KEY

Big Idea 2 – ENERGY AND METABOLISM

1. Energy
   a. Organisms use free energy for organization, growth and reproduction. Loss of order or free energy flow results in death.
   b. More free energy (ex. Food) than needed will be stored for growth (roots, glycogen, fat, etc.).
   c. Matter and energy are not created but change form (1st law of thermo; ex. Sun energy to bond energy in glucose) and entropy is increasing in disorganization of energy (i.e. heat released by cell respiration). More organized or built up compounds have more free energy and less entropy (i.e. glucose) and less organized have less free energy and more entropy (i.e. carbon dioxide).
   d. Reactions can be coupled to maintain a system, ex. Photosynthesis and cell respiration

2. Cellular respiration $C_6H_{12}O_6 + 6O2 \rightarrow 6CO_2 + 6H_2O$
   a. Makes ATP for cell use; uses glucose and oxygen makes waste products of carbon dioxide and water; occurs in mitochondria; NADH is electron carrier used
   b. Glycolysis
      (1) occurs in cytoplasm; anaerobic
      (2) rearranges the bonds in glucose molecules, releasing free energy to form ATP from ADP through substrate-level phosphorylation resulting in the production of pyruvate.
   c. Kreb's cycle
      (1) occurs in mitochondrial matrix
      (2) also called the citric acid cycle
      (3) occurs twice per molecule of glucose
      (4) Pyruvate is oxidized further and carbon dioxide is released ; ATP is synthesized from ADP and inorganic phosphate via substrate level phosphorylation and electrons are captured by coenzymes (NAD+ and FAD).
      (5) NADH and FADH2 carry electrons to the electron transport chain.
   d. Electron Transport Chain and Chemiosmosis
      (1) The electron transport chain captures electrons, pumping H^+ ions into the inter-membrane space of the mitochondria.
      (2) Electrons are accepted by O_2 molecule forming H_2O
      (3) Concentration of H^+ builds up within inter-membrane space lowering the pH and ions rush through ATP synthase into the mitochondria matrix. Rush of ions "spins" ATP synthase protein, causing ADP and P_i to join forming ATP by oxidative phosphorylation

1. Photosynthesis $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$
   a. Photosynthetic organisms capture free energy present in sunlight and use water and carbon dioxide to make carbon products and free oxygen.
   b. Light-dependent reactions- photophosphorylation
      (1) Photosystems I and II (chlorophyll and proteins) are embedded in the internal membranes of chloroplasts (thylakoids of the grana). They pass electrons through an electron transport chain (ETC). When electrons are passed they allow hydrogen ions (protons) across the thykaloid membrane. The formation of the proton gradient powers the process of ATP synthesis to add a phosphate ADP to ATP (chemiosmosis).
      (2) Electrons are passed to NADP+ to make NADPH (electron carrier)
      (3) H_2O is used and O_2 released as by-product

(4) Red and blue light works best (green is reflected typically)
(5) Energy converted from sun into chemical energy of ATP and NADPH to be used in building of sugar (Calvin Cycle)

c. Light-independent reactions- Calvin Cycle
(1) carbon fixation occurs (carbons of CO_2 used to make sugar)
(2) occurs in stroma of chloroplasts
(3) ATP and NADPH generated by light-dependent reactions are used to assemble glucose

2. Anaerobic Fermentation
a. No oxygen; cell only goes through glycolysis followed by fermentation
b. Fermentation recycles NAD needed to restart glycolysis
c. alcohol fermentation ex. yeast cells- glucose → ethyl alcohol + CO_2+ NAD^+
d. lactic acid fermentation ex. muscle cells- glucose → lactic acid + NAD^+
e. Fermentation does not make ATP but glycolysis does- 2ATP; very inefficient; sufficient for microorganisms

AP Lab Investigation 5 Photosynthesis
Overview: Spinach cut out disks were placed in two different syringes (bicarbonate and without) and those photosynthetic rate was calculated by measuring the number that floated over time.
Students then designed their own experiment to see what factors affected photosynthesis.
IV: presence of bicarbonate
DV: number of disks floating
Equations: ET50 = the point at which 50% of the leaf disks are floating (the median or ET50, the
Estimated Time it takes 50% of the disks to float), inverse relationship between rate and ET50 so we graphed 1/ET50 in this lab.

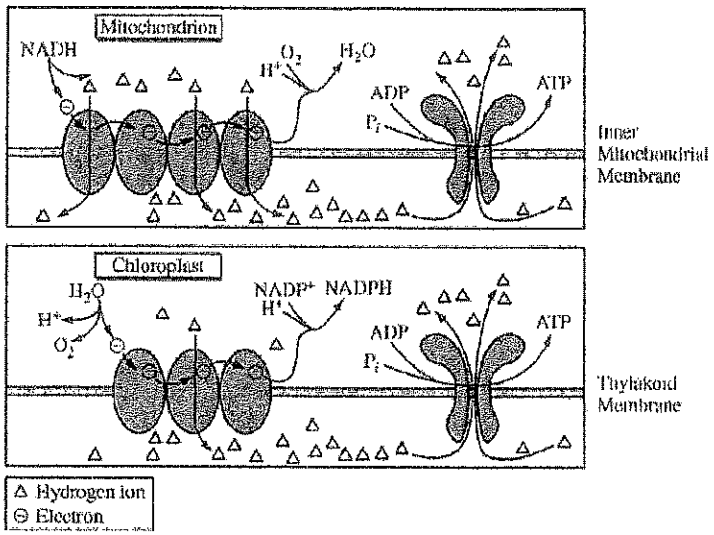
AP Lab Investigation 6 Cell Respiration
Overview: Germinating and non-germinating seeds (peas) were placed in different temperature water baths and cell respiration rate was determined based on oxygen consumption. Design your own experiment to determine what other factors affect cell respiration (type of seed, age of seed, etc.)
IV: germinating or non-germinating and temperature
DV: O2 consumption
*volume was controlled with glass beads, CO2 gas was controlled with KOH, temperature was controlled with water bath
Equations: dY/dt or product formed (dY) over time interval (dt)

Practice Multiple Choice Questions

1. An airtight, temperature-controlled glass box containing actively growing tomato plants was placed under a light source. Plastic wrapping that only transmits green light was placed over the box, and two days later air samples from inside the box were collected and analyzed. The most likely change in air quality is
(A) an increase in nitrogen (N2)
(B) an increase in carbon dioxide (CO2)
(C) an increase in oxygen (O2)
(D) a decrease in carbon dioxide (CO2)

2. Which of the following statements most directly supports the claim that different species of organisms use different metabolic strategies to meet their energy requirements for growth, reproduction, and homeostasis?
(A) During cold periods pond-dwelling animals can increase the number of unsaturated fatty acids in their cell membranes while some plants make antifreeze proteins to prevent ice crystal formation in tissues.
(B) Bacteria lack introns while many eukaryotic genes contain many of these intervening sequences.
(C) Carnivores have more teeth that are specialized for ripping food while herbivores have more teeth that are specialized for grinding food.
(D) Plants generally use starch molecules for storage while animals use glycogen and fats for storage.

The figures below illustrate the similarities between ATP synthesis in mitochondria and chloroplasts.



3. The figures can best assist in answering which of the following questions?
(A) Do electron transport chains create a gradient so that ATP synthase can generate ATP molecules?
(B) What are the sources of energy that drive mitochondrial and chloroplast electron transport systems?
(C) What is the optimal temperature at which ATP synthase chemically converts ADP and a phosphate group into one molecule of ATP?
(D) What is the evolutionary relationship between the ATP synthase in mitochondria and the ATP synthase in chloroplasts?

The chemical reaction for photosynthesis is $6\ CO_2 + 12\ H_2O$ + light energy --> $C_6H_{12}O_6 + 6\ O_2 + 6\ H_2O$

4. If the input water is labeled with a radioactive isotope of oxygen, $_{18}O$, then the oxygen gas released as the reaction proceeds is also labeled with $_{18}O$. Which of the following is the most likely explanation?
(A) During the light reactions of photosynthesis, water is split, the hydrogen atoms combine with the CO2, and oxygen gas is released.
(B) During the light reactions of photosynthesis, water is split, removing electrons and protons, and oxygen gas is released.
(C) During the Calvin cycle, water is split, regenerating NADPH from NADP+, and oxygen gas is released.
(D) During the Calvin cycle, water is split, the hydrogen atoms are added to intermediates of sugar synthesis, and oxygen gas is released.

5. During hibernation, the rate of cellular respiration in a mammal is typically less than half the rate measured when the mammal is not hibernating. Such slowed cellular respiration is probably accompanied by which of the following?

	Pulse Rate	Body Temperature
(A)	Reduced	Reduced
(B)	Unchanged	Reduced
(C)	Reduced	Increased
(D)	Unchanged	Increased
(E)	Increased	Reduced

6. In both photosynthesis and respiration, a electrochemical proton gradient drives chemiosmosis. What establishes the electrochemical gradient across a membrane to provide energy for ATP production?
a. The electron transport system provides the hydrogen ions.
b. Hydrogen ions naturally collect on the outside of the organelle membrane.
c. Hydrogen ions are pumped across the membrane by carrier proteins of the electron transport chain.
d. Active transport of Hydrogen ions causes the unequal distribution of ions on the two sides of the membrane.

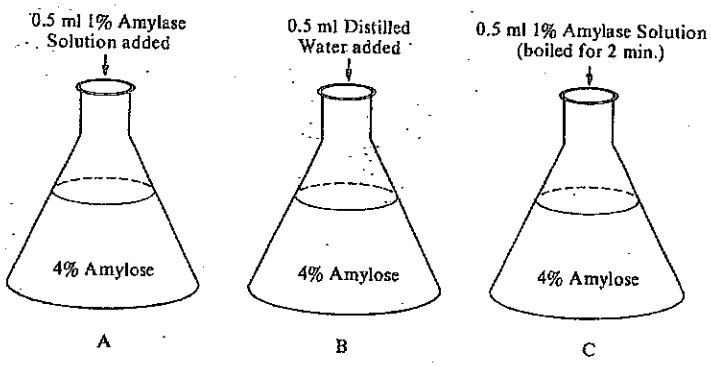
An experiment to measure the rate of respiration in crickets and mice at 10 °C and 25 °C was performed using a respirometer, an apparatus that measures changes in gas volume. Respiration was measured in mL of O_2 consumed per gram of organism over several five-minute trials and the following data were obtained.

Organism	Temperature (°C)	Average respiration (mL O_2/g/min)
Mouse	10	0.0518
Mouse	25	0.0321
Cricket	10	0.0013
Cricket	25	0.0038

7. According to the data, the crickets at 25°C have greater oxygen consumption per gram of tissue than do the crickets at 10°C. This trend in oxygen consumption is the opposite of that in the mice. The difference in trends in oxygen consumption among crickets and mice is due to their
(A) relative size
(B) mode of nutrition
(C) mode of internal temperature regulation
(D) mode of ATP production

8. During aerobic cellular respiration, oxygen gas is consumed at the same rate as carbon dioxide gas is produced. In order to provide accurate volumetric measurements of oxygen gas consumption, the experimental setup should include which of the following?
(A) A substance that removes carbon dioxide gas
(B) A plant to produce oxygen
(C) A glucose reserve
(D) A valve to release excess water

9. According to the data, the mice at 10°C demonstrated greater oxygen consumption per gram of tissue than did the mice at 25°C. This is most likely explained by which of the following statements?
(A) The mice at 10°C had a higher rate of ATP production than the mice at 25°C.
(B) The mice at 10°C had a lower metabolic rate than the mice at 25°C.
(C) The mice at 25°C weighed less than the mice at 10°C.
(D) The mice at 25°C were more active than the mice at 10°C.



Questions 10-12
A biologist prepares an in vitro analysis of the activity of the enzyme amylase, which promotes the hydrolysis of polysaccharides to monosaccharide residues. Three flasks containing 5 milliliters of 4 percent amylose (starch) in water are prepared with the addition at time zero of each of the substances indicated in the diagrams to the right.

10. In an experiment to test the effect of amylase on starch, the control would be
(A) flask A only
(B) flask B only
(C) flask C only
(D) flasks A and B

11. After 2 minutes, a positive test for sugar (monosaccharides) would most likely be observed in
(A) flask A only
(B) flask B only
(C) flask C only
(D) flasks A and C

12. Support for the hypothesis of enzyme denaturation can be obtained by comparing starch digestion in
(A) flasks A and B after 5 minutes
(B) flasks Band C after 5 minutes
(C) flasks A and C after 5 minutes
flask A at time zero and again after 5 minutes

Frogs of three different species are weighed and the amount of oxygen consumed by each species is determined by placing them in a respirometer for 1 hour. The results of this experiment are listed below.

Species	Average Weight in Grams	Total Cubic Centimeters of Oxygen Consumed in 1 Hour
1	15	0.75
2	11	0.55
3	21	1.05

13. From the information in the table, it is most reasonable to conclude that
(A) since all frogs respire through their skin, smaller frogs with smaller surface areas will consume less oxygen per gram of body weight than larger frogs with larger surface areas
(B) frogs placed in a warm environment will respire more rapidly than frogs placed in a colder environment
(C) each species of frog has its own unique rate of respiration
(D) the amount of oxygen consumed per gram of body weight for each species is the same

Questions 14-16

In a laboratory experiment using spectrophotometry, an enzyme is combined with its substrate at time zero. The absorbance of the resulting solution is measured at time zero and at five-minute intervals. In this procedure an increase in absorbance is related to the amount of product formed during the reaction. The experiment is conducted using the three preparations shown in the table below.

Enzyme Preparation	0 min	5 min	10min	15 min	20min
I. 3 mL of enzyme preparation 2 mL of substrate pH 5.0	0.0	0.22	0.33	0.38	0.37
II. 3 mL of boiled enzyme preparation 2 mL of substrate pH 5.0	0.0	0.06	0.04	0.03	0.04
III. 3 mL of enzyme preparation 2 mL of substrate pH 6.0	0.0	0.32	0.37	0.36	0.38

14. The most likely reason for the failure of the absorbance to increase significantly after 10 minutes in preparation III is that
(A) the reaction is thermodynamically impossible at pH 6.0
(B) the enzyme is not active at this pH
(C) a pH of 6.0 prevents color development beyond an absorbance of 0.38
(D) most of the substrate was digested during the first 10 minutes

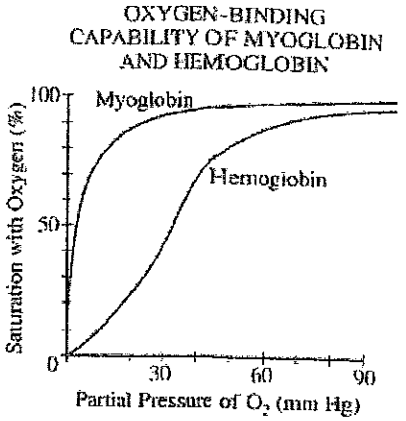
15. Which of the following statements is best supported by the data?
(A) Increasing the pH to 7.0 would yield an absorbance higher than 0.30 after 5 minutes.
(B) The enzyme demonstrates more activity at pH 6.0 than at pH 5.0.
(C) The enzyme has no activity at pH 6.0.
(D) A pH of 5.0 is the optimum for the activity of the enzyme.

16. Which of the following can best be concluded from a comparison of the results of preparation II with those of preparation I?
(A) Heating the enzyme is required to increase the absorbance.
(B) Boiling does not break down the substrate.
(C) Most of the increase in the amount of product in preparation I was due to enzymatic degradation of the substrate.
(D) Enzymatic reactions proceed at a faster rate after boiling the enzyme.

Question 17

Both myoglobin and hemoglobin are proteins that bind reversibly with molecular oxygen. The graph below shows the oxygen-binding saturation of each protein at different concentrations of oxygen.

17. Which of the following statements is correct?
(A) At 10 mm Hg partial pressure, hemoglobin binds oxygen but myoglobin does not.
(B) At 20 mm Hg partial pressure, myoglobin and hemoglobin bind oxygen in equal amounts.
(C) At 40 mm Hg partial pressure, myoglobin has a greater affinity for oxygen than hemoglobin has.
(D) At 80 mm Hg partial pressure, myoglobin binds twice as much oxygen as hemoglobin binds.



Questions 18-20

The following experiment is designed to test the capacity of cell fractions from mouse liver to carry out oxidation of glucose and pyruvic acid.
The liver is first homogenized in a suitable medium and centrifuged to sediment nuclei. The supernatant liquid above the nuclear sediment is centrifuged again at a higher speed to sediment mitochondria. The supernatant above the mitochondrial sediment is the supernatant fraction referred to in the table. The latter fraction contains ribosomes. The separated fractions are then placed in an apparatus designed to measure changes in oxygen pressure.

Oxygen Consumption Expressed As Per Cent of Oxygen Consumed By the Whole Homogenate

Fractions Being Tested	Glucose as Substrate	Pyruvate as Substrate
1. Whole Homogenate	100	100
2. Nuclei	10	5
3. Supernatant	5	5
4. Mitochondria	3	75
5. Mitochondria + nuclei	5	50
6. Mitochondria + supernatant	150	130
7. Mitochondria + supernatant + nuclei	95	100

18. The capacity to oxidize pyruvate resides largely in the
(A) supernatant fraction
(B) mitochondria
(C) nuclei
(D) microsomes

19. From the data in the table, which of the following is an appropriate conclusion about nuclei?
(A) They have the same capacity to utilize pyruvate as do mitochondria.
(B) They contain DNA.
(C) They are unable to oxidize intermediates of the Krebs (oxidative) cycle.
(D) They lower the level of oxidation of pyruvate by mitochondria.

20. Which of the following is an appropriate conclusion about the supernatant fraction?
(A) It oxidizes glucose about as well as the homogenate.
(B) It oxidizes pyruvate more effectively than the homogenate when combined with mitochondria.
(C) It oxidizes pyruvate about as well as the homogenate.
(D) It oxidizes pyruvate as well as mitochondria.

Questions 21-22

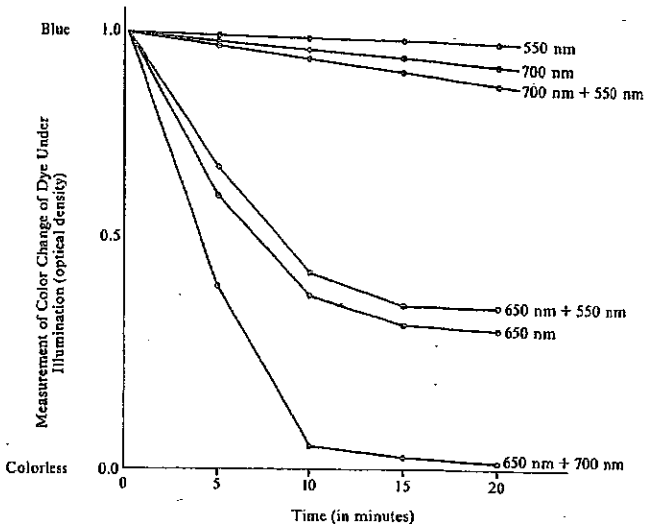
Intact chloroplasts are isolated from blended spinach leaves by low-speed centrifugation and are suspended in a cold, protective buffer. If these chilled chloroplasts are illuminated in the presence of an oxidized colored dye, one may observe the reduction of the dye as the dye loses its color.

$$\text{Oxidized blue dye} \xrightarrow[\text{light}]{\text{chloroplast}} \text{Reduced colorless dye}$$

$$\text{Oxidized blue dye} \xrightarrow{\text{light only}} \text{Oxidized blue dye}$$

An experiment is set up to determine the optimal reduction potential of the chloroplasts under different wavelengths of light energy. The chloroplast suspensions are individually or simultaneously exposed to the following wavelengths of light by the use of special filters: 550 nanometers (green), 650 nanometers (red), and 700 nanometers (far-red). All exposures are at the same light intensity. The data are given below.

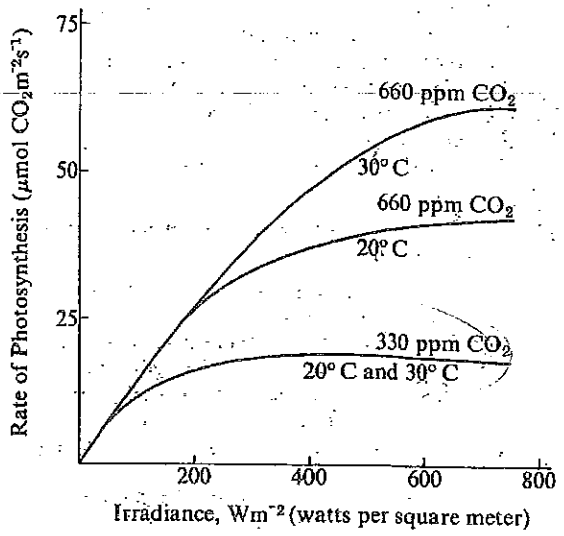
21. According to these data, which of the wavelengths of light energy provides the LEAST energy potential for photosynthesis?
(A) 550 nm only
(B) 650 nm only
(C) 700 nm only
(D) 550 nm and 650 nm



22. The greatest reduction of the blue dye by two different wavelengths of light suggests which of the following?
(A) There are two pigment systems present within the same chloroplast, both absorbing at the same wavelength.
(B) There are at least two pigment systems with different absorption spectra present within the same chloroplast.
(C) Different portions of the plant (stems, leaves, etc.) absorb light from different wavelengths.
(D) Both red and far-red light are transmitted.

Questions 23-25

The graph shows the relationship of photosynthetic rate and irradiance (light intensity) influenced by both temperature and carbon dioxide level.



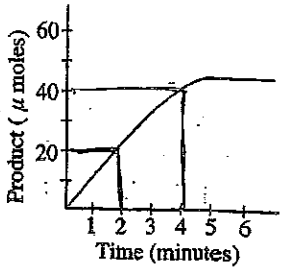
23. According to the graph, the greatest rate of photosynthesis occurs when CO_2 is present at
(A) high concentrations and low temperatures
(B) low concentrations and high temperatures
(C) high concentrations and low irradiance levels
(D) high concentrations and high irradiance levels

24. From the data in the graph, which of the following conclusions is most reasonable?
(A) The rate of photosynthesis is inversely proportional to light intensity.
(B) The rate of photosynthesis at 660 ppm CO_2 is more dependent on temperature than the rate at 330 ppm CO_2.
(C) There is no theoretical maximum for the rate of photosynthesis.
(D) Attempts to increase the photosynthetic yield in field crops should involve the lowering of CO_2 levels.

25. Which of the following seems most likely from the data?
(A) Light produces heat, which causes increases in the rates of photosynthesis.
(B) Light causes the saturation of cytochrome oxidase, which then limits the use of CO_2.
(C) The photosynthetic rate could be increased further by decreasing the CO_2 concentration.
(D) Increasing irradiance levels above 800 Wm^{-2} would have less effect on the rate of photosynthesis than would increasing the CO_2 concentration.

Questions 26-29

A scientist determined the rate of an enzyme-catalyzed reaction by measuring the amount of product formed over time. The following curve was generated from the data collected.



26. Based solely on the curve, what can be said concerning the calculated reaction rates at 1 minute and at 2 minutes?
(A) The rate after 2 minutes is greater than the rate after 1 minute.
(B) The rates are the same at 1 minute and at 2 minutes.
(C) The rates are affected by high concentrations of inhibitors.
(D) The rates are both zero.

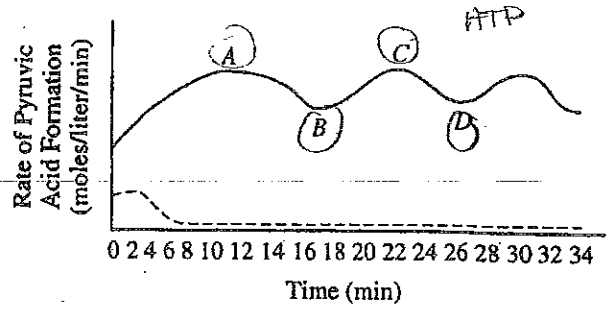
27. The rate of the reaction could also be determined by
(A) measuring the change in the amount of enzyme
(B) measuring the change in the amount of substrate
(C) measuring the change in salt concentration
(D) adding more substrate

28. What is the most likely explanation for the change in the slope of the line between 3 and 5 minutes?
(A) The enzyme had denatured.
(B) The enzyme had achieved its maximum velocity.
(C) A large amount of the substrate had been consumed.
(D) An allosteric inhibitor appeared.

29. During which time interval is the reaction rate lowest?
(A) 0-1 minute
(B) 1-2 minutes
(C) 2-3 minutes
(D) 4-5 minutes

Questions 30-33 refer to the following graph and information.

A tissue culture of vertebrate muscle was provided with a constant excess supply of glucose under anaerobic conditions starting at time zero and the amounts of pyruvic acid and ATP produced were measured. The solid line in the graph above represents the pyruvic acid produced in moles per liter per minute. ATP levels were also found to be highest at points *A* and *C*, lowest at *B* and *D*. A second culture was set up under the same conditions, except that substance X was added, and the results are indicated by the dotted line.



30. The rate of pyruvic acid formation fluctuates because
(A) all glucose has reacted
(B) all enzymes have been used up
(C) the reaction is accelerated by positive feedback
(D) the reaction is affected by negative feedback

31. Which of the following best accounts for the shape of the solid line between points *A* and *D*?
(A) After ten minutes the cellular enzymes became ineffective.
(B) Respiration became uncontrolled.
(C) ATP acted as an allosteric inhibitor on one or more of the enzymes.
(D) The measurements of pyruvic acid were unreliable.

32. It is most reasonable to hypothesize that, in the breakdown of glucose, substance X is
(A) an activator
(B) an inhibitor
(C) a substrate
(D) a coenzyme

33. Which of the following is most likely to result if oxygen is added to the tissue culture?
(A) Lactic acid formation will increase.
(B) For each glucose molecule consumed, more ATP will be formed.
(C) The levels of ATP produced will decrease.
(D) Ethyl alcohol will be produced.

Thinking Questions

The figure below outlines the process of cellular respiration. Glucose and oxygen are both reactants in this process.

a. Describe the journey of a single carbon atom from glucose in cellular respiration

C in glucose → pyruvate after glycolysis then released as CO_2 during Krebs Cycle

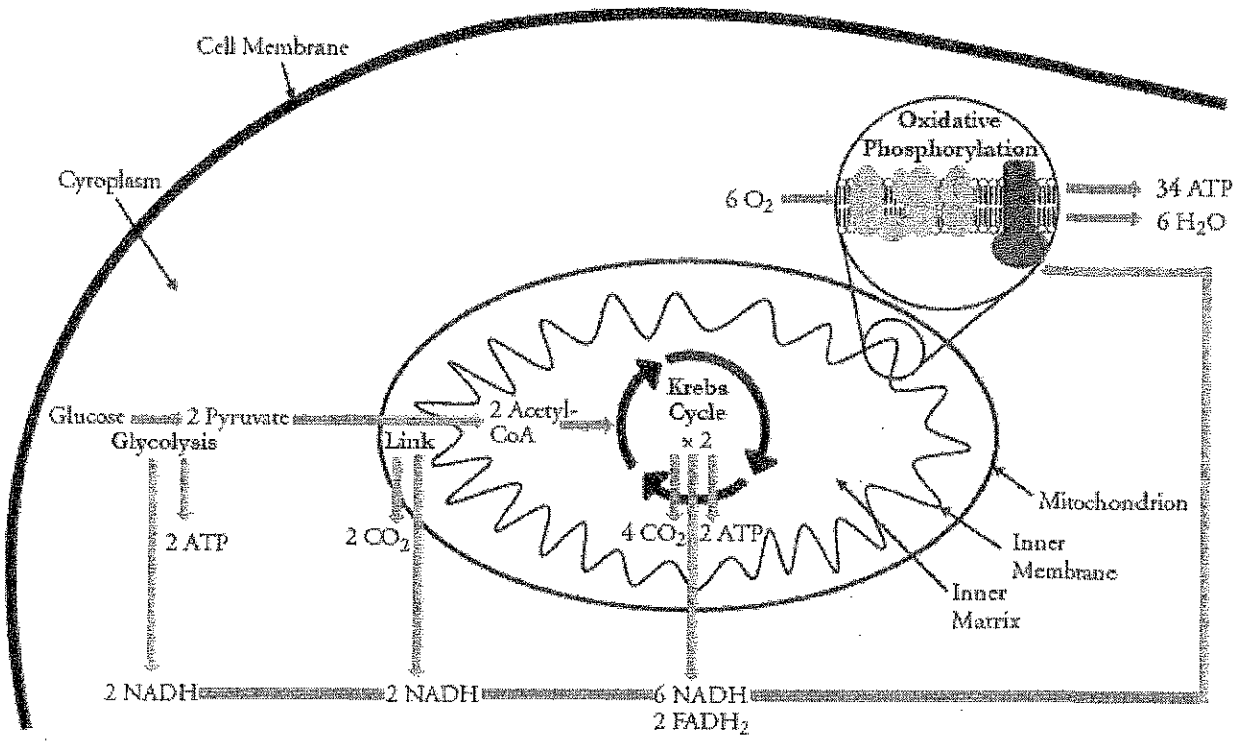
b. Describe the journey of a single hydrogen atom from glucose in cellular respiration

H in glucose → pyruvate after glycolysis ↘ NADH to electron transport attached to ← FADH$_2$ or NADH in Krebs cycle

added to O ← ETC ← H_2O

c. Describe the function of the oxygen molecules in cellular respiration

Final electron acceptor



2. The figure below outlines the process of photosynthesis. Carbon dioxide and water are both reactants in this process.
   a. Describe the journey of a single hydrogen atom from water in photosynthesis.

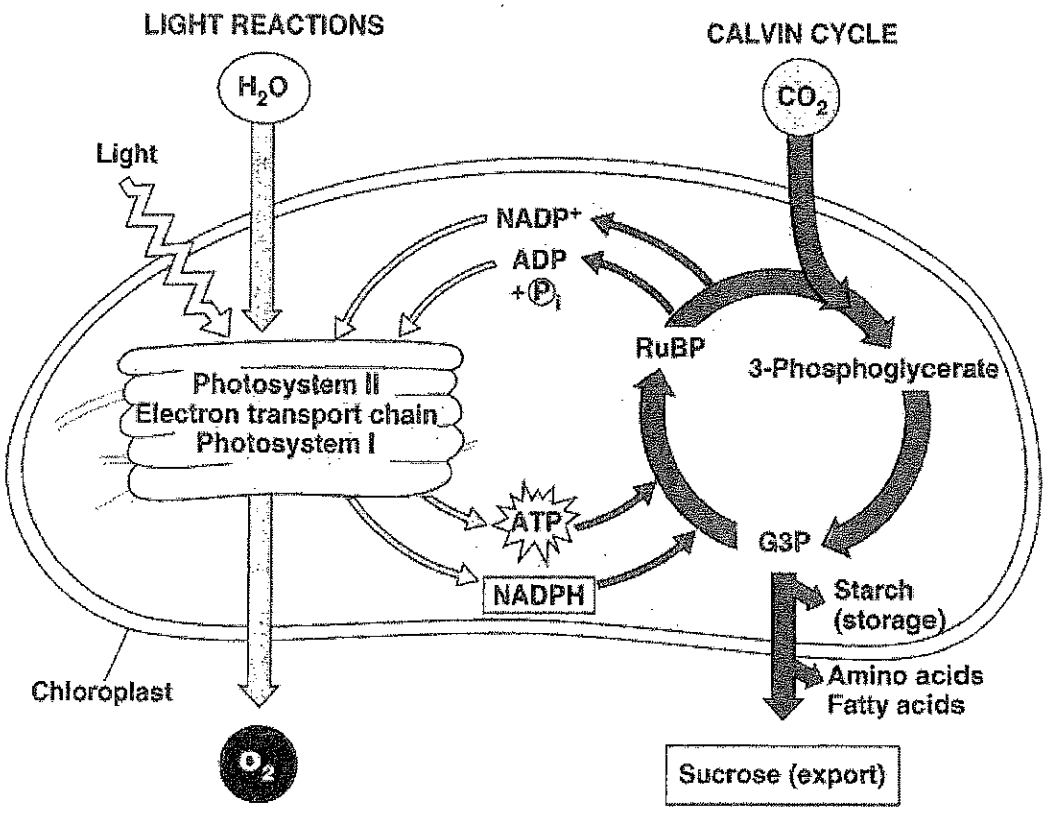
H → NADPH → Calvin cycle → added to CO_2 in Calvin cycle

   b. Describe the journey of a single oxygen atom from water in photosynthesis.

split in light reaction and then released

   c. Describe the journey of a carbon dioxide molecule in photosynthesis.

CO_2 enters Calvin cycle, combined w/ other molecules + H to eventually create glucose



3. It is estimated that more than 2 × 1026 molecules of ATP are hydrolyzed in the human body daily. If each molecule was used only once you would need approximately 160 kg (350 lbs) of ATP daily. The repeated use of ATP molecules through the ATP cycle saves the body a huge amount of resources and energy. ATP is synthesized in two ways:
   - **Substrate-level phosphorylation**—Energy released during a reaction, such as the breakdown of sugar molecules, is used directly to synthesize ATP. A small amount of energy is generated through this process.
   - **Electron transfer (oxidative phosphorylation)**—Energy from the movement of electrons from one molecule to another, via electron carriers, is used to synthesize ATP. Most cellular ATP is synthesized by electron transfer in the mitochondria.

   Dinitrophenol (DNP) is an "uncoupler," which means it interferes with the flow of electrons during electron transfer. Fifty years ago, DNP was given as a drug to help patients lose weight.
   a. Why would taking DNP make someone lose weight?

   ↓ ATP production, ↑ Sugar (fat) metabolism

   b. Why would taking DNP be dangerous?

   Not enough ATP for life functions

4. An experiment to measure the rate of respiration in crickets and mice at 10°C and 25° C was performed using a respirometer, an apparatus that measures changes in gas volume. Respiration was measured in mL of O_2 consumed per gram of organism over several five-minute trials and the following data were obtained.

Organism	Temperature (°C)	Average respiration (mL O_2/g/min)
Mouse	10	0.0518
Mouse	25	0.0321
Cricket	10	0.0013
Cricket	25	0.0038

   a. Which organism at which temperature had the fastest metabolic rate (produced the most ATP) during its trials? Explain how you know.

   Mouse 10°C, most O_2 used

   b. According to the data, the mice at 10°C demonstrated greater oxygen consumption per gram of tissue than did the mice at 25°C. Propose an explanation for why this is.

   Moving to stay warm

5. Under laboratory conditions, muscle cells were broken up and separated into fractions of mitochondria and cytoplasm in an attempt to learn more about cellular respiration. Each fraction was incubated with glucose or pyruvate. Tests were carried out during incubation for the presence of either carbon dioxide or lactic acid. The results are shown below:

Cell Fraction	CO_2	Lactic Acid
Mitochondria incubated with glucose	Absent	Absent
Mitochondria incubated with pyruvate	Present	Absent
Cytoplasm incubated with glucose	Absent	Present
Cytoplasm incubated with pyruvate	Absent	Present

a. What does the presence of lactic acid in a sample indicate about what process is occurring in each cell fraction?

presence of oxygen
aerobic vs. anaerobic respiration

b. Explain why lactic acid was produced by the cytoplasm fraction incubated with glucose, but not the mitochondrial fraction.

anaerobic resp. occurs outside mitochondria

c. Why was no carbon dioxide produced by either fraction incubated with glucose?

- both parts need to be present for aerobic cell respiration
- CO_2 not a waste product of lactic acid fermentation

d. Why did the cytoplasm fraction produce lactic acid in the presence of both glucose and pyruvate?

glucose → pyruvate → lactic acid
ATP

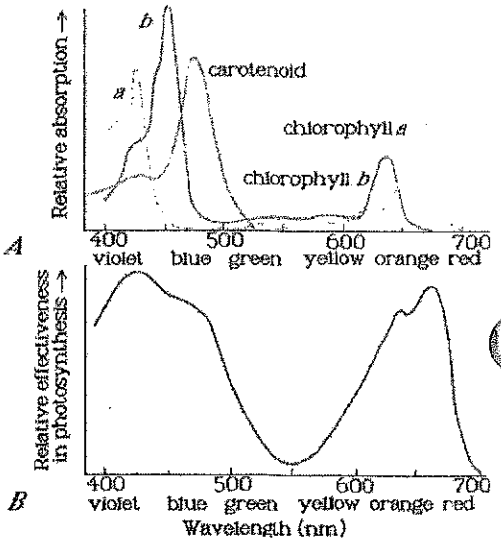
e. Why did the mitochondria produce carbon dioxide in the presence of pyruvate but not in the presence of glucose?

glucose → pyruvate
occurs in cytoplasm

6. The figures to the right display the absorption range for several different pigments found in plants (top) and the rate of photosynthesis at varying conditions of wavelength in one plant species (bottom):

a. What color and wavelength of light is reflected by the plant species tested? How do you know?

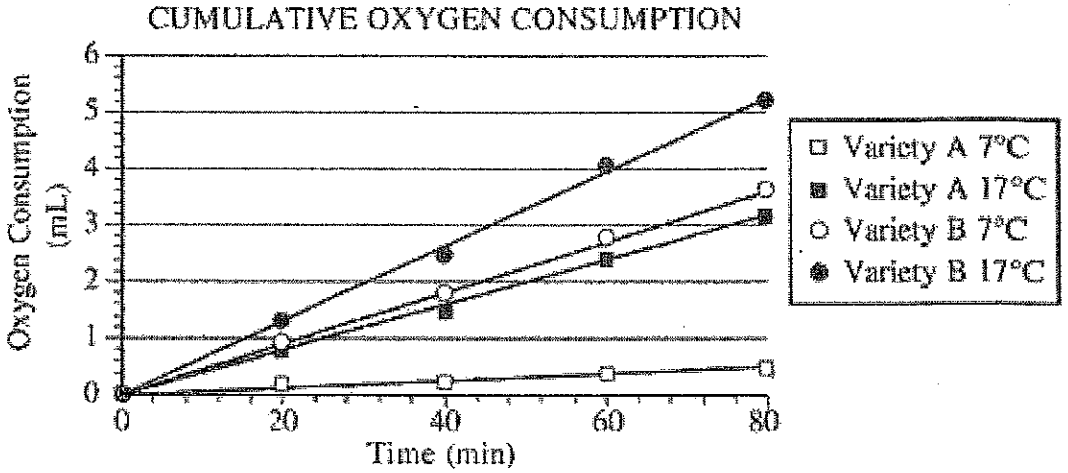
green - yellow
Not used in photosynthesis



b. What wavelength(s) increase the rate of photosynthesis in the plant species tested? What pigment does this correspond to? How do you know? orange/Red – violet/blue chlorophyll a+b

Energy and Metabolism Short Free Response (4 points)

An agricultural biologist was evaluating two newly developed varieties of wheat as potential crops. In an experiment, seedlings were germinated on moist paper towels at 20°C for 48 hours. Oxygen consumption of the two-day-old seedlings was measured at different temperatures. The data are shown in the graph below.



In a second experiment, Variety A seedlings at 17°C were treated with a chemical that prevents NADH from being oxidized to NAD+. **Predict** the most likely effect of the chemical on metabolism and oxygen consumption of the treated seedlings. **Explain** your prediction.

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Prediction (1 point each; 2 points maximum)

- Metabolism/respiration stops/declines/decreases/slows down.
- Oxygen consumption stops/declines/decreases/slows down.

Explanation (1 point each; 3 points maximum)

- Glycolysis/Krebs cycle/ETC will stop.
- ATP levels will drop/decline/decrease.
- Oxygen cannot accept electrons from ETC.