Biology EOC Study Guide: Part 2, Cell Biology

Grades 9 – 11: Processes within cells: Cells contain the mechanisms for life functions, reproduction, and inheritance. Big Idea: Structures and Functions of Living Organisms

Content Standards	**Performance Expectations**
Students know that:	***Students are expected to:***
1. Carbon-containing *compounds* are the building blocks of life. *Photosynthesis* is the process that plant cells use to combine the *energy* of sunlight with *molecules* of carbon dioxide and water to produce *energy*-rich *compounds* that contain carbon (food) and release oxygen.	*Explain how* plant cells use *photosynthesis* to produce their own food. Use the following equation to illustrate how plants rearrange *atoms* during *photosynthesis*: $6CO_2+6H_2O \xrightarrow{\text{Light energy}} C_6H_{12}O_6+6O_2$ *Explain* the importance of *photosynthesis* for both plants and animals, including humans.

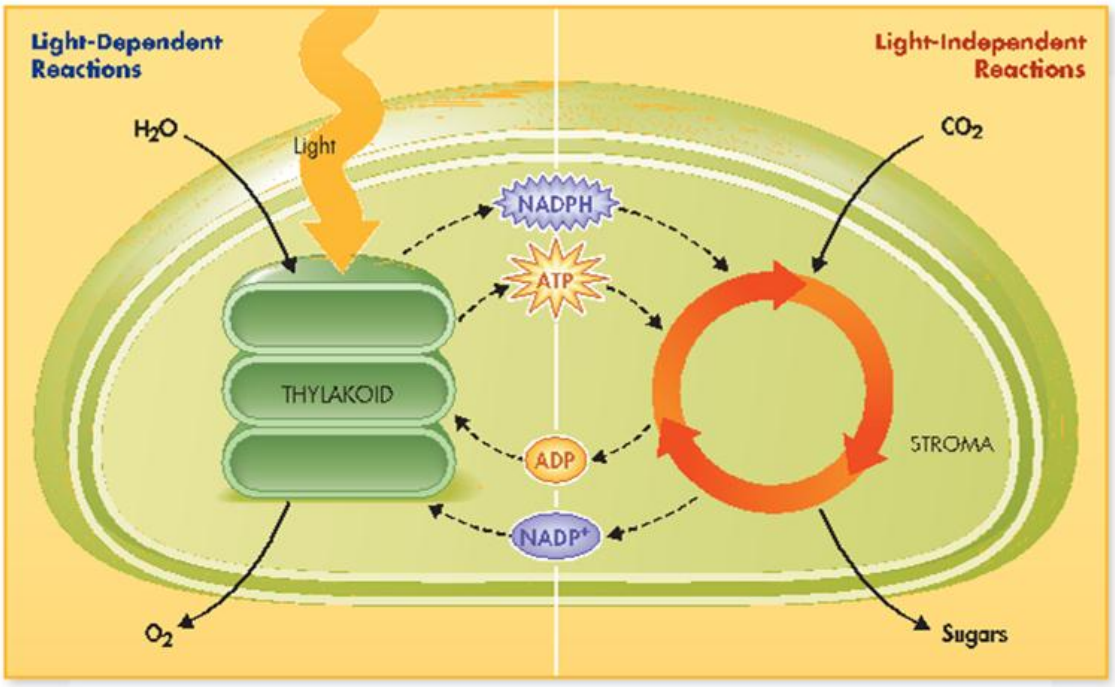
In Other Words

- All organisms use carbon-containing compounds to **BUILD** their bodies **AND TO BURN** for energy.
- Photosynthesis is the process that takes CO_2 from the air, water from the soil (usually), and energy from sunlight to make simple sugars from which these carbon-containing/energy-rich compounds are made.
- A waste product of photosynthesis is O_2 gas.
- Thus, plants make their own food to build and to burn. Animals must consume plants to get the food to build and to burn.

Important Notes

Photosynthesis converts light energy to chemical energy. It occurs in two-steps:

1. The first step is a set of reactions that occur on membranes inside a chloroplast and these membranes (the thylakoid membranes) contain the molecules of chlorophyll that pick up light energy. The light energy is used to produce two energy-carrying compounds: ATP and NADPH. Water is also broken down. Its electrons and hydrogens are used in making the ATP and NADPH, but its oxygen is given off as the waste product O_2. Because all these reactions require light, we call them the light-dependent reactions.
2. The second step in photosynthesis does not require light, so its set of reactions are called the light-independent reactions. They involve a series of reaction that occur outside the thylakoid membranes. Here, in a complicated series of reactions called the Calvin Cycle, the energy of ATP and NADPH are used to convert CO_2 gas from the atmosphere into solid, simple sugars. All other macromolecules (carbohydrates, proteins, fats) are made from these beginning sugars.



What to look out for:

- All cells need ATP for energy. So why not just use the ATP made in photosynthesis as the source of all ATP needs or all organisms? Because ATP doesn't last very long, AND it cannot go through cell membranes to get to the other cells that need it (like in the roots of plants). So plants store the energy in the form of sugar (which lasts a long time and can be delivered to other cells).
- **PLANTS ARE NECESSARY; ANIMALS ARE OPTIONAL**. Remember!!! Plants are making this sugar energy and oxygen waste for themselves, not for animals! Plants will burn the sugar (with the aid of the oxygen waste) in the mitochondria of their own cells to produce the ATP they need to survive. It's just that animals take advantage of plants and eat the plants before they have a chance to use all the sugars they made. **PLANTS DO BOTH: Photosynthesis and Cellular Respiration** (see below). **ANIMALS ONLY DO ONE THING: Cellular Respiration.** There will probably be a question on the test that tries to trip you up by making you think that plant ONLY make food and oxygen for animals, and animals make CO_2 for plants. Yes, the CO_2 animals make (and is produced by burning timber and fossil fuels) can only be taken up by plants. But plants STILL need to use their own food to build and to burn.

2. The gradual combustion of carbon-containing *compounds* within cells, called *cellular respiration*, provides the primary *energy* source of living *organisms*; the combustion of carbon by burning of *fossil fuels* provides the primary *energy* source for most of modern society.	*Explain how* the process of *cellular respiration* is similar to the burning of *fossil fuels* (e.g., both processes involve combustion of carbon-containing *compounds* to *transform* chemical *energy* to a different *form* of *energy*).

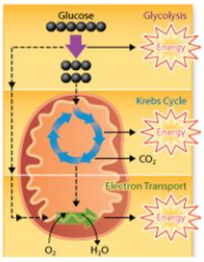
In Other Words

- The energy contained in carbon-containing compounds (such as sugar and cellulose) is released when they are burned. In a fire, fuel (e.g., wood), O_2 (oxygen gas) and heat (a match) are used to begin the reactions. Once begun, the burning releases so much heat that it continues spontaneously. Light energy is also released. In organisms, fuel is broken down slowly in chemical reactions that usually require enzymes. Although heat energy is given off because the reactions are not 100% efficient, the usable product is the energy-carrying chemical ATP (and two other chemicals, CO_2 and H_2O are wastes).
- There are two major ways these compounds are broken down:
    - anaerobically (without oxygen) which produces very little energy (2 ATP) and
    - aerobically (with oxygen) which produces a lot of energy (34-36 more ATP). The chemical equation for cellular respiration is

$$C_6H_{12}O_6+6O_2 \text{—> } 6CO_2+6H_2O + 36\text{-}38 \text{ ATP}.$$

Important Notes

- Cellular respiration has three major steps:
    1. **Glycolysis**: One molecule of glucose is broken down into two molecules of pyruvate (pyruvic acid). This occurs in the cytosol (cytoplasm of the cell). This process produces a net of 2 ATP.
    2. **Krebs Cycle**: Through a series of reactions, the pyruvate is oxidized into carbon dioxide and water (waste products). This process releases energy that is captured by the cell in the form of high energy electron carriers (NADH and $FADH_2^+$).
    3. **Electron Transport Chain** and **Chemiosmosis**: The high energy electron carriers (NADH and $FADH_2^+$) then travel to an electron transport chain where their stored energy is given off to power the production of ATP via an enzyme called ATP Synthase (in the process of chemiosmosis). Here, about 32-34 ATP are eventually produced per glucose molecule.
- Other carbon containing compounds, like carbohydrates, fats, and proteins, can be broken down via cellular respiration.
- Without oxygen present, glycolysis can continue but pyruvate is not the end product. Rather lactic acid or ethanol is produced via lactic acid fermentation (in animals) or alcoholic fermentation (in yeast).
- Some organisms that live in extreme environments, like in hot pools or on the bottom of the sea floor, can utilize hydrogen sulfide and other inorganic compounds as energy sources. These organisms are not dependent on the sun for energy!



Key Terms

- **Cellular respiration:** The process by which molecules are converted into useable energy in cells.
- **Mitochondria:** The organelle in eukaryotic cells that carry on cellular respiration, release energy from food molecules, and store it in ATP.

What to look for

- Again, just be sure you are aware that plants have mitochondria and use cellular respiration to break down the food they make so they can have a ready source of ATP. It's not just

something that happens in animals! ALL organisms (bacteria, protists, fungi, plants, and animals) must use cellular respiration. But only plants, some protists, and some bacteria create the starting product: sugar. **THIS IS A CRITICAL POINT. READ IT AND LEARN IT!!!**

3. Cells contain specialized parts for determining essential *functions* such as regulation of cellular activities, *energy* capture and release, formation of proteins, waste disposal, the *transfer* of information, and movement.	Draw, label, and *describe* the *functions* of components of essential structures within cells (e.g., *cellular membrane*, *nucleus*, *chromosome*, *chloroplast*, *mitochondrion*, *ribosome*)

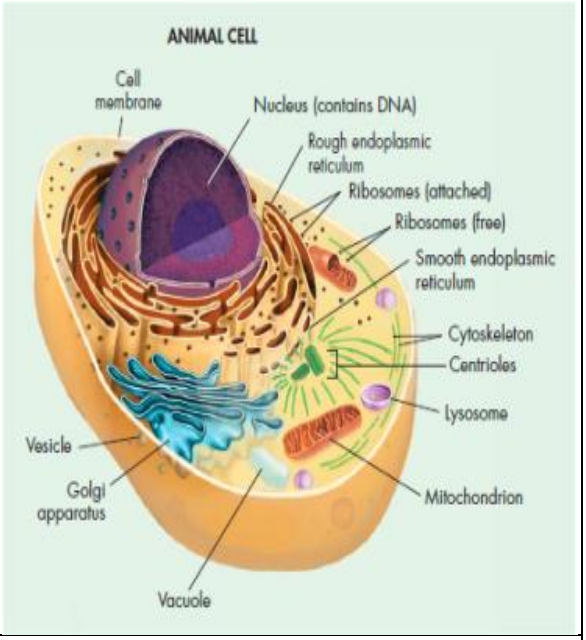
In Other Words

- There are numerous organelles that carry out important functions in the cell. Know their names and their functions.

Important Notes

Here is a quick list of important organelles found in a **eu**karyotic cell ("true nucleus"):

1. Cell membrane: Regulates what can enter and leave a cell. It is composed of a phospholipid bilayer (see below for details).
2. Cell nucleus: Houses DNA that are wrapped around proteins forming long, coiled strands called chromosomes. Also, mRNA and tRNA are produced here.
3. Ribosomes: Convert an mRNA message from the DNA into protein.
4. Endoplasmic reticulum: Ribosomes can "dock" on the ER and inject the proteins they build. The ER then alters the proteins.
5. Golgi apparatus: Further modifies proteins and sends them to their final destination.
6. Chloroplasts: Are only found in plant and some protist cells (see above for details). They produce sugar (and O_2 as a waste).
7. Mitochondria: Are found in all eukaryotic cells: plants, animals, protists, and fungi (see above for details). They use sugar and other organic compounds to produce energy in the form of ATP (and CO_2 as a waste).
8. Lysosome: Uses enzymes to breaks apart large organic compounds.



What to look for

- Know that green plant cells have chloroplasts and animal cells do not.
- It would be wise to understand how the parts of a cell work as a system, rather than just memorizing the parts. Try this:
    - Food that comes into the cell is digested by the enzymes in lysosomes. The food goes two places: Carbohydrates go to the mitochondria to be used for energy. The amino acids from proteins get picked up by tRNA and taken to the ribosomes. Here, mRNA, carrying directions from the DNA in the nucleus, tell the ribosomes what new order to put the amino acids in to make new proteins for the cell. The new protein goes into the endoplasmic reticulum where other chemicals are added to it, and is then sent to the golgi apparatus where final packaging for export occurs.
- You should know this, even though it was not listed: Eukaryotic cells are large compared to

prokaryotic cells. They are compartmentalized to allow for specialization and thus a division of labor.

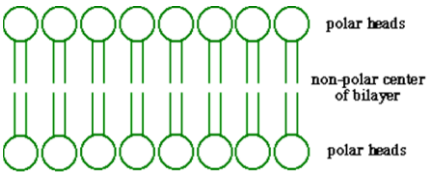
- You should know this, even though it was not listed: Bacterial cells (prokaryotes) only have cell membranes, ribosomes, and a large circular DNA. This is just enough "stuff" to allow them to make proteins, many of which are enzymes, which make chemical reactions occur, and this life to exist.

4. The cell is surrounded by a membrane that separates the interior of the cell from the outside world and determines which substances may enter and which may leave the cell.	*Describe* the structure of the *cell membrane* and how the membrane regulates the flow of materials into and out of the cell.

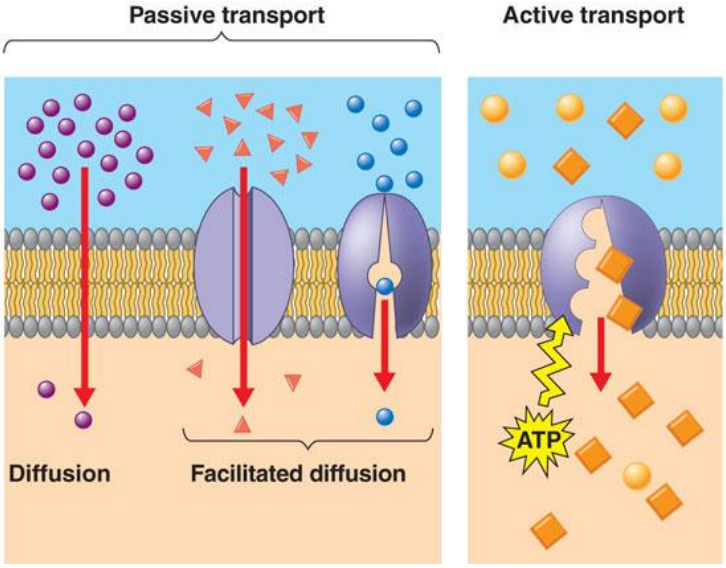
In Other Words

- The cell membrane is composed of a phospholipid bilayer that is selectively permeable. Small, uncharged particles may pass through the phospholipid bilayer, but other molecules must pass through protein channels.

Important Notes



- The cell membrane is composed of a phospholipid bilayer (see diagram). The long lipid tails are hydrophobic, so only allow small hydrophobic molecules to diffuse through (like CO_2 and O_2). They prevent large or polar or charged molecules from passing through.
- To allow for charged, polar, or large molecules to pass through the membrane there must be a carrier protein that acts like a tunnel for the movement of these molecules into and out of a cell. These tunnels (better: protein channels) may be specific to one kind of molecule or nonspecific.



- If molecules are in a higher concentration on one side of a cell compared to the other side, they may pass through the cell membrane by diffusion: the passive movement of molecules from an area of higher concentration to an area of lower concentration.
- The diffusion of the polar molecule water is through a specific protein called an aquaporin. The diffusion of water is so important that it has its own name: osmosis.
- If a cell "needs" to have molecules in a higher concentration on one side than another, they may use active transport, in which a protein pump uses the energy of ATP to keep the molecules concentrated. (That is, they "shove" the molecules either into or out of the cell, as need be.)
- For larger molecules or "chunks" of food to pass through the membrane, the cell membrane must engulf them in a process called endocytosis. Large molecules can also be expelled using the opposite process: exocytosis.

Key Term

Cellular membrane: The biological membrane separating the interior of a cell from the outside environment. It is a semipermeable lipid bilayer found in all cells.

What to look for

- In a standard diagram of a cell membrane, the top of the diagram represents the outside of the cell and the lower part of the diagram represents the inside of the cell.
- It is unclear whether the test will get as specific as asking you about what a plant or animal cell will do in a hypotonic, isotonic, or hypertonic solution. Without going into the logic, just remember that "hypo-" sounds like "hippo" and hippos are fat. A cell in a hypotonic solution (think, "pure water") will get fat. If it's an animal cell, it will burst. If it's a plant cell, the cell wall will keep it from bursting (and the cell becomes turgid). "Iso-" means "the same," so a cell in an isotonic solution (same concentration as the cell) will not be harmed. "Hyper-" means under, so a cell in a hypertonic solution (think "lots of salt") will shrivel up. SO, remembering "hypo" sounds like "hippo" should be enough to get you through!

5. The *genetic information* responsible for inherited *characteristics* is encoded in the DNA *molecules* in *chromosomes*. DNA is composed of four subunits (A,T,C,G). The sequence of subunits in a *gene* specifies the amino acids needed to make a protein. Proteins express inherited traits (e.g., eye color, hair texture) and carry out most cell *function*.	*Describe* how DNA *molecules* are long chains linking four subunits (smaller *molecules*) whose sequence encodes *genetic information*. Illustrate the process by which *gene* sequences are copied to produce proteins.

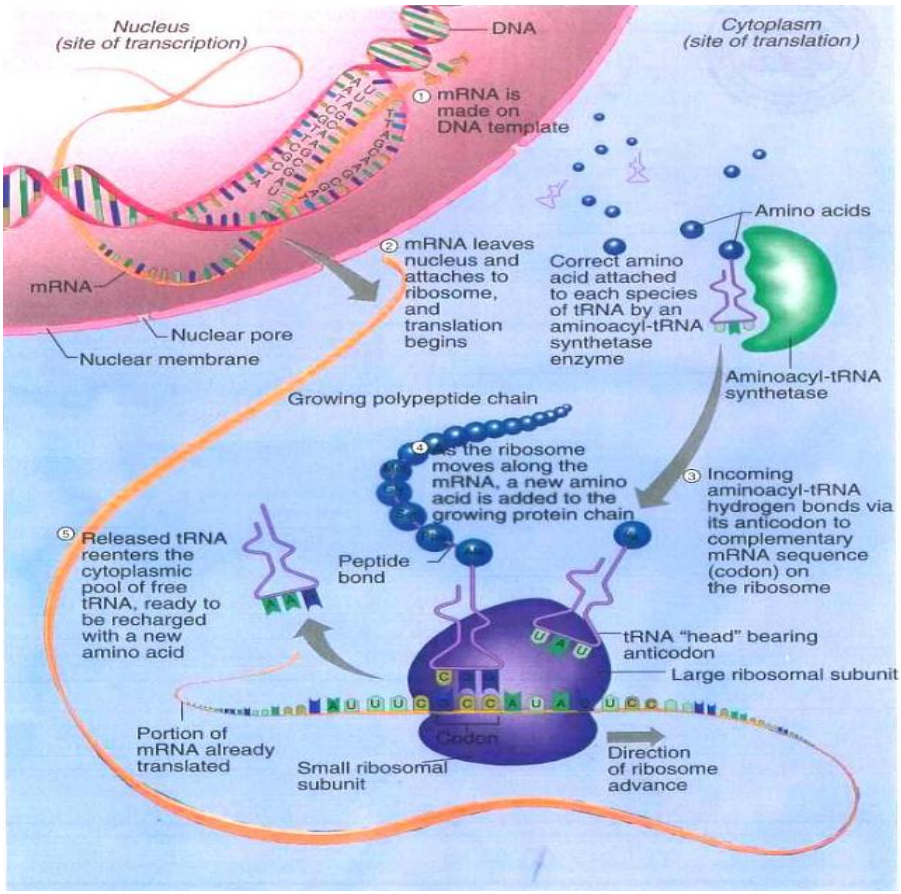
In Other Words

- DNA holds the codes (**genes**) that tell a cell how to put **amino acids** together to make **proteins**. The code is encrypted in the order of four bases: A,T,C,G, of which there are hundreds of in a single gene.
- The DNA code is what is passed on from cell to cell through cellular reproduction (one cell making two identical cells) and through sexual reproduction (half of the DNA code going into a sperm or egg, then these two uniting to make a **different** but complete set of DNA).
- **DNA→mRNA→proteins** describes the three basic steps in protein synthesis.

Important Notes

- All organisms store information in the form of DNA.
- DNA stores genetic information as a code, using the chemicals adenine (A), thymine (T), cytosine (C) and guanine (G).
    - Every sequence of three letters codes for one of the 20 amino acids. A long chain of amino acids makes a protein.
        - Some proteins are for building new parts, but most are **enzymes** that control what chemical reactions occur. If the DNA controls what enzymes are made, it controls what **chemical reactions** will occur, and thus all the **characteristics** of a cell (what kind of cell it will be, what chemicals it produces, how it functions, etc.)

- The DNA code is transcribed into mRNA and translated by ribosomes to produce proteins. This is the process of **PROTEIN SYNTHESIS: DNA→mRNA→Protein**
  - Part of a DNA molecule, called a gene, is copied and turned into mRNA.
  - mRNA leaves the nucleus and goes to a ribosome.
  - The Ribosome calls on tRNA molecules to match up with the mRNA. The tRNA are pulling amino acids behind them.
  - The amino acids line up in the order originally dictated by DNA.
  - A new protein is made. It is used for a new cell structure or as an enzyme.
- In eukaryotes this information is stored in the cell nucleus in the form of chromosomes (DNA wrapped around proteins), while in prokaryotes this information floats as a circular DNA molecule in the cytoplasm



Key Terms

Chromosome: An organized structure of DNA and supporting regulatory proteins found in cells. Chromosomes contain many genes.

DNA: Large molecules inside the nucleus of living cells that carry genetic information. The scientific name for DNA is deoxyribonucleic acid.

Ribosome: A cell organelle constructed in the nucleus. It consists of two subunits and functions as the site of protein synthesis in the cytoplasm.

What to look for:

- The process may seem a bit overwhelming because of all the words and parts that seem similar. Don't let that bother you. Just remember that DNA holds the code in the four bases A, T, C, and G. The DNA cannot leave the nucleus, so it gives a "copy" of the code to mRNA. The mRNA goes to the ribosome where the code is laid out, and tRNAs pulling amino acids line up according to the code. The amino acids bond and form the protein the DNA wants. DNA→mRNA→protein.

6. All of the *functions* of the cell are based on *chemical reactions*. Food *molecules* are broken down to provide the *energy* and the chemical constituents needed to synthesize other *molecules*. Breakdown and synthesis are made possible by proteins called *enzyme*s. Some of these *enzymes* enable the cell to store *energy* in special chemicals, such as ATP, that are needed to drive the many other *chemical reactions* in a cell.	*Explain how* cells break down food *molecules* and use the constituents to synthesize proteins, sugars, fats, DNA and many other *molecules* that cells require. *Describe* the role that *enzymes* play in the breakdown of food *molecules* and synthesis of the many different *molecules* needed for cell structure and *function*. *Explain how* cells extract and store *energy* from food *molecules*.

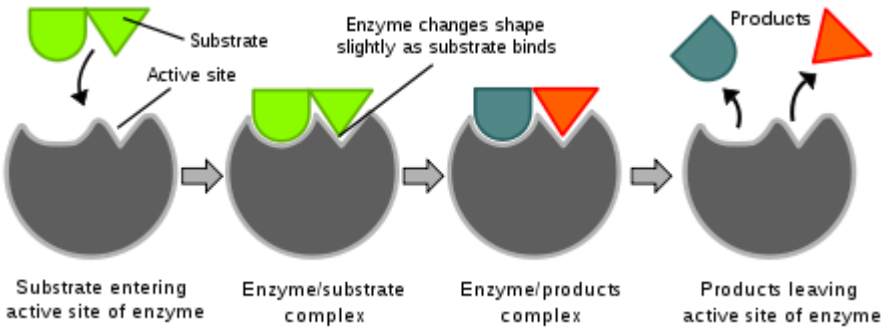
In Other Words

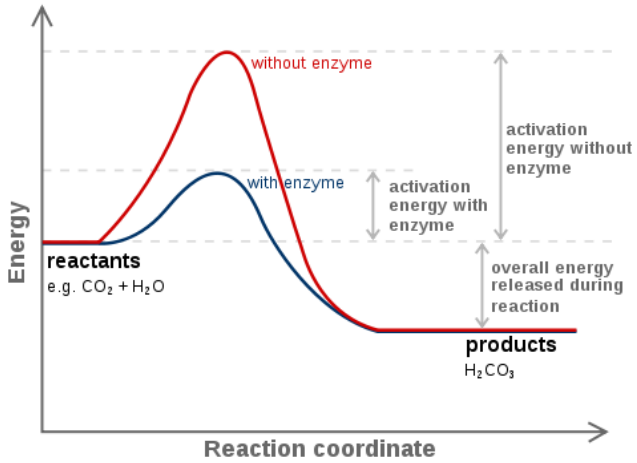
- Organisms are bags of chemical reactions.
- Cells break down food and nutrients* to
  - release energy (see above) and store it in the form of ATP.
  - reuse the organic components to construct macromolecules that are needed by the organism.
- Enzymes are useful in this process because they allow for these chemical changes to happen in a very precise manner at low temperatures.

* Food = organic molecules that can supply both building blocks and energy. Nutrients include food AND other chemical "helpers" that are not organic molecules, such as potassium, calcium, and sodium, H_2O, O_2, and CO_2.

Important Notes

- Cells extract energy from food molecules by breaking high energy bonds, like C – H bonds, creating low energy C – O bonds.
  - The energy that's lost in the C – H bonds is captured by molecules like ATP (see above for details).
- Enzymes are proteins that stabilize reactants, lowering the energy of activation, and thereby allow for chemical reactions to occur in a very controlled way at relatively low temperatures.
  - Many enzymes can work in both directions. If too many products are made, they reverse the direction and turn products back into the original reactants.
  - Enzymes can be used over and over again.
  - Many vitamins are parts of enzymes. They make sure the enzyme is the correct shape.
- All organisms – including plants – must do some form of cellular respiration.





What to look for:

- There is nothing particularly tricky about this topic. Because there are so many different sources of food and so many different enzymes, we only talk about them in general terms.

7. Cells use the DNA that forms their *genes* to encode *enzymes* and other proteins that allow a cell to grow and divide to produce more cells, and to respond to the *environment*.	*Explain that* regulation of cell *functions* can occur by changing the activity of proteins within cells and/or by changing whether and how often particular *genes* are expressed.

In Other Words

- Cells are not static. They can change from minute to minute!
- Cells can respond to their environment by changing how their proteins function or by changing which genes are expressed (turned "on") and which genes are silenced (turned "off").

Important Notes

- Cells can sense their environment by detecting chemical messages on the cellular membrane. For example, the hormone testosterone is produced in greater quantities than in children when human males reach puberty. It will trigger different genes to be expressed in certain cells, causing such results as the production of sperm, the increase in muscle mass, and the production of facial hair.
- The relatively new science of **epigenetics** studies how chemicals from our external environment can also cause gene expression to change.

KEY TERMS

Function: The normal and specific contribution of a bodily or cellular part to the economy of a living

organism.

What to look for

- Nothing tricky here. Just be careful that you do not start thinking that genes change because they "need" to. There will always be some chemical signal that starts or stops things from happening. If it works and is an advantage, great. If it doesn't, the organism may die and not pass of that trait or ability to respond to a change.

8. *Genes* are carried on *chromosomes*. Animal cells contain two copies of each *chromosome* with *genetic information* that regulate body structure and *functions*. Most cells divide by a process called *mitosis,* in which the *genetic information* is copied so that each new cell contains exact copies of the original *chromosomes*.	*Describe* and *model* the process of *mitosis*, in which one cell divides, producing two cells, each with copies of both *chromosomes* from each pair in the original cell.

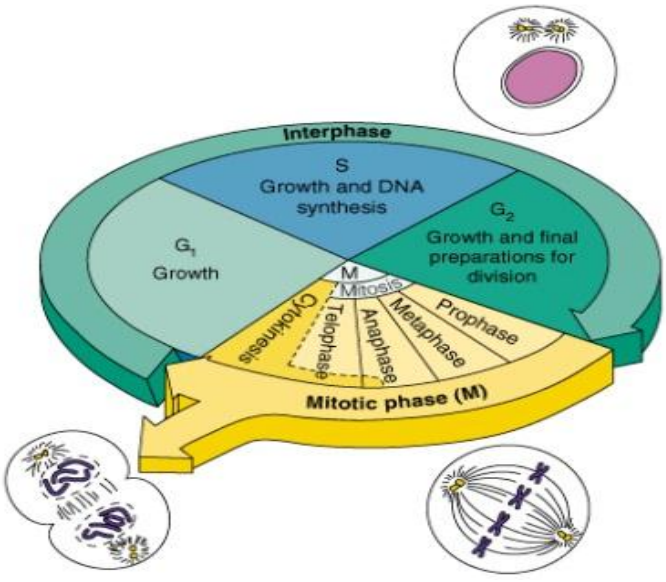
In Other Words

- Genes are sequences of DNA. Genes are located on chromosomes that are housed within the cell nucleus. Mitosis is the process of cell division that results in an exact copy of the cell.

Important Notes

The process of mitosis:

1. G_1 Phase: Growth Phase 1. The cell grows.
2. S Phase: Synthesis Phase. The cell copies its chromosomes (it synthesizes a copy of each of its chromosomes). The copies are held together at a point called the centromere.
3. G_2 Phase: Growth Phase 2. The cell grows again.
4. M Phase: Mitotic Phase consists of 4 parts:
    a. Prophase: The cell's nucleus dissolves and chromosomes condense.
    b. Metaphase: The cell's chromosomes line up single file along the middle of the cell.
    c. Anaphase: The centromeres split and the chromosome pairs pull apart to opposite sides of the cell.
    d. Telophase: The two sets of chromosomes form two new nuclei.
5. Cytokinesis: The cell's cytoplasm splits in two forming two new cells. This usually happens at the same time as Telophase. However, there are some cells that do not go through cytokinesis and instead form cells with many nuclei in them (multinucleate cells). Fungi have multinucleated cells. Your muscle cells are also multinucleate.



Key Terms

Mitosis: The production of two identical nuclei in one cell usually followed by cell division and the production of two cells with the same genetic makeup as the original cell.

Asexual reproduction: Involves the growth of a new organism by fission of cell nuclei. Asexual reproduction usually involves one parent and leads to offspring that are genetically identical to the **parent** and to one another.

What to look for

- Nothing tricky here. The cell's chromosomes make a "Xerox copy" of themselves and put one set in each of two new cells.

9. Egg and sperm cells are formed by a process called *meiosis* in which each resulting cell contains only one representative *chromosome* from each pair found in the original cell. *Recombination* of *genetic information* during *meiosis* scrambles the *genetic information*, allowing for new *genetic* combinations and *characteristics* in the offspring. *Fertilization* restores the original number of *chromosome* pairs and reshuffles the *genetic information*, allowing for *variation* among offspring.	*Describe* and *model* the process of *meiosis* in which egg and sperm cells are formed with only one set of *chromosomes* from each parent. *Model* and *explain* the process of *genetic recombination* that may occur during *meiosis* and how this then results in differing *characteristics* in offspring. *Describe* the process of *fertilization* that restores the original *chromosome* number while reshuffling the *genetic information*, allowing for *variation* among offspring. *Predict* the outcome of specific *genetic* crosses involving two *characteristics*

In Other Words

- Meiosis halves genetic information from mom and dad to make sex cells with only one of each pair of chromosomes (haploid sex cells).
- During meiosis, the chromosomes can "cross over," resulting in chromosomes that have parts of each of a pair of chromosomes.
- Once egg and sperm cells fuse together, the diploid state is restored (chromosomes are in pairs again).
- So sexual reproduction mixes up genes during crossing over of meiosis, by the way the chromosomes line up in meiosis, and in random fertilization of the sex cells.

Important Notes

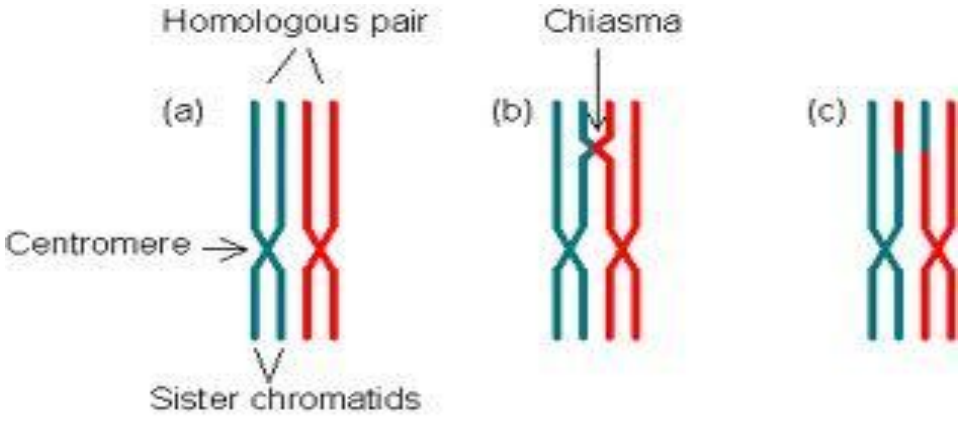
- Adult mammals are diploid, meaning that they have two sets of chromosomes in each somatic* cell. One of these sets is from the father and the other is from the mother.
- Sex cells reduce the chromosome number by half, resulting in haploid cells. These haploid cells (also known as gametes) are called eggs in females and sperm in males.
    - During fertilization these haploid gamete cells combine to form a diploid, fertilized egg. The chromosome number of somatic cells is now restored. If sex cells had the full number of chromosomes, each generation would double the number of chromosomes in its cells. This would be impossible.
- How meiosis works…is sort of like mitosis done two times in a row, except some major

differences in the beginning. The differences are in bold and underlined. What happens is mitosis has a line through it.

- Prophase **I**: The cell's nucleus dissolves and chromosomes condense.
- Metaphase **I**: The cell's chromosomes line up ~~single file~~ **in their pairs** along the middle of the cell. Here is where the mixing of genes occurs in two of three ways:
  - Recall that each pair of chromosomes is composed of one that came from "mom" and one that came from "dad." When they line up in their pairs, it is random, and therefore lots of combinations are possible:

Chrm pair 1	MOM	DAD		MOM	DAD		DAD	MOM		
Chrm pair 2	MOM	DAD	OR	DAD	MOM	OR	MOM	DAD		ETC.
Chrm pair 3	DAD	MOM		DAD	MOM		DAD	MOM		

  - When the chromosomes line up, their tips can cross and exchange with each other, a process called "crossing over."



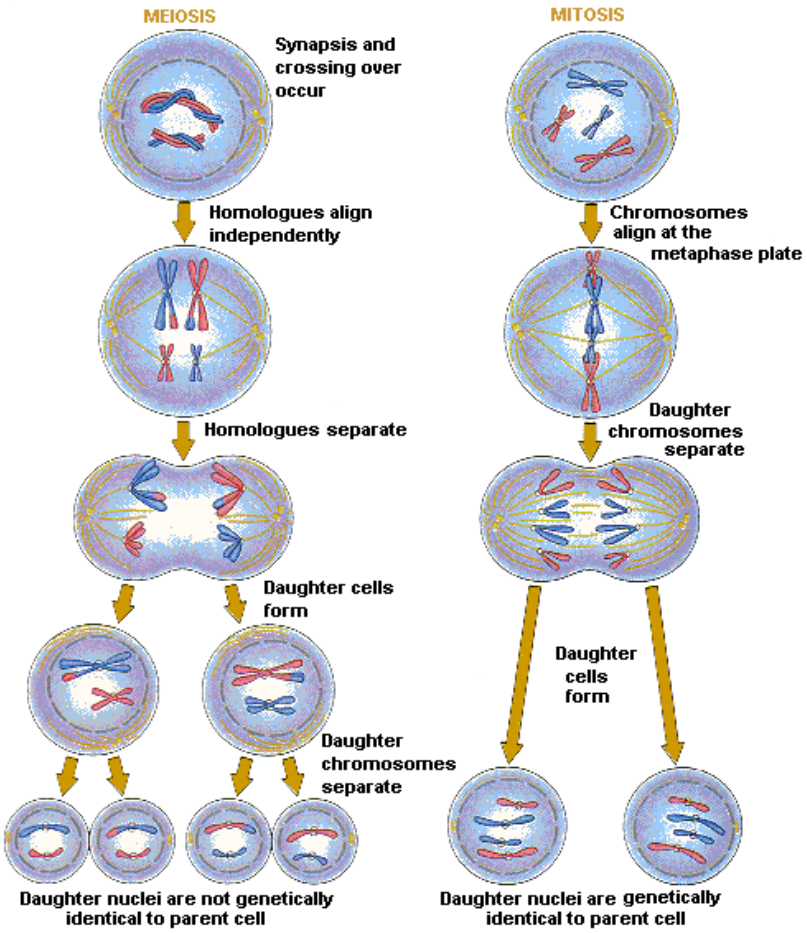
- Anaphase **I**: The ~~centromeres split and the chromosome pairs~~ **centromeres do not split. Each duplicated chromosome is** pulled to the opposite sides of the cell.
- Telophase **I**: ~~The two sets of chromosomes form~~ two new nuclei **are formed, each with ½ the number of chromosomes as the parent cell.** The cell splits in half.

NOW THERE ARE TWO CELLS. EACH DOES THE FOLLOWING

- **Metaphase II:** The cell's chromosomes line up single file along the middle of the cell.
- **Anaphase II:** The centromeres split and the chromosome pairs-are pulled to the opposite sides of the cell.
- **Telophase II**: Two new nuclei formed. The cell splits in half.

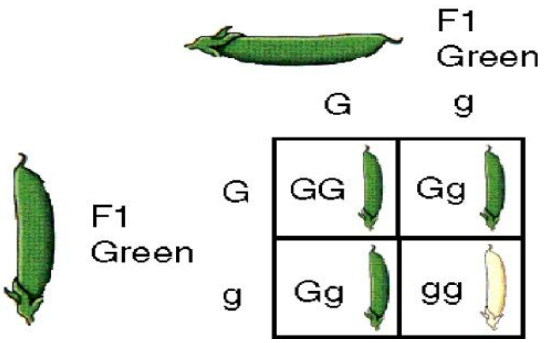
NOW THERE ARE FOUR CELLS.

* A somatic cell is a "normal" body cell. That is, a non-sex cell.



Comparison of Meiosis and Mitosis

- Gregor Mendel was the first to examine inheritance by using controlled experiments with pea plants. For example, he found that if a pea plant with the dominant green pod color genotype, Gg, was crossed with another pea plant with the same genotype, then the possible offspring would be GG, Gg, Gg, and gg.



Key Terms

Heredity: The passing of traits to offspring. This is the process by which an offspring cell or organism acquires the characteristics of its parent cell or organism.

Meiosis: A process of cell division that produces reproductive cells known as gametes. Each gamete contains only one set of the unpaired chromosomes and half as much genetic information as the original cell.

What to look for

- I doubt they will try to stump you on all the processes of mitosis and meiosis. But I'll bet there will be a question concerning mixing up the genetic information. That occurs in three places:
    - when the pairs of chromosomes line up randomly in meiosis. See the "mom/dad" example above.
    - when they line up in their pairs, crossing over occurs.
    - Finally, there is mixing up of genetic information when sperm meets egg.

1. People sweat to help maintain body temperature. What type of feedback happens when sweating regulates body temperature?

o **A**. Positive feedback, because sweating can increase body temperature

o **B**. Positive feedback, because sweating can decrease body temperature

o **C**. Negative feedback, because sweating can decrease body temperature

o **D**. Negative feedback, because sweating can increase body temperature

2. Plants use nitrogen to make proteins. What is present in the soil that makes nitrogen d**irectly** available to plants?

o **A**. Air

o **B**. Water

o **C**. Sugars

o **D**. Bacteria

Foaming Spuds

Directions: Use the following information to answer questions 3 through 6.

Mike and Kelsey were studying how hydrogen peroxide (H_2O_2) in cells breaks down to form water and oxygen. When this reaction happens, bubbles of oxygen gas are released, producing foam. This reaction is described as follows:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

$$\text{hydrogen peroxide} \rightarrow \text{water} + \text{oxygen}$$

A protein named *catalase*, found in all cells including potatoes, increases the rate of this reaction. Mike and Kelsey used potato juice as the source of *catalase* to do the following controlled experiment.

Question: What is the effect of the acidity of potato juice on the volume of foam produced when hydrogen peroxide is added to potato juice?

Prediction: As the acidity of potato juice decreases (higher pH), the volume of foam will increase.

Materials:
graduated cylinders labeled pH 6, pH 7, pH 8, and pH 9
potato juice from the same potato, divided and adjusted to four acidities: pH 6, pH 7, pH 8, and pH 9
hydrogen peroxide (H_2O_2)
beaker
stopwatch
stirring rods
thermometer

Procedure:
1. Label four graduated cylinders, one for each acidity.
2. Put 10 milliliters of potato juice at pH 6 in the appropriately labeled cylinder.
3. Do the same for each of the other cylinders.
4. Monitor the room temperature to make sure the temperature remains the same throughout the investigation.
5. Add 5 milliliters of hydrogen peroxide to each graduated cylinder, stir for two seconds. Wait three minutes.
6. Measure and record the volume of foam in each graduated cylinder as Trial 1.
7. Clean all graduated cylinders and stirring rods.
8. Repeat steps 1 through 7 two times for Trials 2 and 3.
9. Calculate and record the average volume of foam for each acidity of potato juice.

Data: Acidity of Potato Juice vs. Volume of Foam				
Acidity of Potato Juice (pH)			**Volume of Foam** (milliliters)	
pH	Trial 1	Trial 2	Trial 3	Average
6	22	25	25	24
7	32	38	36	35
8	41	42	42	42
9	32	29	30	30

3. How could Mike and Kelsey be more certain the results of their experiment are **reliable**?

o **A**. Test the reaction with other acidities of potato juice.

o **B**. Repeat the experiment the same way.

o **C**. Increase the volume of potato juice.

o **D**. Use a different type of plant juice.

4. Write a conclusion for this controlled experiment. In your conclusion, be sure to:

- Answer the experimental question.
- Include **supporting** data from the Acidity of Potato Juice vs. Volume of Foam table.
- Explain how these data **support** your conclusion.
- Provide a **scientific** explanation for the trend in the data.

Question: What is the effect of the acidity of potato juice on the volume of foam produced when hydrogen peroxide is added to potato juice?

Conclusion:

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5. What did Mike and Kelsey do to make the results of their experiment **valid**?

o **A**. Recorded the volume of foam in milliliters.

O **B**. Calculated the average volume of foam for each acidity.

O **C**. Measured the volume of foam at each acidity three times.

O **D**. Waited three minutes before measuring the volume of foam.

Plan a controlled experiment to answer the question in the box. You may use any materials and equipment in your procedure.
Be sure your procedure includes:

- logical steps to do the experiment
- two controlled (kept the same) variables
- one manipulated (independent) variable
- one responding (dependent) variable
- how often measurements should be taken and recorded

Question: What is the effect of the temperature of potato juice on the time for bubbling to stop after hydrogen peroxide is added?
Procedure:

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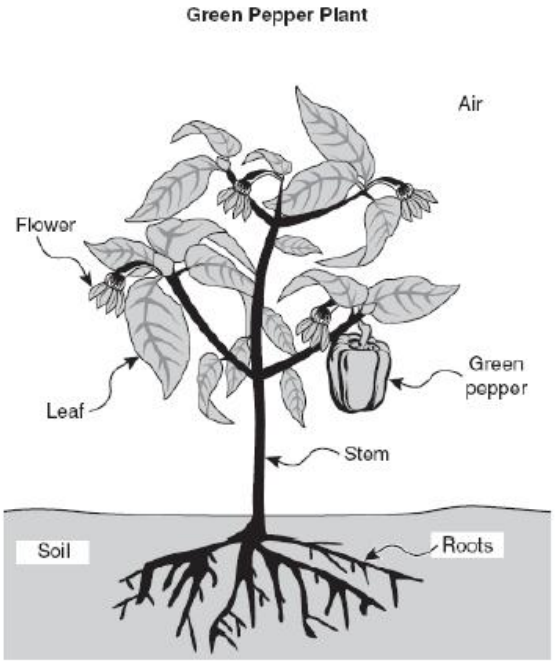
The Green Machine
Directions: Use the following information to answer questions 6 through 9 on pages 19 through 21.

While helping to plant a school garden, Becky and Juan observed many different types of plants. They drew the following diagram of a green pepper plant growing in the garden.



6. The green pepper plant has proteins that control the process of making glucose. How does the plant obtain these proteins?

O **A**. The plant makes the proteins using the instructions in DNA.

O **B**. The proteins are absorbed from the soil by the roots of the plant.

O **C**. The light energy changes molecules in the plant cell into proteins.

O **D**. The proteins are all present in the seed before germination occurs.

7. Becky and Juan want to increase the mass of food produced in the school garden. Which of the following questions could lead to a possible solution to this problem?

O **A**. How much carbon dioxide do plants require?

O **B**. Which mineral nutrients do plants need?

O **C**. Which plants provide the most protein?

O **D**. Which plant seeds are largest?

8. What is the role of cellular respiration in plants?

O **A**. To absorb carbon dioxide

O **B**. To release oxygen

O **C**. To produce ATP*

O **D**. To form glucose

9. Becky and Juan used a greenhouse as a model of a garden ecosystem to predict effects of amount of sunlight on green pepper production in a garden ecosystem.

- Describe **two** ways the greenhouse model may lead to unreliable predictions about the effects of amount of sunlight on green pepper production in a garden ecosystem. In your description, be sure to:
- Describe **two** differences that make a garden ecosystem more complex than the greenhouse.
- Describe how **each** difference could cause predictions about green pepper production in a garden ecosystem to be unreliable.

One Way

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Another way:

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