Standards At A Glance: Biology I

Cells

SPI 3210.1.1	Identify the cellular organelles associated with major cell processes.

Key Vocabulary

Nucleus –

Nucleolus –

Ribosome –

Endoplasmic reticulum (smooth and rough) –

Golgi Apparatus –

Vesicle –

Mitochondrion –

Chloroplast –

Vacuole –

Lysosome –

Cell membrane –

Cell wall –

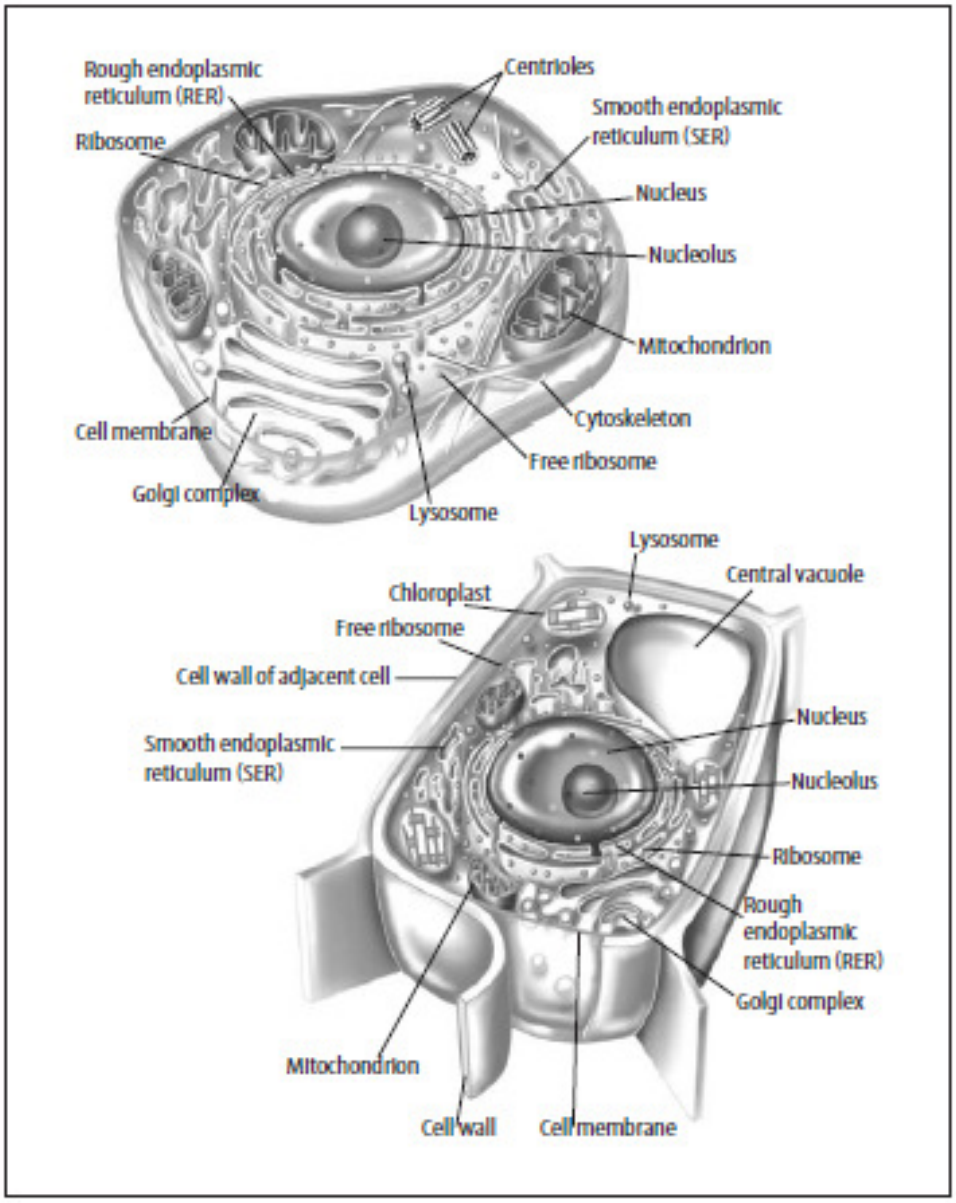
Centriole –

***Table 1* Organelles and Their Functions**

 **Nucleus** the organelle that contains the cell's DNA and is the control center of the cell	 **Chloroplast** the organelle that uses the energy of sunlight to make food
 **Ribosome** the organelle in which amino acids are hooked together to make proteins	 **Golgi complex** the organelle that processes and transports proteins and other materials out of cell
 **Endoplasmic reticulum** the organelle that makes lipids, breaks down drugs and other substances, and packages proteins for Golgi complex	 **Large central vacuole** the organelle that stores water and other materials
 **Mitochondrion** the organelle that breaks down food molecules to make ATP	 **Lysosome** the organelle that digests food particles, wastes, cell parts, and foreign invaders

Key concepts

The main concepts behind this standard is to (1) know the main organelles and their function, (2) identify them from an image, and (3) understand how they work together to achieve cellular processes. You should also be able to compare and contrast plant cells from animal cells.



Example EOC question:

Protein synthesis occurs on which cellular organelle?

F chloroplast

G ribosome

H mitochondrion

J nucleus

SPI 3210.1.2 Distinguish between prokaryotic and eukaryotic cells.

Key Vocabulary

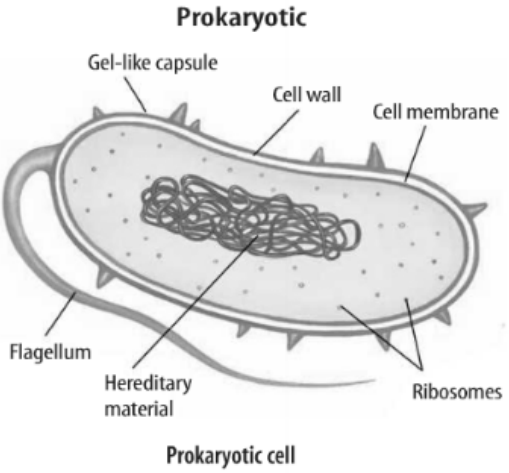
Eukaryote –

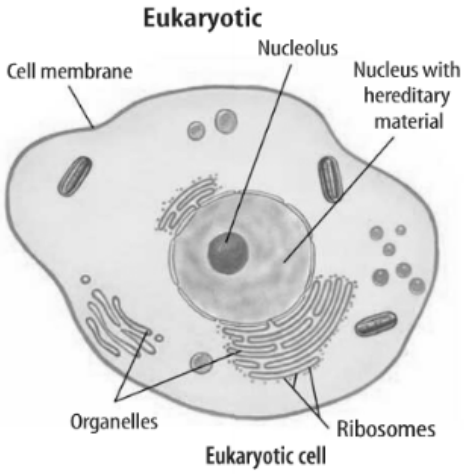
Prokaryote –

Key concepts

The standard speaks for itself: tell the difference between a prokaryotic cell and a eukaryotic cell.

Prokaryotes	Eukaryotes
Bacteria Archaea	Plants Animals Fungi Protists
No membrane-bound nucleus	Membrane-bound nucleus
No organelles	Has organelles





Example EOC question:

Which is the most accurate description of a eukaryotic cell?

A moves using cilia
B contains a nucleus
C produces food by photosynthesis
D reproduces only by binary fission

SPI 3210.1.3 Distinguish among proteins, carbohydrates, lipids, and nucleic acids.

Key Vocabulary

Amino acid -

Carbohydrate -

Lipid -

Monomer -

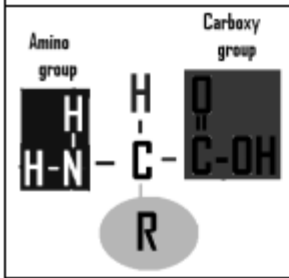
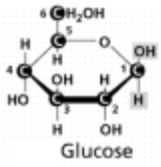
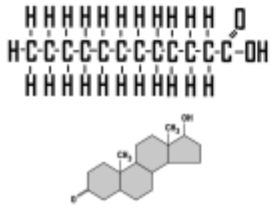
Nucleic acid -

Polymer -

Protein -

Key concepts

Carbon-based molecules are the foundation of life. The four main types of carbon-based molecules in living things are carbohydrates, lipids, proteins, and nucleic acids. The molecules have different functions that are based on their different structures. Carbohydrates have a ratio of C:H:O of 1:2:1, lipids have very little oxygen, proteins have a nitrogen base and an R-group (amino group), and nucleic acids have a sugar attached to a nitrogen base and a phosphate.

ORGANIC MOLECULE	SUBUNIT	MAKES THIS MACROMOLECULE
	NUCLEOTIDE SUBUNITS (A, T, G, C, or U)	NUCLEIC ACIDS (DNA OR RNA) 
	AMINO ACIDS (20 different R groups)	 PROTEINS
	CARBOHYDRATES 1 carbon: 2 hydrogen: 1 oxygen	SIMPLE SUGARS MONOSACCHARIDES = 1 sugar (Ex : glucose, fructose, galactose, ribose, deoxyribose) COMPLEX CARBO's POLYSACCHARIDES=many sugars (Ex : glycogen, starch, cellulose)
	Mostly CARBON & HYDROGEN ATOMS in long chains or rings with very little oxygen	LIPIDS Includes: Fats, oils, waxes, steroids

Example EOC question:

Amino acids are a structural component of which macromolecule?

F lipids
G proteins
H carbohydrates
J nucleic acids

SPI 3210.1.4 Identify positive tests for carbohydrates lipids, and proteins.

Key Vocabulary

Benedict's reagent -

Biuret reagent -

Lugol's iodine –

Solution –

Solvent –

Sudan III or IV –

Key concepts

You will need to memorize which reagent to use to test for the appropriate macromolecule and the color changes that occur when testing positive.

Carbon molecule	Reagent	Control color	Positive test
Carbohydrate – sugar	Benedict's solution	Blue	Reddish-orange
Carbohydrate – starch	Lugol's Iodine	Yellow-brown	Violet/black
Protein	Biuret's Reagent	Blue	Purple
Lipids	Sudan III (Brown paper bag)	Dilutes red throughout No mark	Stains red (separates) Translucent spot

Example EOC question:

When Benedict's solution is added to an unknown substance and then heated in a hot water bath, the solution turns an orange-brown color. This indicates the presence of which molecule?

A lipids
B proteins
C carbohydrates
D nucleic acids

SPI 3210.1.5 Identify how enzymes control chemical reactions in the body.

Key Vocabulary

Activation energy –

Catalyst –

Enzyme –

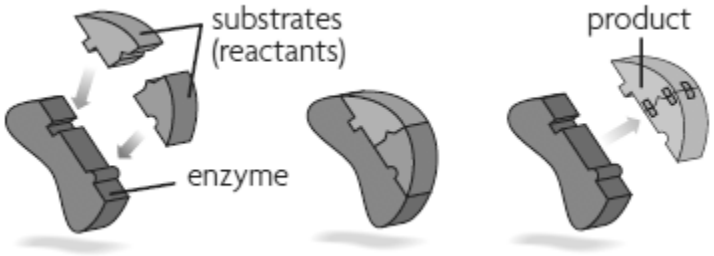
Equilibrium –

Reaction rate –

Substrate –

Key concepts

Enzymes are catalysts for chemical reactions in living things. Enzymes increase the rate of reactions and decrease the activation energy for reactions. Each enzyme catalyzes a specific reaction, and a change in an enzyme's structure changes its function.



Example EOC question:

How does the reduction in activation energy by an enzyme affect a chemical reaction?

F The products are not stable.

G The reaction proceeds at a faster rate.

H Less energy is gained from the reaction.

J The reaction is less efficient when the enzyme is present.

SPI 3210.1.6 Determine the relationship between cell growth and cell reproduction.

Key Vocabulary

Cell cycle –

Mitosis –

Interphase –

Prophase –

Metaphase –

Anaphase –

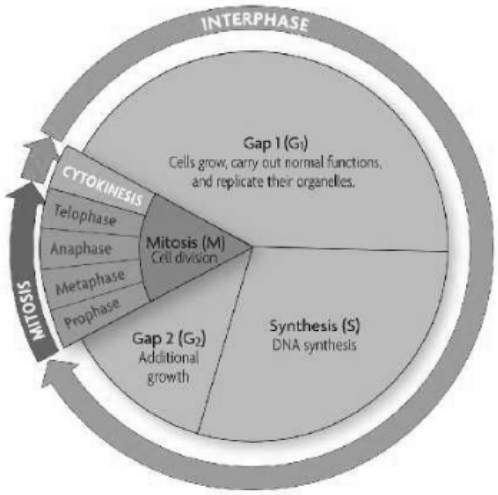
Telophase –

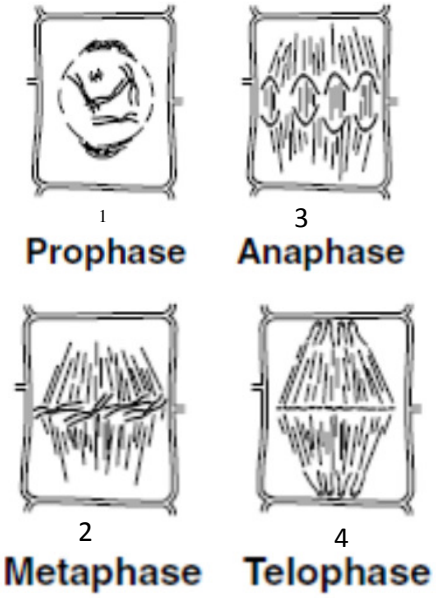
Cytokinesis –

Surface area - to - volume ratio –

Key concepts

Know the cell cycle and how it relates to growth and division. Most of the cell spends its life during interphase, which has an initial growth phase called Gap 1 (G_1) followed by a DNS synthesis phase (S) and finally a Gap 2 (G_2) growth phase. When the surface area to volume ratio gets too low (i.e., the cell gets too big to efficiently exchange materials through the cell membrane) it undergoes division (M phase) followed by cytokinesis.





Example EOC question:

What must occur during the cell cycle to ensure proper division of the chromosomes?

A The cell must grow in size.

B The mitochondria must divide.

C The DNA of the cell must replicate.

D The cell membrane must dissolve.

SPI 3210.1.7 Predict the movement of water and other molecules across a selectively permeable membrane.

Key Vocabulary

Fluid-mosaic model –

Selective permeability –

Diffusion –

Osmosis –

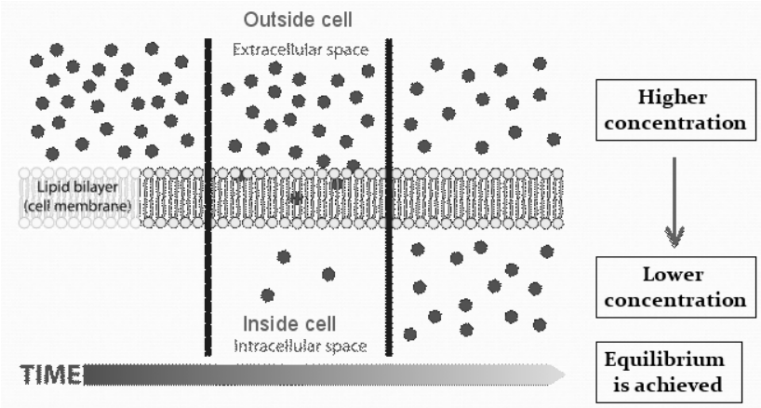
Isotonic –

Hypotonic –

Hypertonic –

Key concepts

The plasma (cell) membrane is composed of two layers of phospholipids. For that reason we call it a phospholipid bilayer. Embedded in the phospholipid bilayer are proteins, which can facilitate diffusion or carry large molecules across the membrane. The plasma membrane is said to be selectively permeable, where it selects which large molecules pass through (permeable means "capable of being passed through." Molecular diffusion, or more simply, diffusion, is when molecules naturally move from an area of high concentration to an area of low concentration. If the molecule in consideration is water, then the term is called osmosis. The amount of water that moves into or out of a cell and the resulting volume change is referred to as tonicity.



Example EOC question:

What will <u>most</u> likely occur when a cell is placed into a saline solution that has a higher salt concentration than inside the cell?

F Water molecules will move into the cell.

G Salt molecules will move out of the cell.

H Salt molecules will move until the salt concentration is the same inside and outside of the cell.

J Water molecules will move until the salt concentration is the same inside and outside of the cell.

SPI 3210.1.8 Compare and contrast active and passive transport.

Key Vocabulary

Active transport –

Facilitated diffusion –

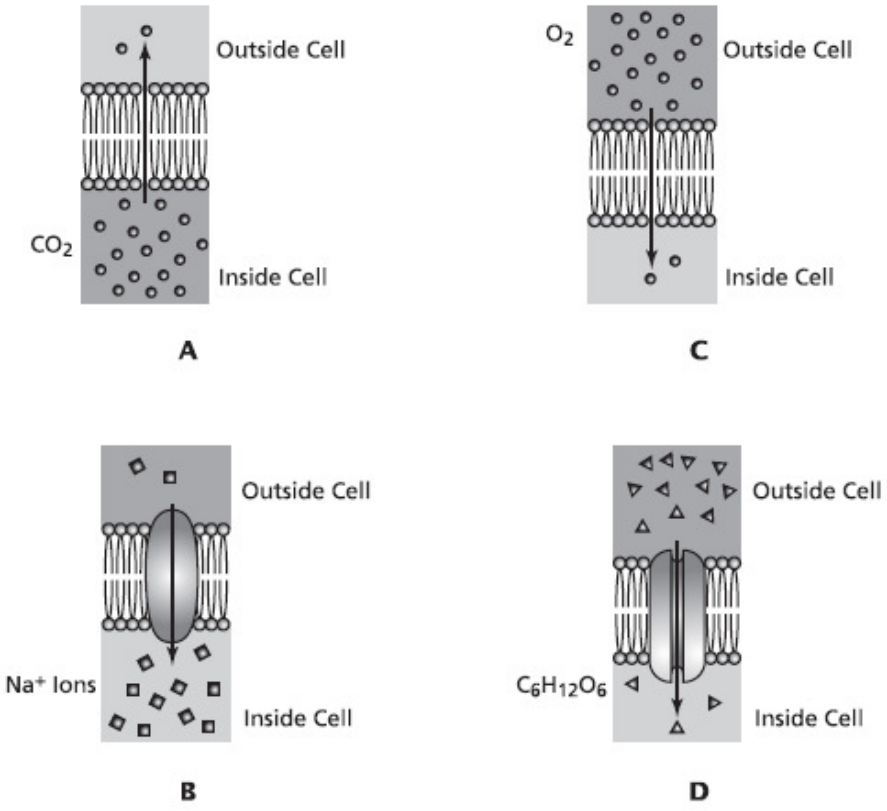
Passive transport –

Key concepts

The main difference between active and passive transport is that active transport requires energy to move molecules, adenosine triphosphate (ATP). The reason why active transport requires energy (ATP) is because it is moving molecules opposite of molecular diffusion. In other words, it is moving molecules against a concentration gradient (from lower concentration to higher concentration). Passive transport, however, is synonymous with diffusion, for our purposes. Facilitated diffusion is a type of diffusion, but carrier proteins embedded in the cell membrane help ease the movement of molecules (make it easier to move from high concentration to low concentration.

Example EOC question:

Which diagram represents active transport?



Interdependence

SPI 3210.2.1 Predict how population changes of organisms at different trophic levels affect an ecosystem.

Key Vocabulary

Autotrophs (producers) – organisms that make their own food/energy

Competition – When two organisms vie for the same prey (interspecific/intraspecific)

Decomposers – organisms that break down dead material for food/energy

Food chain – a linear sequence of successive energy flow from one organism to another

Food web – a dynamic feeding relationship that shows all feeding possibilities in an ecosystem. (all possible food chains combined)

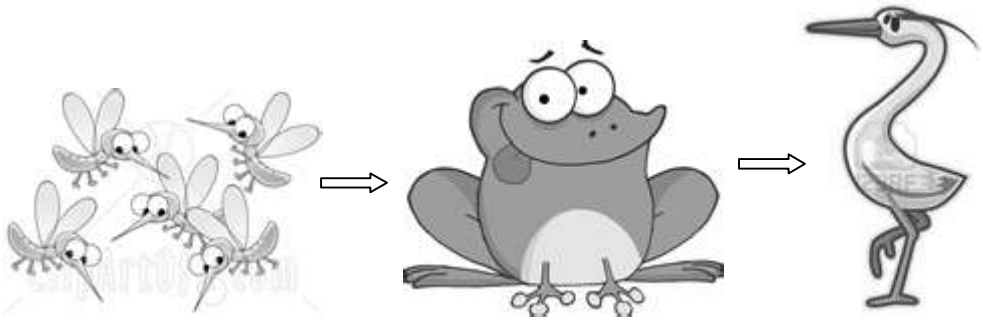
Heterotrophs (consumers) – organisms that have to eat other organisms to obtain food/energy

Predator/prey – a relationship between two organisms where one organism (predator) eats another (prey)

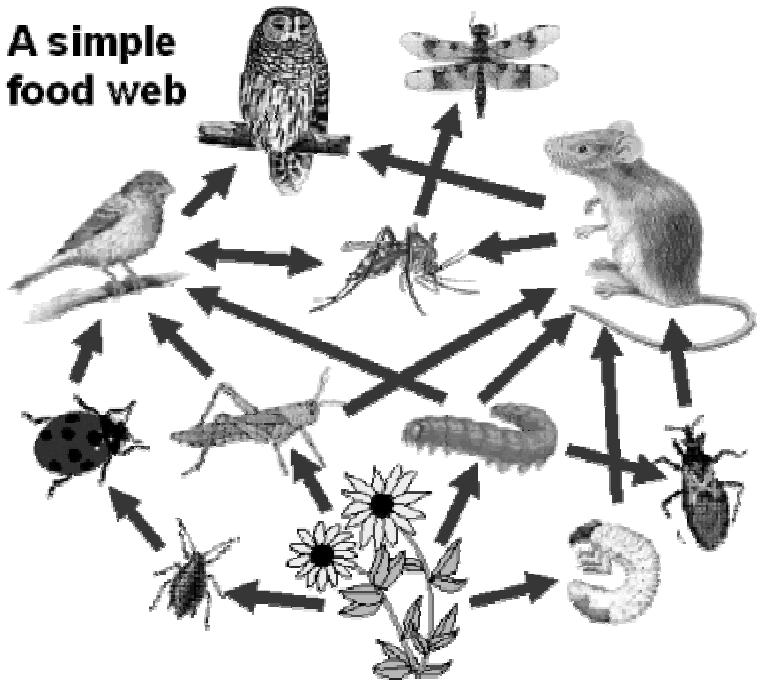
Trophic level – the feeding level of an organism

Key concepts

The main learning objective behind this standard is to understand that population changes in one species of organism will have connections to other organisms in its ecosystem that are involved in the same feeding relationship. There can be direct or indirect effects on both sides of a food chain. For example, if a population of frogs decreases due to an environmental change, then the number of herons feeding on these frogs may decrease (due to lack of food availability). On the other hand , the number of mosquitoes may increase due to lack of feeding pressure by frogs.



It can be more complicated in a food web because feeding pressure can shift on to other organisms, which may increase competition with other organisms that happen to feed on the same prey.



In the food web above, the owl can eat the bird or the mouse. You can see that if the mouse population were to decline, that could either reduce the owl population or shift the feeding burden onto the birds. The ecosystem might see population increases in all of the organisms lower than mouse and bird.

Example EOC question:

In a grassland ecosystem, a certain species of predator preys mainly on large herbivores. Which would most likely result if there were a sudden decrease in the predator population?

F a decrease in primary consumer populations
G an increase in grassland biodiversity
H overgrazing of producers
J greater competition among predators

SPI 3210.2.2 Interpret the relationship between environmental factors and fluctuations in population size.

Key Vocabulary

Abiotic factors – all the nonliving elements of an ecosystem (water, air, rocks, temperature, etc.)

Biotic factors – All the living (or once alive) elements of an ecosystem (animals, plants, microorganisms, etc.)

Biotic potential – the reproductive potential of an organism; how many offspring it can produce

Birth rate/death rate – the rate of change of a population by birth or death

Density-dependent factors – factors that can impact a population due to overcrowding

Density-independent factors – factors that can impact a population regardless of population density

Emigration - when organisms exit an area

Immigration – when organisms enter an area

Limiting factors – any factor which can limit the population growth (water, food, space, etc.)

Key concepts

The main learning objective behind this standard is to understand that population changes can be affected by environmental changes as well. Changes in abiotic factors can alter the population, such as availability of water, physical space, and climate changes like temperature and precipitation. Several biotic factors can change the population of a species such as emigration/immigration, death/birth rate, and biotic potential.

Example EOC question:

A delay in warm spring weather in an ecosystem could result in decreased populations of primary consumers. What would best explain the decrease in primary consumers?

A a decrease in the availability of producers
B an increase in competition with secondary consumers
C a decrease in the local concentration of atmospheric oxygen
D an increase in the activity of scavengers and decomposers

SPI 3210.2.3 Determine how the carrying capacity of an ecosystem is affected by interactions among organisms.

Key Vocabulary

Carrying capacity – The maximum number of organisms of a population that an ecosystem can support

k-strategists – a reproductive strategy characterized by few young with a lot of care to ensure that genes will be passed on

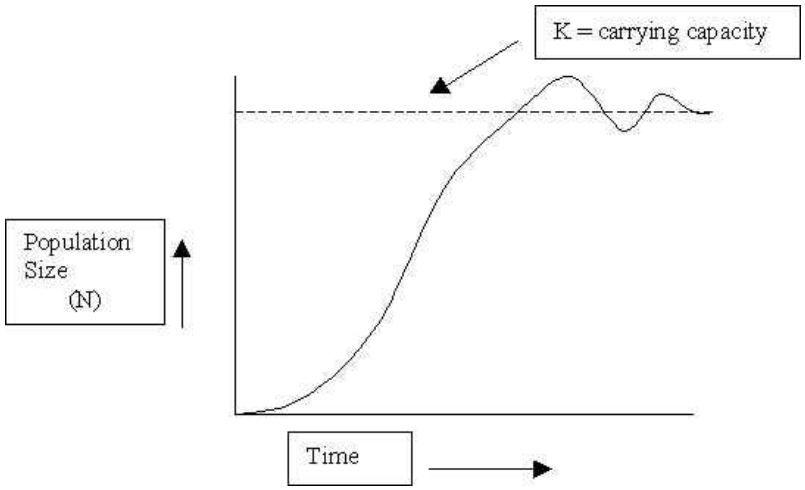
Population density – the number of individuals living in a certain area

r-strategists – a reproductive strategy characterized by having large numbers of offspring with little/no care for young and rely on statistical probability to pass on genes

Survivorship curve – a graph that indicates the number of surviving members of a particular population over time from a measured set of births

Key concepts

The main learning objective behind this standard is to understand that an ecosystem can only support so many organisms before it stresses the population.



Example EOC question:

Which would most likely increase the carrying capacity for a deer population in a forest ecosystem?

F a decrease in parasites
G a decrease in predators
H a decrease in producers
J a decrease in competitors

SPI 3210.2.4 Predict how various types of human activities affect the environment.

Key Vocabulary

Eutrophication – the process where nutrients are added to an aquatic environment that first stimulates an algal bloom followed by bacterial decomposition and subsequent oxygen drop. This can result in a fish kill.

Greenhouse gases – any gas such as carbon dioxide, methane, water vapor, that traps solar energy

Habitat fragmentation – dividing a habitat in sections, for example, the construction of a highway

Indicator species – an organism that serves as a gauge for ecosystem health

Pollution – any unwanted substance that does harm to the environment; can target air, water, or land

Urbanization – The process of turning natural environments into urban areas (housing/commercial buildings, roadways, etc.)

Key concepts

This standard requires you to predict possible outcomes given a situation. The best thing you can do is to read carefully, use clues within the text to logically come up with the best possible conclusion. The focus of this standard will most likely be on climate change, pollution, natural resources, agricultural and industrial practices, and urbanization.

Example EOC question:

Scientists hypothesize that the use of certain pesticides is causing a decline in the population of honeybees, which pollinate many fruit and vegetable plants. How would a decline in the honeybee population most impact the environment?

A Populations of plants that reproduce asexually would decline.
B Populations of primary consumers would increase.
C Production of some food crops would decrease.
D Flowering plants would produce more nectar.

SPI 3210.2.5 Make inferences about how a specific environmental change can affect the amount of biodiversity.

Key Vocabulary

Biodiversity – the number of different species in an area

Specialist – a consumer that has a very specific diet

Generalist – a consumer that can eat a variety of prey/producers

Invasive species – a non-native species that out competes native organisms

Key Concepts

This standard is fairly straightforward. If an environment changes, the number of different kinds of species can increase or decrease, depending on the environmental change. For example, if there is a warming of the climate, organisms who are not adapted to the temperature change will have to move or die. Another example might be that zebra mussels not native to an environment are introduced and flourish. They out-compete native organisms for space, food, and other resources. This could disrupt other populations of organisms resulting in a loss of biodiversity. Conversely, if a farm is abandoned, for example, you might see an increase in biodiversity as new species move into that space.

Example EOC question:

The kudzu plant was imported into the United States as an ornamental plant and was later planted to help reduce soil erosion. Kudzu is a vine that grows in a wide range of conditions and soil types. Due to its rapid growth, the plant has taken over many native plant species, resulting in

F a decrease in biodiversity.
G a decrease in rate of cellular respiration.
H an increase in surface runoff.
J an increase in habitat for native species.

SPI 3210.2.6 Predict how a specific environmental change may lead to the extinction of a particular species.

Key Vocabulary

Extinction – when an organism is gone from Earth forever

Endangered species – when an organism is in danger of becoming extinct

Threatened species – when a population gets so low that it can become endangered

Key Concepts

This standard is the same as the previous, except it continues on to include extinction. While extinction is a normal part of Earth's history, and not necessarily bad, human-caused extinction is bad. It is believed that current estimates say that humans have increased extinction rates by 1000 times, mainly due to the items listed in SPI 2.4. Extinction is more common among specialists, whereas generalists are more likely to survive.

Example EOC question:

The spotted owl is an endangered species found in the northwestern United States. Which environmental condition would most likely lead to the extinction of the spotted owl?

A a drought that lasts for one year
B the clear-cutting of wildlife habitat
C the immigration of a new species of prey
D an abnormally cold winter

SPI 3210.2.7 Analyze factors responsible for the changes associated with biological succession.

Key Vocabulary

Primary succession – the gradual change in an ecosystem that starts from bare rock

Secondary succession – the gradual change in an ecosystem after a disturbance

Pioneer species – the first organism to recruit to an area (lichens, mosses)

Climax community – the stable phase of succession

Key Concepts

Succession is the sequence of biotic changes that regenerate a damaged community or create a community in a previously uninhabited area. Primary succession begins with bare rock, worn down and colonized by pioneer species. Secondary succession begins with established soil in which many different plants can grow. Pioneer species, such as mosses and lichens, can break down rock into smaller pieces. When they die, their remains mix with tiny pieces of rock to form a thin layer of soil. They change the ecosystem in ways that enable the support of more diverse species. Freshwater ecosystems can undergo succession to a terrestrial ecosystem as well by the gradual filling in through sedimentation and evaporation.

Example EOC question:

Which environmental disturbance would most likely result in lichens colonizing an area?

F the burning of a forest
G abandoning farm fields for many years
H the melting of a glacier that exposes rock
J clearing a meadow for new construction

Flow of Matter and Energy

SPI 3210.3.1 Interpret a diagram that illustrates energy flow in an ecosystem.

Key Vocabulary

biomass – the amount of biological matter in an ecosystem (usually expressed as grams per dry weight (g/dry weight)

Energy pyramid – An illustration depicting energy flow through an ecosystem at various trophic levels

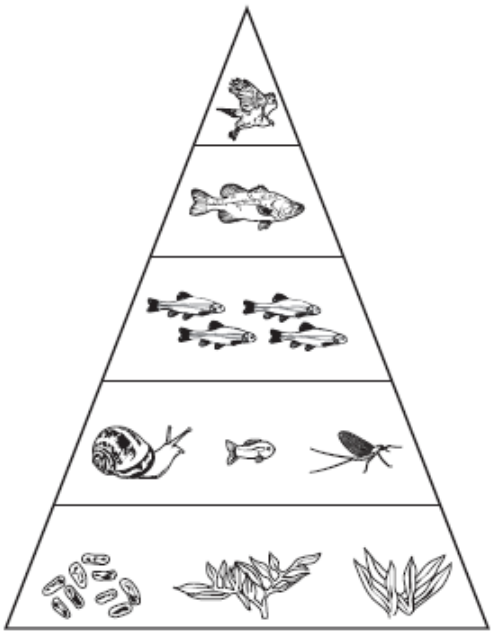
kilocalorie – the unit of energy on an energy pyramid

Key concepts

The main learning objective behind this standard is to understand a diagram that depicts energy flow in an ecosystem. Most commonly, these are a pyramid. They may be expressed as a pyramid of energy, which shows the amount of energy at each trophic level, a pyramid of numbers, which shows the number of organisms in a species at each trophic level, or a pyramid of biomass, which depicts the amount of biological mass at each trophic level in an ecosystem. It may be required that with a pyramid of energy, energy calculations be performed to determine what is available to each trophic level. This is to be done with the knowledge that approximately 90% of the energy at each trophic level is converted to unusable forms (namely heat), and that only around 10% is transferred to the next trophic level . This number is an approximate and has been known to occur even higher or lower depending on the organisms.

Example EOC question:

An energy pyramid is shown below.



As energy moves through the pyramid, the amount of available energy

A increases as the size of the organisms increases.
B doubles as it moves up each trophic level.
C remains the same as it is transferred to the next trophic level.
D decreases because it is released as heat into the environment.

SPI 3210.3.2 Distinguish between aerobic and anaerobic respiration.

Key Vocabulary

Adenosine triphosphate (ATP) –

Aerobic respiration –

Anaerobic respiration –

Fermentation –

glycolysis –

Kreb's cycle –

Lactic acid –

Key concepts

To understand this standard you need to know that aerobic respiration takes place in the presence of oxygen. When oxygen is too low or depleted, anaerobic respiration occurs. Aerobic respiration takes place in the mitochondrion, while anaerobic respiration takes place in the cytoplasm. You should also be able to distinguish the two by their energy yield. Aerobic respiration produces way more energy (ATP) than anaerobic respiration. The following table should help organize your thoughts on how to distinguish aerobic respiration from anaerobic respiration:

	Aerobic	**Anaerobic**
Oxygen requirement	Yes	No
Site of reactions (Location)	Mitochondrion	Cytoplasm
Stages:	Glycolysis, pyruvate oxidation, Krebs cycle	Glycolysis
Energy production (ATP)	38 mol ATP per 1 mol of glucose	2 mol ATP per 1 mol of glucose
Main function	Production of energy (ATP) from food (sugars, lipids, proteins)	Produce energy when oxygen is not available
How NADH recycled	Using the electron transport chain	Using lactic acid fermentation in muscle cells (makes lactate) or alcohol fermentation (converts pyruvate to CO_2 and ethanol)
Cells that use	Most	Yeast, some prokaryotes, muscle cells

Example EOC question:

***Clostridium botulinum* bacteria grow well in low-oxygen environments, including improperly canned foods. Which of these processes does *Clostridium botulinum* use to produce energy when in these low-oxygen environments?**

F aerobic respiration
G anaerobic respiration
H photosynthesis
J chemosynthesis

SPI 3210.3.3 Compare and contrast photosynthesis and cellular respiration in terms of energy transformation.

Key Vocabulary

Chemosynthesis –

Chlorophyll –

Grana –

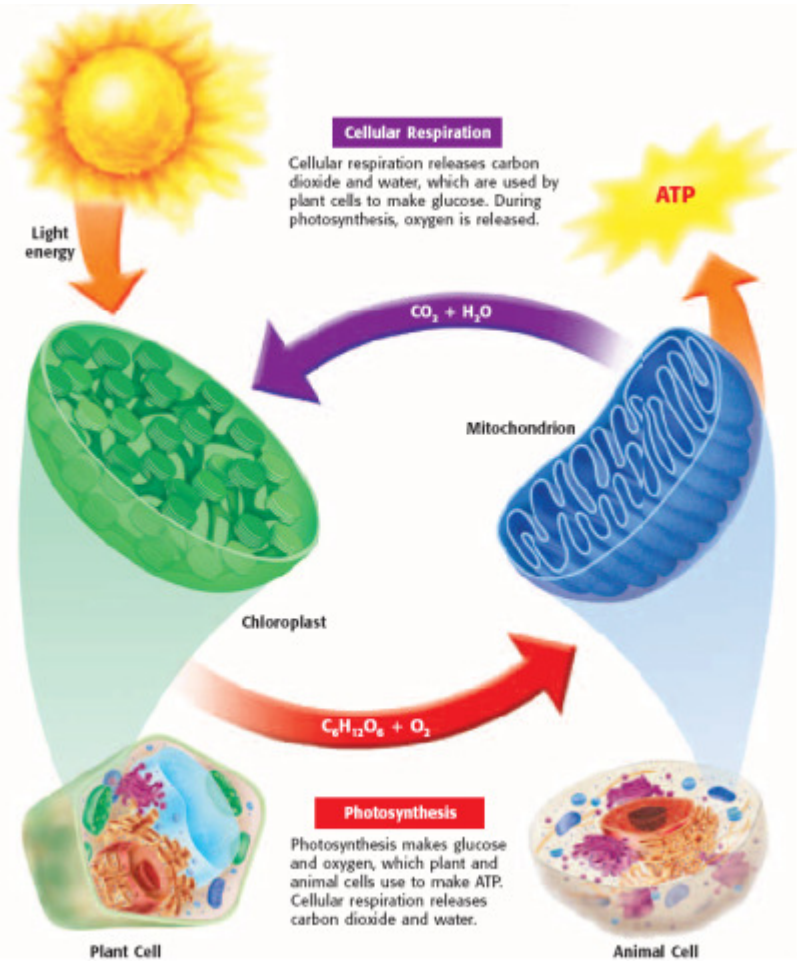
Photosynthesis –

Thylakoid –

Key concepts

You need to know the reactants and products of both cellular respiration and photosynthesis. This standard also asks you to focus on energy flow: energy from light (sun) transfers to the bonds stored in glucose. Cellular respiration then transforms the energy from glucose to a more useable form, adenosine triphosphate (ATP).

Standards at a Glance: Flow of Matter and Energy



Example EOC question:

Photosynthesis converts light energy to stored chemical energy. What form of chemical energy is used in cellular respiration?

A glucose
B oxygen
C chlorophyll
D carbon

SPI 3210.3.4 Predict how changes in a biogeochemical cycle can affect an ecosystem.

Key Vocabulary

Hydrologic cycle

Evaporation

Condensation

Transpiration

Runoff

Precipitation

Combustion

Photosynthesis

Respiration

Nitrogen fixation

Denitrification

Ammonification

Nitrification

Phosphate

Inorganic

Organic

Nitrate/nitrite

Ammonia

Biogeochemistry

Key concepts

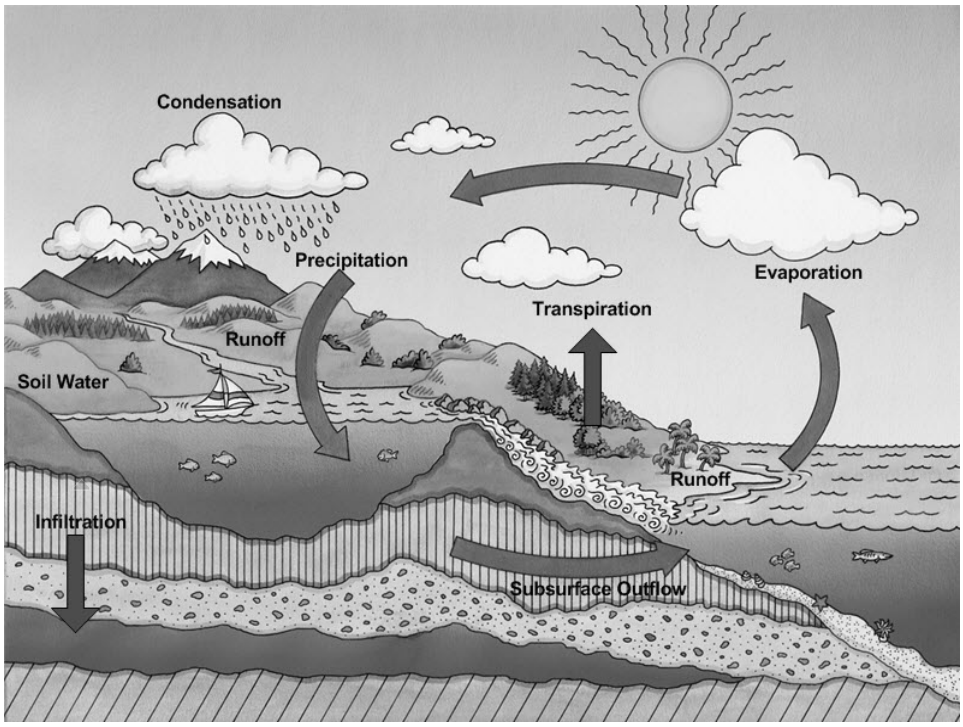
Earth has biogeochemical cycles, and most of them are heavily regulated by bacteria. Humans can have a negative impact on each of the biogeochemical cycles. The cycling of water between liquid and gaseous states is essential to all life.

Carbon is cycled from carbon dioxide to its organic state through photosynthesis. Respiration, decomposition and combustion (particularly from fossil fuels) then return that carbon back to the atmosphere.

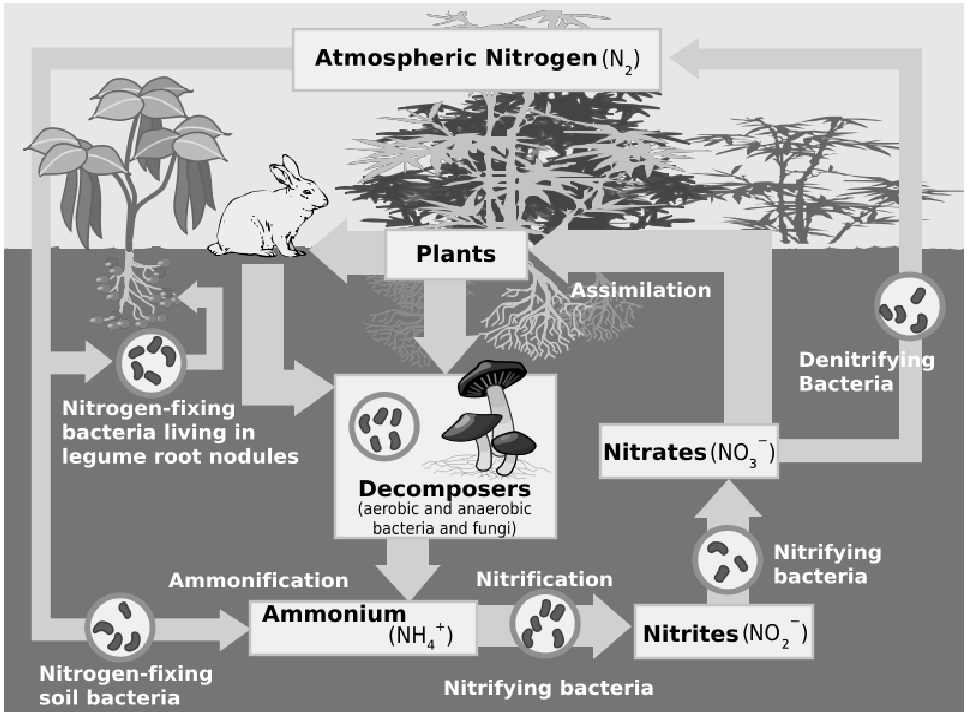
Nitrogen also cycles between the inorganic and organic state (assimilation). Nitrogen gas in our atmosphere is fixed for plants. Nitrogen works its way through the food web and becomes an integral part of life via amino acids, proteins, and DNA. When organisms die, decomposers take that nitrogen and cycle it back to the soil where it can be made available for plants again.

Phosphorous cycling is also important. Its primary source comes from the weathering of rock. In a similar way to nitrogen it cycles between its inorganic state (phosphate) to its organic state. Animal waste and decomposition by bacteria return it back to the ecosystem.

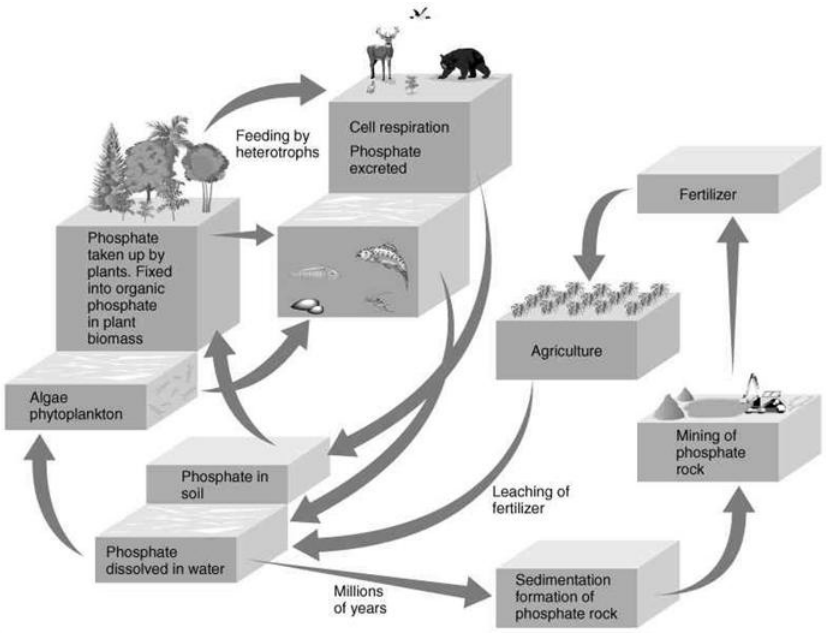
The Water Cycle



The Nitrogen Cycle

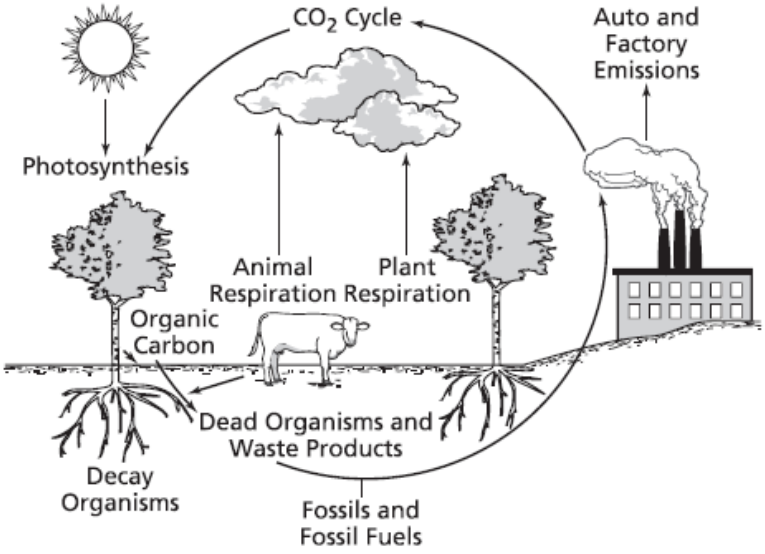


The Phosphorous Cycle



Example EOC question:

A diagram of the carbon cycle is shown below.



Which of these could cause the amount of carbon dioxide in the atmosphere to decrease?

F increased burning of fossil fuels
G increased numbers of decomposers
H increased numbers of producers
J increased respiration in animals

Heredity

SPI 3210.4.1 Identify the structure and function of DNA

Key Vocabulary

Nitrogen bases –

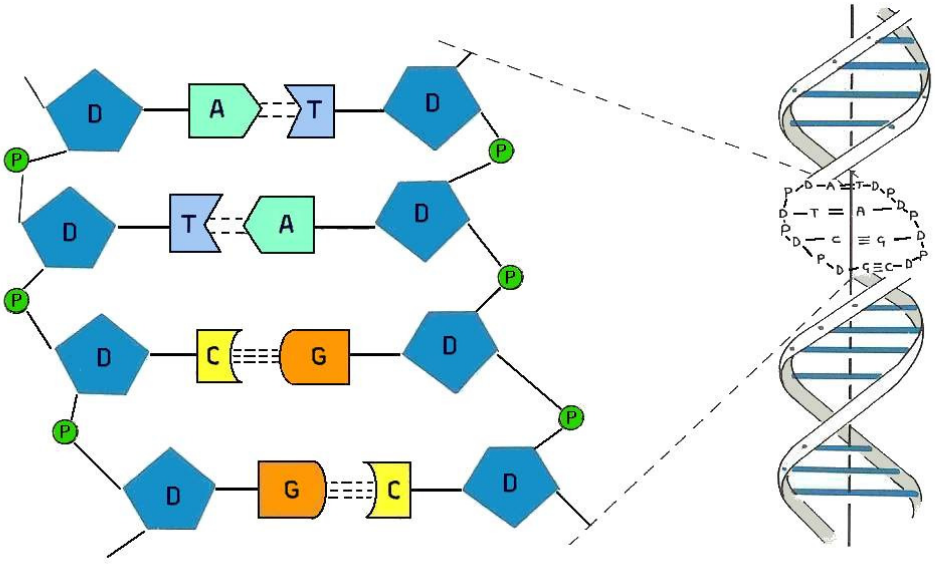
Deoxyribonucleic acid (DNA) –

Ribonucleic acid (RNA)–

Key concepts

DNA is made up of nucleotides. Recall that a nucleotide is a phosphate combined with a five-carbon sugar (deoxyribose for DNA; ribose for RNA) and a nitrogen base (adenine (A), thymine (T, uracil, U, for RNA), cytosine (C), guanine (G)). The nucleotides form long chains and connect together like a twisted ladder. Only certain bases can join together (A-T; C-G), which is why the two strands are said to be complementary. This is what we describe as the double helix. Notice in the diagram below how the nucleotide pairs are bonded together. Adenine and thymine have a double hydrogen bond whereas cytosine and guanine have a triple hydrogen bond. Both are easily formed and broken when it comes time to replicate the DNA

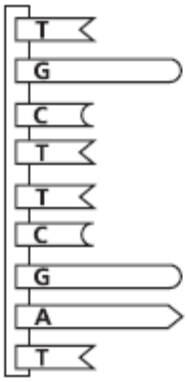
.



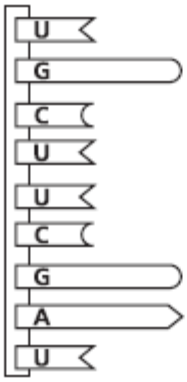
Example EOC question:

Which diagram best represents a segment of a normal DNA molecule?

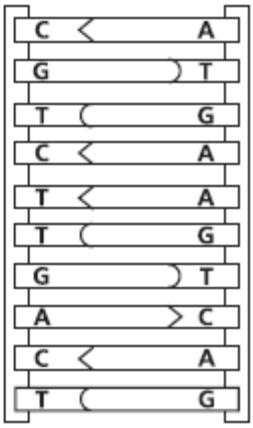
A



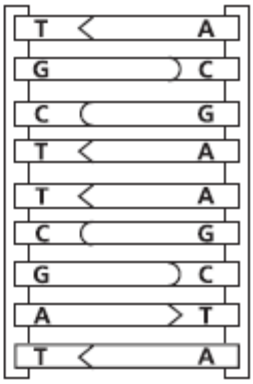
B



C



D



SPI 3210.4.2 Associate the process of DNA replication with its biological significance

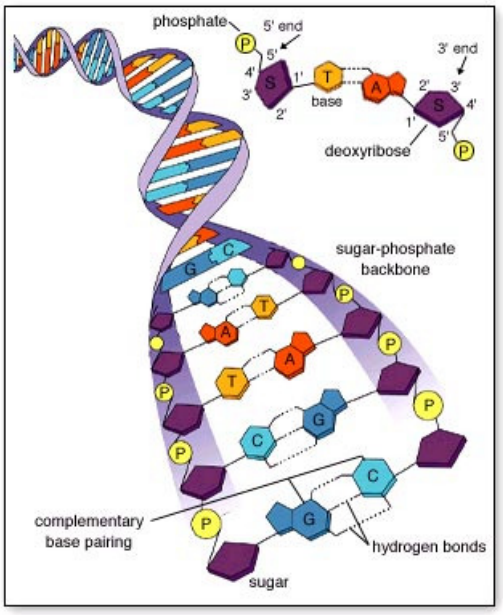
Key Vocabulary

DNA replication –

DNA polymerase –

Key concepts

When a cell divides through mitosis, the resulting daughter cells have identical copies of the original DNA. Each cell that has replicated comes from its parent cell. The copying of this DNA takes place during interphase (the *S* stage of the cell cycle). During this DNA replication, the complementary strands of DNA are "unzipped" with an enzyme by breaking weak hydrogen bonds between the nitrogen bases. Each strand then has the code to re-form a new complementary strand, thus making two complete copies. An enzyme called DNA polymerase assists the creation of complementary strands. The biological significance is that this process allows genetic information to be copied when new cells are created.



Example EOC question:

The main purpose of DNA replication is to

F capture sunlight.
G store energy.
H synthesize proteins.
J copy genetic information.

SPI 3210.4.3 Recognize the interactions between DNA and RNA during protein synthesis

Key Vocabulary

Transcription –

Translation –

Amino acid –

Messenger RNA (mRNA) –

Transfer RNA (tRNA) –

Ribosomal RNA (rRNA) –

Codon –

Key concepts

DNA is a macromolecule that directs the assembly of proteins that carry out and regulate activities of the cell (recall that almost all enzymes are proteins too), so the information in DNA is used to make proteins. These proteins can determine traits such as hair color and eye shape. Proteins are chains of amino acids. All proteins are made of 20 different amino acids. The combination and arrangement of the amino acids determine a protein's structure and therefore function.

Transcription

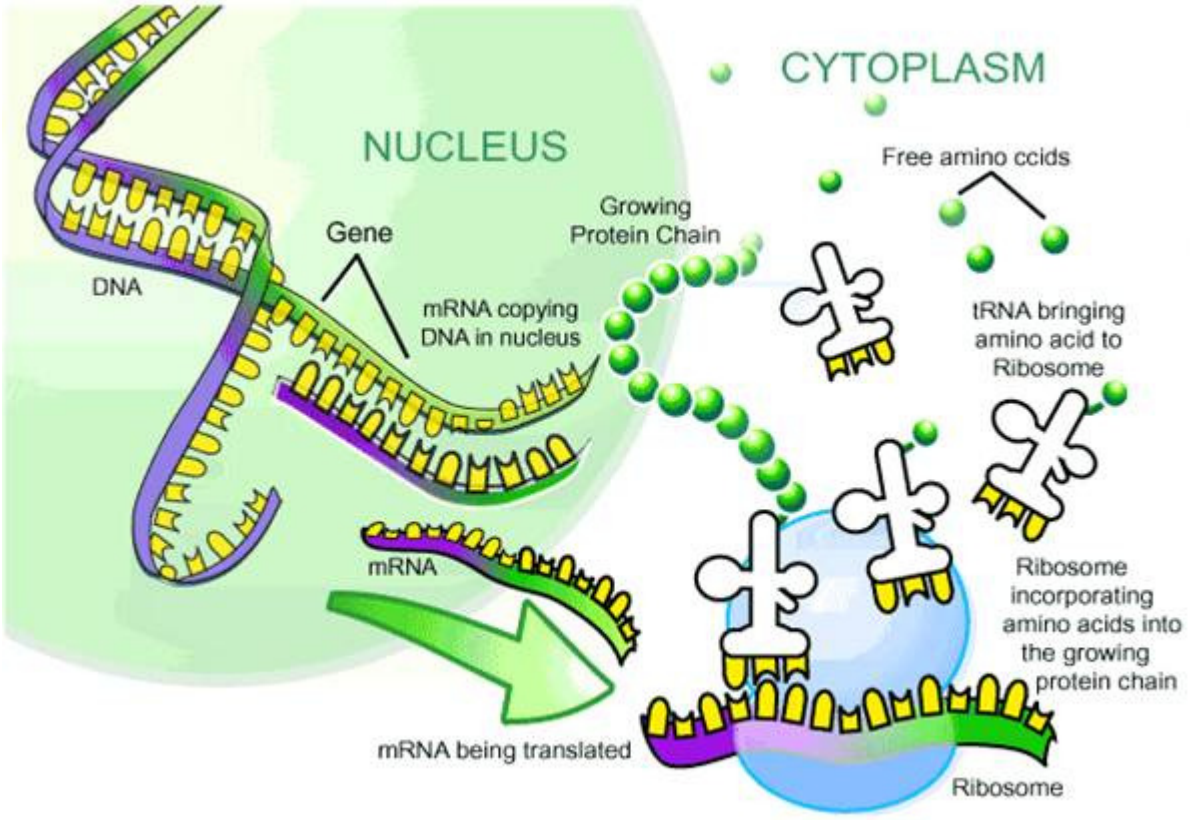
The instructions in DNA are contained in the sequence of nitrogen bases. Nucleotides are arranged in groups of three, or triplets. There are 64 possible codes from the four bases arranged as triplets. The instructions for making a protein are passed from the DNA to a complementary strand of RNA (ribonucleic acid). RNA is not a double strand, but simply one strand (also Thymine gets substituted for Uracil, U). DNA is copied to RNA similar to DNA replication. Remember that proteins are made with the ribosomes. The transcribed DNA on to the RNA is called messenger RNA (mRNA) because it acts like a messenger by carrying the DNA's instructions. The mRNA is made as sequences of three nucleotide sequences called codons. Each codon either codes for a particular amino acid, or marks the beginning or end of a protein. The chart below shows all 64 codons. To use the chart, find each letter along the designated side. Consider UUC. Find the first U under first base, the second U under second base, and the C under the third base. The amino acid coded for by UUC is phenylalanine.

Table of mRNA codons

First Base	Second Base U	Second Base C	Second Base A	Second Base G	Third Base
U	phenylalanine	serine	tyrosine	cysteine	U
	phenylalanine	serine	tyrosine	cysteine	C
	leucine	serine	STOP	STOP	A
	leucine	serine	STOP	tryptophan	G
C	leucine	proline	histidine	arginine	U
	leucine	proline	histidine	arginine	C
	leucine	proline	glutamine	arginine	A
	leucine	proline	glutamine	arginine	G
A	isoleucine	threonine	asparagine	serine	U
	isoleucine	threonine	asparagine	serine	C
	isoleucine	threonine	lysine	arginine	A
	START methionine	threonine	lysine	arginine	G
G	valine	alanine	aspartate	glycine	U
	valine	alanine	aspartate	glycine	C
	valine	alanine	glutamate	glycine	A
	valine	alanine	glutamate	glycine	G

Translation

After the mRNA carries the information to the cytoplasm, translation begins. During translation, the information is decoded to arrange amino acids into proteins. We learned that proteins are made by the ribosomes. What really happens is that another type of RNA will transfer the amino acids to the ribosomes. We call this RNA transfer RNA or tRNA. A third type of RNA on the ribosomes will continue to assemble the proteins. This is called ribosomal RNA or rRNA. This whole process is called protein synthesis.



Example EOC question:

Which sequence depicts the correct order of protein synthesis within a cell?

A DNA ⟶ mRNA ⟶ amino acids ⟶ proteins

B DNA ⟶ amino acids ⟶ mRNA ⟶ proteins

C DNA ⟶ mRNA ⟶ proteins ⟶ amino acids

D DNA ⟶ proteins ⟶ amino acids ⟶ mRNA

SPI 3210.4.4 Determine the probability of a particular trait in an offspring based on the genotype of the parents and the particular mode of inheritance.

Key Vocabulary

codominance –

incomplete dominance –

alleles –

dominant –

recessive –

heterozygous –

homozygous –

genotype –

phenotype –

law of independent assortment –

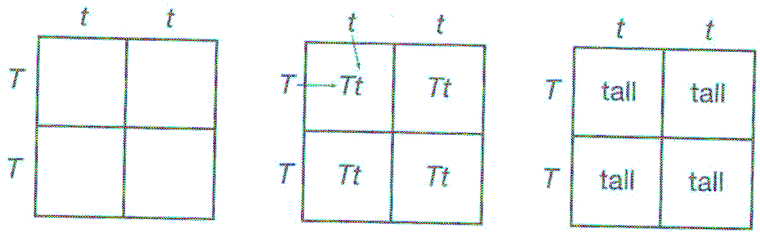
monohybrid/dihybrid cross –

Key concepts

Genes received from parents determine how cells grow and develop. All the genes that are passed on are called its genotype. The traits that an organism expresses or shows because of the genotype is called its phenotype. Recall that genes are on chromosomes. Genes that determine a certain trait are in matching locations on homologous chromosomes. Many traits can control a specific gene. Alternate forms of the same gene are called alleles. Alleles can be dominant or recessive for a particular trait. A dominant allele is the one that is expressed when it is present. For a recessive allele to be expressed, an organism has to inherit two copies of recessive alleles.

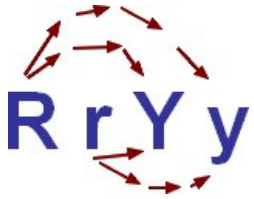
A genotype is written as two letter (one from each parent). Capital letters are used for dominant alleles, and lower case letters are used for recessive alleles. There are three possible genotypes: homozygous dominant (*FF*), heterozygous (*Ff*), and homozygous recessive (*ff*). If at least on dominant allele is inherited (*F*), then the dominant phenotype is expressed.

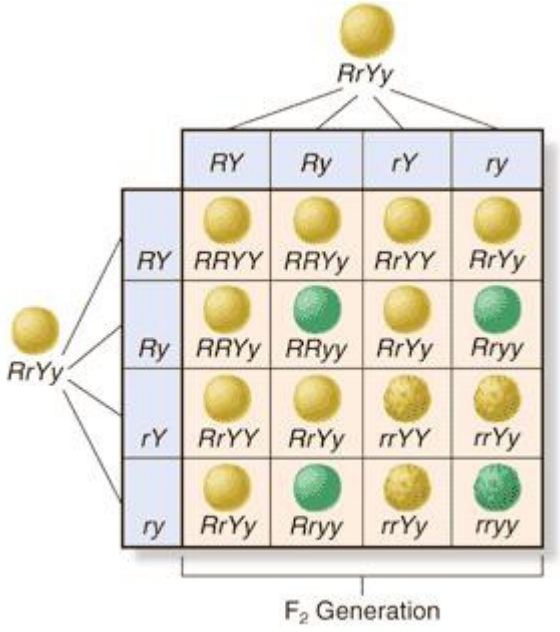
A Punnett square is a tool used to predict the results of a genetic cross. A cross is a mating of two parent organisms. You can use a Punnett square to determine the probability of genotypes and phenotypes in offspring. To make a Punnett square, first separate the parent alleles, each on one side of the square (outside left, and top - it doesn't matter which). Notice, however, that the dominant allele, *T*, is always written first. Look at the example below that test for the phenotype of tall (*TT*, *Tt*) or short (*tt*).



The cross above takes two parents, one homozygous dominant (*TT*; tall) and the other homozygous recessive (*tt*, short), written as *TT x tt*. What is the probability that the offspring will be short? The answer to the question is 0% because none of the offspring yield a *tt* combination. All of the possible genotypes will result in the heterozygous genotype, or *Tt* and show the dominant phenotype, tall.

Because many times genes are linked or inherited together, it may be beneficial to cross two traits in a dihybrid cross. Consider a pea plant that has yellow (*Y*) and green (*y*) seeds and round (*R*) or wrinkled (*r*) seeds. The trait for color and shape are linked together. Consider crossing two parents that are heterozygous for both traits (*RrYy*), you must write out all the possible gene combinations:





The resulting phenotypic ration is 9:3:3:1 or 9 yellow and round, 3 yellow and wrinkled, 3 green and round, and 1 green and wrinkled.

Example EOC question:

In Bengal tigers, the allele for an orange coat is dominant to the allele for a white coat. If a homozygous recessive tiger is crossed with a tiger heterozygous for coat color, what is the percent probability that one of the offspring will be orange?

F 0%
G 25%
H 50%
J 75%

SPI 3210.4.5 Apply pedigree date to determine various modes of genetic inheritance.

Key Vocabulary

Pedigree –

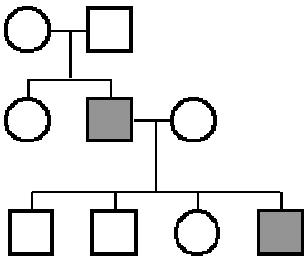
polygenic inheritance –

sex linkage –

autosomal dominant/recessive -

Key concepts

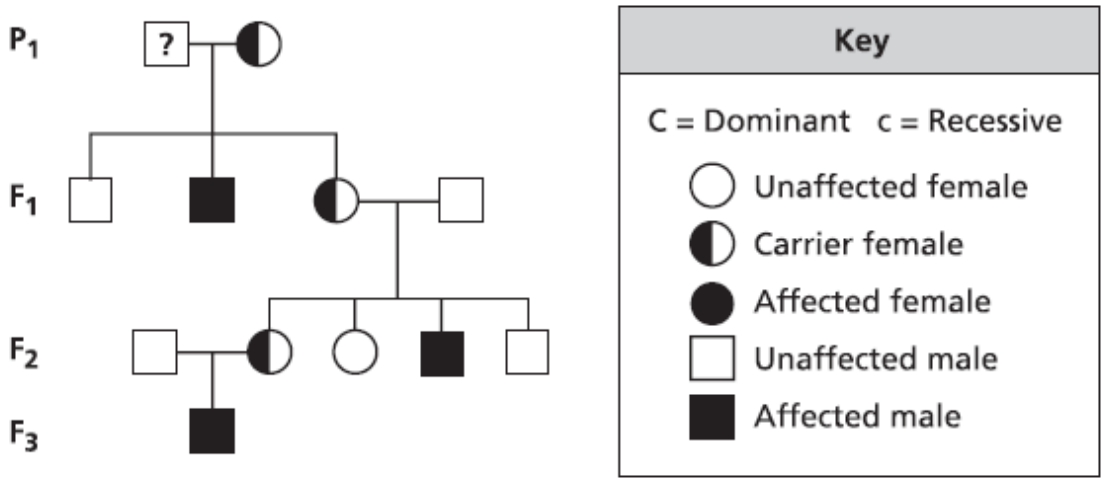
From http://faculty.clintoncc.suny.edu/faculty/Michael.Gregory/files/Bio%20101/Bio%20101%20Laboratory/Pedigree%20Analysis/PEDIGREE.HTM : A pedigree is a diagram of family relationships that uses symbols to represent people and lines to represent genetic relationships. These diagrams make it easier to visualize relationships within families, particularly large extended families. Pedigrees are often used to determine the mode of inheritance (dominant, recessive, etc.) of genetic diseases. A sample pedigree is below.



In a pedigree, squares represent males and circles represent females. Horizontal lines connecting a male and female represent mating. Vertical lines extending downward from a couple represent their children. Subsequent generations are therefore written underneath the parental generations and the oldest individuals are found at the top of the pedigree. If the purpose of a pedigree is to analyze the pattern of inheritance of a particular trait, it is customary to shade in the symbol of all individuals that possess this trait, or to shade half to indicate that the person is a carrier of the trait. In the exercises below, assume that the trait in question is a genetic disease or abnormality. You should know patterns of inheritance that have the following modes: autosomal dominant, autosomal recessive, X-linked recessive.

Example EOC question:

The inheritance of a trait is shown in the pedigree below.



Based on the pedigree, what is the genotype of the male in the P_1 generation?

A X^CY^c
B X^cY^c
C X^CY
D X^cY

SPI 3210.4.6 Describe how meiosis is involved in the production of egg and sperm cells

Key Vocabulary

Meiosis –

Gametes –

Somatic cells –

Zygote –

Homologous chromosomes –

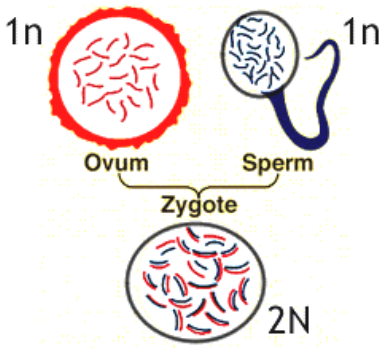
Haploid (n) –

Diploid (2n) –

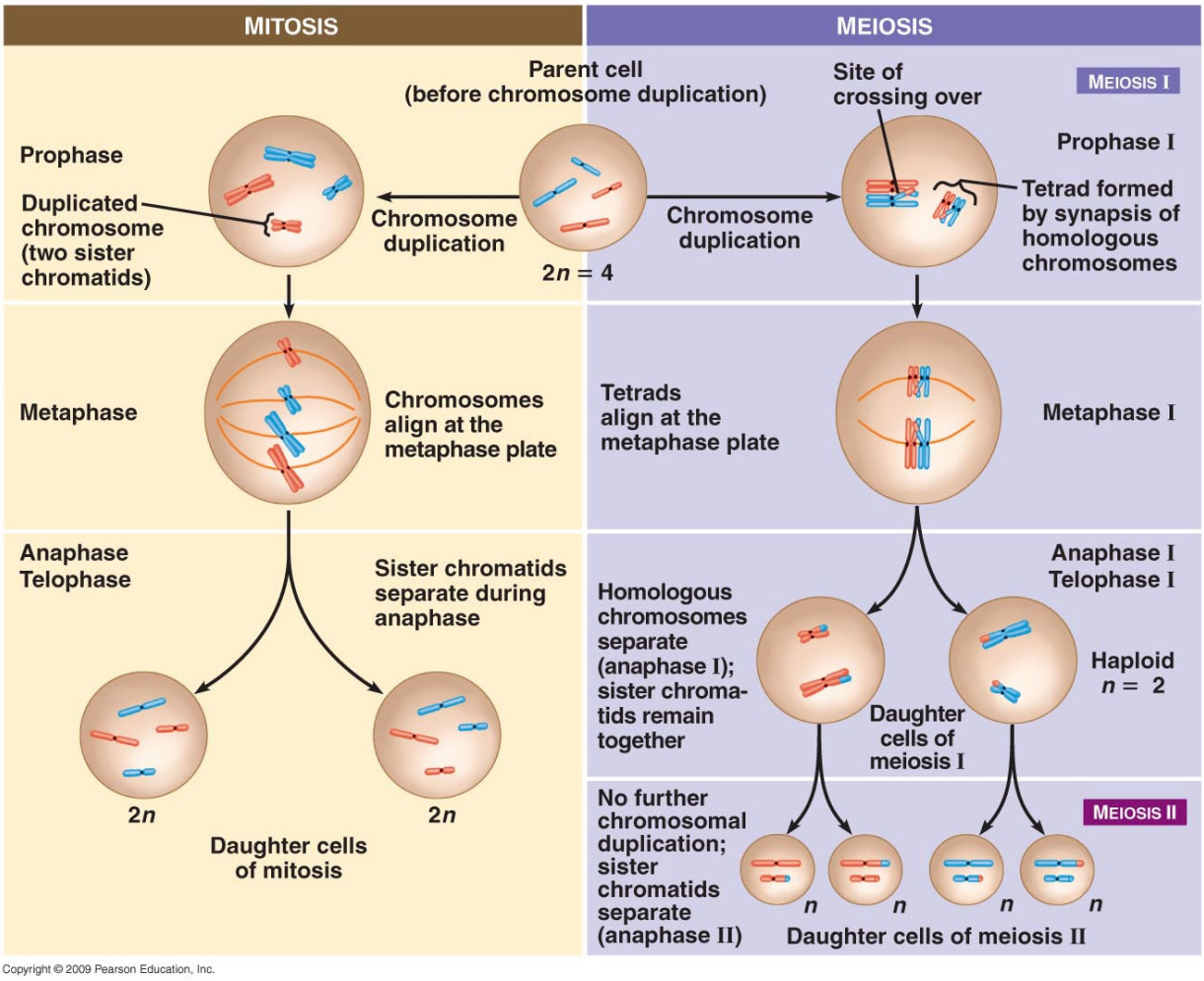
Key concepts

While mitosis is the cellular division of somatic cells (body cells), meiosis is the cellular division of sex cells (gametes, or sperm and eggs). The steps of meiosis are similar to mitosis but there are important differences. Mitosis results in two genetically identical cells, while meiosis results in four genetically different cells. The results of meiosis are two nuclear divisions (called meiosis I and meiosis II) that result in half of the number of chromosomes (haploid, n).

Each human gamete contains 23 chromosomes. Other organisms have varying numbers of chromosomes, so we use a variable, n, to describe in general the haploid number of chromosomes. Remember that n is the haploid, or half of the chromosomes, of the organisms' somatic cells (which are diploid or 2n). When two haploid gametes fuse (called fertilization), a zygote is formed.



Standards at a glance: Heredity



Example EOC question:

Which statement best explains the role of meiosis in the production of sex cells?

F to produce cells with half the DNA of the original cell

G to produce cells that are genetically identical to each other

H to combine the DNA of two identical cells

J to combine the DNA of two different cells

SPI 3210.4.7 Describe how meiosis and sexual reproduction contributes to genetic variation in a population.

Key Vocabulary

Independent assortment -

Sexual reproduction –

Asexual reproduction –

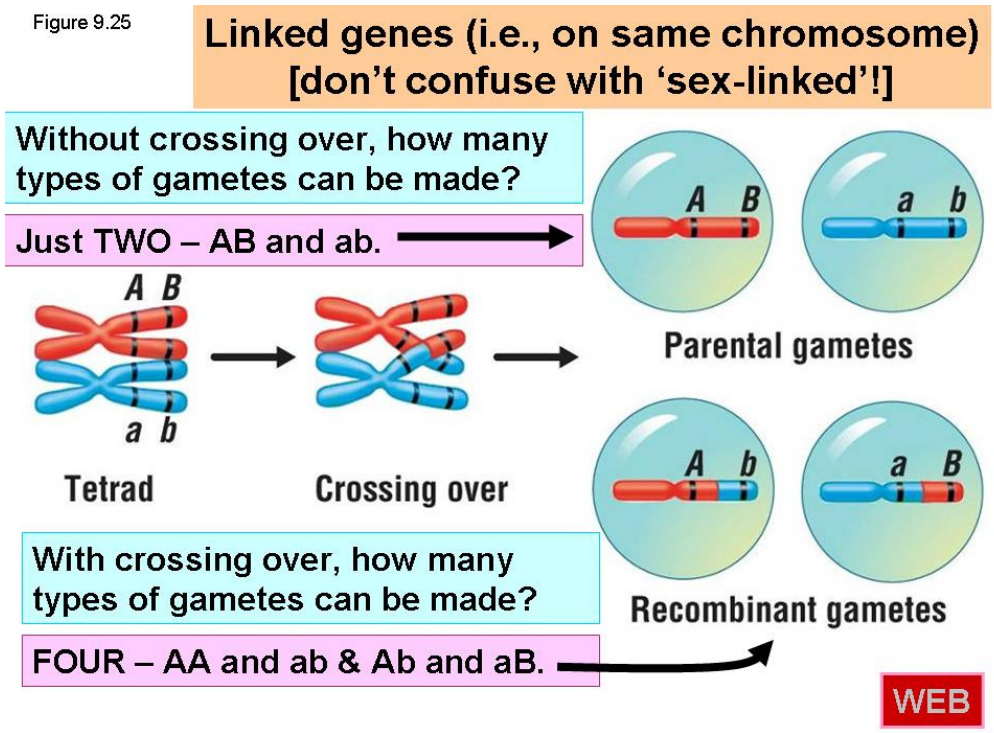
Crossing-over -

Nondisjunction -

Key concepts

Meiosis explains the great diversity among organisms. Diversity, or variability, is the amount of difference among members of a population or species. Organisms show different traits or characteristics because of how meiosis and sexual reproduction works. Meiosis results in the production of four different gametes, so each organism (even from the same two parents) will receive different combinations of alleles (genes).

In prophase I, homologous chromosomes pair up in a process called synapsis. During prophase I crossing-over occurs. Chromosome segments are broken off and exchanged between homologous chromosomes. This will also lead to additional genetic variation.



Example EOC question:

Which best explains how meiosis is a contributing factor to genetic variation within a species?

A Meiosis reduces the number of mutations within an organism.

B Meiosis produces daughter cells that will contain identical chromosomes.

C Meiosis results in offspring that contain alleles from only one parent gamete.

D Meiosis allows for crossing over of chromosomes, resulting in new gene combinations.

SPI 3210.4.8 Determine the relationship between mutations and human genetic disorders.

Key Vocabulary

Point mutation –

Frameshift mutation –

Insertion –

Deletion –

Translocation –

Duplication –

Karyotype -

Nondisjunction –

Polyploidy –

Down syndrome –

Turner syndrome –

Klinefelter syndrome –

Cystic fibrosis –

Muscular dystrophy –

Sickle cell anemia –

Hemophilia –

Color blindness –

Tay-Sachs disease -

Phenylketonuria –

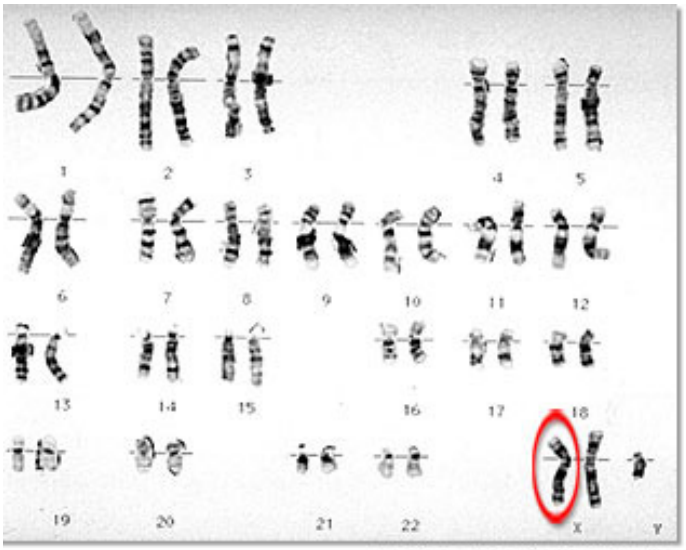
Polydactyly –

Huntington's Disease -

Key concepts

You learned that chromosomes are long strands of condensed DNA wrapped around proteins (histones). Recall that genes have a specific location (locus) on the chromosomes. If anything happens to the structure of the inherited chromosomes, either in meiosis or other parts of the cell cycle (interphase), we call this alteration a mutation. Mutations come in several varieties and there are many genetic abnormalities or conditions that result. As the alteration replicates during mitosis, or if it is a gamete during fertilization, then the copy is replicated.

Mutations occur for a variety of reasons, sometimes a spontaneous error takes place during replication, while others result from environmental factors (ultraviolet radiation). Still, other mutations are performed deliberately in the laboratory (gene insertion from one organism to another). What you should be able to is to identify a particular type of mutation (from above) both conceptually and perhaps from a karyotype. The picture below shows a karyotype of a human with Klinefelter's syndrome (XXY). You can tell this by the extra X chromosome.



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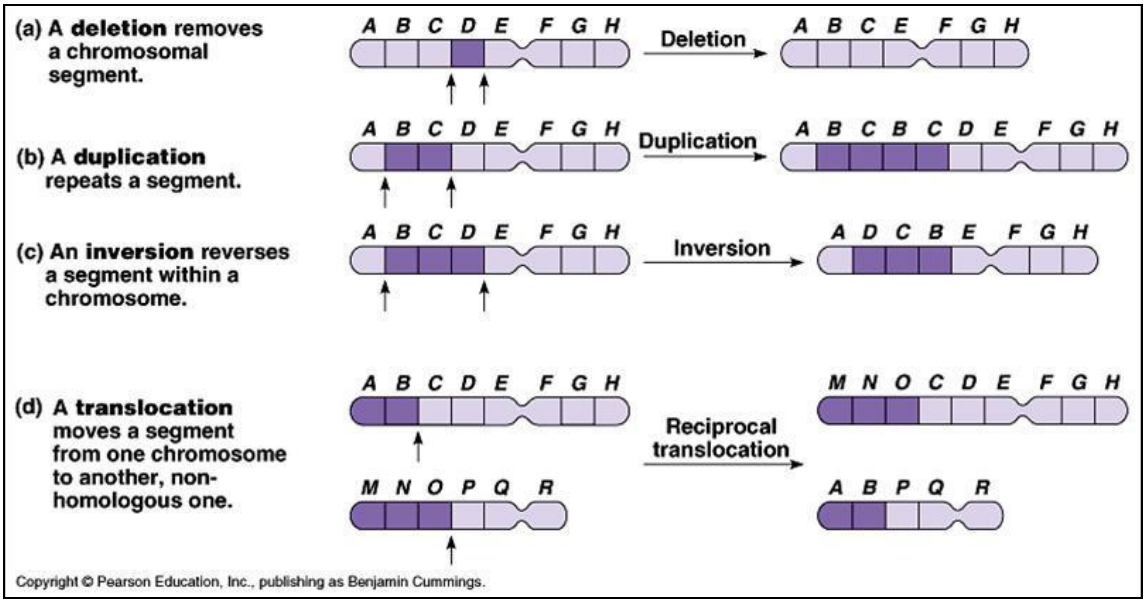


Example EOC question:

Down syndrome (Trisomy 21) and Klinefelter's syndrome (XXY) are both a result of an extra chromosome due to which type of mutation?

F deletion
G frameshift
H insertion
J nondisjunction

SPI 3210.4.9 Evaluate the scientific and ethical issues associated with gene technologies: genetic engineering, cloning, transgenic organism production, stem cell research, and DNA fingerprinting.

Key Vocabulary

Stem cells –

Differentiation –

Genetic engineering –

Transgenic organisms –

DNA fingerprinting –

Cloning –

Gene Therapy –

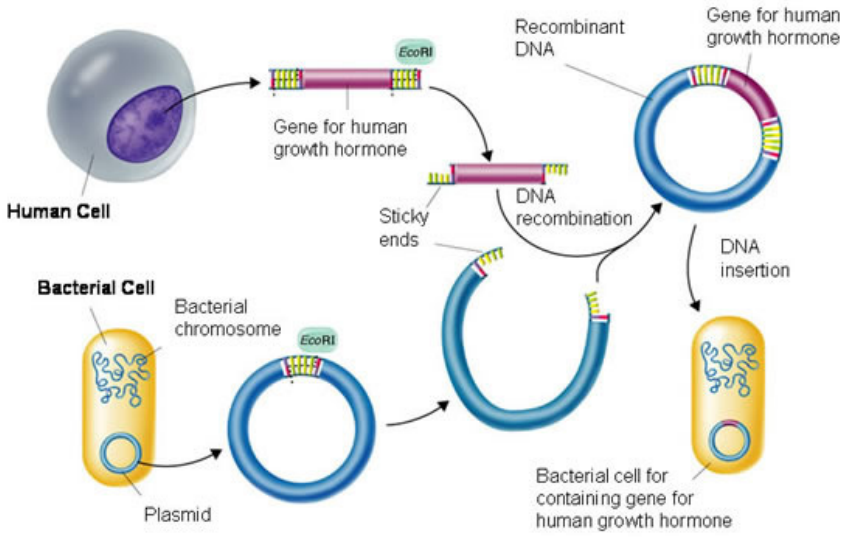
Recombinant DNA –

Plasmid –

Key concepts

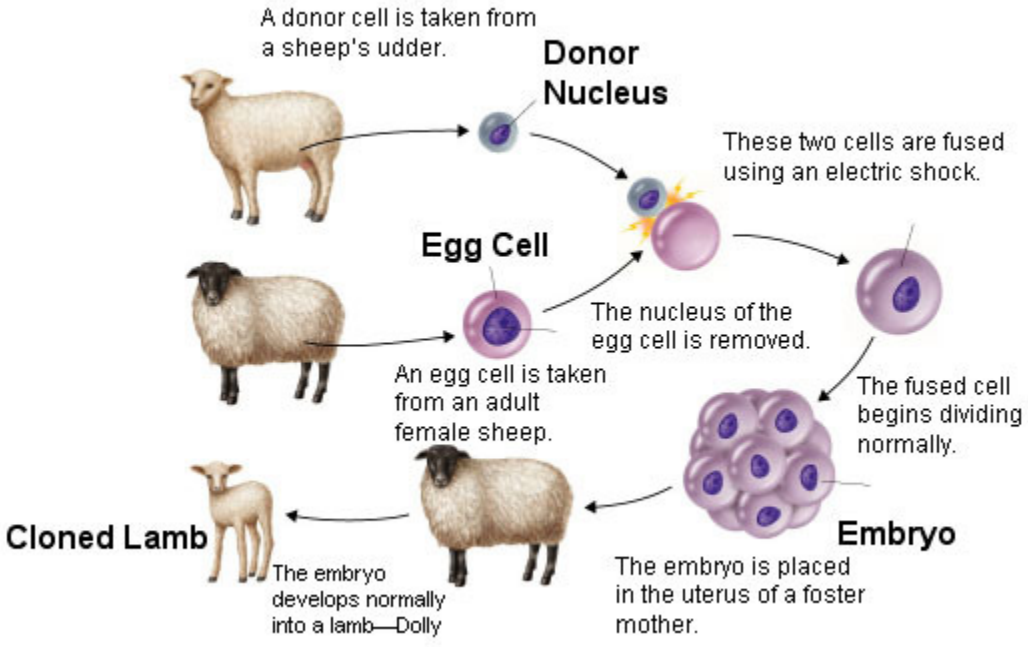
There are ethical considerations with our advancements in biotechnology. In 2007, after much advancement in cloning technology, Congress passed the Human Cloning Prohibition Act. This was a critical step in assigning ethic considerations to biological processes. Similarly, the European Union has blocked all importation of genetically modified crops from the United States, mainly due to the lack of information of long-term effects, and the introduction of mutant species to natural ecosystems impacting biodiversity.

Starting in the 1980's, scientists have been using genetic engineering (modifying an organism's genes) to make organisms with desired traits, such as disease resistance. One of the early examples was the insertion of a Bt gene in corn, which produces a natural pesticide against the corn borer (a pest), but environmentalists worry that it might impact desirable insects as well. The resulting DNA or is called recombinant DNA (think re-combined) and has formed a mutant organism. Recombinant DNA can also be used to make medicine. Scientists can take a section of DNA, which may code for the production of certain protein and insert it into bacterial DNA for example (called a plasmid). Then the bacterial cell will produce the desired protein.



Cloning

Cloning produces an identical offspring by removing the nucleus from an egg cell (haploid) and replacing it with a nucleus from a somatic cell (diploid). After nuclear insertion, mitosis occurs to have the new organism grow and develop naturally. There are a number of reasons to clone, perhaps to increase the population of animals on the endangered species list, however ethical considerations need to be made. Human cloning is illegal in most countries.

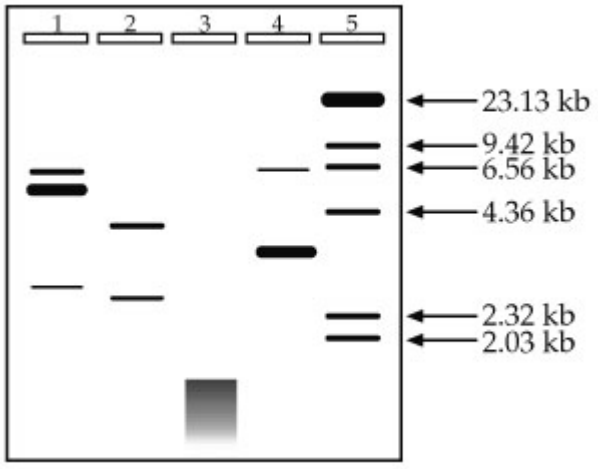


Stem Cell Research

A single zygote will eventually divide to form billions of different cells (called differentiation). Scientists can collect these cells and use them for various research activities. For example, stem cells may be used to investigate regeneration capabilities, or perhaps even grow organs instead of patients waiting for donors. On the other hand, while many stem cells can be harvested from placentas, umbilical cords, and even bone marrow, they are also taken from embryos. The last example can be objectionable to some people because of the sensitivity regarding human life.

DNA Fingerprinting

No two people's fingerprints are the same. Similarly, with the exception of identical twins, no two people have the same DNA. This technology has led to DNA fingerprinting. One process used to fingerprint DNA is called gel electrophoresis where a small electrical current will separate DNA bands out according to their size (lightest ones move the furthest). We can compare the separation pattern of an unknown against other individuals and see if there is a match.



Example EOC question:

What is the main ethical argument against the use of transgenic organisms, which have DNA from another organism?

A Transgenic organisms may cause unknown reactions in an ecosystem.

B Transgenic organisms may eliminate certain harmful diseases.

C Transgenic organisms may increase food production in many crops.

D Transgenic organisms may prevent harmful mutations.

Biodiversity and Change

SPI 3210.5.1 Compare and contrast the structural, functional, and behavioral adaptations of animals or plants found in different environments.

Key Vocabulary

Adaptation –

Behavioral adaptation –

Structural adaptation –

Coevolution –

Functional adaptation –

Key concepts

Any structure or behavior that leads to an organism's increased chance of survival in an environment is known as an **adaptation**. Realize that an adaptation may be favorable in one environment, but unfavorable in another (for example, white fur in the tundra, but not in a tropical rainforest). A **structural adaptation** is related to its form, or structure. A **functional adaptation** is related to the way a part works. A **behavioral adaptation** is something that an animal does that helps it survive.

Consider some structural adaptations of desert plants: wide spreading roots that are shallow to absorb as much rainfall as possible; Long deep roots to access water stored deep underground; spines that ward off herbivores; wax coatings on leaves to reduce water loss; thick stems and leaves to store water.

Now consider some functional adaptations of desert plants: the ability of stems to photosynthesize; flowers can open at night instead of day to prevent water loss; slower growth rates to reduce the need for food from photosynthesis (which also requires water); seeds can lie dormant for long periods of time and then germinate after a storm.

The following list of adaptations for animals:

Specialized to the cold environment: structural adaptations (blubber, pads on feet); behavioral adaptations (hibernation, migration; food gathering and storage)

Specialized to the dry climate: large ears (radiators), long legs (get them off the hot ground) , nocturnal, water storage abilities, etc.

Now think about some other environments and adaptations required to live there: high altitudes, deep water, tropical rainforest, fast moving rivers, etc.

Coevolution is a process where two closely related animals (think symbiosis) evolve together in response to changes in the other. An example might be plants and pollinators.

Example EOC question:

Walruses, found in the Arctic regions, have a six-inch layer of body fat. River otters, found in rivers in parts of the United States and Canada, have a thick undercoat and an outer coat of coarse guard hairs. These structures most likely help the walrus and the otter

F stay warm.

G transfer energy to offspring.

H move through their environment.

J resist infection.

SPI 3210.5.2 Recognize the relationship between form and function in living things.

Key Vocabulary

evolution -

homologous structure -

vertebrate -

analogous structure -

vestigial structure -

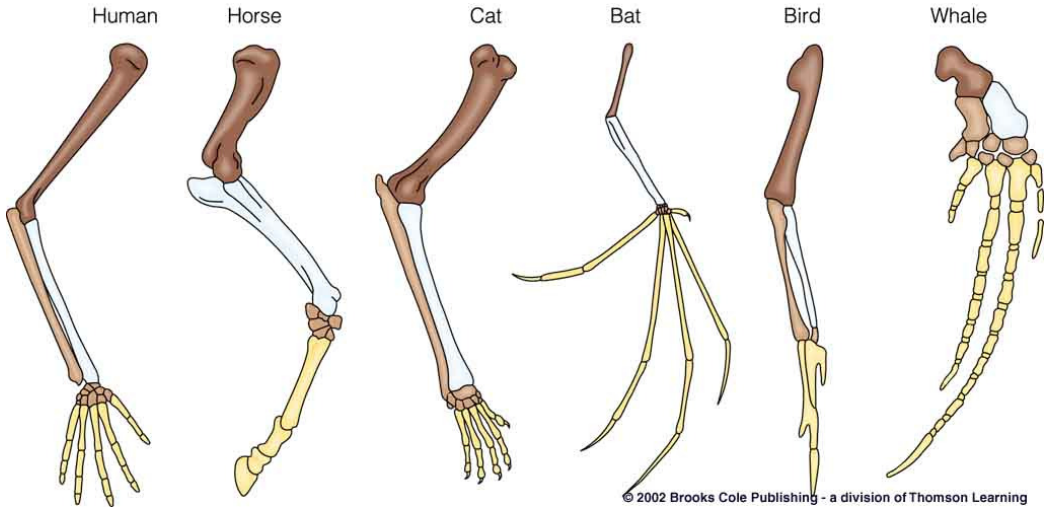
embryology -

Key concepts

The process by which species change is called evolution. The study of the form and function of body parts helps us understand the processes of evolution and the relationships among organisms.

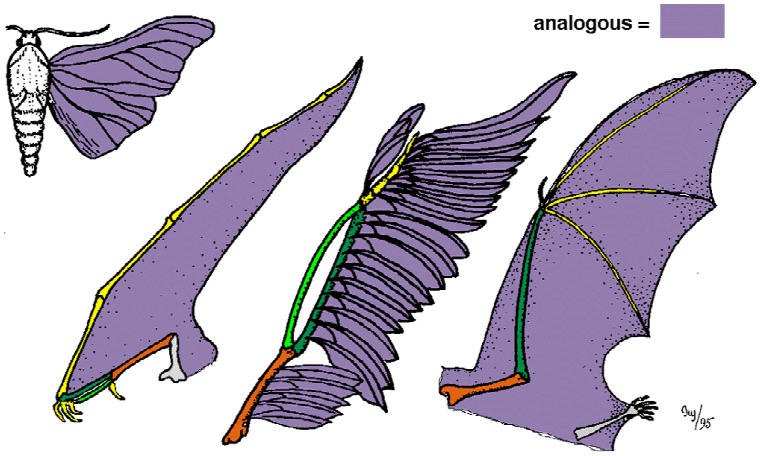
Comparative Anatomy Often times we compare similar anatomical structures between organisms. For example, organisms that have feathers, although very different (ostrich and a sparrow) come from a common ancestor. Similarly, a dog and a cat are more closely related because they both have fur. Scientists study anatomical structures to discover how organisms are related and from which ancestors they evolved. Now consider the bat. It has wings but no feathers, it is covered in fur. So where do scientists believe the ancestor to be? A study of homologous, analogous, and vestigial structures will provide us a closer look.

Homologous Structures Many organisms possess similar structures that have different functions. These are homologous structures, and they can reveal evolutionary relationships among organisms.



The basic form is similar, but the function is very different. Even though their functions are currently different, the similar structure suggests a common ancestor for all the animals in the picture above. that ancestor was a vertebrate, an animal with a backbone. This is why all the animals shown are in the same phylum: Vertebrata.

Analogous Structures Some body parts have different structures with the same function. These are called analogous structures.



Analogous structures, unlike homologous structures do not indicate a common ancestry. For example, birds and moths both have wings for flight, but they are very different with a different evolutionary history. Birds are vertebrates, and moths are insects.

Vestigial Structures Vestigial structures are body parts that do not seem to play a role in the body. Rats have an appendix that aids in digestion. Humans have an appendix that has no apparent function (no need for survival). Ostriches have wings that are incapable of flight. Another example would be the pelvis and hind leg found inside whales

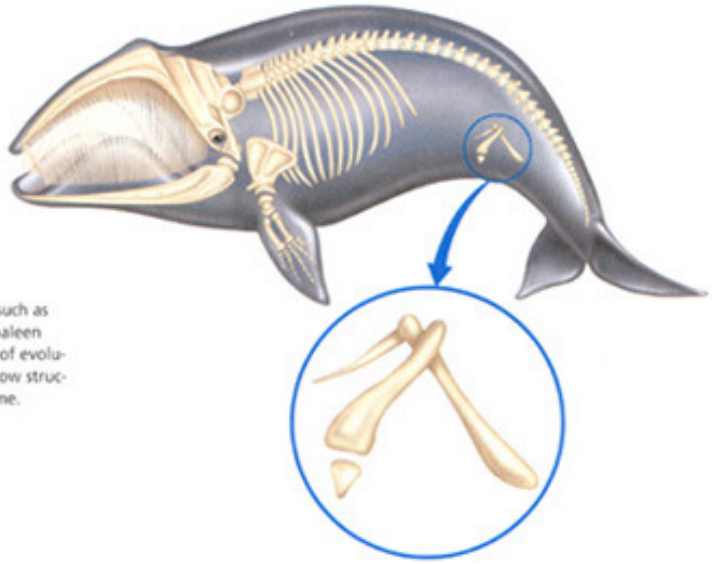
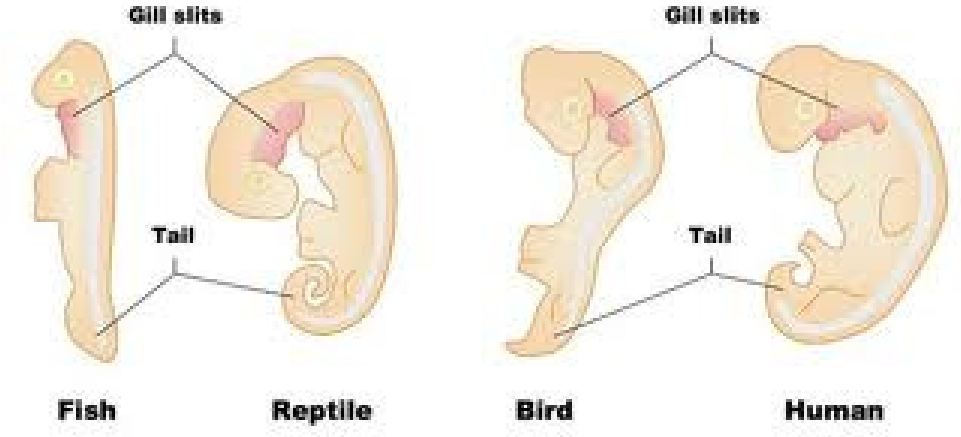


Figure 15.8
Vestigial structures, such as pelvic bones in the baleen whale, are evidence of evolution because they show structural change over time.

Embryology The structure of embryos during development provides clues to their evolutionary history. Often times, many embryos have structures that are not present after an organism is born.



All of the vertebrate organisms have gill pouches and tails. For some organisms these parts vanish and others they continue to develop. Also there are chemical similarities such as codes for sequencing amino acids. The more they have in common, the more similar they are.

Example EOC question:

A certain species of lynx that lives in arctic regions has very large and furry paws. Which best explains how these paws help the lynx adapt to its habitat?

A increase the lynx's ability to catch prey
B provide camouflage for the lynx
C help the lynx attract a mate
D help the lynx maintain body temperature

SPI 3210.5.3 Recognize the relationships among environmental change, genetic variation, natural selection, and the emergence of a new species.

Key Vocabulary

species -

speciation -

natural selection -

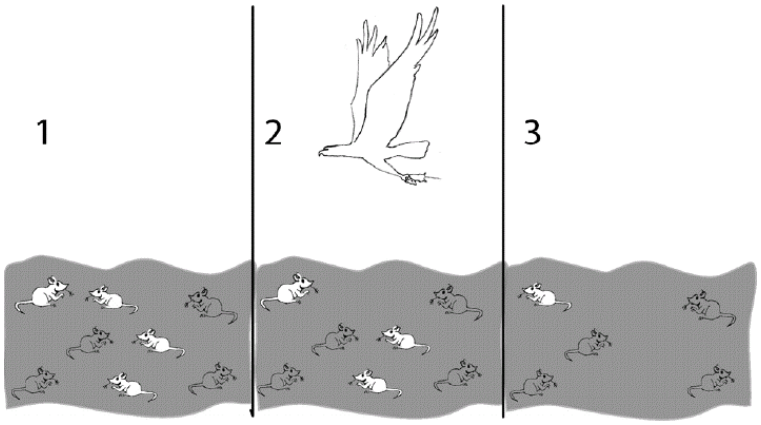
population -

extinct -

Key concepts

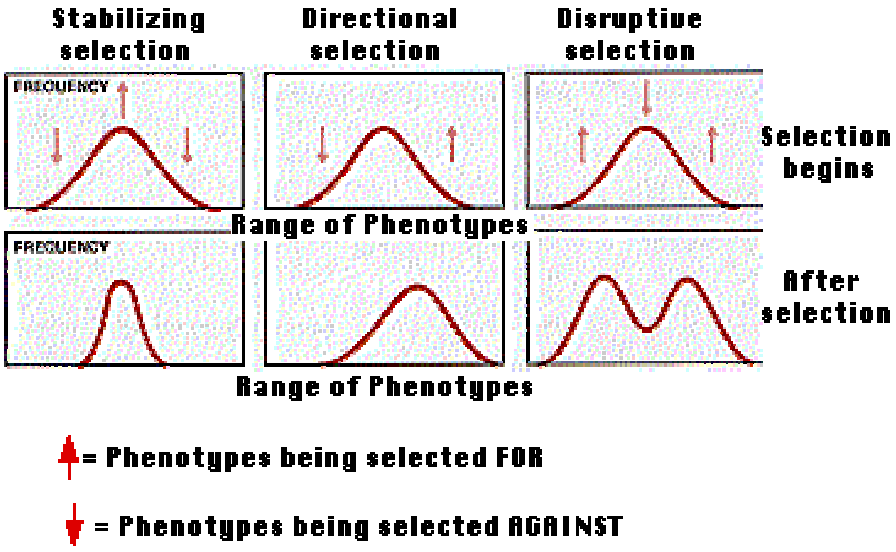
Natural selection is the process by which organisms best suited for the environment survive and reproduce. Evolution is the consequence of natural selection. The four principles of natural selection are summarized below:

1. **Variation exists within populations.**
2. **Organisms compete for limited natural resources.**
3. **Organisms produce more offspring than can survive.**
4. **Individuals with traits suitable for their habitat survive and reproduce.**



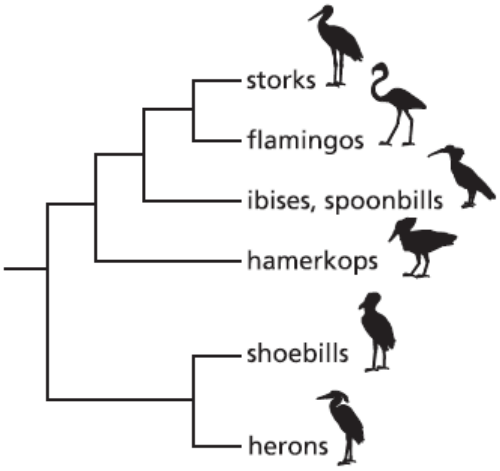
Natural selection ensures that only organisms most adapted to their environment live long enough to reproduce. Abrupt changes in the environment from some catastrophe will keep organisms not adapted to the new change from continuing to live there while organisms that are adapted will survive and reproduce. Over a long enough period of time, organisms can become so different from the earliest generations that they are considered a new species. This is called **speciation**. Whenever a population becomes separated due to an environmental change, one or both populations may change enough so that they can no longer interbreed.

Natural selection can be directional, disruptive or stabilizing, as shown in the picture below:



Example EOC question:

The diagram below shows that different wading birds arose from a single ancestor.



Which of these does not provide an explanation for how different wading birds arose from a single ancestor?

F Random genetic changes occurred in the ancestral population.

G Gradual genetic divergence occurred between isolated populations.

H Environmental factors selected for genetic change in the population.

J Dominant traits increased survival in the population more than recessive traits did.

SPI 3210.5.4 Describe the relationship between the amount of biodiversity and the ability of a population to adapt to a changing environment.

Key Vocabulary

population -

biodiversity -

species diversity -

genetic diversity -

variation –

Key concepts

We talked about in standard 2.5 how biodiversity is good for a changing environment. This standard is similar. A **population** is made up of all the individuals of a species living in the same area. **Biodiversity** refers to the differences among living things. A population becomes more diverse through sexual reproduction between individuals that are somewhat different from one another. The variation of phenotypes and **genetic diversity** within a population can also vary from population to population. But remember there is more to diversity than what can be seen. Resistance to disease for example can also be a part of biodiversity.

The greater the diversity of a population, the greater the chances that certain members of the population will survive. Since Earth has always been changing, its organisms have had to cope with the challenges of a changing environment. The diversity of a population affects whether it survives changes in its environment.

As an example, consider our own species. Often times throughout history, epidemics have swept through killing millions of people (bubonic plague, influenza, etc.). However, none has wiped out the human species. There are many reasons for our success and survival, and biodiversity is one of them. Some people catch a disease while others do not. Those that do catch it have varying degrees of seriousness. Others that do not will pass on their genes to offspring.

Example EOC question:

A section of rain forest was isolated from the rest of the rain forest by logging. As a result, a population of beetles was isolated from other members of the same beetle species in the main rain forest.

Which of the following is the most likely effect on the isolated population of beetles?

A The isolated population will begin to breed with other beetle species.

B The isolated population may start to differ from the population of the same species living in the main rain forest if conditions in their isolated forest change.

C The isolated population will go extinct without interaction with beetles from the main rain forest if conditions in their isolated forest change.

D The isolated population will grow uncontrollably without competition from beetles in the main rain forest.

Standards at a Glance: Biodiversity and Change

SPI 3210.5.5 Apply evidence from the fossil record, comparative anatomy, amino acid sequences, and DNA structure that support modern classification systems.

Key Vocabulary

homologous structures -

analogous structures -

vestigial structures -

comparative anatomy -

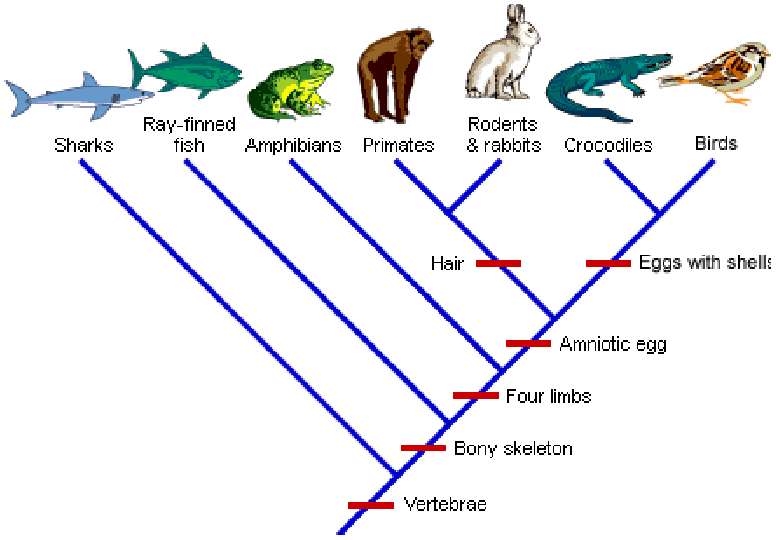
embryology -

cladogram–

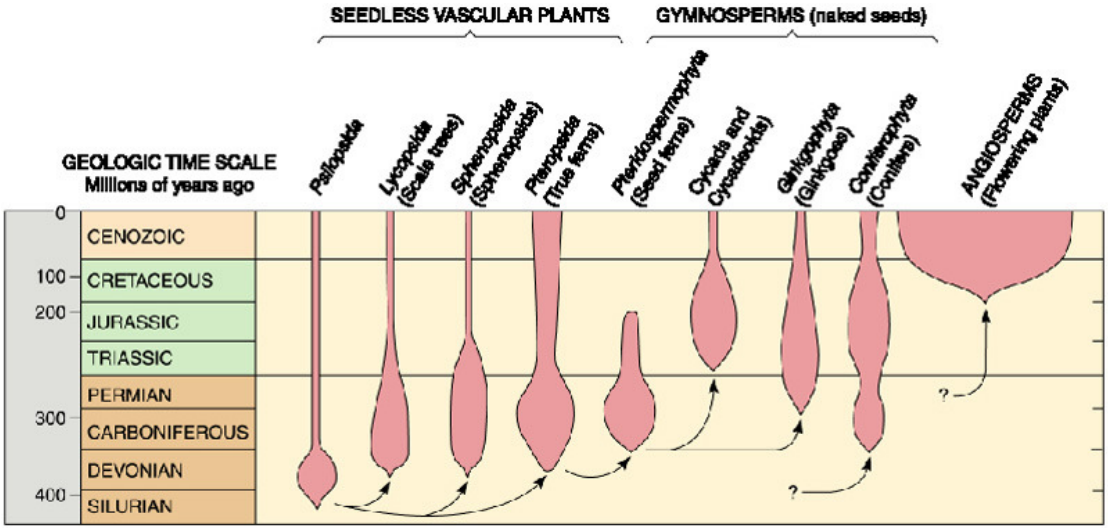
Key concepts

Scientists use fossils, anatomy, genetic and biochemical evidence to classify relationships between both modern organisms and extinct ancestors. Although physical traits are often used to classify, DNA structure and amino acid sequences will provide stronger evidence of relatedness.

Representing evolutionary relationships Often times scientists will use cladograms to show relatedness among organisms. In the cladogram below, organisms are arranged according to like characteristics and relatedness. The crocodiles and birds are more closely related than the bird and shark. They can also be used to show common ancestors.



Other times we may wish to represent levels of biodiversity across geologic time. For this case we may use a chart similar to the one below:



The thicker the shaded area, the more biodiversity of that type classification of organisms. Of course, if the shaded region does not extend itself to the top (present day) then it has gone extinct.

Example EOC question:

A scientist studied a specific DNA segment from four different species. The table below shows the base sequence for each species.

Species	Base Sequence
1	CTT ACT GCT
2	CTA ACC GGT
3	CTT AGT CGT
4	CTA ACT GCT

According to the results above, which two species are most closely related?

F Species 1 and 3
G Species 2 and 4
H Species 2 and 3
J Species 1 and 4

SPI 3210.5.6 Infer relatedness among different organisms using modern classification systems.

Key Vocabulary

binomial nomenclature -

taxonomy -

phylogeny -

domain -

kingdom -

genus -

species -

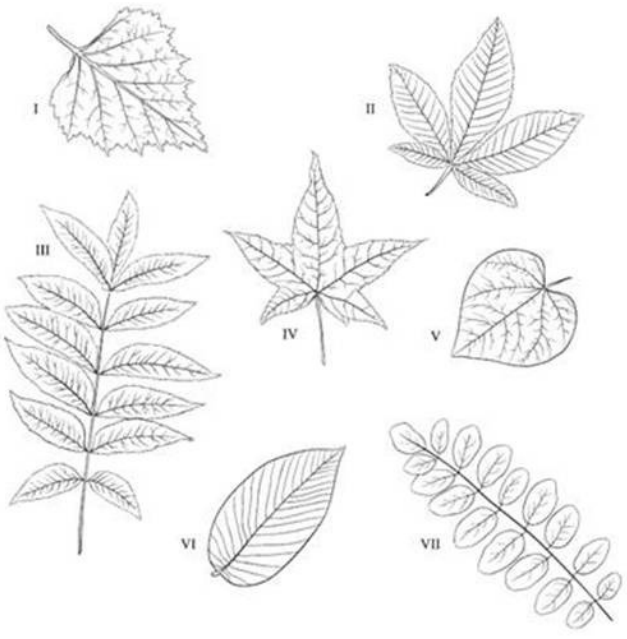
dichotomous key –

Key concepts

In biology, organisms are classified into groups or subgroups based on how the organisms are related. **Taxonomy** is the classification or sorting of animals by relatedness. Taxonomists analyze and compare physical traits, development, and DNA, and place organisms into groups that reflect evolutionary relationships. There are eight major levels of classification: **Domain, Kingdom, phylum, class, order, family, genus, and species.** Each level increases in specificity as you approach the species subgroup. There are three domains (Eubacteria, Archaea, and Eukarya) and six kingdoms: Eubacteria, Archaea, Protista, Fungi, Plantae, and Animalia.

Linnaeus devised a naming system called **binomial nomenclature,** which uses a Latin-based scientific name. The two-name system refers to an organism's genus and species using the syntax *Genus species*. Note the italics and capitalization. **Phylogeny** is a way to study evolutionary relationships and **cladograms** are visual representations of those relationships.

Dichotomous keys are systematic ways to identify an individual based on a series of yes or no questions. Use the dichotomous key below to identify the genus of the tree that goes which each of the leaves.



Dichotomous Key for Leaves

1. Compound or simple leaf
   - 1a) Compound leaf (leaf divided into leaflets) .....go to step 2
   - 1b) Simple leaf (leaf not divided into leaflets) .....go to step 4
2. Arrangement of leaflets
   - 2a) Palmate arrangement of leaflets (leaflets all attached at one central point) .....*Aesculus* (buckeye)
   - 2b) Pinnate arrangement of leaflets (leaflets attached at several points) .....go to step 3
3. Leaflet shape
   - 3a) Leaflets taper to pointed tips .....*Carya* (pecan)
   - 3b) Oval leaflets with rounded tips .....*Robinia* (locust)
4. Arrangement of leaf veins
   - 4a) Veins branch out from one central point .....go to step 5
   - 4b) Veins branch off main vein in the middle of the leaf.....go to step 6
5. Overall shape of leaf
   - 5a) Leaf is heart-shaped.....*Cercis* (redbud)
   - 5b) Leaf is star-shaped .....*Liquidambar* (sweet gum)
6. Appearance of leaf edge
   - 6a) Leaf has toothed (jagged) edge .....*Betula* (birch)
   - 6b) Leaf has untoothed (smooth) edge .....*Magnolia* (magnolia)

Example EOC question:

The chart below shows the classification of four different organisms.

	Organism 1	Organism 2	Organism 3	Organism 4
				
Kingdom	Plantae	Plantae	Plantae	Plantae
Phylum (Division)	Magnoliophyta	Magnoliophyta	Magnoliophyta	Magnoliophyta
Class	Magnoliopsida	Liliopsida	Liliopsida	Magnoliopsida
Order	Rosales	Typhales	Orchidales	Rosales
Family	Rosaceae	Typhaceae	Orchidaceae	Hydrangeaceae

According to the classification chart, which two organisms are most closely related?

A Organisms 1 and 3
B Organisms 1 and 4
C Organisms 2 and 3
D Organisms 2 and 4