down
polymers are disassembled by **Hydrolysis** – energy is released when bond is broken.

![Diagram showing hydrolysis process](image)
Condensation vs. Hydrolysis

- In your notes, construct T-chart and contrast condensation with hydrolysis.
- Contrast using at least 3 characteristics for each.
Practice condensation/hydrolysis
The large molecules (biomolecules OR polymers) are formed when smaller building blocks (monomers) bond covalently.

### The building blocks of organisms

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carbohydrates

main characteristics:
- Made up of: C, H, and O

Function
- Main function
  - key source of immediate *Energy*
- Other
  - structural

Examples:
- sugars, starch, cellulose, glycogen chitin
Monomer - Monosaccharide (ex. Glucose or fructose) is the main source of Energy in cells.

Disaccharide (glucose + fructose = sucrose) is a polymer.

Polymers - Polysaccharides are made from monomers.
Formation of a disaccharide

condensation reaction – removal of water, requires energy
(dehydration synthesis)
Importance of GLUCOSE

$C_6H_{12}O_6$

required molecule for cellular respiration - very important cellular function!!
consists entirely of glucose monomers

(b) Starch: 1–4 linkage of α glucose

(c) Cellulose: 1–4 linkage of β glucose

serves as a glucose storage molecule
Formation of a polysaccharide

Starch

Cellulose

Glycogen

stored in plants

used for structure

stored in muscles and liver
Carbohydrates are stored in the muscle and the liver as **GLYCOGEN**. This can quickly be converted into glucose and used as ENERGY in the Muscles.
Carbohydrates are used in plants as **CELLULOSE**. It is used to construct the plant cell walls.

**Most abundant organic compound on earth**

**Predominant component of plant cell walls**

**Most organisms cannot digest cellulose – why?**
used for structure: example -- Chitin

exoskeleton of insects, spiders and crustaceans
Build a Glucose Molecule

- Use your chart as a guide
The large molecules *(biomolecules OR polymers)* are formed when smaller building blocks *(monomers)* bond covalently.

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in all the membranes of your body
- Contain C, H, O
Where lipids are needed → phospholipids

Cell membranes
monomer
3 FA and 1 glycerol

polymer
triglyceride

3 fatty acid

+ glycerol

→ triglyceride
nonpolar = insoluble in water

The macromolecules are not polymers by definition (polymers are covalently bonded), but they form large molecules due to Van der Waals forces.
Main Function: Energy storage

Other
  > Regulatory – hormones and
  > Thermal insulator
  > Water repellant
  > Structural
C-H bonds = energy rich
- energy is stored in the C-H bonds

fat stores over twice as much energy/gram as carbohydrates
There are 2 types of Fat:

1. saturated fats
2. unsaturated fats
fatty acids

(a) Saturated fat and fatty acid. At room temperature, the molecules of a saturated fat such as this butter are packed closely together, forming a solid.

saturated
Can’t compact to form solid due to double bonds, must stay liquid
The trans-fat "hype"

Causes cancer
Cholesterol manufactured in the liver is an important component of membranes and is the starting material for steroids such as testosterone.
many steroids are *hormones*: important molecules that function as chemical signals
Anabolic steroids

- Derivative of male hormone TESTOSTERONE

- Increase protein synthesis in cells → increase cellular tissue in muscles

- Blocks cortisol (hormone that reduces inflammation in muscle cells, breaks down muscle) receptor sites on muscle cells

- In response to more testosterone in body, more cortisol is produced

- Decrease the body's natural production of testosterone
Anabolic steroid side effects

-Once off of anabolic steroids, body has elevated levels of cortisol, therefore muscle is lost fast, levels of natural testosterone are low
-Side effects:
  - Liver function – lesions, anemia, jaundice
  - Increase cholesterol levels
  - Aggression
  - Depression
  - Structural changes in heart – heart disease
  - Female characteristics in males
  - Male characteristics in females
  - In teenagers – stunted bone growth
  - Suppresses immune system
  - Acne
waxes

- long-chain nonpolar lipids.
- protective coating on plant leaves and animals (honeybee wax, cuticles of insects, skin lipids, etc.), algae, fungi and bacteria.
Build a triglyceride molecule

- Use your chart as a guide
Polymers are formed when smaller building monomers bond covalently.

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Each nucleotide consists of (C,H,O,N and P):
1. Phosphate group – Phosphorous, Oxygen
2. Pentose sugar – Carbon, Hydrogen and Oxygen
Pentose Sugar – 2 kinds

2-Deoxyribose

Ribose

(Klug & Cummings 1997)
5 Nitrogenous Bases

Nitrogenous Base

DNA Bases: Thymine, Adenine, Guanine, Cytosine

RNA Bases: Uracil
Making a Polymer – Nucleotides join to form RNA or DNA – RNA or DNA is the polymer

- Phosphate bonds to Carbon on Sugar

Sugar – Phosphate Backbone
RNA – Single Stranded
DNA – Double Stranded

Two strands joined together by hydrogen bonds
Certain bases only join with other bases
DNA and its Bases

Nitrogenous Base

Adenine - Thymine

Guanine - Cytosine
ATP and ADP – (nucleotides)

- nucleotides – high energy bonds between phosphate molecules
- energy used by cells
What is the function of DNA?

- Stores heredity information for all living organisms
- Sequence of bases on DNA strand determines individual traits
What is the function of RNA

→ RNA is instrumental in the production of PROTEINS
Food sources for nucleic acids

- Body makes them
- Any food that was once alive!
The building blocks of organisms

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All proteins consist of polymers that are folded into specific shapes. Their shape controls their function.
Their importance is all in the name: Protios

Greek for “first place”

These are very large, 3 dimensional macromolecules.

Responsible for almost all functions in a living organism

All proteins have C, H, O and N
**function of proteins:**

**structural** molecule in the cell

as **energy** sources

**most importantly as** **enzymes**

Spider web silk is a structural protein.
Amino acid

Made up of C, H, O and Nitrogen

R groups – unique side chains

Polypeptide (protein)
- R groups can be any of 20 different forms
- 20 different amino acids
Amino acids cannot be stored, they must be continually eaten

- **Sources:**
  - animal proteins
  - plant proteins
10 (of 20) are essential

Need **Nitrogen** from foods to manufacture other amino acids

arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine.
amino acid

peptide bonds

polypeptide

monomer → polymer
Condensation

Carboxyl group ↔ amino group

(a) Peptide bond

(b) Side chains

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Build an amino acid (monomer of a protein)
Biomolecule Foldable and Review
structure of proteins:

Primary

Secondary

Tertiary

Quaternary
"The sequence of amino acids in the polypeptide chain."

Amino acids are bound together with a "peptide" bond.
Model primary structure
There are two types of secondary structure in proteins, the α-helix and the β-pleated sheet.
- attraction of the R groups within the same chain can causes the chain to twist into a coil (α helix)

- held together by hydrogen bonds between the hydrogen and oxygen atoms of the amino acid backbone.
Keratin is a structural protein found in hair and nails, skin, and tortoise shells.

The α Helix nature of wool is what makes it shrink.
Model secondary structure - alpha helix
Caused by hydrogen bonding between the hydrogen atoms (amino group) and the oxygen atoms (carboxyl group) of amino acids on *two chains (or more)* lying *side-by-side*.
Model secondary structure – beta pleated sheet
Interactions between “R” groups – form ionic, disulfide bridges and hydrogen bonds

Hydrophobic interactions (clustering of hydrophobic groups away from water) and van der Waals interactions

Polypeptide backbone

Hydrogen bond

Disulfide bridge

Ionic bond

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The strong covalent bonds hold the protein in its specific 3D shape.

The 3D shape creates "pockets" or "holes' in the surface of the protein which are very important in enzyme function (as we shall see).
Model tertiary structure – Remainder group interaction
This last level of organization is simply taking 2 or more tertiary proteins and sticking them together to form a larger protein. Many enzymes and transport proteins are made of two or more parts.
Hemoglobin: an oxygen carrying protein in red blood cells which is made of 4 parts.
Model quaternary structure – with your table group!
Enzymes – biological catalysts

When a biological reaction occurs, *Energy* is involved.
generally, chemical reactions proceed only after an initial input of energy
the amount of Energy needed to start a reaction

*Activation Energy*
In non-living systems, HEAT can be used to increase the energy and overcome the activation energy barrier, then the reaction may proceed…

But….

that would kill most living cells
In addition - Protein structure is sensitive to environmental conditions ---- weak bonds are broken:

Temperature increases
When heated, proteins can unfold or **denature**.

loss of shape usually means a *loss of the protein’s function*.

If the denatured protein is allowed to cool it will sometimes refold back into it’s original conformation.
So...

By lowering the activation energy, the reaction could proceed with less energy input, thereby preventing harm to the organism.
Time for reaction to occur

Many reactions that occur in cells take too long to be useful; therefore, cells have to speed them up.
are biological *catalysts*

Speed up reactions and do so with less energy

Are not altered in reaction
The catalyst increases the rate of the reaction – but is not permanently altered in the process
All enzymes are *proteins*.

But not all proteins are enzymes.

Catalysts do not cause a reaction that would not happen eventually on its own.
Enzymes lower the activation energy needed for the reaction to proceed, resulting in increasing the rate of reaction.
Enzymes are highly specific – protein enzymes catalyze a specific reaction. Each chemical reaction in an organism requires its own specific enzyme.
**Substrate** - each chemical that is worked on by an enzyme

**Active site** – where substrate and enzyme attach
enzymes are named for the substrate they act on OR by the pathways they participate in – “ase” ending

Sucrose

Sucrase

Glucose

Fructose
THE LOCK AND KEY MODEL

1. Enzyme and substrate are available
2. Substrate binds to enzyme
3. Substrate is converted to products
4. Products are released

Enzyme (sucrase)
Active site
Fructose
Glucose
Substrate (sucrose)
Enzyme-substrate complex
+ H₂O

Locked substrate
Unlocked substrate
Key - enzyme
enzymes act by:

orienting substrates
enzymes act by:

- inducing strain
- temporarily altering the chemistry of the substrate
enzymes act by:

• adding charges to substrate
Factors that affect enzymes

(a) Temperature

(b) pH

(c) Substrate concentration
PROJECT : MY RESTAURANT