A] PHOTOSYNTHESIS

- Almost all living organisms depend on energy from the sun, either directly or indirectly
- This energy is captured by green plants through the process of photosynthesis
- General formula:

  \[
  \text{chlorophyll} \\
  6 \text{CO}_2 + 12 \text{H}_2\text{O} + \text{light} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2 + 6 \text{H}_2\text{O}
  \]

  - \(\text{CO}_2 = \text{carbon dioxide}\)
  - \(\text{H}_2\text{O} = \text{water}\)
  - \(\text{C}_6\text{H}_{12}\text{O}_6 = \text{glucose}\)
  - \(\text{O}_2 = \text{oxygen}\)
- can also be represented as: **carbon dioxide plus water plus light, in the presence of chlorophyll, yields glucose, water and oxygen**
- the energy of sunlight is captured and stored as chemical energy (in the bonds between the carbon atoms in the molecule of glucose)
- This is the general or overall formula of photosynthesis, actually the process is not a single step but a complex series of reactions that occur in the chloroplasts of green plant cells
- Plants usually store excess glucose in the form of the polysacharide starch
- Effect of light intensity on photosynthesis
  - in lab we use the aquatic plant called Elodea
  - rate of photosynthesis is measured indirectly by our apparatus
  - actual measurement is on movement of blue fluid in U-tube
  - blue fluid moves due to the increase in air pressure caused by production of oxygen (an end product of photosynthesis)
  - temperature of water bath is monitored and maintained constant to eliminate a possible second variable (heat) that could affect the experimental results
  - **as light intensity increases, the rate of photosynthesis increases** (a direct relationship)
- **Potassium bicarbonate** was added to the water that we placed the Elodea in to make sure that the water contained a high level of carbon dioxide (therefore, the only possible limiting factor is amount of light)

B] RESPIRATION

- Organisms cannot directly use the chemical energy stored in glucose (or most other energy molecules)
the energy molecule directly used to supply the constant energy needs of life is ATP
respiration is the process by which most organisms transfer the energy stored in a
molecule of glucose to the useable form of ATP - it is a complex chain of enzyme
controlled reactions
the first part of respiration occurs in the cytoplasm of the cell (glycolysis) and the
rest of the reactions occur in the mitochondria (Kreb’s cycle & electron transport
chain)

- General formula:

\[
\text{enzymes}
\]

\[
C_6H_{12}O_6 + 6 O_2 \rightarrow 6 CO_2 + 6 H_2O + 36 ATP + \text{heat}
\]

- all cells undergo respiration - both plant and animal
- humans eat to supply all their cells with energy containing molecules (e.g. glucose)
- humans breath to supply all their cells with oxygen for respiration
- humans exhale carbon dioxide produced as an end product of respiration
- humans can store excess glucose in the form of fat, but cannot store oxygen (this
  is why we die faster from suffocation than from starvation)
- because this reaction requires oxygen, it is called an aerobic reaction
- another way of saying the formula is: glucose plus oxygen, in the presence of
  enzymes, yields carbon dioxide, water, 36 ATP, and heat

- Relationship between exercise and rate of cellular respiration
  - increasing energy needs (e.g. exercising) increases the rate that the cells undergo
    respiration
  - rate of cellular respiration was measured indirectly in lab by looking at increases
    in carbonic acid formed in water as exhaled carbon dioxide is bubbled through it
  - higher amounts of cellular respiration should result in higher production of carbon
    dioxide which should produce higher amounts of carbonic acid when bubbled
    through water
  - production of carbonic acid lowers the pH of the water
  - measured by using phenolphthalein - a pH indicator that changes color as the
    liquid environment changes from acid (pH less than 7) to base (pH greater than 7)
    - note: color does not change due to carbon dioxide - it changes due to a
      change in the pH of the solution

- Fermentation
  - while most organisms manufacture the ATP they need by the respiration
    processes noted above, some organisms (like yeast cells) can produce ATP by a
different method - fermentation
  - general formula:

\[
\text{enzymes}
\]

\[
C_6H_{12}O_6 \rightarrow 2 C_2H_5OH + 2 CO_2 + 2 ATP + \text{heat}
\]
- C$_2$H$_5$OH = ethyl alcohol
- another way of saying this formula is: glucose, in the presence of enzymes, yields ethyl alcohol, carbon dioxide, 2 ATP and heat
- ethyl alcohol produced as an end product of this reaction is used to make alcoholic beverages
- maximum alcohol production under natural conditions is around 11-13% alcohol
- when the alcohol content reaches that level it kills the yeast cells (they poison their own environment)
- higher alcohol contents of liquors or “distilled spirits” comes from concentrating the alcohol by distillation - a process that takes advantage of the fact that alcohol boils at a lower temperature than water
- bottlers have to worry about the carbon dioxide that is also produced because, if fermentation occurs after the product is bottled, it can cause the bottles to explode
  - carbon dioxide produced as an end product of this reaction allows bread dough to rise
    - the bubbles of carbon dioxide serves to “foam” the dough, causing it to rise
    - ethyl alcohol is also formed, but it evaporates off when the dough is cooked
    - when heat kills the yeast cells, the rising process will end (no more fermentation going on)
- yeast is different from salt or pepper when you buy it in the store - it is a living organism (a single celled fungus) that only works if it is alive