Energy and Cell Chemistry

What is energy?

*Symplocarpus foetidis*
*Skunk cabbage*

*Sauromatum venosum*
*Voodoo lily*
Two types of energy

• Potential Energy
• Kinetic Energy
The laws of thermodynamics

• **First law of thermodynamics**: Energy can not be created or destroyed but only converted into another form (law of conservation of energy)

• **Second law of thermodynamics**: The energy transformation if not 100% efficient, that is, certain amount of energy is lost in all transformation (law of entropy)

• How efficient are our combustible engines running our modern automobile?

• What does increase in entropy means?

• Photosynthesis and Cellular Respiration are two primary primary energy transformation in plants

What is metabolism?
Metabolism : powers life

Metabolic Pathways:

Sugar + O₂ => H₂O + ATP + heat

- Catabolic Reactions (Catabolism)
- Anabolic Reactions (Anabolism)

- Oxidation: Loss of electrons
- Reduction: Gain of electrons

Oxidation-reduction reactions are coupled
ATP is the energy currency of cells

ATP (adenosine triphosphate), the Energy Currency of Cells

\[ \text{ATP} + \text{H}_2\text{O} \rightarrow \text{ADP} + \text{Pi} + \text{energy} \] (Hydrolysis)

\[ \text{ADP} + \text{Pi} + \text{energy} \rightarrow \text{ATP} + \text{H}_2\text{O} \]
ATP is ideally suited for energy currency

1. The amount of energy released is ~ twice as much as is needed to drive many cellular reactions

2. ATP does not cross cell membrane and is short lived

3. The third phosphate bond of ATP is weak, unstable to break easily

Coupled Reactions
Phosphorylation

NAD: nicotinamide adenine dinucleotide (nicotinic acid, a B vitamin

NAD$^+$ is reduced to NADH
Enzymes are required for cellular

Human Diseases:

Lactose intolerance
Diabetes

Drugs:

Nerve gas
Penicillin (mode of action)
Plant cells and tissues consist of 4 types of large organic compounds:

- Carbohydrates
- Proteins
- Nucleic Acids
- Lipids

Polymers:

- Starch
- Proteins
- Glutenins
- Lignin

Plants: Photosynthesis

$\text{CO}_2$ from air, water and minerals from soil
Synthesis and Hydrolysis of Sucrose

\[
\text{Glucose} + \text{Fructose} \rightleftharpoons \text{Sucrose} + \text{Water}
\]

\[
\text{Monosaccharide} + \text{Monosaccharide} \rightleftharpoons \text{Disaccharide} + \text{Water}
\]
Carbohydrates: $C_nH_{2n}O_n$ (eg, $C_6H_{12}O_6$)

- Monosaccharides
- Disaccharides
- Polysaccharides

  - Simple sugars
  - Complex carbohydrates

Acer saccharum
(sugar maple)

Sucrose
Cellulose: Most abundant polymer on earth

Arrangement of Fibrils, Microfibrils, and Cellulose in Cell Walls

Pectins and hemicelluloses

Starch
DNA makes RNA makes Proteins

Transcription

Translation

DNA:
- Purines: A&G
- Pyrimidines: T&C

RNA:?
Proteins: Polymers of amino acids

(a) Primary structure  (b) Secondary structure

Disulfide bond

(c) Tertiary structure

Hydrogen bond

(d) Quaternary structure
Proteins

**Structural Proteins:** Cell Wall

**Storage Proteins:** zeins (corn), glutenins (wheat), globulins (legumes)

Corn and Barley: low in essential aa’s
Beans and Peas: low in cysteine & methionine
Soybean: Rich source of protein

Proteases (Papaya) *Carica papaya*
Acylglyceride bond
Lipids help form membranes and serve as storage for carbon and energy

Major plant lipids: oils, phospholipids and waxes

- **Saturated fatty acids**: no carbon-carbon double bonds: palm and coconut oil (bad oil)
- **Non saturated fatty acids**: canola, peanut, olive (good oil)

Oil are liquids at room temperature: Because?

**Seed oils**: cotton, sesame, sunflower, safflower, corn, peanut, coconut, castor bean
Structure of a Phospholipid

Hydrophilic head

\[ \text{R} \]
\[ \text{O} \]
\[ \text{O=PO}_3^- \]
\[ \text{O} \]
\[ \text{CH}_2-\text{CH}-\text{CH}_2 \]
\[ \text{CH}_2 \]
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Hydrophobic tails

\[ \text{CH}_2 \]
\[ \text{CH}_2 \]
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Phosphate

Glycerol

Fatty acids
Waxes

Waxes: complex mixture of fatty acids and other lipids

Copernicia cerifera
Carnabou wax

Myrica pensylvanica
Novelty candles
Secondary metabolites (Terpenoids)

Eucalyptus

Purple foxglove (Digitalis purpurea)

Tomato (Lycopersicon esculentum)
Secondary metabolites (Alkaloids)

Quinine tree

Papaver somniferum

Strychnine tree
Secondary metabolites (Phenolics)

*Salix nigra* (*Salicaceae: willow*): salicylic acid, aspirin
LABORATORY 1 (b)

Anacharis (Elodea) leaf cells

x1000. This plant is sold in pet stores for use in home fish aquaria. Green chloroplasts appear mottled because of their internal grana. In this specimen you can see a nucleus and nucleolus, something not often seen in such cells

OBJECTIVES:

Cytoplasm is the fluid material encased by the plasma membrane of a cell. Cytoplasm does much of the work of a cell by moving intracellular organelles. Cytoplasm is a heterogeneous material that is able to change its viscosity. Cytoplasmic streaming is the flowing movement of cytoplasm, internal and external to the plant cell, in a rapid orderly fashion. In plant cells, cytoplasmic streaming carries chloroplasts, which are the sites of photosynthesis, from one part of the cell to another. This helps maximize photosynthesis and subsequent cell growth. The objective of this experiment was to observe cytoplasmic streaming in the aquatic plant Elodea by low power microscopy.
Osmosis and Elodea
Onion Cells:

1. With forceps, remove the thin, membranous layer of cells from the concave part of the onion.
2. Being careful not to fold the membranous layer of cells, place the layer in a drop of water on the microscope slide.
3. Cover with a coverslip.
4. Turn the microscope focus knob so the stage is as far from the objective as possible.
5. Turn on the light source.
6. Place the microscope slide on the microscope stage.
7. Turn the 4X objective such that it is directly above the slide. It should "click" in to place.
8. Slowly turn the coarse focus adjust know until the stage is near by NOT touching the slide.
9. While looking through the microscope slowly turns the coarse adjust knob in the opiate direction until the onion cells are in focus. Use the fine focus knob to bring the specimen into focus. The stage will be moving DOWN and AWAY from the objective. Do NOT let the objective touch the microscope slide. This may damage the lens.
10. Carefully move the higher magnification objective (10X) into place. Adjust with the fine focus as needed. Be sure the objective does not touch the slide.
11. Record/draw what you see.
12. Lower the microscope stage.
13. Remove the slide. Place 1 drop of Lugol's iodine solution on the side of the coverslip.
14. Remove excess by touching a Kim Wipe to the side of the cover slip opposite from the stain.
15. Look at the stained specimen as described in steps 8-10
16. Record/draw what you see. What, if any, are the differences that you see?
Onion epidermis x100. Each cell has a nucleus. The specimen has been stained with gram iodine to give the nuclei more contrast.
Onion epidermis nucleus x1000. One of the three nucleoli visible in the nucleus is labeled.
Tradescantia
Tradescantia stamen hairs

stigma

petal
in sucrose
*Tradescantia* stamen hair cells

stamen filament
nucleus

thin layer of cytoplasm

nucleus