AP Biology
Review Packet 2020

Science Practices

Chemistry of Life (8-11%)

Cell Structure & Function (10-13%)

Cellular Energetics (12-16%)

Cell Communication & Cell Cycle (10-15%)

Heredity (8-11%)

Gene Expression & Regulation (12-16%)

Natural Selection (13-20%)

Ecology (10-15%)

Task Verbs (CED pg. 199)

- There are several key task verbs that CB will use to direct you in the free response questions. You are expected to know what these verbs are telling you to do. Interpret the expectations for the following selected task verbs:
- Calculate
- Construct
- Describe
- Identify
- Evaluate
- Explain

Task Verbs (CED pg. 199)

- There are several key task verbs that CB will use to direct you in the free response questions. You are expected to know what these verbs are telling you to do. Interpret the expectations for the following selected task verbs:
- Justify
- Represent
- State
- Make A Claim
- Make A Prediction
- Support A Claim

Basic Science Concepts

- What is a **null hypothesis**?
- What is an **alternative hypothesis**?
- What is an **independent variable**?
- What is a **dependent variable**?
- What is the difference between a **controlled variable** and a **control group**?

Experimental Design

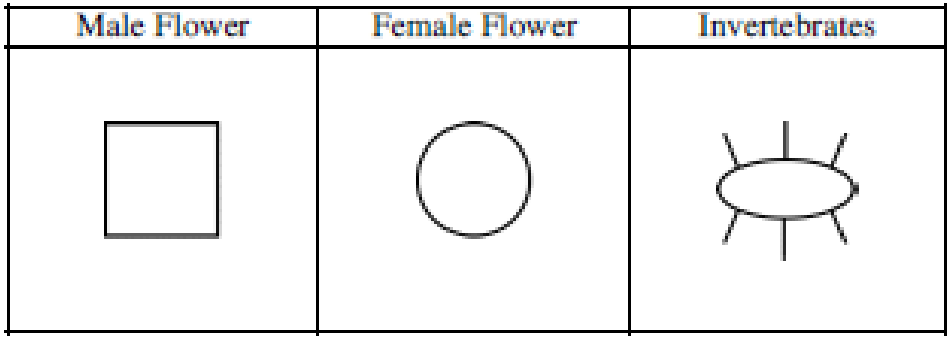
- Design an experiment to test the effect of fertilizer on plan growth. Be sure to include all needed components of experimental design.

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

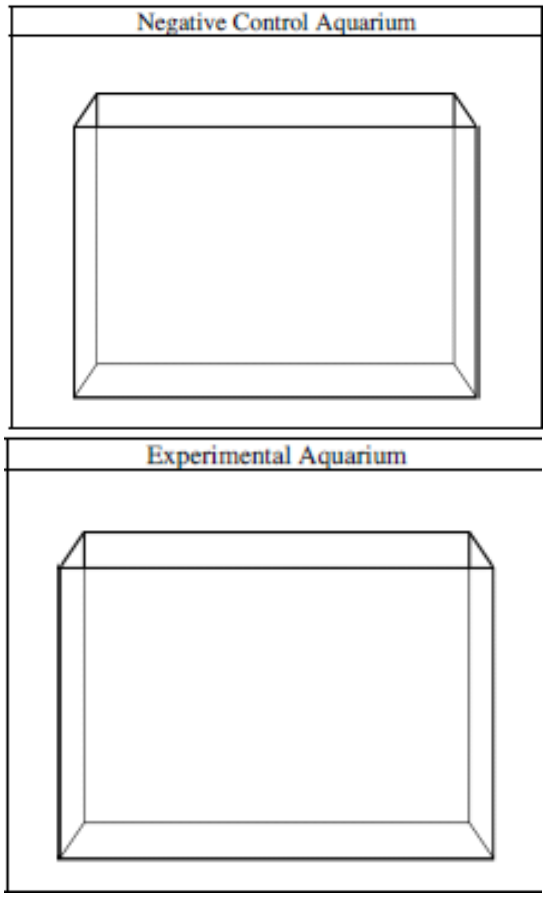
Seagrasses are aquatic plants that reproduce sexually. Male seagrass flowers produce sticky pollen that is carried by circulating water to female flowers, resulting in fertilization. A researcher claims that mobile aquatic invertebrates can also transfer pollen from male to female flowers in the absence of circulating water. To investigate this claim, the researcher set up aquariums to model the possible interactions between the invertebrates and seagrasses.

(a) Use the symbols below and the template aquariums to demonstrate the experimental design for testing the researcher's claim that mobile aquatic invertebrates can pollinate seagrass in the absence of circulating water. **Draw** the appropriate symbols in the negative control aquarium AND the experimental aquarium. Do not use any symbol more than once in the same aquarium.



(b) **Identify** the dependent variable in the experiment. **Predict** the experimental results that would support the researcher's claim that mobile aquatic invertebrates can also transfer pollen from male to female flowers in the absence of circulating water.

FRQ Practice Answer



FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

In an experiment, rats averaging 300 g of body mass were tested several times over a three-month period. For each individual rat, urine was collected over a three-hour period after ingestion of 10 mL of liquid (water, 1% ethyl alcohol solution, or 5% ethyl alcohol solution). The volume of urine was then measured, and the results were averaged for all individuals within each experimental group. The data are shown in the table below.

THREE-HOUR URINE OUTPUT FOLLOWING FLUID INGESTION

Fluid ingested (10 mL)	Water	1% Ethyl Alcohol	5% Ethyl Alcohol
Average urine output (mL)	3.5	3.8	4.7

(a) **Pose** ONE scientific question that the researchers were most likely investigating with the experiment.

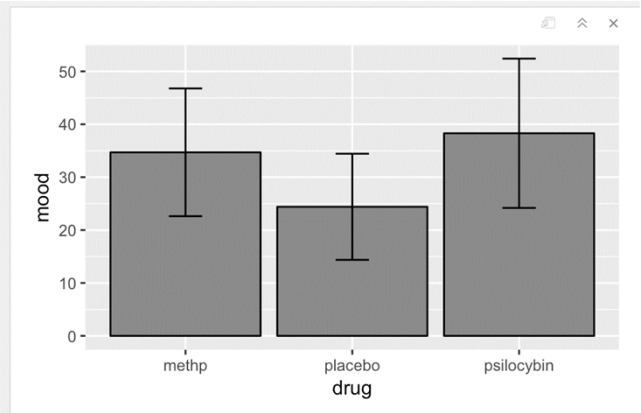
(b) **State** a hypothesis that could be tested to address the question you posed in part (a).

(c) Using the data in the table, **describe** the effect of ethyl alcohol on urine production.

FRQ Practice -Answer

Confidence Intervals & Error Bars

- What does the graph provided tell me?



- What is the relationship between **confidence intervals** and the standard error of the mean?

- What level of confidence is typically used in science? Why?

- What is the difference between standard error and standard deviation?

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink

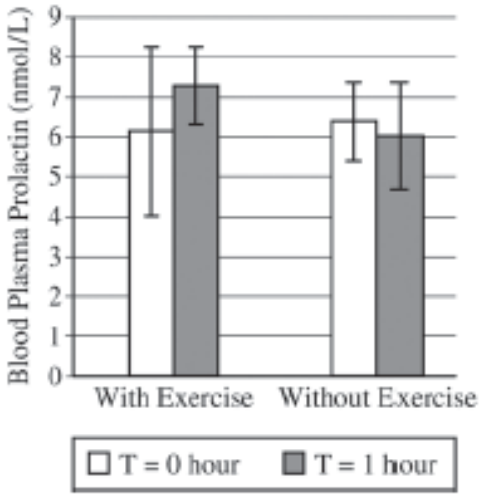


Figure 1. Effect of exercise on blood prolactin levels in adult males. The data represent the means $\pm 2SE_{\bar{x}}$.

Researchers conducted a study to investigate the effect of exercise on the release of prolactin into the blood. The researchers measured the concentration of prolactin in the blood of eight adult males before (T = 0 hour) and after one hour (T = 1 hour) of vigorous exercise. As a control, the researchers measured the concentration of blood prolactin in the same group of individuals at the same times of day one week later, but without having them exercise. The results are shown in Figure 1.

(a) **Justify** the use of the without-exercise treatment as the control in the study design.

(b) Using evidence from the specific treatments, **determine** whether prolactin release changes after exercise. **Justify** your answer.

FRQ Practice -Answer

Graphing Basics

- In AP Biology you must be able to interpret and construct a graph, plot, or chart (XY; Log Y; Bar; Histogram; Line; Dual Y; Box & Whisker; Pie)
  - When is a **line graph** appropriate?
  - When is a **bar graph** appropriate?
  - When is a **pie graph** appropriate?
  - When is a **scatter plot** appropriate?

Graphing Basics

- A mnemonic to remember the necessary components of the graph is SULTAN. Describe what is meant by each component:
  - Scale
  - Units
  - Labels
  - Title
  - Accuracy
  - Neatness

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink

TABLE 1. EFFECT OF 0.1 mM CAFFEINE ON MEMORY IN BEES

Treatment	Memory (average probability of revisiting a nectar source $\pm 2SE_{\bar{X}}$)	
	10 Minutes	24 Hours
Control	0.72 ± 0.09	0.41 ± 0.07
Caffeine	0.83 ± 0.07	0.78 ± 0.08

In flowering plants, pollination is a process that leads to the fertilization of an egg and the production of seeds. Some flowers attract pollinators, such as bees, using visual and chemical cues. When a bee visits a flower, in addition to transferring pollen, the bee can take nectar from the flower and use it to make honey for the colony.

Nectar contains sugar, but certain plants also produce caffeine in the nectar. Caffeine is a bitter-tasting compound that can be toxic to insects at high concentrations. To investigate the role of caffeine in nectar, a group of researchers studied the effect of 0.1 mM caffeine on bee behavior. The results of an experiment to test the effect of caffeine on bees' memory of a nectar source are shown in Table 1.

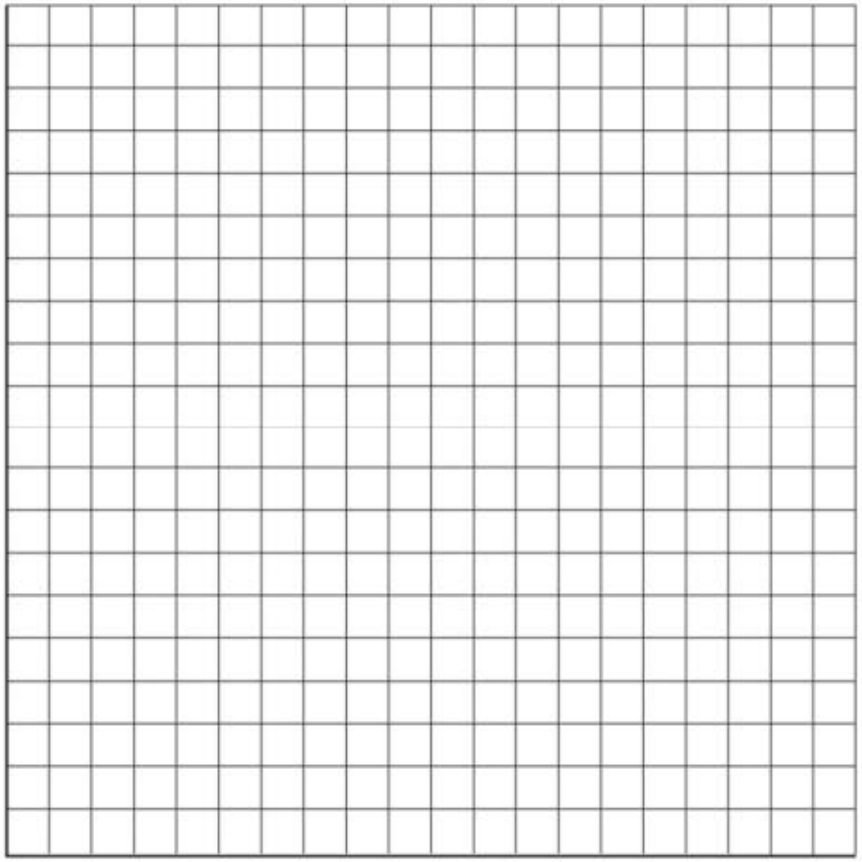
(a) On the axes provided, **construct** an appropriately labeled graph to illustrate the effect of caffeine on the probability of bees revisiting a nectar source (memory).

(b) Based on the results, **describe** the effect of caffeine on each of the following:

- Short-term (10 minute) memory of a nectar source
- Long-term (24 hour) memory of a nectar source

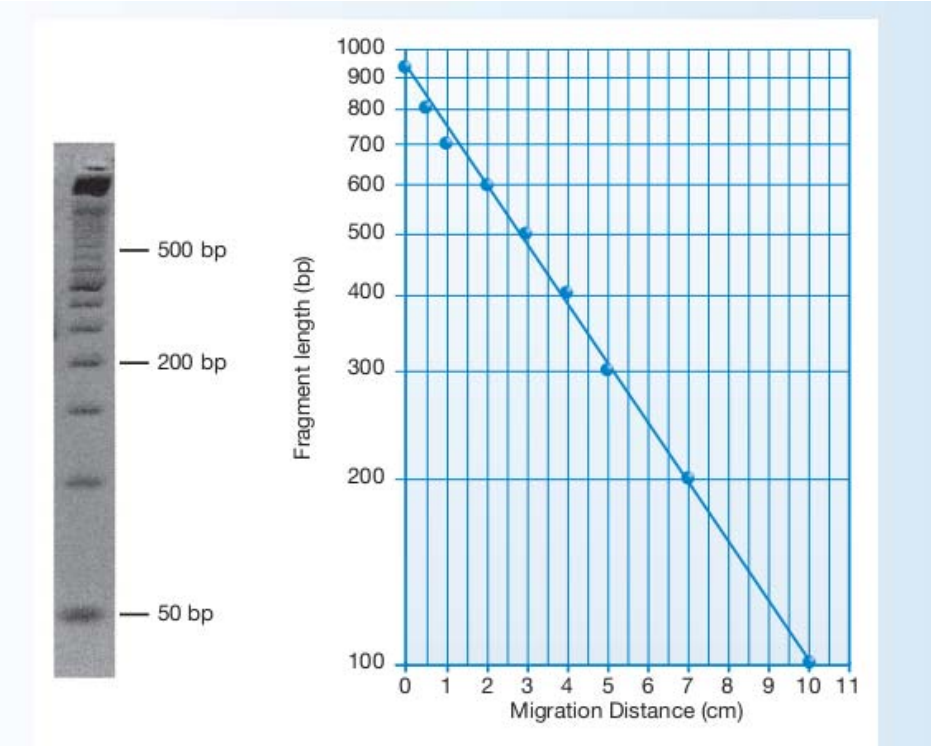
(c) **Design an experiment** using artificial flowers to investigate potential negative effects of increasing caffeine concentrations in nectar on the number of floral visits by bees. **Identify** the null hypothesis, an appropriate control treatment, and the predicted results that could be used to reject the null hypothesis.

FRQ Answer



Graphing Basics – Log Y

- How does a **log Y graph** compare to a standard line graph?



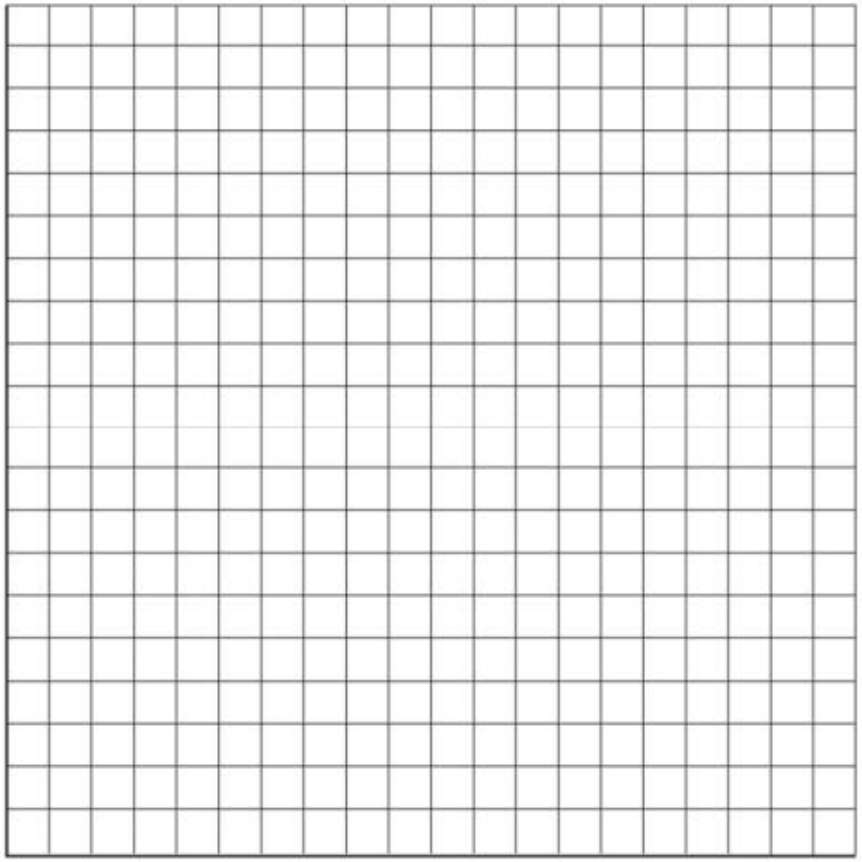
- How was the standard curve for this DNA ladder generated?
- How can this be used to extrapolate the size of an unknown fragment?
- If a fragment of DNA migrates 6 cm, what is its size in bp?

Graphing Basics - Histogram

- What is a **histogram**?

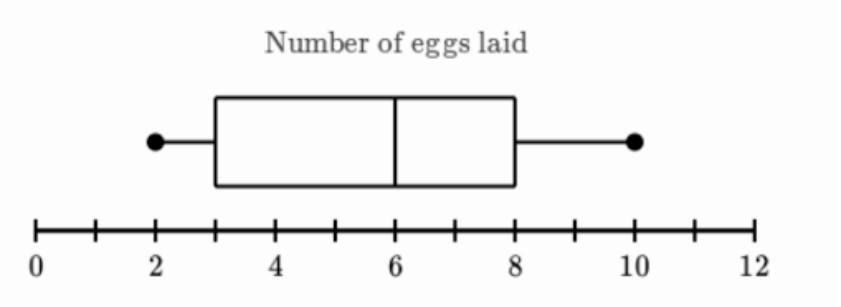
- What is the difference between a bar graph and a histogram?

- Create a histogram for the data set: 3, 11, 12, 19, 22, 23, 24, 25, 27, 29, 35, 36, 37, 45, 49 (hint: don't forget bins)



Graphing Basics – Box & Whisker Plot

- A simple **box and whisker plot** has been provided.
  - What are **quartiles**?



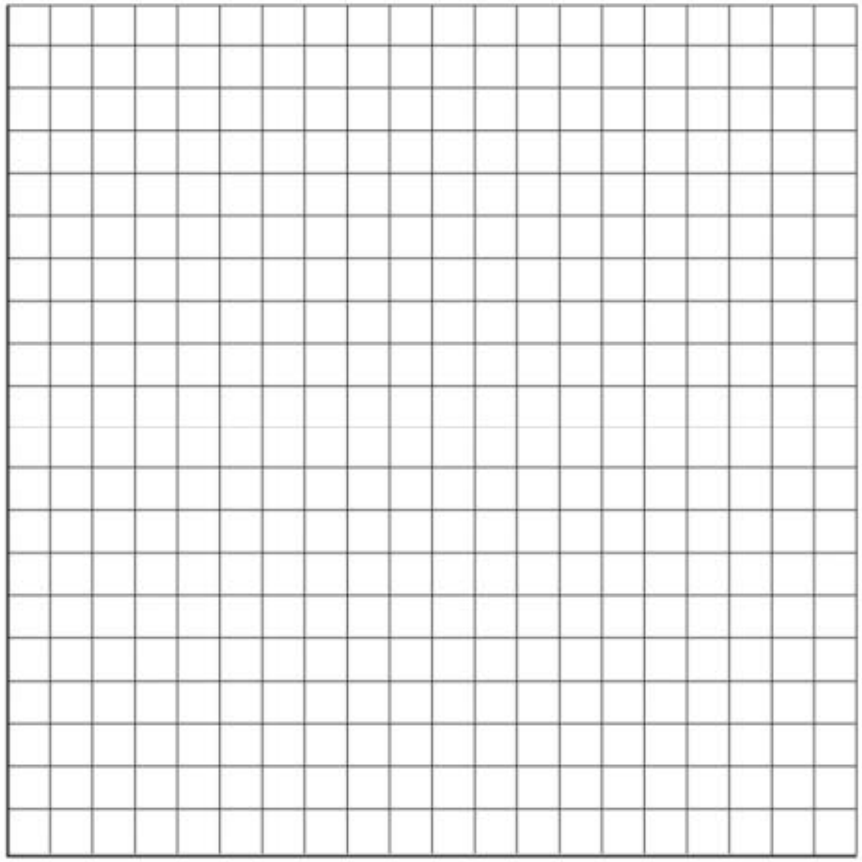
  - What is the **median**? Circle where this can be found on the graph.
  - What does the "box" component of this graph type represent?
  - What does the "whisker" component of this graph type represent?
  - New data emerges that there was an outlier of 12 eggs laid. How would this be represented on the graph above?

Graphing Basics – Dual Y

- What is the purpose of a **Dual Y graph**?

- Create a **climatograph** using the following info

Month	Average Precipitation (mm)	Average Temperature (°C)
J	436	4
F	382	5
M	355	6
A	249	8
M	165	10
J	138	12
J	77	14
A	94	15
S	134	13
O	340	10
N	475	7
D	462	5



Metric Conversions

- 1 meter = _____ centimeters = _____ millimeters
- 56.2 millimeters = _____ meters = _____ centimeters
- 13 kilometers = _____ meters = _____ decimeters
- 16 ml = _____ µl
- 94.3 µl = _____ L
- 32 mm = _____ nm
- 2.4 kg = _____ mg

2. 7 g = _____ mg

2.3 µl = _____ mL

19 m = _____ km

82 cm = _____ Gm

- Convert the density of gold, 19.3 g/cm^3, to kg/L (Show work).

Quantitative Skills (Show Work)

- A researcher has sections of two different types of skin cancers from human patients. She stains them for the protein CD31, which is a marker of endothelial cells. She then takes pictures of the immunofluorescent sections and counts the number of blood vessels present . She takes five pictures of each slide.
  - Slide A: 10, 8, 7, 8, 11
  - Slide B: 3, 2, 4, 4, 4
- What is the **mean**, **median**, and **mode** for each dataset?
- What is the **standard deviation** for each data set?
- What is the **standard error** for each data set?
- What does the information tell you about the data?

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink

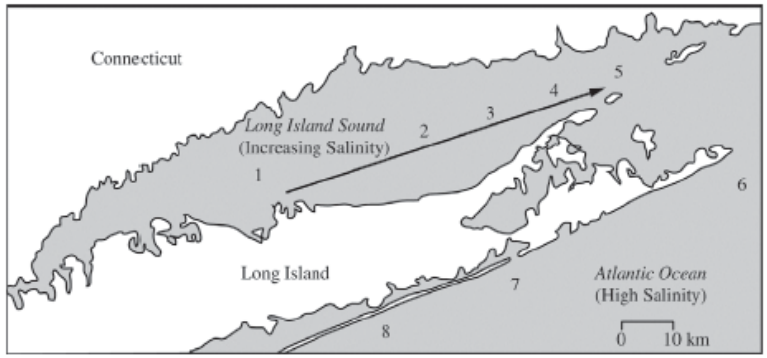


Figure 1. Sampling sites of marine mussels at various locations (1–8) in Long Island Sound and the Atlantic Ocean

TABLE 1. PERCENT OF INDIVIDUALS POSSESSING *lap*^{94} ALLELE

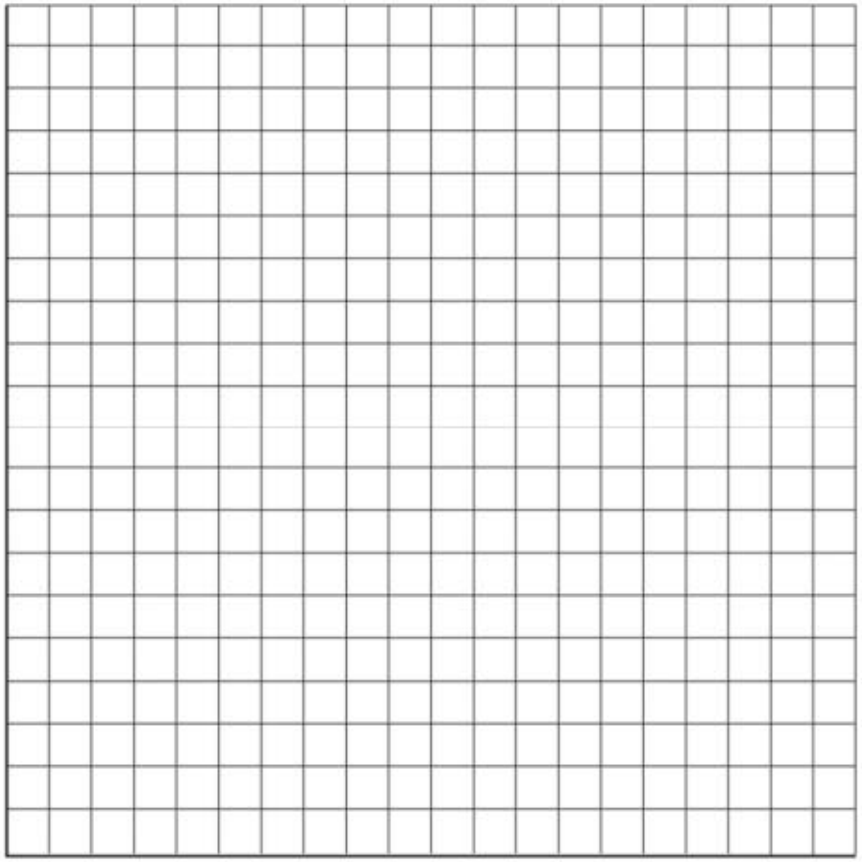
	Long Island Sound					Atlantic Ocean		
Site	1	2	3	4	5	6	7	8
lap^{94} frequency (%)	13	16	25	37	55	59	59	59
Salinity	Low →				High	High		

Leucine aminopeptidases (LAPs) are found in all living organisms and have been associated with the response of the marine mussel, *Mytilus edulis*, to changes in salinity. LAPs are enzymes that remove N-terminal amino acids from proteins and release the free amino acids into the cytosol. To investigate the evolution of LAPs in wild populations of *M. edulis*, researchers sampled adult mussels from several different locations along a part of the northeast coast of the United States, as shown in Figure 1. The researchers then determined the percent of individuals possessing a particular *lap* allele, *lap*^{94}, in mussels from each sample site (table 1).

(a) On the axes provided, **construct** an appropriately labeled bar graph to illustrate the observed frequencies of the *lap*^{94} allele in the study populations.

(b) Based on the data, **describe** the most likely effect of salinity on the frequency of the *lap*^{94} allele in the marine mussel populations in Long Island Sound. **Predict** the likely *lap*^{94} allele frequency at a sampling site between site 1 and site 2 in Long Island Sound.

FRQ Answer



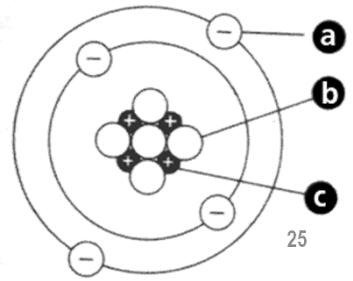
Subatomic Particles

- Identify and describe the location and key properties of the **subatomic particles** in the atom below.

- Identify the **atom**. How do you know?

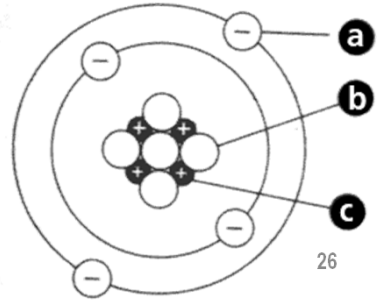
- What is its **atomic mass**?

- What is the **charge** of the atom? Why?



Subatomic Particles

- What would happen to the atom if I…
  - added a **proton**? What is this process called?
  - added a **neutron**? What did I produce?
  - added an **electron**? What kind of ion is it?
  - removed an **electron**? What kind of ion is it?



Elements of Life

- What are the most common elements in the human body? What percentage of the body do each represent?

- Micronutrient vs.. Macronutrient?

- What makes a nutrient **essential** to the body?

- What role do **trace elements** play in the body? Identify two trace elements & their biological function.

Chemical Bonding

- Define **covalent bond**:

  - **nonpolar** vs.. **polar covalent**:

- Define **ionic bond**:

- Define **hydrogen bond**:

Chemical Bonding

- What is **electronegativity**?

- What are the three most electronegative elements?

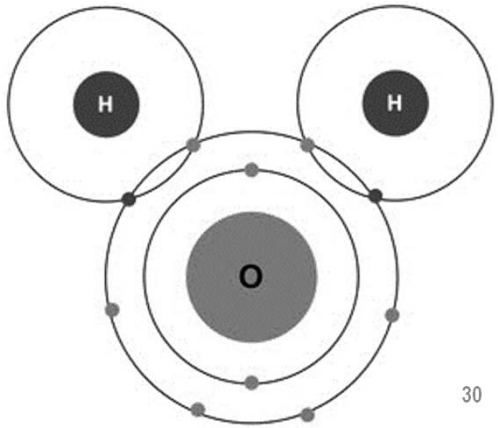
- How does electronegativity affect…
  - ionic & covalent bonding?

  - hydrogen bonding?

Polarity of Water

- Why are water molecules **polar**?

- Indicate the charge on each part of the water molecule shown. Why is this important?



- Draw a second water molecule and show how it would hydrogen bond

Properties of Water

- Define each and describe why it is important for life on Earth.
    - o Cohesion:
    - o Adhesion:
    - o Surface Tension:
    - o High Heat Capacity:
    - o Expansion on Freezing:

Acids & Bases

- Define **acidic**:
- Define **basic/alkaline**:
- Define **neutral**:
- How is **pH** determined?
- What is the **[H+]** of a substance with a pH of 4?
- What is the **pOH** of a substance with a [H+] of 0.000001?
- How many times more alkaline is a substance that goes from a pH of 2 to 5?

Organic vs.. Inorganic

- **Organic** vs.. **Inorganic** Compounds:

- What properties of **carbon** make it central to life on Earth?

- What are the four classes of **organic macromolecules** central to life on Earth?

Functional Groups

- Identify and describe the properties of the seven key biological **functional groups**:

Monomers & Polymers

- Monomer vs. Polymer:

- Diagram Dehydration Synthesis:

- Diagram Hydrolysis:

Carbohydrates

- Highlight the components of the mnemonic that relate to this macromolecule: C H N O P S

- Identify two common **monosaccharides** and describe their use in the body.

- What is the name of the dehydration synthesis bond?

- **Glucose**, **galactose**, and **fructose** are all **isomers**. What does this mean?

Carbohydrates

- Describe the structure and function of the 5 major **polysaccharides**.

- Why is **starch/amylose** digestible by humans but **fiber/cellulose** is not?

Lipids

- Highlight the components of the mnemonic that relate to this macromolecule: C H N O P S
- Why are **lipids** not polymers?
- What is the name of the dehydration synthesis bond?
- Describe the structure and function of the 4 major types of lipid molecule.

Lipids

- Diagram and describe the difference between saturated and unsaturated fatty acids.

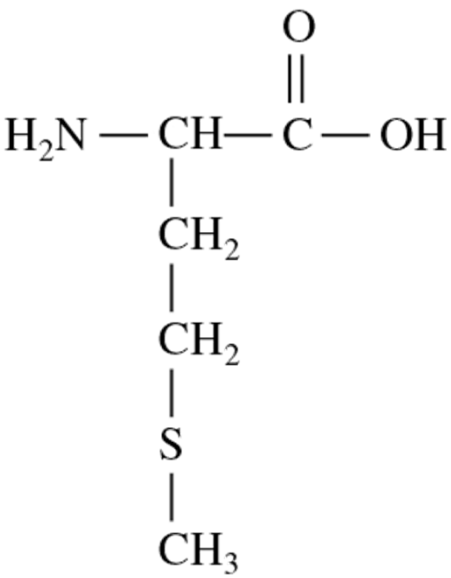
- What effect(s) do saturated fatty acids have on human health?

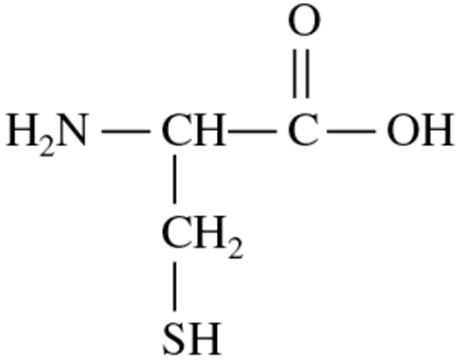
Proteins

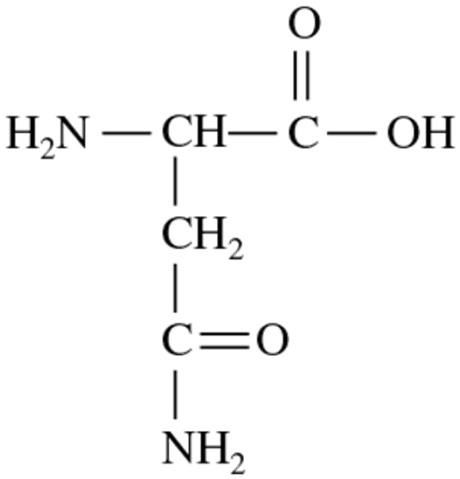
- Highlight the components of the mnemonic that relate to this macromolecule: C H N O P S
- Create a diagram of an **amino acid** and indicate the functional groups involved.
- What determines **directionality** in a protein?
- What does the **R group** represent?
- What is the name of the dehydration synthesis bond?

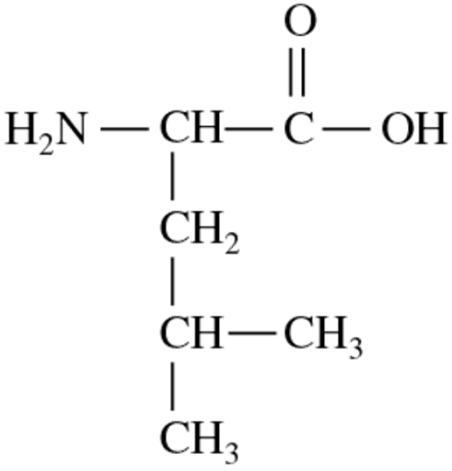
Proteins

- For each of the amino acids below indicate if it is **polar/nonpolar and hydrophilic/hydrophobic**
- Highlight where **sulfhydryl** bridges can form.
- Circle where dehydration synthesis bonds can form.









Proteins

- Describe the four levels of **protein structure**.

- What are the role of **chaperonins**?

- What can lead to the **denaturation** of a protein?

Nucleic Acids

- Highlight the components of the mnemonic that relate to this macromolecule: C H N O P S

- Diagram a **nucleotide** and identify its key components.

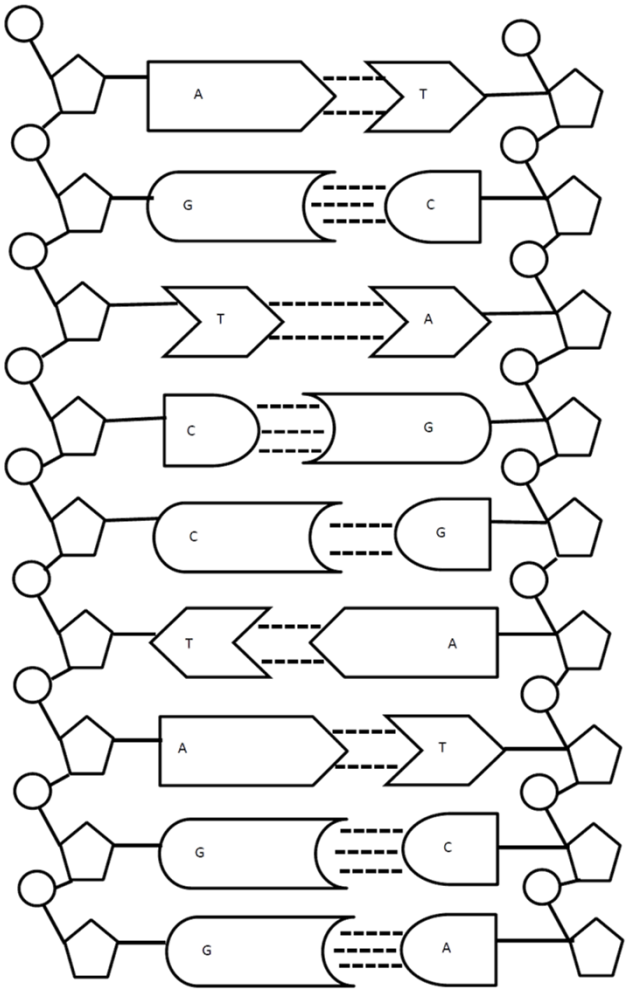
- What is the name of the dehydration synthesis bond?

- What determines directionality in a **polynucleotide**? Indicate the carbon numbers on the nucleotide you diagramed above.

Nucleic Acids

- Label a **nucleotide**, **5' ends**, **3' ends**, make **phosphodiester bonds** bold, and circle **hydrogen bonds**.

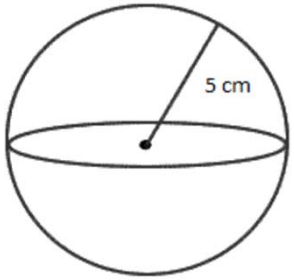
- What are the major differences between RNA & DNA?



Cell Size

- Explain the **surface area-to-volume ratio** and **genome-to-volume ratio** in relation to cell shape and size.

- What is the surface area-to-volume ratio of this cell? Show your work.



- How does SA/V ratio relate to the shape & function of specific cells such as **root hair cells** & **gut epithelial cells**?

Microscopy

- What determines the smallest item that a microscope can visualize?

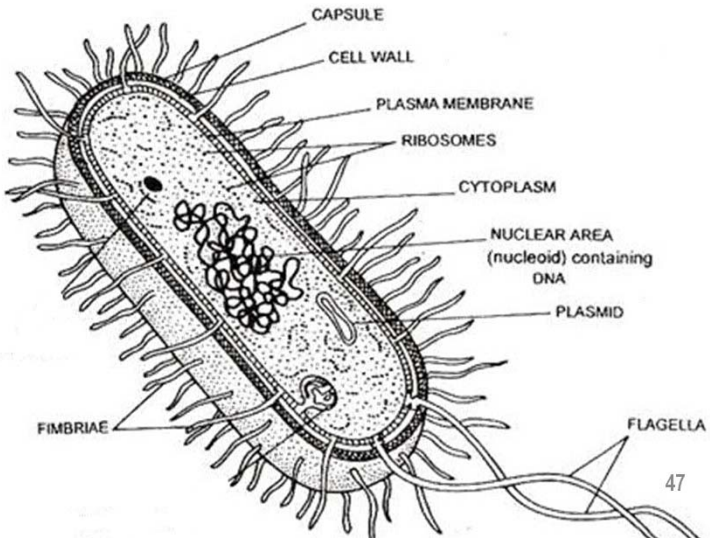
- Light Microscopy vs. Electron Microscopy

- Scanning Electron vs. Transmission Electron Microscope

- Magnification vs. Resolution

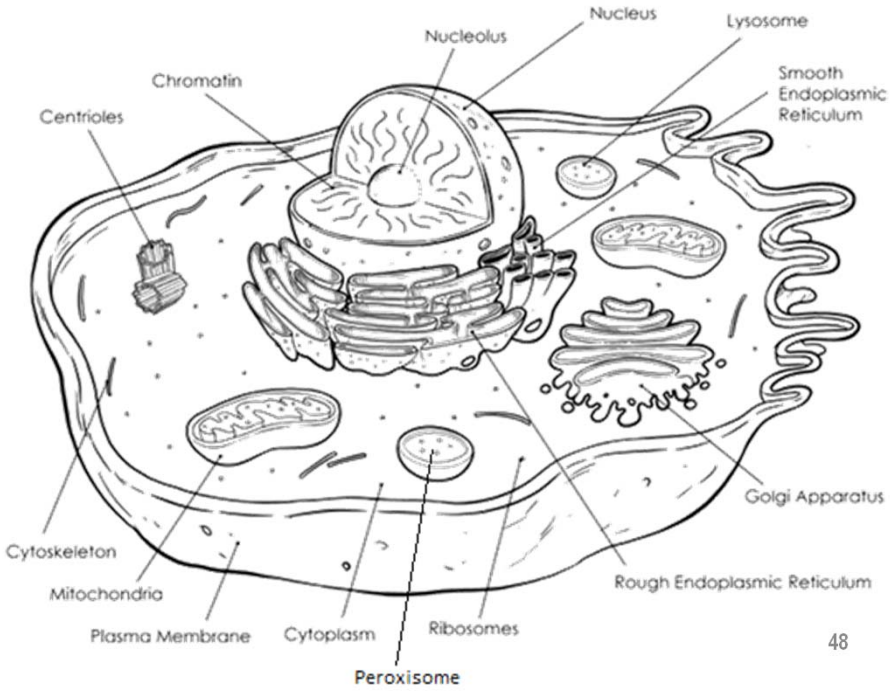
Prokaryotic Cell

- Describe the function of the parts of the **prokaryotic cell** below:

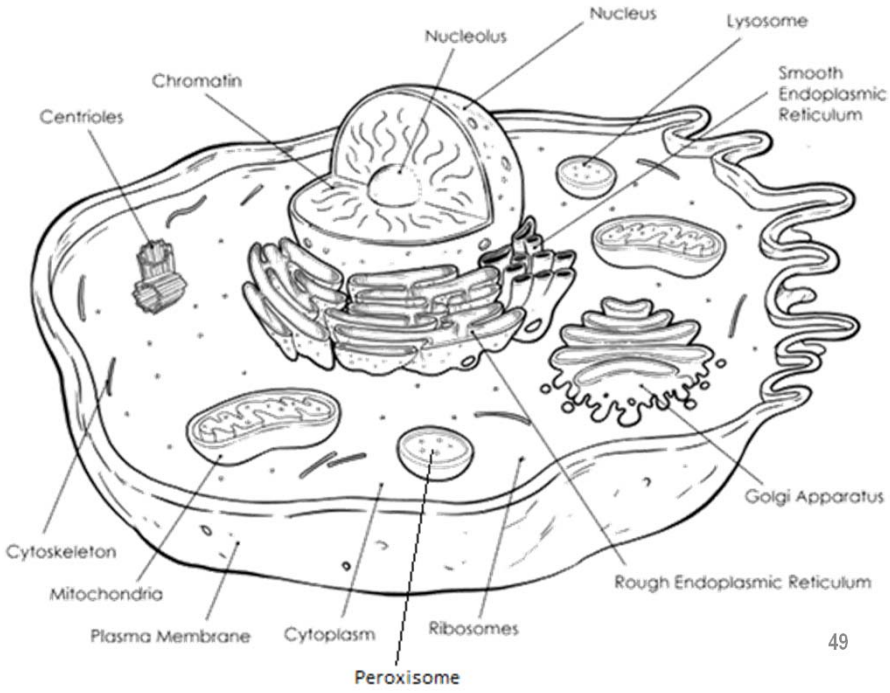


Eukaryotic Cell

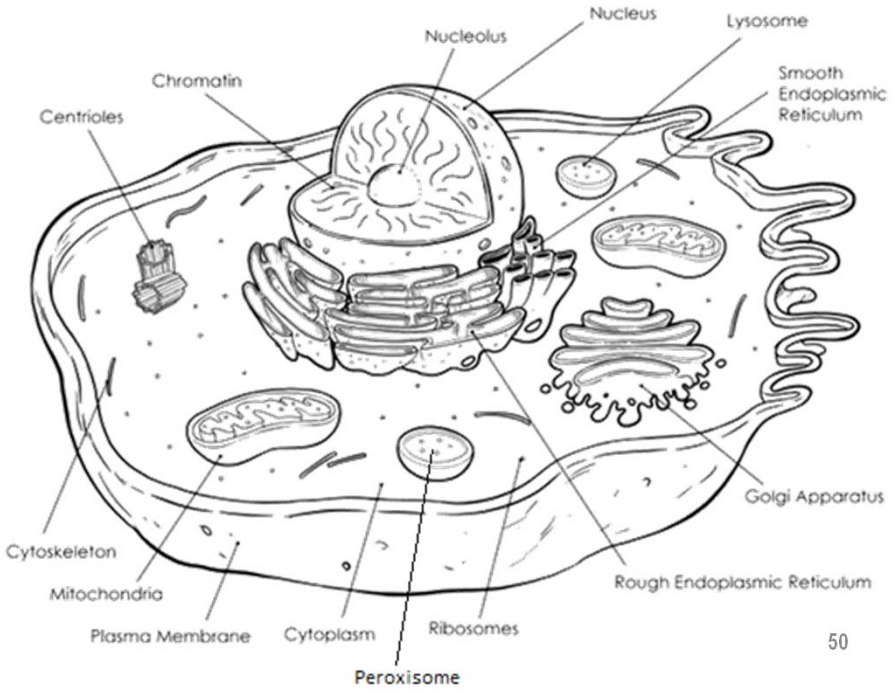
- Describe the purpose of each of the labeled **cell organelles** in the diagram below in the space provided on this slide and the next two.



Eukaryotic Cell



Eukaryotic Cell



IE: Glycosylation & Signaling

- Describe how **glycosylation** and other chemical modifications of proteins that take place in the Golgi determine protein function & targeting as part of the **endomembrane system**.

- How do **lysosomes** and **peroxisomes** relate to the rest of the eukaryotic cell organelles?

Plant vs. _____ Cells

- Identify the key differences between **plant cells** & **animal cells**.

- Plant cells are not the only cells with **cell walls**. What other cells have cell walls and what makes them different?

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

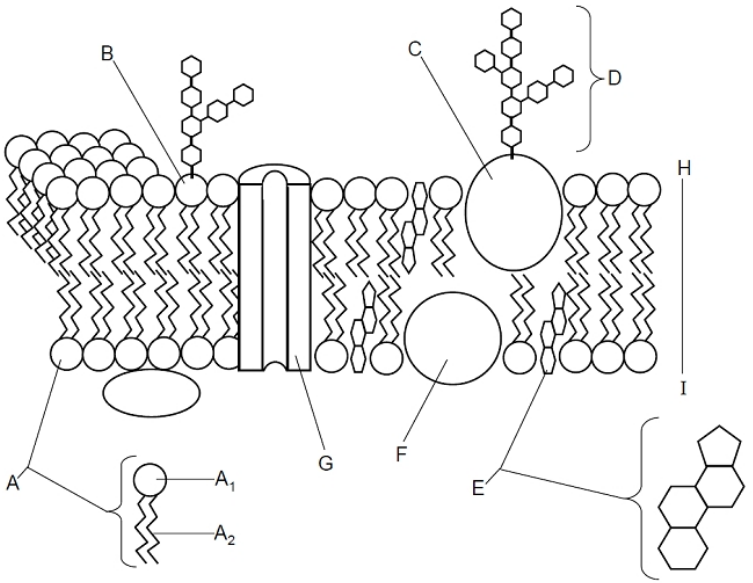
In eukaryotic cells, ribosomes are found both free in the cytosol and attached to the endoplasmic reticulum (ER). Proteins produced on the attached ribosomes are delivered to the ER, while proteins produced on free ribosomes are delivered to the cytosol. **Briefly explain** in one or two sentences the two processes in terms of the following:

- ONE ultimate destination of a protein produced on an attached ribosome, and ONE general function of the protein (You do not need to identify the specific protein.)
- ONE ultimate destination of a protein produced on a free ribosome, and ONE general function of the protein (You do not need to identify the specific protein.)

FRQ Practice -Answer

Plasma Membrane

- Identify the components of the **plasma membrane** labeled below and describe their function.



External Cell Structures

- Describe the structure and function of the **extracellular matrix**.

- Identify and describe the 4 types of **cellular junctions**.

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

The following data were collected by observing subcellular structures of three different types of eukaryotic cells.

RELATIVE AMOUNTS OF ORGANELLES IN THREE CELL TYPES

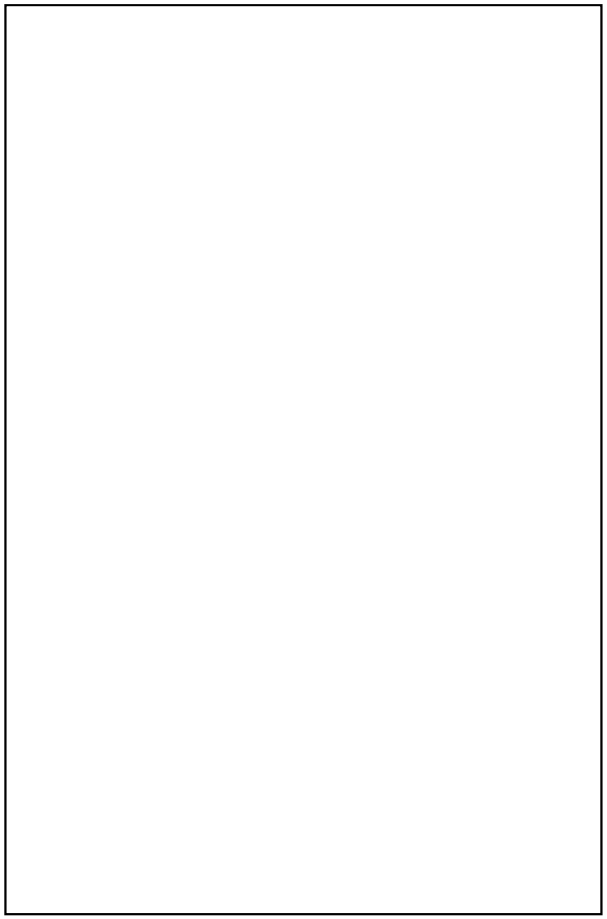
Cell Type	Smooth ER	Rough ER	Mitochondria	Cilia	Golgi Bodies
X	Small amount	Small amount	Large number	Present	Small amount
Y	Large amount	Large amount	Moderate number	Absent	Large amount
Z	Absent	Absent	Absent	Absent	Absent

Based on an analysis of the data, **identify** a likely primary function of each cell type and **explain** how the data support the identification.

FRQ Practice -Answer

Passive Transport

- Define **simple diffusion**.
- Define **facilitated diffusion**.
- Identify the two most common **protein channel** types.
- In the space on the right diagram both types of diffusion.

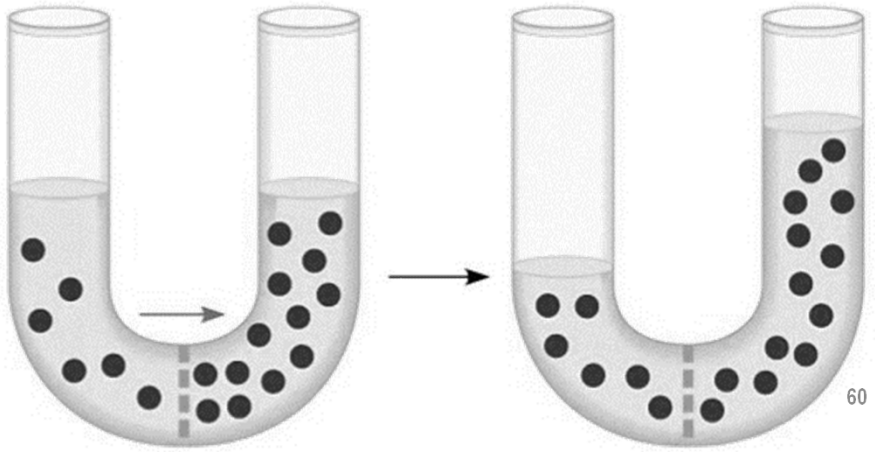


Osmosis & Tonicity

- Define **osmosis**.

- **Solute** vs. **solvent**:

- Use the concepts you have learned to explain the provided image.



Osmosis & Tonicity

- Create a diagram showing **hypotonic**, **hypertonic**, and **isotonic**.

- What **tonicity** is best for an animal cell? A plant cell? Why?

- How does tonicity explain specialized organelles such as the **contractile vacuole** of protists?

Water Potential

- Define **water potential**:

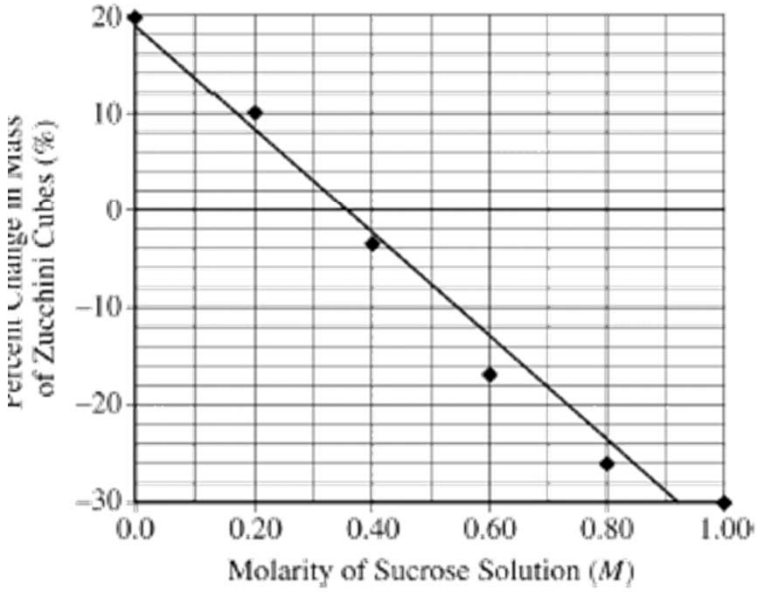
- Relate the movement of water in osmosis to water potential.

- The molar concentration of a sugar solution in an open beaker has been determined to be 0.22M. Calculate the solute potential at 27 °C. Show your work and round your answer to the nearest tenths.

Quantitative Skills

- Answer the question and explain your reasoning.

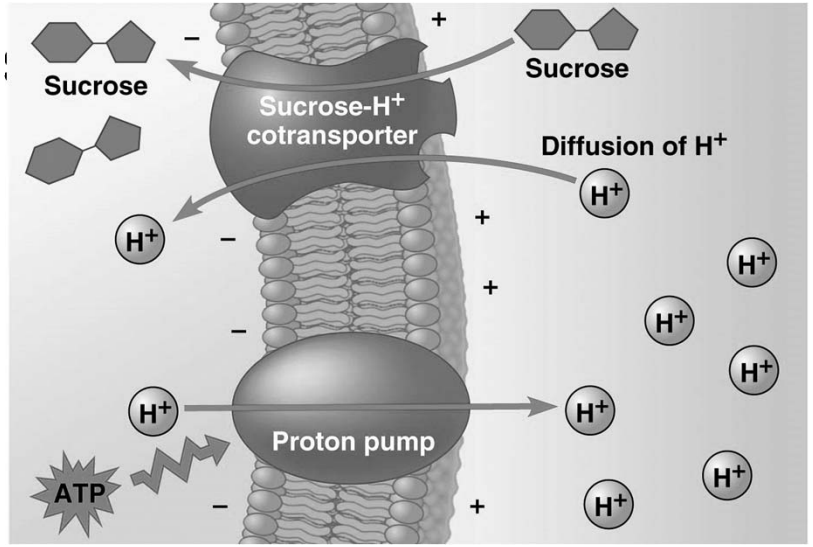
A zucchini squash was peeled and cut into six identical cubes. After being weighed, each cube was soaked in a different sucrose solution for 24 hours in an open container and at a constant temperature of 21°C. The cubes were then removed from the sucrose solutions, carefully blotted on paper towels, and weighed again. The percent change in mass (due to a net gain or loss of water) was calculated for each cube, and the results are shown in the graph below. A straight line is drawn on the graph to help in estimating results from other sucrose concentrations not tested.



Using the straight line on the graph above, calculate the water potential (in bars) of the zucchini squash at 21°C. Give your answer to one decimal place.

Active Transport

- How is **active transport** different than passive trans



- Use the image to discuss the differences between **primary** and **secondary active transport**.

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

Cystic fibrosis is a genetic condition that is associated with defects in the CFTR protein. The CFTR protein is a gated ion channel that requires ATP binding in order to allow chloride ions (Cl^-) to diffuse across the membrane.

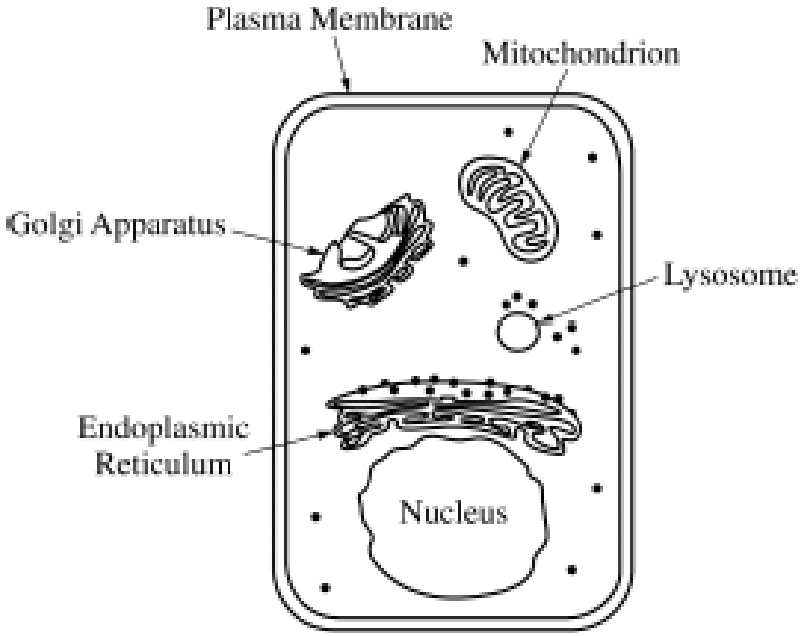
(a) In the provided model of a cell, **draw** arrows to describe the pathway for production of a normal CFTR protein from gene expression to final cellular location.

(b) **Identify** the most likely cellular location of the ribosomes that synthesize CFTR protein.

(c) **Identify** the most likely cellular location of a mutant CFTR protein that has an amino acid substitution in the ATP-binding site.

(d) Indicate on the diagram where you will find phospholipid bilayers.

FRQ Practice Answer



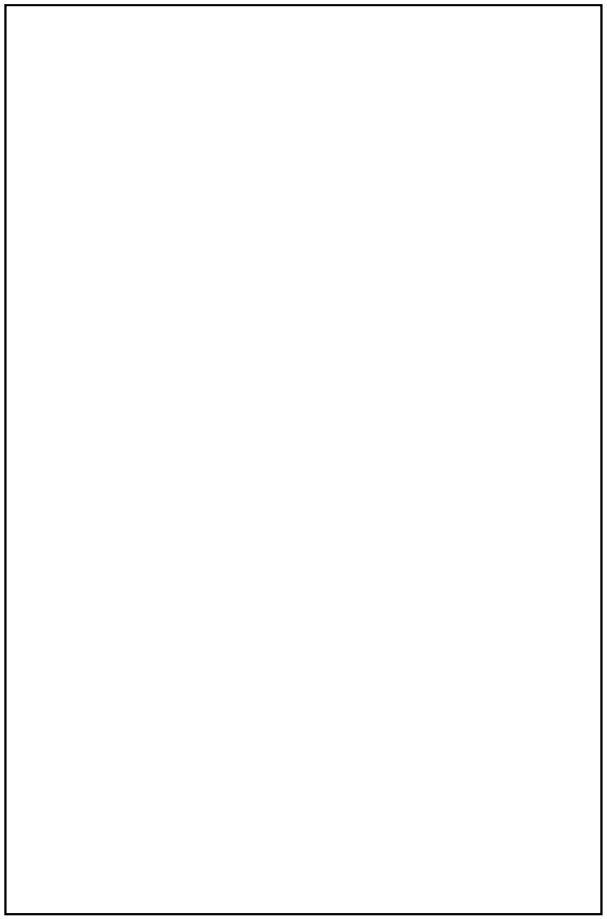
Bulk/Vesicular Transport

- Vacuole vs. Vesicle:

- Identify & define the three types of endocytosis.

- Define exocytosis.

- In the space on the right diagram endocytosis & exocytosis.



Origins of the Cell

- Describe the **Oparin & Haldane Hypothesis**:

- Describe the **Miller & Urey Experiment**:

- How does the work of the scientists above relate to the **RNA-World Hypothesis**?

Endosymbiosis

- Define **endosymbiosis** and describe how it relates to the origin of the mitochondria and the plastids such as the chloroplast.

- What evidence do we have for this theory?

Thermodynamics

- What is the First Law of Thermodynamics? What does this mean for living organisms?

- What is the Second Law of Thermodynamics? What does this mean for living organisms?

Gibbs Free Energy

- What is Gibbs Free Energy?

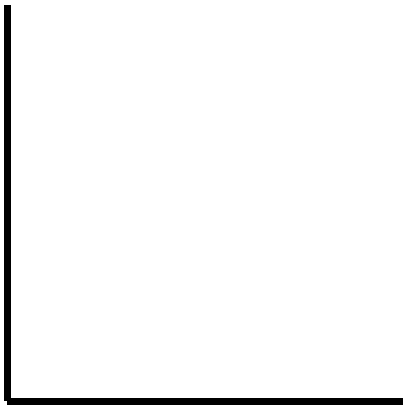
- Identify the formula for Gibbs Free Energy and explain its components.

Types of Reactions

- Define **exergonic reactions**:

- Define **catabolic reactions**:

- Create an energy diagram for this type of reaction using the space provided showing energy vs. reaction process. Be sure to include ΔG

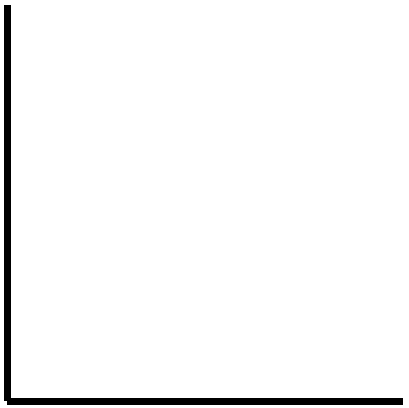


Types of Reactions

- Define **endergonic reactions**:

- Define **anabolic reactions**:

- Create an energy diagram for this type of reaction using the space provided showing energy vs. reaction process. Be sure to include ΔG



Energy Coupling

- Explain the function of energy coupling and the role it plays in biology by diagraming the ADP-ATP cycle and explaining the components.

- How does ATP relate to the nucleotide?

Enzymes & Energy

- Define **activation energy** (be sure to use the term transition state). Why is this necessary? Diagram this in the space provided.

- How do **enzymes** effect activation energy? Indicate this on the diagram.

- How do enzyme effect ΔG? Indicate this on the diagram.

Enzymes

- Create a diagram of enzyme function that includes the following components: substrate, enzyme, active site, allosteric site, enzyme-substrate complex, product

- Describe the induced-fit model of enzyme function.

Enzyme Activation & Inhibition

- What role do **cofactors** and **coenzymes** play in enzyme function?

- Describe & diagram the following types of **enzyme inhibition**:
  - Competitive Inhibition

  - Allosteric/Noncompetitive Inhibition

Factors Affecting Reaction Rate

- Many things can alter the reaction rate when enzymes are involved. For each of the following describe the affect it would have on reaction rate:
  - Altering temperature
  - Altering pH
  - Altering substrate concentration
  - Altering enzyme concentration

Redox Reactions

- Use the formula for cellular respiration to explain **reduction** and **oxidation reactions** and their role in **cellular energetics**.

- What mnemonic helps remember the movement of electrons in redox reactions? Explain.

Electron Carriers

- What is the purpose of **electron carriers** in cellular energetics?

- Identify the three electron carriers used in cellular respiration & photosynthesis and indicate which process they function in.

- Which ones can be found in plant cells? Why?

Energy & Organisms

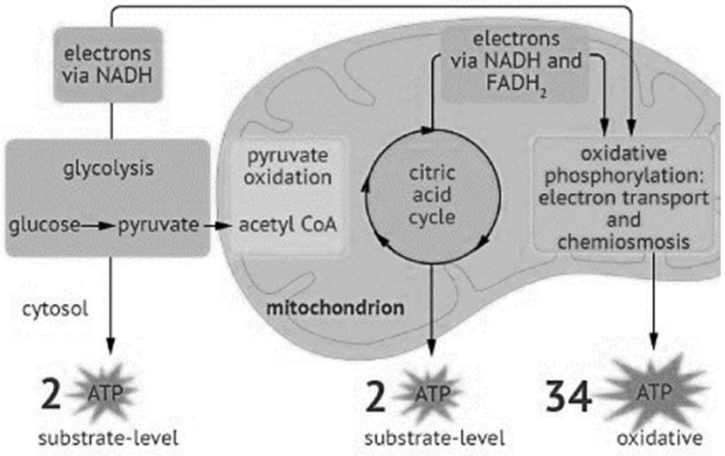
- What does it mean for an organism to be a photoautotroph?
- What does it mean for an organism to be a chemoautotroph?
- What does it mean for an organism to be a photoheterotroph?
- What does it mean for an organism to be a chemoheterotroph?

Chloroplast vs. Mitochondria

- Create a diagram of both of these organelles being sure to label all of their internal structures. Be sure to include the following terms: **inner/outer membrane**, **stroma**, **lumen**, **thylakoid**, **granum**, **ribosomes**, DNA, **intermembrane space**, **cristae**, **matrix** (some terms will be in both diagrams).

Cellular Respiration

- Describe the basics of the major stages of **cellular respiration** using the image below.



Glycolysis & Pyruvate Oxidation

- Why is **glycolysis** considered to be one of the earliest **metabolic pathways** to evolve?

- Why does glycolysis need to input 2 ATP to gain 4 ATP?

- What is the purpose of **pyruvate oxidation** in cellular respiration?

Citric Acid Cycle/Krebs Cycle

- What are the inputs and outputs of the **Krebs Cycle**?

- The **Citric Acid Cycle** produces very little ATP. Why is the process conserved evolutionarily?

- Both glycolysis and Krebs use **substrate level phosphorylation** to produce ATP. What does this mean?

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

The pyruvate dehydrogenase complex (PDC) catalyzes the conversion of pyruvate to acetyl-CoA, a substrate for the Krebs (citric acid) cycle. The rate of pyruvate conversion is greatly reduced in individuals with PDC deficiency, a rare disorder.

(a) **Identify** the cellular location where PDC is most active.

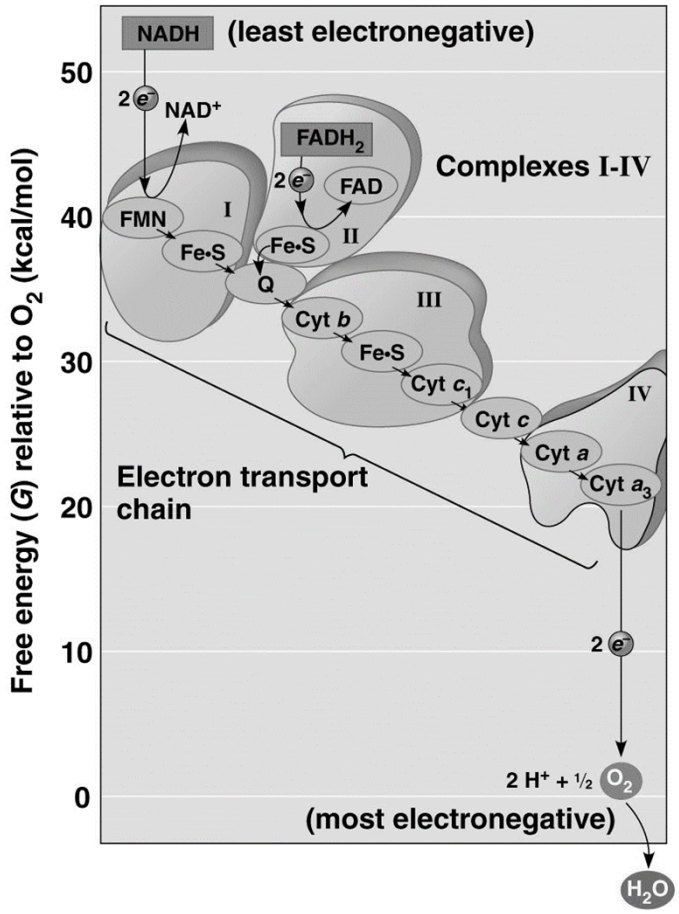
(b) **Make a claim** about how PDC deficiency affects the amount of NADH produced by glycolysis AND the amount of NADH produced by the Krebs (citric acid) cycle in a cell. **Provide reasoning** to support your claims based on the position of the PDC-catalyzed reaction in the sequence of the cellular respiration pathway.

(c) PDC deficiency is caused by mutations in the *PDHA1* gene, which is located on the X chromosome. A male with PDC deficiency and a homozygous female with no family history of PDC deficiency have a male offspring. **Calculate** the probability that the male offspring will have PDC deficiency.

FRQ Practice -Answer

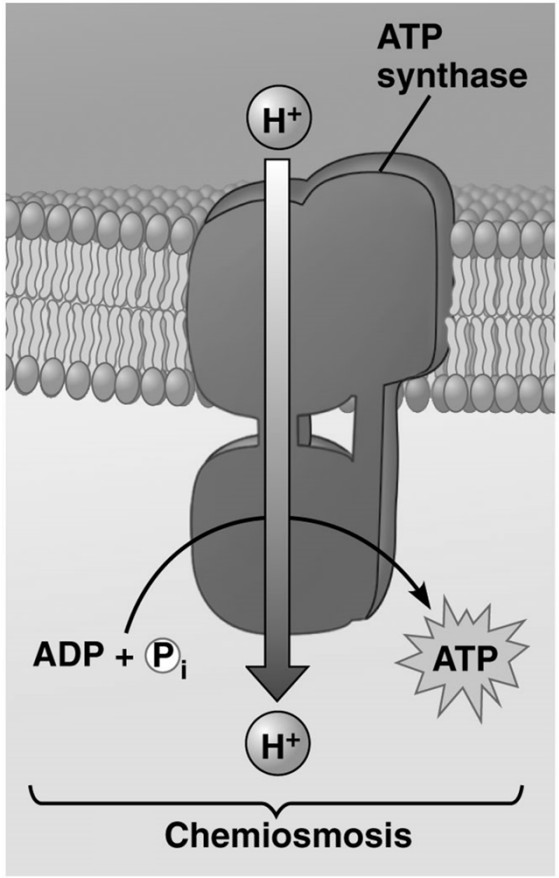
Electron Transport Chain

- Use the image provided to describe the process of the **electron transport chain** in cellular respiration. Be sure to include the terms electronegativity, free energy, and **oxidative phosphorylation**.



Chemiosmosis

- Use the diagram provided to discuss the process of chemiosmosis. Be sure to include the concept of a proton motive force.



Fermentation

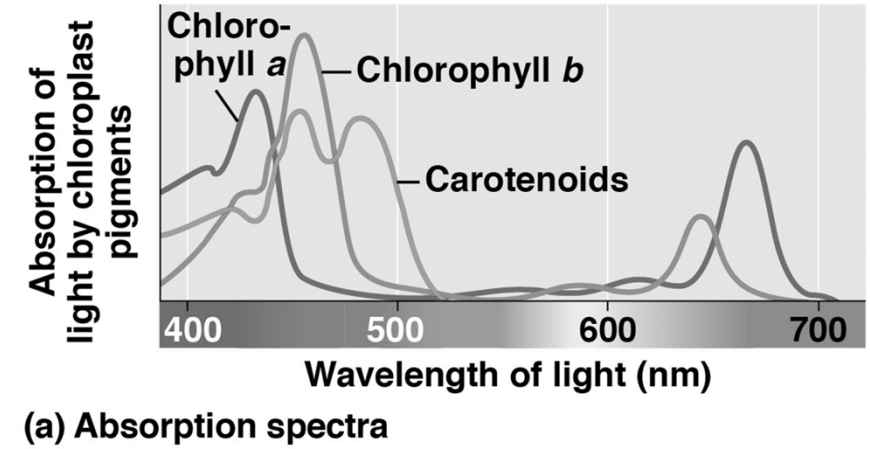
- What is the role of anaerobic respiration/fermentation?

- Identify and describe the two most common types of fermentation. Be sure to include the most common examples of organisms that use them.

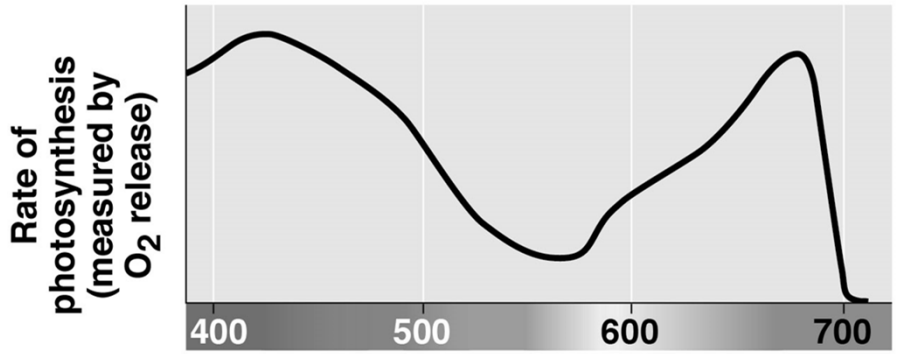
Photosynthetic Pigments

- What do the graphs to the right tell me about the role of the different pigment types in plants?

- Explain the role of these pigments in photoprotection.



(a) Absorption spectra



(b) Action spectrum

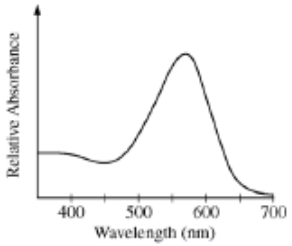
FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

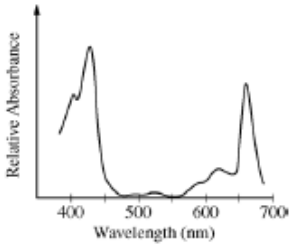
An absorption spectrum indicates the relative amount of light absorbed across a range of wavelengths. The graphs above represent the absorption spectra of individual pigments isolated from two different organisms. One of the pigments is chlorophyll *a*, commonly found in green plants. The other pigment is bacteriorhodopsin, commonly found in purple photosynthetic bacteria. The table above shows the approximate ranges of wavelengths of different colors in the visible light spectrum.

(a) **Identify** the pigment (chlorophyll *a* or bacteriorhodopsin) used to generate the absorption spectrum in each of the graphs above. **Explain** and **justify** your answer.

(b) In an experiment, identical organisms containing the pigment from Graph II as the predominant light-capturing pigment are separated into three groups. The organisms in each group are illuminated with light of a single wavelength (650 nm for the first group, 550 nm for the second group, and 430 nm for the third group). The three light sources are of equal intensity, and all organisms are illuminated for equal lengths of time. **Predict** the relative rate of photosynthesis in each of the three groups. **Justify** your predictions.



Graph I



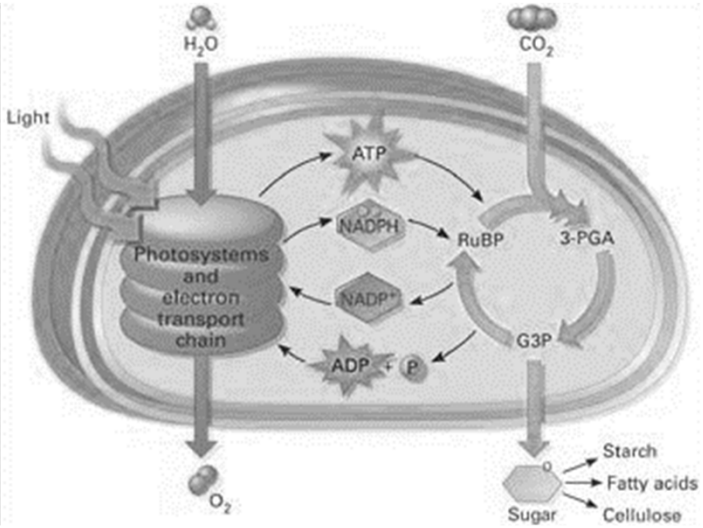
Graph II

Color	Wavelength (nm)
Violet	380–450
Blue	450–475
Cyan	475–495
Green	495–570
Yellow	570–590
Orange	590–620
Red	620–750

FRQ Practice

Photosynthesis

- Describe the basics of the major stages of **photosynthesis** using the image below.



Light Reactions

- What is the role of **chlorophyll** in the light reactions?

- What is a **photosystem**?

- How does photosynthesis produce ATP?

Calvin Cycle

- Identify and describe the three major stages of the **Calvin Cycle**.

- Why is the basic form of photosynthesis called C_3 **Photosynthesis**?

- How is the **G3P** produces by the Calvin Cycle used?

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink

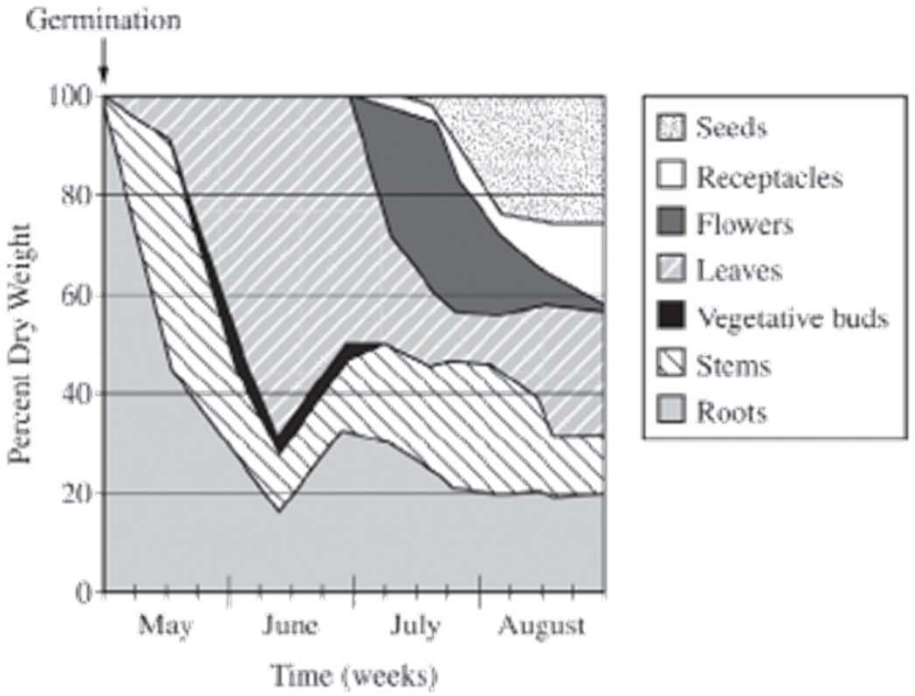


Figure 1. Percent dry weight of different plant structures during the growing season for an annual plant

The graph above illustrates the percent dry weight of different parts of a particular annual plant (plants that live less than one year) from early May to late August. The percent dry weight can be used to estimate the amount of energy a plant uses to produce its leaves, vegetative buds, stems, roots, and reproductive parts (seeds, receptacles, and flowers).

(a) **Identify** the direct source of the energy used for plant growth during the first week of May, and **identify** the part of the plant that grew the most during the same period.

(b) Based on the data on the graph, **estimate** the percent of the total energy that the plant has allocated to the growth of leaves on the first day of July.

FRQ Practice -Answer

Evolution of Photosynthesis

- Explain the process of **photorespiration**.

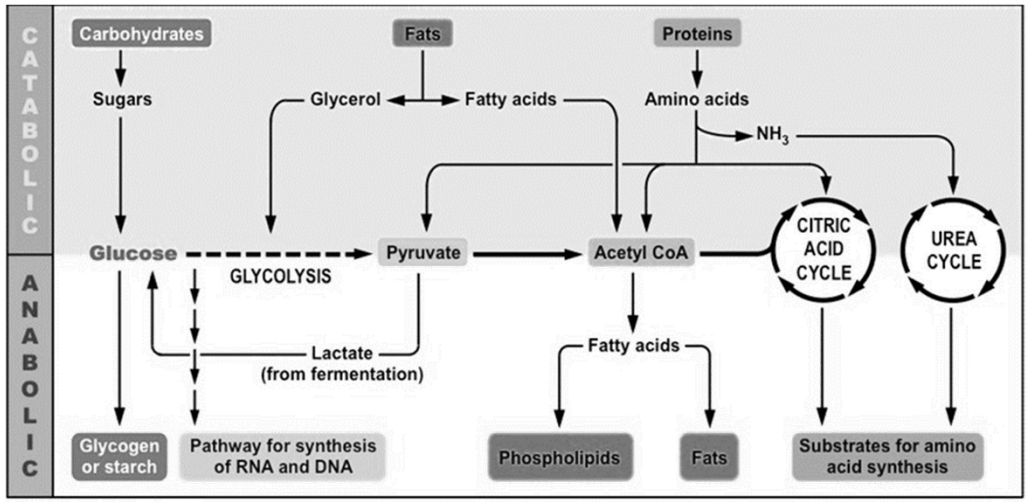
- Describe three physical adaptations that plants have evolved to conserve water.

- Compare and contrast **CAM** and **C_4 Photosynthesis**.

Connecting Catabolism to Anabolism

- What is **metabolism**?

- Explain the image provided and its importance in maintaining your body and metabolism.



Energy Shapes Evolution

- It can be said that energy shapes evolution. Provide an example of this for…
  - Prokaryotes
  - Plants
  - Animals

IE: Fitness & Energetics

- The following are illustrative examples provided by CB. Research and explain each of the following and how it connects concepts of energetics and evolution.
  - Different types of **phospholipids** (& amounts of cholesterol) in cell membranes allow the organisms flexibility to adapt to different environmental temperatures.
  - Different types of **hemoglobin** maximize oxygen absorption in organisms at different developmental stages.
  - Different **chlorophylls** (& accessory pigments) give the plant greater flexibility to exploit/absorb incoming wavelengths of light for photosynthesis.

Homeostasis & Feedback

- Define **homeostasis**.

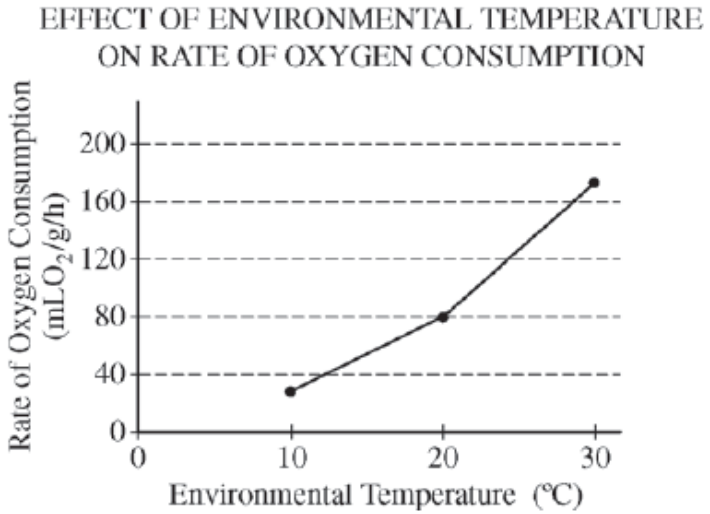
- Provide an example of a **positive** and a **negative feedback loop** that helps maintain homeostasis.

IE: Feedback

- The following are illustrative examples provided by CB. Research and explain each of the following and how it connects concepts of feedback in the human body.
  - Blood sugar regulation by **insulin/glucagon**
  - **Lactation** in mammals
  - Onset of **labor** in childbirth

FRQ Practice

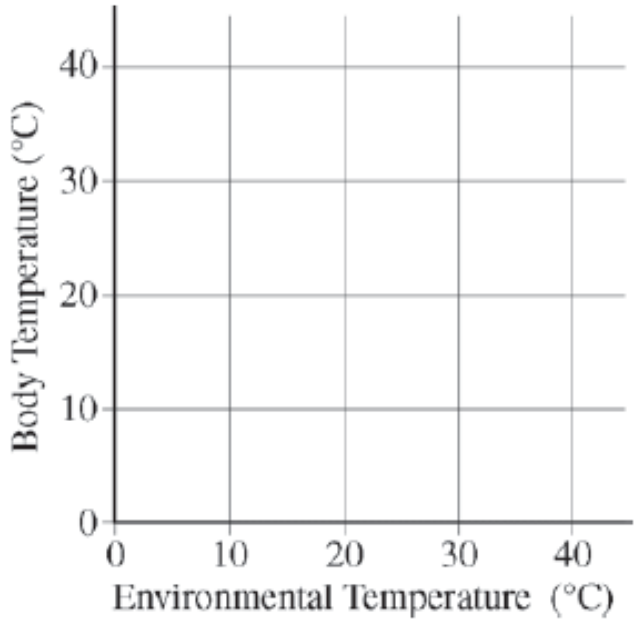
- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.



(a) Based on the graph, **describe** a specific method of thermoregulation used by the species of animal. **Provide** support for your answer using the data.

(b) On the labeled axis provided below, **draw** a line to indicate the most likely relationship between body temperature and environmental temperature in the species.

FRQ Practice - Answer



Cell Signaling & Communication

- Define the following…
  - Autocrine Signaling
  - Juxtracrine Signaling
  - Paracrine Signaling
  - Endocrine Signaling
  - Synaptic Signaling

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

Smell perception in mammals involves the interactions of airborne odorant molecules from the environment with receptor proteins on the olfactory neurons in the nasal cavity. The binding of odorant molecules to the receptor proteins triggers action potentials in the olfactory neurons and results in transmission of information to the brain. Mammalian genomes typically have approximately 1,000 functional odorant-receptor genes, each encoding a unique odorant receptor.

(a) **Describe** how the signal is transmitted across the synapse from an activated olfactory sensory neuron to the interneuron that transmits the information to the brain.

(b) **Explain** how the expression of a limited number of odorant receptor genes can lead to the perception of thousands of odors. Use the evidence about the number of odorant receptor genes to **support** your answer.

FRQ Practice -Answer

Stages of Cell Signaling

- Diagram and describe the three major stages of **cell signaling**.

- What does the receptor's location tell you about the ligand?

Reception

- Describe the basic function of the following receptor types:
  - Ligand/Voltage-Gated Ion Channel
  - G Protein-Coupled Receptor
  - Protein Kinase Receptor
  - Intracellular Receptor

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

. Estrogens are small hydrophobic lipid hormones that promote cell division and the development of reproductive structures in mammals. Estrogens passively diffuse across the plasma membrane and bind to their receptor proteins in the cytoplasm of target cells.

(a) **Describe** ONE characteristic of the plasma membrane that allows estrogens to passively cross the membrane.

(b) In a laboratory experiment, a researcher generates antibodies that bind to purified estrogen receptors extracted from cells. The researcher uses the antibodies in an attempt to treat estrogen-dependent cancers but finds that the treatment is ineffective. **Explain** the ineffectiveness of the antibodies for treating estrogen-dependent cancers.

FRQ Practice -Answer

Transduction

- Describe a **phosphorylation cascade**.

- What is the role of a **secondary messenger**?

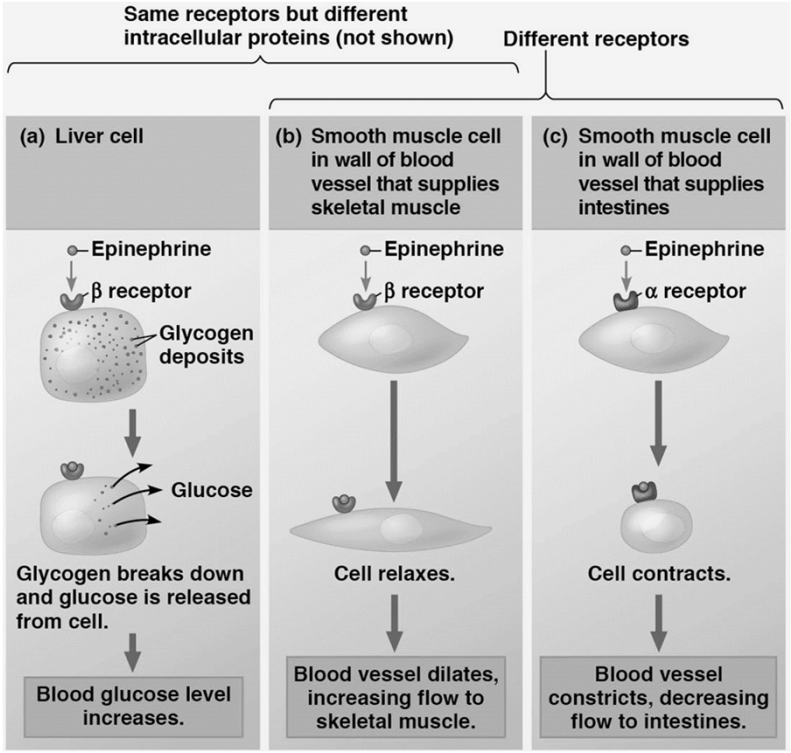
- What are the key advantages to the complexity of many **transduction pathways**?

IE: Cell Communication

- The following are illustrative examples provided by CB. Research and explain each of the following and how it connects concepts of cell communication.
  - Immune cells interact by **cell-to-cell contact**, **antigen-presenting cells**, **helper T-cells**, and **killer T-cells**.
  - Cell communication often depends on cell communication using local regulators such as **morphogens** in embryonic development.

IE: One Hormone, Different Effects

- Signals releases by one cell type can travel long distances to target cells of another type. The diagram provided relates this to the **epinephrine** pathway. Research the types of cells that another hormone effects such as **insulin**, **human growth hormone**, **testosterone**, or **estrogen**.

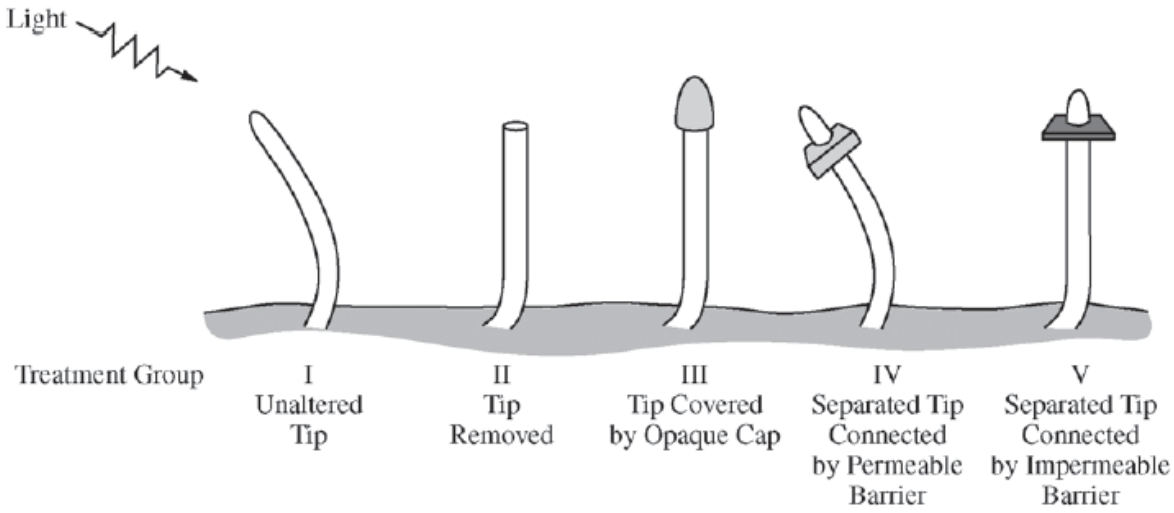


IE: Cell Communication

- The following are illustrative examples provided by CB. Research and explain each of the following and how it connects concepts of signal transduction & cell communication.
  - Use of chemical messengers by microbes to communicate with other nearby cells and to regulate specific pathways in response to population density (**quorum sensing**).
  - **HOX genes** and their role in **development**.

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.



Phototropism in plants is a response in which a plant shoot grows toward a light source. The results of five different experimental treatments from classic investigations of phototropism are shown above.

(a) **Give support** for the claim that the cells located in the tip of the plant shoot detect the light by comparing the results from treatment group I with the results from treatment group II and treatment group III.

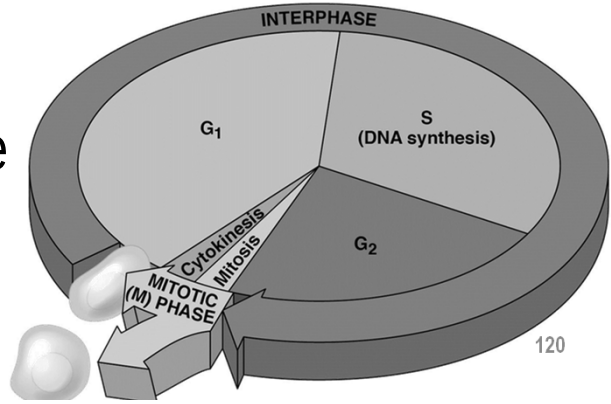
(b) In treatment groups IV and V, the tips of the plants are removed and placed back onto the shoot on either a permeable or impermeable barrier. Using the results from treatment groups IV and V, **describe** TWO additional characteristics of the phototropism response.

FRQ Practice -Answer

Cell Cycle

- Describe the basic stages of the **Cell Cycle** using the diagram provided.

- What would be the result of a cell that completed the cell cycle but did not undergo cytokinesis?



Mitosis

- Identify & describe the 5 major stages of **mitosis**.

- What is the role of **motor proteins** in mitosis?

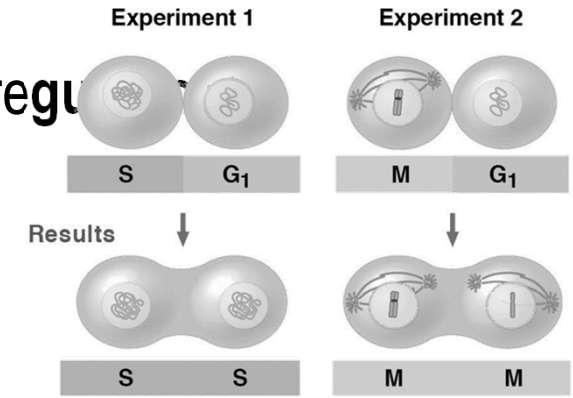
Cytokinesis

- How is **cytokinesis** different from mitosis?

- How is cytokinesis different in animals and plants?

Cell Cycle Regulation

- What does the provided image demonstrate about **cell cycle regu**



- Identify and describe the three major **checkpoints** of the cell cycle.

Cell Cycle Regulation

- Explain the role of CDK & Cyclin in cell cycle regulation.

- Explain the role of MPF in cell cycle regulation.

- Explain the role of APC/C in cell cycle regulation.

Growth Factors

- Explain the role of **growth factors** in the control of the cell cycle.

- Define **density-dependent inhibition**.

- Define **anchorage dependence**.

Cancer

- Why is **cancer** considered uncontrolled cellular growth?

- Define **oncogenes**.

- Define **tumor suppressor genes**.

Cancer

- Diagram how mutations in the **p53** and **Ras** pathways can lead to cancer.

Asexual Reproduction

- What are the advantages and disadvantages of **asexual reproduction**?

- Identify and describe three methods of asexual reproduction.

Horizontal Gene Transfer

- Identify and describe the three major methods of **horizontal gene transfer** in bacteria.

- How does the **lytic** & **lysogenic cycle** of viruses relate to horizontal gene transfer?

Sexual Reproduction

- What are the advantages and disadvantages of **sexual reproduction**?

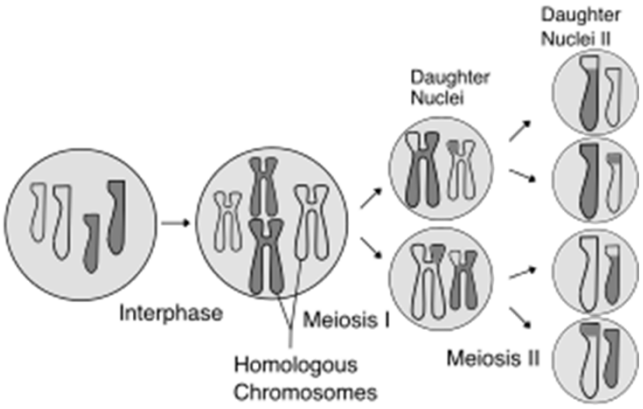
- Define **gamete**:

- **Haploid** vs. **Diploid**:

- Define **zygote**:

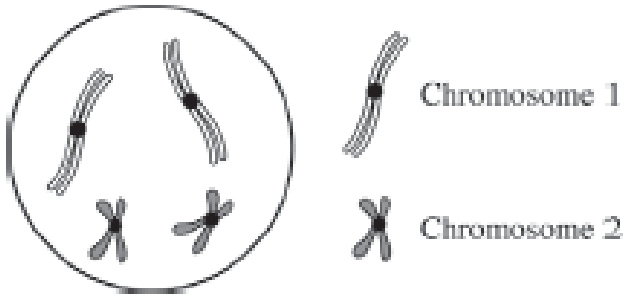
Meiosis

- Describe the basic processes of **meiosis** using the diagram provided.



FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink



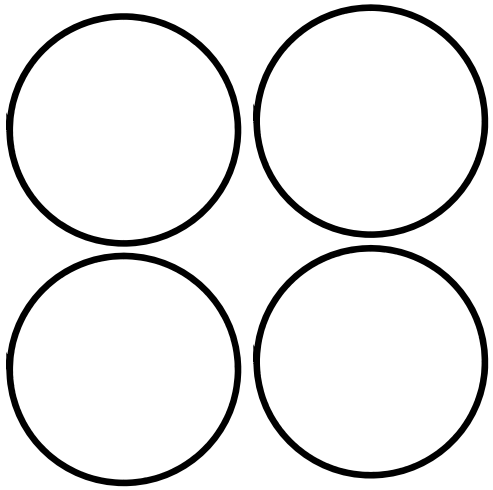
In a certain species of plant, the diploid number of chromosomes is 4 (2n = 4). Flower color is controlled by a single gene in which the green allele (*G*) is dominant to the purple allele (*g*). Plant height is controlled by a different gene in which the dwarf allele (*D*) is dominant to the tall allele (*d*). Individuals of the parental (P) generation with the genotypes *GGDD* and *ggdd* were crossed to produce F_1 progeny.

(a) **Construct** a diagram below to depict the four possible normal products of meiosis that would be produced by the F_1 progeny. Show the chromosomes and the allele(s) they carry. Assume the genes are located on different chromosomes and the gene for flower color is on chromosome 1.

(b) **Predict** the possible phenotypes and their ratios in the offspring of a testcross between an F_1 individual and a *ggdd* individual.

(c) If the two genes were genetically linked, **describe** how the proportions of phenotypes of the resulting offspring would most likely differ from those of the testcross between an F_1 individual and a *ggdd* individual.

FRQ Practice Answer



Sources of Variation

- Identify and describe the three sources of **variation** from sexual reproduction.

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

Both mitosis and meiosis are forms of cell division that produce daughter cells containing genetic information from the parent cell.

(a) **Describe** TWO events that are common to both mitosis and meiosis that ensure the resulting daughter cells inherit the appropriate number of chromosomes.

(b) The genetic composition of daughter cells produced by mitosis differs from that of the daughter cells produced by meiosis. **Describe** TWO features of the cell division processes that lead to these differences.

FRQ Practice -Answer

Gametogenesis

- Diagram and describe the differences between **spermatogenesis** and **oogenesis**.

Meiotic Errors

- Define **nondisjunction**:

- Define **aneuploidy**:

- Identify the one **autosomal** and one **allosomal** aneuploidy:

- Define **polyploidy**:

Chromosomal Alterations

- Diagram and describe the four most common **chromosomal alterations**.
  - o Deletion
  - o Duplication
  - o Inversion
  - o Translocation

Mitosis vs. Meiosis

- Diagram and describe the major similarities and differences between **mitosis** and **meiosis**.

Mendelian Genetics

- Define the following terms:
  - Gene
  - Allele
  - Locus
  - Phenotype
  - Genotype

Mendelian Genetics

- Describe the three principles of Mendelian genetics:
  - Dominance
  - Segregation
  - Independent Assortment

Punnett Square

- Create a **monohybrid** and **dihybrid heterozygous Punnett square** in the space below and describe the results.

Quantitative Skills (Show Work)

- Wisconsin Fast Plants have two very distinctive visible traits (stems and leaves). Each plant will either have a purple (P) or green (p) stem and also have either have green (G) or yellow (g) leaves. Suppose that we cross a dihybrid heterozygous plant with another plant that is homozygous purple stem and heterozygous for the leaf trait. Make a Punnett square to figure out the expected ratios for the phenotypes of the offspring.

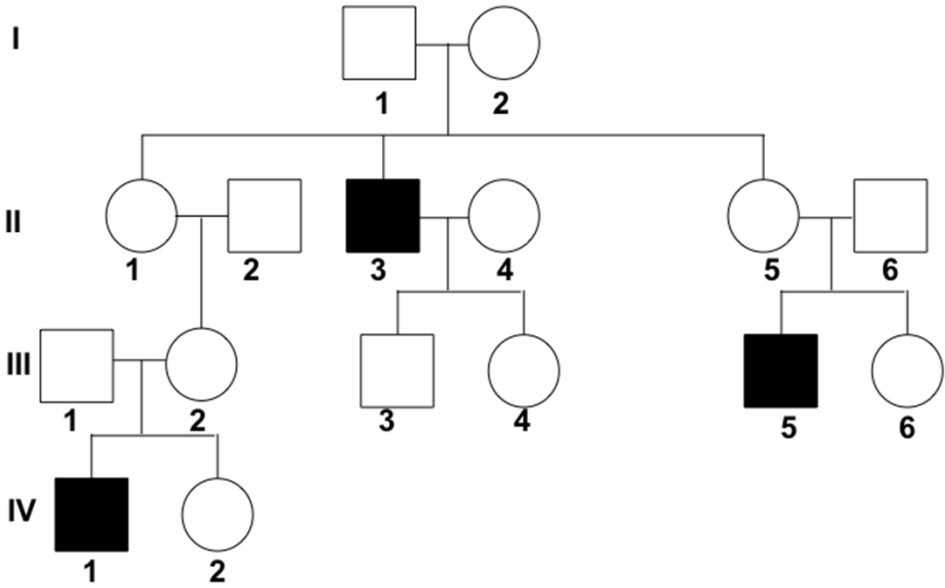
- Suppose a class observed that there were 234 plants that were purple stem/green leaves and 42 that were purple stem/yellow leaves. Does this provide good evidence against the predicted phenotype ratio?

Rules of Probability

- Explain how the **rules of probability** can be used to solve complex genetics calculations and create (and answer) an example problem in the space below.

Pedigree Charts

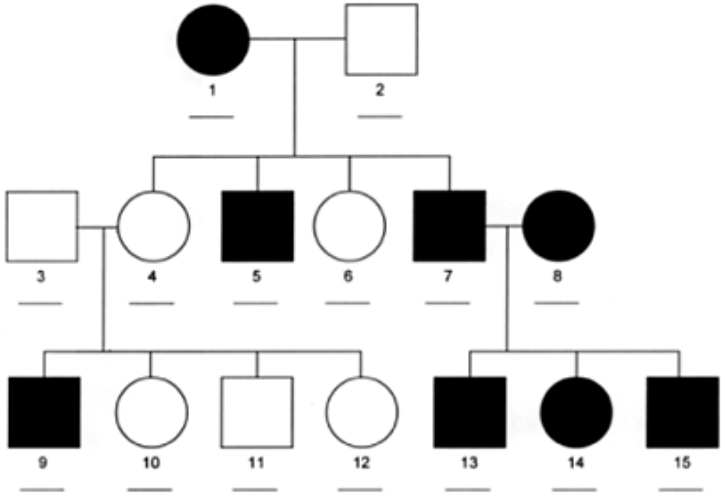
- What do the symbols of a pedigree chart mean

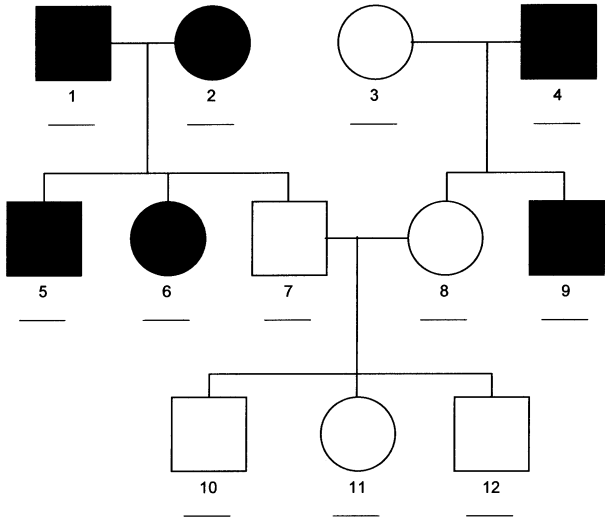


- State whether the trait is **dominant** or **recessive**, and explain your reasoning.

- State whether the trait is **sex linked/allosomal** or **autosomal**, and explain your reasoning.

Pedigree Charts





- State whether the trait for each is **dominant** or **recessive**, and explain your reasoning.

- State whether the trait for each is **allosomal** or **autosomal**, and explain your reasoning.

Non-Mendelian Genetics

- Describe and provide an example of each of the following:
  - Incomplete Dominance
  - Codominance
  - Multiple Alleles

Non-Mendelian Genetics

- Describe and provide an example of each of the following:
  - Epistasis
  - Polygenic Inheritance
  - Pleiotropy

IE: Non-Mendelian Genetics

- The following are illustrative examples provided by CB. Research and explain each of the following and how it connects concepts of non-mendelian genetics.
  - In mammals and flies, females are XX and males are XY; as such, X-linked recessive traits are much more likely to be expressed in males.
  - In certain species, the chromosomal basis of sex determination is not based on X and Y chromosomes (ex. birds & bees)

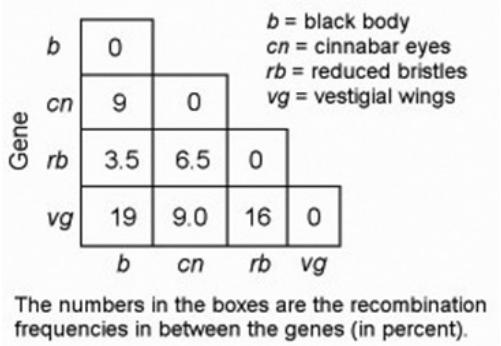
Genetics Practice Problems

1. How many unique gametes could be produced through independent assortment of the genotype AaBbCCDdEEFf? Why?

2. Albinism is a recessive trait. A man and woman both show normal pigmentation, but both have one parent who has albinism. What is the probability that their first child will have albinism? Their second? Why?

3. Gray seed color in peas is dominant to white. Assume that Mendel conducted a series of experiments where plants with gray seeds were crossed among themselves, and the following progeny were produced: 302 gray and 98 white. What is the most probable genotype of each parent? Why?

4. Create a linear chromosome map using the data provided.



Linked Genes & Recombination

- What does it mean to say that two genes are **linked**?

- How do you calculate **recombination frequency**?

Non-nuclear Inheritance

- What other organelles can provide genetic material?
- Why do these organelles have their own genetic material?
- How does this type of inheritance show itself in a pedigree chart?

Environmental Effect on Traits

- Define phenotypic plasticity:

- Identify three examples of how the environment can influence traits both directly and indirectly.

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink

In the tongue sole fish (*Cynoglossus semilaevis*), sex is determined by a combination of genetics and environmental temperature. Genetically male fish have two Z chromosomes (ZZ), and genetically female fish have one Z chromosome and one W chromosome (ZW). When fish are raised at 22°C, ZZ fish develop into phenotypic males and ZW fish develop into phenotypic females. However, when fish are raised at 28°C, the Z chromosome is modified (denoted as Z*). Z*W individuals develop as phenotypic males that are fertile and can pass on the Z* chromosome to their offspring even when the offspring are raised at 22°C. A cross between a ZW female and a Z*Z male is shown in the Punnett square below.

	Z	W
Z*	Z* Z	Z* W
Z	Z Z	Z W

(a) **Predict** the percent of phenotypic males among the F_1 offspring of the cross shown in the Punnett square if the offspring are raised at 22°C.

(b) At least one Z or Z* chromosome is necessary for survival of the fish. A researcher crossed two fish and observed a 2:1 ratio of males to females among the offspring. Based on the information, **identify** the genotype of the male parent in the cross. **Describe** ONE fitness cost to the female of mating with this particular male.

FRQ Practice -Answer

IE: Chromosomal Inheritance

- The following are illustrative examples provided by CB. Research and explain each of the following and how it connects concepts chromosomal inheritance and human genetic disorders.
  - Sickle Cell Anemia
  - Tay-Sachs Disease
  - Huntington's Disease
  - X-linked Color Blindness
  - Trisomy 21/Down Syndrome

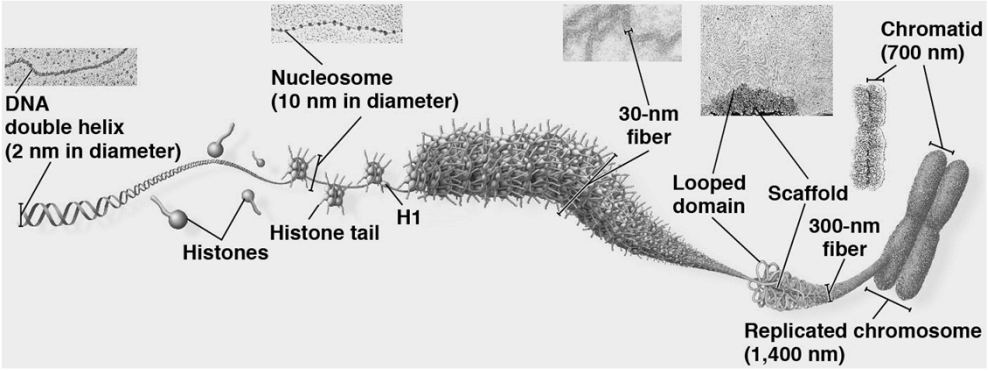
Epigenetics

- What is epigenetics?

- Describe the effects of the following epigenetic changes:
  - Methylation
  - Acetylation
  - Phosphorylation

Eukaryotic Chromosome

- Describe the major stages of the packaging of the eukaryotic chromosome.



The Race for the Double Helix

- Describe the process and the conclusions of each of the following experiments:
  - Griffith
  - Avery, McCarthy, & MacLeod
  - Chargaff

The Race for the Double Helix

- Describe the process and the conclusions of each of the following experiments:
  - Hershey & Chase
  - Watson & Crick (+ Franklin & Wilkins)
  - Meselson & Stahl

DNA Replication

- Describe the role of the following proteins & enzymes in DNA Replication:
  - Initiation Protein
  - Helicase
  - Topoisomerase
  - Single-strand Binding Proteins
  - Primase

DNA Replication

- Describe the role of the following proteins & enzymes in DNA Replication:
  - DNA polymerase III
  - DNA polymerase I
  - Endonuclease
  - Ligase

DNA Replication

- Describe the general process of DNA replication. Be sure to include the terms **leading strand**, **lagging strand**, **Okazaki fragments**, and **semiconservative**.

DNA Replication

- Compare and contrast DNA replication in prokaryotes & eukaryotes.

Telomeres

- What is a **telomere**?

- Why does DNA replication of a linear chromosome have trouble replicating telomeres?

- What is the role of **telomerase** in the human body?

Ribonucleic Acids

- Identify the major function of the following types of RNA:
  - mRNA
  - rRNA
  - tRNA
  - snRNA
  - miRNA
  - siRNA
  - piRNA

Transcription

- Describe the general process of transcription in eukaryotes. Be sure to include the terms initiation, elongation, termination, downstream, promoter, transcription, RNA polymerase II, template strand, coding strand, pre-mRNA

RNA Processing

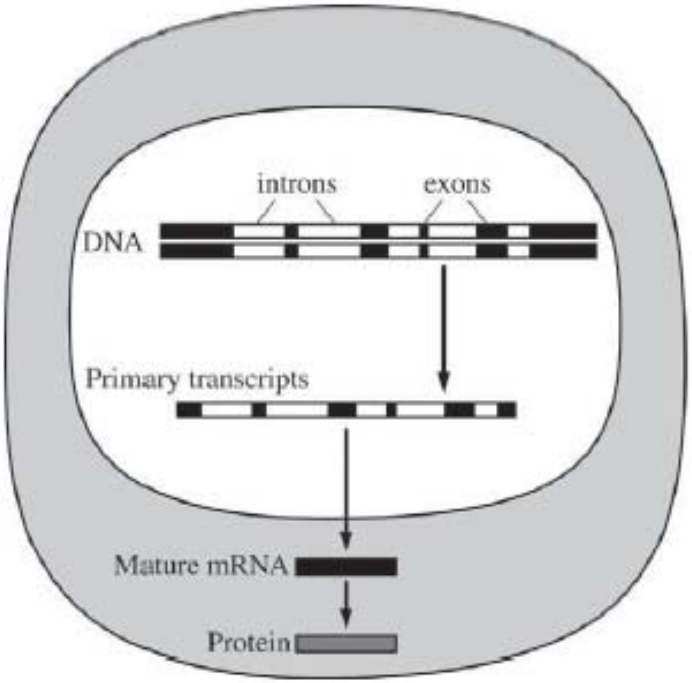
- What are the three major steps of **eukaryotic** RNA **processing**?

- Describe the process of **splicing**.

- Why is RNA processing important for eukaryotes?

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.



The figure represents the process of expression of gene *X* in a eukaryotic cell.

(a) The primary transcript in the figure is 15 kilobases (kb) long, but the mature mRNA is 7 kb in length. **Describe** the modification that most likely resulted in the 8 kb difference in length of the mature mRNA molecule. **Identify** in your response the location in the cell where the change occurs.

(b) **Predict** the length of the mature gene *X* mRNA if the full-length gene is introduced and expressed in prokaryotic cells. **Justify** your prediction.

FRQ Practice -Answer

Translation

- Describe the general process of **translation** in eukaryotes. Be sure to use the terms **ribosomal subunits**, **tRNA**, **amino acid**, **methionine**, **codon**, **anticodon**, **translation initiation complex**, **GTP**, **peptide bond**, **polypeptide**, **stop codon** & **release factor**.

Transcription & Translation in Prokaryotes

- Describe the major differences between prokaryotic and eukaryotic transcription & translation.

Prokaryotic Gene Regulation - Trp Operon

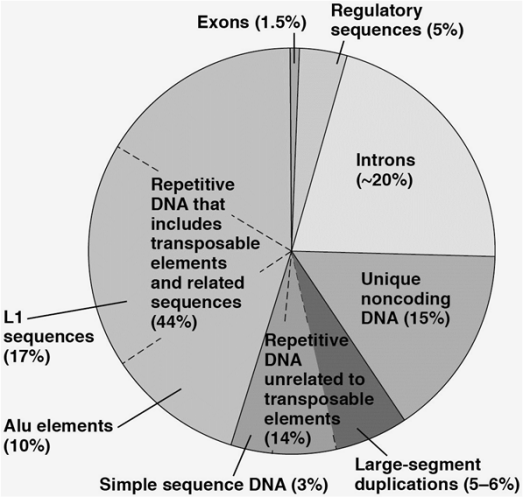
- Diagram and describe the major components & processes involved in the operation of this operon.

Prokaryotic Gene Regulation - Lac Operon

- Diagram and describe the major components & processes involved in the operation of this operon. Be sure to include the concept of upregulation.

The Human Genome

- Describe the major groups within the human genome using the diagram provided.



Eukaryotic Gene Regulation

- Eukaryotes rely upon many levels of **gene regulation** to control the genetic process of multicellular organisms. Describe the method of regulation for each of the indicated levels of control provided.
  - o Chromatin Modification
  - o Transcription
  - o RNA Processing

Eukaryotic Gene Regulation

- Eukaryotes rely upon many levels of **gene regulation** to control the genetic process of multicellular organisms. Describe the method of regulation for each of the indicated levels of control provided.
  - mRNA Degradation
  - Translation
  - Protein Processing & Degradation

Gene Mutations

- Describe what happens in each of the following gene mutations:
  - Substitution (Silent)
  - Substitution (Missense)
  - Substitution (Nonsense)
  - Frameshift (Insertion/Deletion)

IE: Mutations

- The following are illustrative examples provided by CB. Research and explain each of the following and how it connects to the concepts of how changes in genotype can result in changes to phenotype and that mutations can be positive, negative, or neutral.
  - Mutations in the CFTR gene disrupt ion transport and result in cystic fibrosis.
  - **Antibiotic resistance** mutations in bacteria.
  - **Sickle Cell Disorder & Heterozygote Advantage**

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink

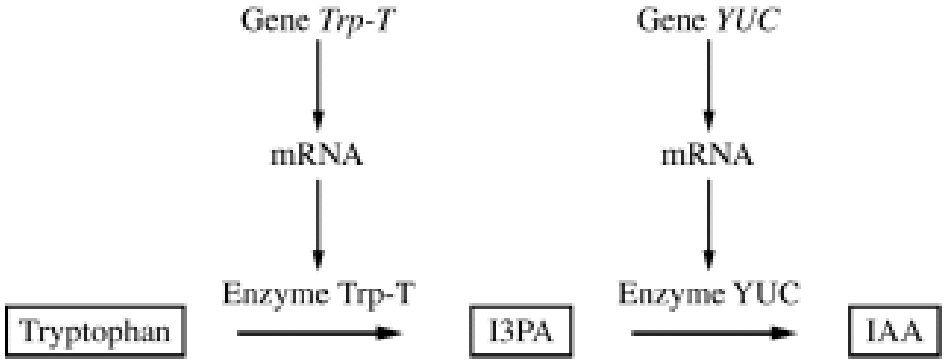


Figure 1. Model of two-step enzymatic plant pathway for synthesis of IAA from tryptophan

Auxins are plant hormones that coordinate several aspects of root growth and development. Indole-3-acetic acid (IAA) is an auxin that is usually synthesized from the amino acid tryptophan (Figure 1). Gene *Trp-T* encodes an enzyme that converts tryptophan to indole-3-pyruvic acid (I3PA), which is then converted to IAA by an enzyme encoded by the gene *YUC*.

(a) **Circle** ONE arrow that represents transcription on the template pathway. **Identify** the molecule that would be absent if enzyme YUC is nonfunctional.

(b) **Predict** how the deletion of one base pair in the fourth codon of the coding region of gene *Trp-T* would most likely affect the production of IAA. **Justify** your prediction.

(c) **Explain** one feedback mechanism by which a cell could prevent production of too much IAA without limiting I3PA production.

FRQ Practice -Answer

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

The table below shows the amino acid sequence of the carboxyl-terminal segment of a conserved polypeptide from four different, but related, species. Each amino acid is represented by a three-letter abbreviation, and the amino acid residues in the polypeptide chains are numbered from the amino end to the carboxyl end. Empty cells indicate no amino acid is present.

	Relative Amino Acid Position									
Species	1	2	3	4	5	6	7	8	9	10
I	Val	His	Leu	Val	Glu	Glu	His	Val	Glu	His
II	Val	His	Leu	Lys	Glu	Glu	His	Val	Glu	His
III	Val	His	Leu	Val	Glu	Glu	His	Val		
IV	Val	His	Leu	Val	Arg	Trp	Ala	Cys	Met	Asp

(a) Assuming that species I is the ancestral species of the group, **explain** the most likely genetic change that produced the polypeptide in species II and the most likely genetic change that produced the polypeptide in species III.

(b) **Predict** the effects of the mutation on the structure and function of the resulting protein in species IV. **Justify** your prediction.

FRQ Practice -Answer

Biotechnology

- How is **artificial selection** (ex. **selective breeding/hybridization**) different from **genetic modification**?

- What is a **recombinant organism**?

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

Genetically modified crops have been developed that produce a protein that makes the plants resistant to insect pests. Other genetic modifications make the crops more resistant to chemicals that kill plants (herbicides).

(a) **Describe** TWO potential biological risks of large-scale cultivation and use of such genetically modified plants.

(b) For each of the risks you described in part (a), **propose** a practical approach for reducing the risk.

FRQ Practice -Answer

Biotechnology - Transformation

- Describe the process of **transformation** in regards to its application to biotechnology. Be sure to include the terms **plasmid**, **vector**, **restriction enzyme**, **sticky ends**, **ligase**.

- Provide two examples of how this process could provide useful results in the real world.

Biotechnology - Cloning

- Describe the process behind the following types of **cloning**:
  - Natural Cloning
  - Gene Cloning
  - Organismal Cloning
- Why is PCR considered a more efficient option than gene cloning in some situation?

Biotechnology – DNA Sequencing

- Describe the **Sanger Method** of DNA sequencing. What are the pros/cons?

- Describe the **"Shotgun" Method** of DNA sequencing. What are the pros/cons?

- Why is sequencing of DNA an important tool of biotechnology?

Biotechnology - Electrophoresis

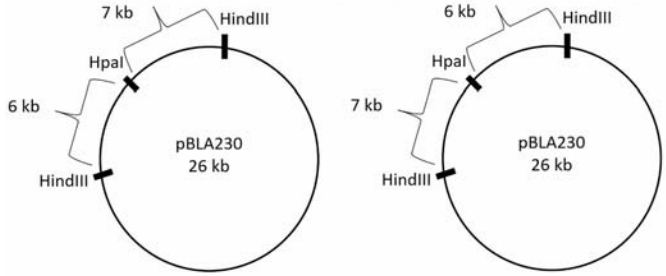
- Explain the process of **gel electrophoresis**.

- What is the importance of **DNA Fingerprinting** of **RFLPs** & **STRs** in regards to the analysis of an electrophoresis gel.

Biotechnology – Restriction Digest

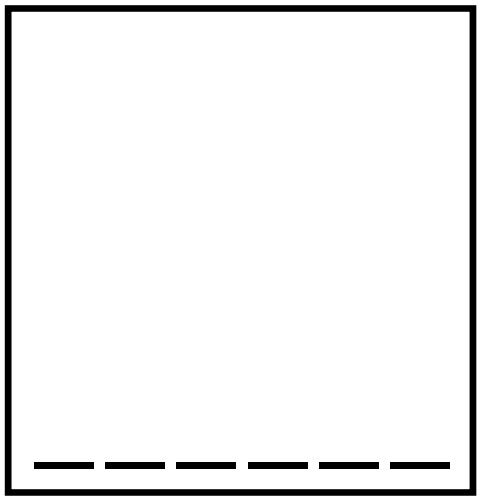
- A **restriction digest** has been performed on the plasmid provided below. What does this mean?

Digest Performed	Size of Fragments Obtained
HpaI	26 kb
HindIII	13 kb, 6 kb, 4 kb, 3 kb
HpaI + HindIII	7 kb, 6 kb (2), 4 kb, 3 kb



- Why does the provided plasmid interpretation have two possible results? What could be done to discover which map is correct?

- Create a diagram of what the electrophoresis gel would look like if the DNA ladder cut at 25, 20, 15, 10, & 5 kb. There should be a lane for the ladder, each single digest, and the double digest.



Biotechnology

- There are many advanced processes and applications of biotechnology. Describe the basic process and utilization of each of the following:
  - CRISPR
  - cDNA
  - iPS
  - Retroviral Vectors

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

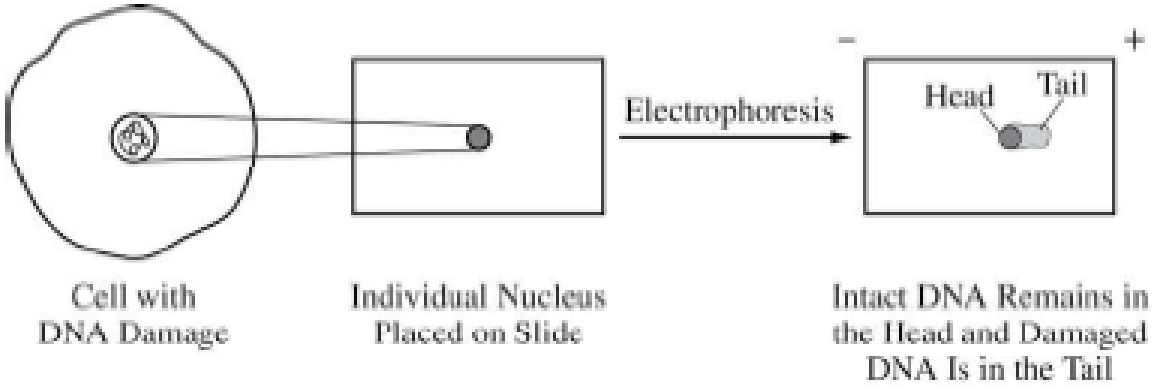


Figure 1. Comet assay to detect double-stranded breaks in DNA

A comet assay is a technique used to determine the amount of double-strand breaks in DNA (DNA damage) in cells. The nucleus of an individual cell is placed on a microscope slide coated with an agarose gel. An electric current is applied to the gel that causes DNA to move (electrophoresis), and the DNA is stained with a fluorescent dye. When viewed using a microscope, undamaged DNA from the nucleus appears as a round shape (the head), and the fragments of damaged DNA extend out from the head (the tail). The length of the tail corresponds to the amount of the damage in the DNA (see Figure 1).

(a) To explain the movement of DNA fragments in the comet assay, **identify** one property of DNA and **provide reasoning** to support how the property contributes to the movement during the comet assay technique.

(b) In a different experiment, cells are treated with a chemical mutagen that causes only nucleotide substitutions in DNA. **Predict** the likely results of a comet assay for this treatment.

FRQ Practice -Answer

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

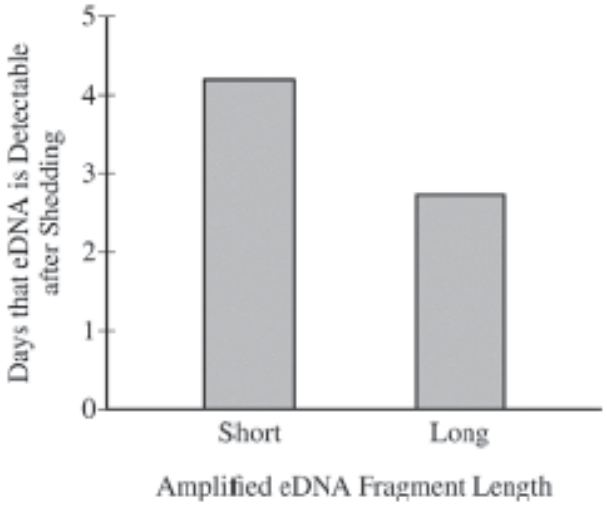


Figure 1. Detectability of eDNA fragments of varying lengths

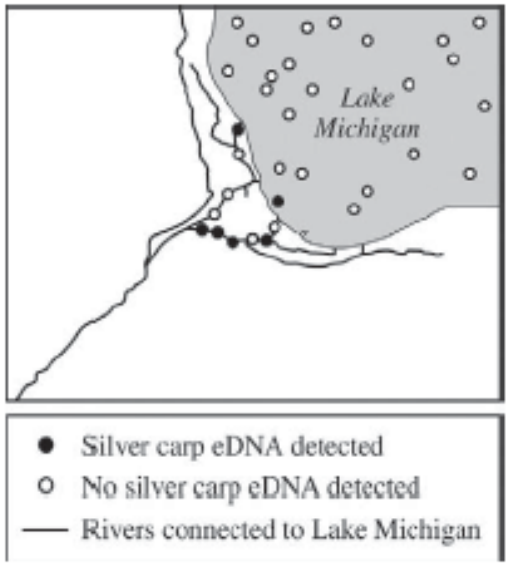


Figure 2. Map of the waterways that connect a nearby river system to Lake Michigan

Living and dead organisms continuously shed DNA fragments, known as eDNA, into the environment. To detect eDNA fragments in the environment, the polymerase chain reaction (PCR) can be used to amplify specific eDNA fragments. eDNA fragments of different lengths persist in the environment for varying amounts of time before becoming undetectable (Figure 1).

To investigate whether silver carp, an invasive fish, have moved from a nearby river system into Lake Michigan, researchers tested water samples for the presence of eDNA specific to silver carp (Figure 2).

(a) **Justify** the use of eDNA sampling as an appropriate technique for detecting the presence of silver carp in an environment where many different species of fish are found. **Propose** ONE advantage of identifying long eDNA fragments as opposed to short fragments for detecting silver carp.

(b) The researchers tested a large number of water samples from Lake Michigan and found eDNA specific to silver carp in a single sample in the lake, as indicated in Figure 2. The researchers concluded that the single positive sample was a false positive and that no silver carp had entered Lake Michigan. **Provide reasoning** other than human error to support the researchers' claim.

FRQ Practice -Answer

Evolutionary Theory

- Describe the contributions of **Thomas Malthus** to evolutionary theory:

- Describe the contributions of **Jean-Baptiste Lamarck** to evolutionary theory:

- Describe the contributions of **Charles Lyell** to evolutionary theory:

Observations & Inferences

- Summarize **Charles Darwin's** theory of **evolution** in terms of his four key observations and the two inferences he made as discussed in our course notes.

- How did Darwin define evolution?

- Define evolution in the modern **Neo-Darwinist/Modern Synthesis** vernacular.

Darwin's Finches

- Darwin's finches speciated due to pressures on the species in the Galapagos Islands. Use the finches to describe the relationship between the following terms: **adaptive radiation**, **competition**, **competitive exclusion**, **character displacement**.

Fitness & Selection

- What does it mean for something to be **evolutionarily fit**?

- Identify and describe the three patterns of **selection** in evolution using the example of the **peppered moth**. How do these patterns compare to the standard bell curve of polygenic traits?

Evolutionary Forces

- Define Natural Selection
- Define Artificial Selection
- Define Sexual Selection
- Define Frequency-Dependent Selection

FRQ Practice

- Complete the following FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

Trichomes are hairlike outgrowths of the epidermis of plants that are thought to provide protection against being eaten by herbivores (herbivory). In a certain plant species, stem trichome density is genetically determined.

To investigate variation in stem trichome density within the plant species, a student counted the number of trichomes on the stems of six plants in each of three different populations. The student used the data to calculate the mean trichome density (numbers of hairs per square centimeter) for each population. The results are provided in the table below.

TRICHOME DENSITY IN THREE PLANT POPULATIONS (number of trichomes/cm^2)

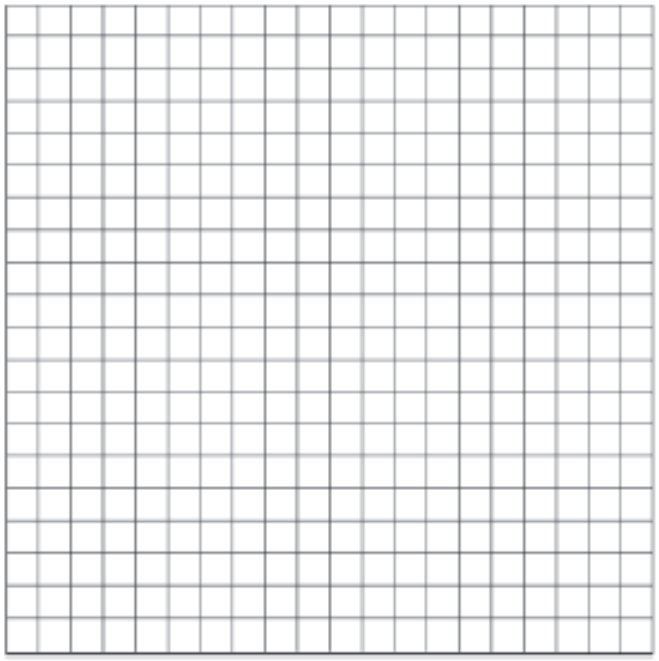
Population	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 6	Mean	Standard Error of the Mean (SEM)
I	8	11	9	10	8	6	9	1
II	12	6	15	9	13	8	11	1
III	13	17	9	14	12	16	14	1

(a) On the axes provided, **create** an appropriately labeled graph to illustrate the sample means of the three populations to within 95% confidence (i.e., sample mean ± 2 SEM).

(b) Based on the sample means and standard errors of the means, **identify** the two populations that are most likely to have statistically significant differences in the mean stem trichome densities. **Justify** your response.

(c) **Describe** the independent and dependent variables and a control treatment for an experiment to test the hypothesis that higher trichome density in plants is selected for in the presence of herbivores. **Identify** an appropriate duration of the experiment to ensure that natural selection is measured, and **predict** the experimental results that would support the hypothesis.

FRQ Practice - Answer



Evolutionary Forces

- Define **Genetic Drift**
    - Define **Bottleneck Effect**
    - Define **Founder Effect**
- Define **Gene Flow**

Hardy-Weinberg Equilibrium

- What is the purpose of the Hardy-Weinberg Equilibrium?

- Identify the five conditions of HW Equilibrium. Identify what evolutionary force(s) it counteracts.

Quantitative Skills (Show Work)

- Complete the provided questions and explain your reaso

Researchers observe a large population of birds on a remote island. Birds in the population are found to have either red crest feathers or white crest feathers on their heads. Genetic analysis indicates that the allele for red crest feathers is dominant over the allele for white crest feathers. In a survey of the population, the researchers determine the frequencies of the crest-feather phenotypes. The results of the survey are shown in the table below.

PHENOTYPE FREQUENCIES IN AN ISOLATED BIRD POPULATION	
Phenotype	Number of Individuals
Red crest feathers	11,088
White crest feathers	1,759

Assuming that the bird population is in Hardy-Weinberg equilibrium, what proportion of future populations is expected to be heterozygous for the allele controlling crest feather color? Give your answer as a value between 0 and 1, rounded to two decimal places.

ABO blood type in humans is determined by three alleles of a single gene: I^A, I^B, and i. The I^A and I^B alleles are codominant, and both alleles are completely dominant to the i allele.

Shown in the table are the approximate genotype frequencies of ABO blood types for a large human population.

Phenotype	Genotype	Frequency
Type A	I^AI^A or I^Ai	0.41
Type B	I^BI^B or I^Bi	0.10
Type AB	I^AI^B	0.04
Type O	ii	0.45

The Hardy-Weinberg principle can be applied to a genetic locus with three alleles by using the following equations.

$$p^2 + q^2 + r^2 + 2pq + 2pr + 2qr = 1$$
$$p + q + r = 1$$

Assuming that the population is in Hardy-Weinberg equilibrium with respect to blood type, what is the frequency of the i allele? Give your answer to two decimal places.

In a population of certain frogs in which the allele for brown skin is dominant to the allele for green skin, a drought leads to selection against green-skinned frogs. When the drought ends, 12 percent of the remaining frogs exhibit the green-skin phenotype. If the population is now in Hardy-Weinberg equilibrium, what will be the frequency of the green-skin allele in the next generation? Provide your answer to the nearest hundredth.

Evidence for Evolution

- Summarize the evidence for evolution that comes from the following fields:
  - Anatomy
  - Embryology
  - Biogeography

Evidence for Evolution

- Summarize the evidence for evolution that comes from the following fields:
  - Paleontology

  - Biochemistry/Molecular Biology

  - Continuing Evolution/Experimental Evidence

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

Fossils of lobe-finned fishes, which are ancestors of amphibians, are found in rocks that are at least 380 million years old. Fossils of the oldest amphibian-like vertebrate animals with true legs and lungs are found in rocks that are approximately 363 million years old.

Three samples of rocks are available that might contain fossils of a transitional species between lobe-finned fishes and amphibians: one rock sample that is 350 million years old, one that is 370 million years old, and one that is 390 million years old.

(a) **Select** the most appropriate sample of rocks in which to search for a transitional species between lobe-finned fishes and amphibians. **Justify** your selection.

(b) **Describe** TWO pieces of evidence provided by fossils of a transitional species that would support a hypothesis that amphibians evolved from lobe-finned fishes.

FRQ Practice - Answer

Common Ancestry

- What is LUCA and how does it relate to all life on Earth?

- What are the three domains in our current breakdown of the tree of life?

- What are the six kingdoms in our current breakdown of the tree of life?

Phylogenetic Trees & Cladograms

- What is the difference between a **phylogenetic tree** and a **cladogram**?

- All phylogenetic trees are considered to be hypothesis. There are several methods used to determine which tree is most likely correct. Describe each of the following:
  - Maximum Parsimony

  - Maximum Likelihood

- What type of evidence is the best type of evidence to use to construct a tree?

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

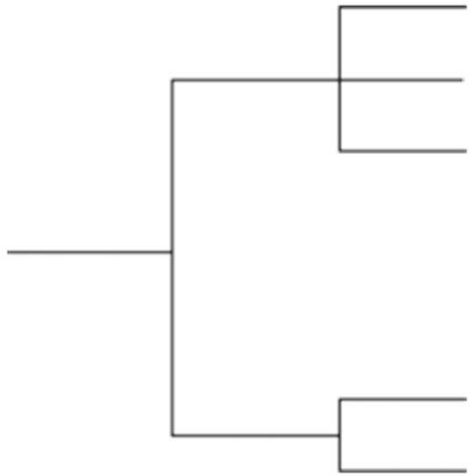
Mammalian milk contains antibodies that are produced by the mother's immune system and passed to offspring during feeding. Mammalian milk also contains a sugar (lactose) and may contain proteins (protein A, protein B, and casein), as indicated in the table.

MILK COMPONENTS IN DIFFERENT MAMMALS

Character	Cat	Cow	Horse	Human	Pig
Lactose	+	+	+	+	+
Protein A	+	+	+	+	+
Protein B	–	+	+	–	+
Casein	–	+	+	–	+
+ indicates the presence of the character, and – indicates the absence of the character					

(a) Using the data in the table, **construct** a cladogram on the template provided to indicate the most likely evolutionary relationships among the different mammals. **Indicate** on the cladogram where each of the characters most likely arose in the evolutionary process, and **justify** the placement of the characters on the cladogram.

FRQ Practice -Answer



What is a species?

- What is the **Biological Species Concept**?

- Identify two other species concepts and describe their function.

- Why are there so many different species concepts?

Speciation

- Define **Speciation**:

- Define **Hybridization**:

- What is the implication of the potential outcomes of hybridization to speciation?

Speciation

- Describe the following four types of speciation:
  - Allopatric
  - Sympatric
  - Parapatric
  - Peripatric

IE: Speciation & Variation

- The following are illustrative examples provided by CB. Research and explain each of the following and how it connects concept that speciation results in diversity of life forms and the importance of variation for species survival.
  - Pick One: Hawaiian *Drosophila*, Caribbean *Anolis*, or Apple maggot *Rhagoletis*.
  - Explain how the Potato Blight shows the importance of variation.

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

A research team has genetically engineered a strain of fruit flies to eliminate errors during DNA replication. The team claims that this will eliminate genetic variation in the engineered flies. A second research team claims that eliminating errors during DNA replication will not entirely eliminate genetic variation in the engineered flies.

(a) **Provide** ONE piece of evidence that would indicate new genetic variation has occurred in the engineered flies.

(b) **Describe** ONE mechanism that could lead to genetic variation in the engineered strain of flies.

(c) **Describe** how genetic variation in a population contributes to the process of evolution in the population.

FRQ Practice -Answer

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

The amino acid sequence of cytochrome *c* was determined for five different species of vertebrates. The table below shows the number of differences in the sequences between each pair of species.

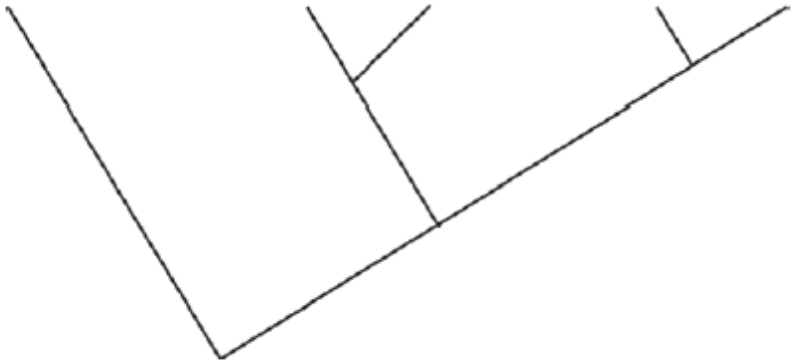
THE NUMBER OF AMINO ACID DIFFERENCES
IN CYTOCHROME *c* AMONG FIVE SPECIES

	E. ferus	*D. polylepis*	*G. gallus*	*A. forsteri*	*E. africanus*
E. ferus	0	21	11	13	1
D. polylepis		0	18	17	20
G. gallus			0	3	10
A. forsteri				0	12
E. africanus					0

(a) Using the data in the table, **create** a phylogenetic tree on the template provided to reflect the evolutionary relationships of the organisms. **Provide reasoning** for the placement on the tree of the species that is least related to the others.

(b) **Identify** whether morphological data or amino acid sequence data are more likely to accurately represent the true evolutionary relationships among the species, and **provide reasoning** for your answer.

FRQ Practice - Answer



Reproductive Barriers

- How do **prezygotic barriers** lead to speciation? Be sure to identify the five types of prezygotic barriers.

- How do **postzygotic barriers** lead to speciation? Be sure to identify the three types of postzygotic barriers.

Evolutionary Patterns

- Microevolution vs. Macroevolution:

- Define and provide an example of divergent evolution:

- Define and provide an example of parallel evolution:

- Define and provide an example of convergent evolution:

Extinction

- What does it mean for a species to become **extinct**?
- How is this different from a species being **extirpated**?
- Why are **endemic species** more vulnerable to extinction?
- How are humans altering extinction rates?

Behavioral Ecology

- Behavioral ecology uses the idea of the **ultimate causation** and the **proximate causation** of behavior. Define these terms and provide a real world example of their application.

Basic Behavioral Terms

- Define **taxis** & **kinesis**:

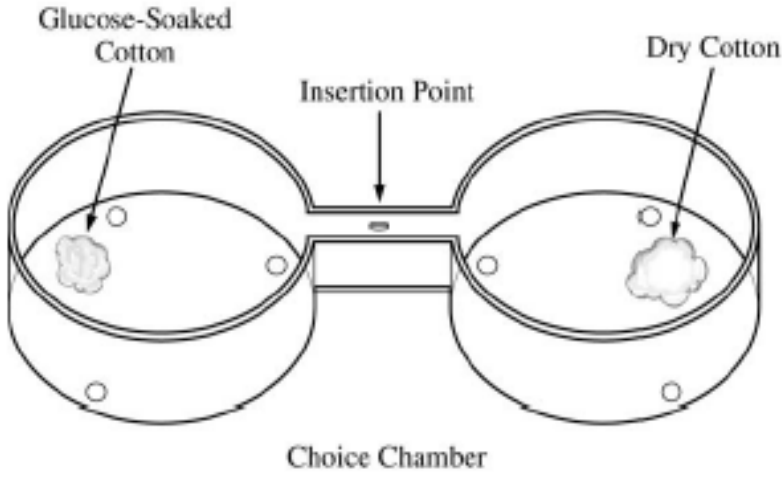
- Provide two specific examples from the real world for both of the previous terms (i.e. positive phototaxis).

- **Nocturnal** vs. **Diurnal**

- **Estivate** vs. **Hibernate**

FRQ Practice (Part 1)

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink



Choice Chamber

In an investigation of fruit-fly behavior, a covered choice chamber is used to test whether the spatial distribution of flies is affected by the presence of a substance placed at one end of the chamber. To test the flies' preference for glucose, 60 flies are introduced into the middle of the choice chamber at the insertion point indicated by the arrow in the figure above. A cotton ball soaked with a 10% glucose solution is placed at one end of the chamber, and a dry cotton ball with no solution is placed at the other end. The positions of flies are observed and recorded every minute for 10 minutes.

(a) **Predict** the distribution of flies in the chamber after 10 minutes and **justify** your prediction.

(b) **Propose** ONE specific improvement to each of the following parts of the experimental design and **explain** how the modification will affect the experiment.

- Experimental control
- Environmental factors

FRQ Practice (Part 2)

- This question continues the previous question.

(c) The experiment described above is repeated with ripe bananas at one end and unripe bananas at the other end. Once again the positions of the flies are observed and recorded every minute for 10 minutes. The positions of flies after 1 minute and after 10 minutes are shown in the table below.

DISTRIBUTION OF FLIES IN CHOICE CHAMBER

Time (minutes)	Position in Chamber		
	End with Ripe Banana	Middle	End with Unripe Banana
1	21	18	21
10	45	3	12

Perform a chi-square test on the data for the 10-minute time point in the banana experiment. **Specify** the null hypothesis that you are testing and **enter** the values from your calculations in the table below.

(d) **Explain** whether your hypothesis is supported by the chi-square test and **justify** your explanation.

(e) Briefly **propose** a model that describes how environmental cues affect the behavior of the flies in the choice chamber.

FRQ Practice – Part 1 Answer

FRQ Practice – Part 2 Answer

PART (C): CHI-SQUARE CALCULATION

Null Hypothesis:			
	Observed (o)	Expected (e)	$(o - e)^2/e$
End with ripe banana			
Middle			
End with unripe banana			
Total			

Plant Behavior

- Define the following types of plant behavior and describe how the behavior is controlled in plants:
  - Photoperiodism
  - Phototropism
  - Gravitropism
  - Thigmotropism

Communication

- Provide an example of communication in the real world that is:
  - Chemical
  - Visual
  - Electrical
  - Tactile

Innate Behavior

- Define **innate behavior**:

- How does this relate to the idea of **instinct**? Provide an example.

- How does this relate to the idea of a **fixed action pattern**? Provide an example.

Learned Behavior

- Describe each of the following types of learned behavior:
  - Imprinting
  - Spatial Learning
  - Habituation

Learned Behavior

- Describe each of the following types of learned behavior:
  - Associative Learning
  - Social Learning
  - Cognition

Social Behavior

- Summarize the following social behavioral patterns:
  - Agonistic Interactions
  - Territoriality
  - Parental Care
  - Altruistic Behavior

Levels of Ecological Interaction

- Describe the meaning of the following levels of **ecological interaction**:
  - Population
  - Community
  - Ecosystem
  - Biosphere

Key Ecological Concepts

- Explain the following key concepts:
  - Keystone Species
  - Foundational Species
  - 10% Rule
- What is the difference between **bioaccumulation** & **biomagnification** in a food chain?

Roles of Organisms

- What is the role of **producers/autotrophs** in the ecosystem?
- What is the role of **consumers/heterotrophs** in the ecosystem?
- What is the role of **decomposers** in the ecosystem?
- What is the differences between a **detritovore** and a decomposer?

Energy Flows, Matter Cycles

- Create a simple **food web** that demonstrates the statement of the title of this slide. Be sure to include the concept of the loss of heat as well as the following terms: **primary producers**, **primary consumers**, **secondary consumers**, **tertiary consumers**, **detritus**, **decomposer**.

- Why do **food chains** typically not go above the **quaternary consumer** level (if that)?

IE: Energy Flow

- The following are illustrative examples provided by CB. Research and explain each of the following and how it connects concept of energy flow through ecosystems.
  - Seasonal reproduction in animals & plants
  - **Life-history strategies** such as biennial plants and **reproductive diapause**
  - **Trophic Pyramids**

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink

DIETARY COMPOSITION OF ORGANISMS IN AN AQUATIC ECOSYSTEM

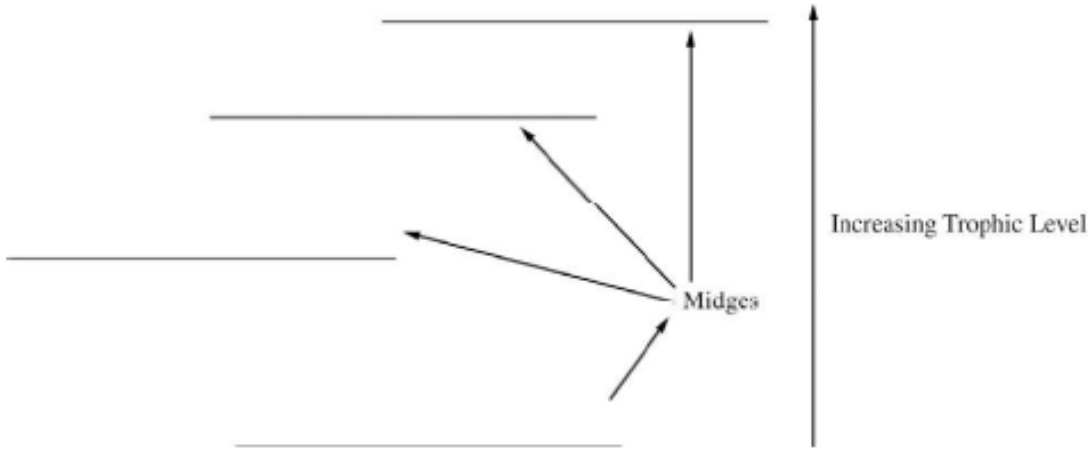
Organism	Food Source (% of diet)				
	Algae	Stoneflies	Midges	Hellgrammites	Caddisflies
Algae					
Stoneflies			90		10
Midges	100				
Hellgrammites		20	10		70
Caddisflies	70		30		

The table above shows how much each organism in an aquatic ecosystem relies on various food sources. The rows represent the organisms in the ecosystem, and the columns represent the food source. The percentages indicate the proportional dietary composition of each organism. High percentages indicate strong dependence of an organism on a food source.

(a) Based on the food sources indicated in the data table, **construct** a food web in the template below. Write the organism names on the appropriate lines AND draw the arrows necessary to indicate the energy flow between organisms in the ecosystem.

(b) In an effort to control the number of midges, an area within the ecosystem was sprayed with the fungus *Metarhizium anisopliae*, which significantly decreased the midge population. Based on the data in the table, **predict** whether the spraying of the fungus will have the greatest short-term impact on the population of the stoneflies, the caddisflies, or the hellgrammites. **Justify** your prediction.

FRQ Practice Answer



Production

- What is **net primary production**? How does this relate to **biomass**?

- How is this different from **gross primary production**?

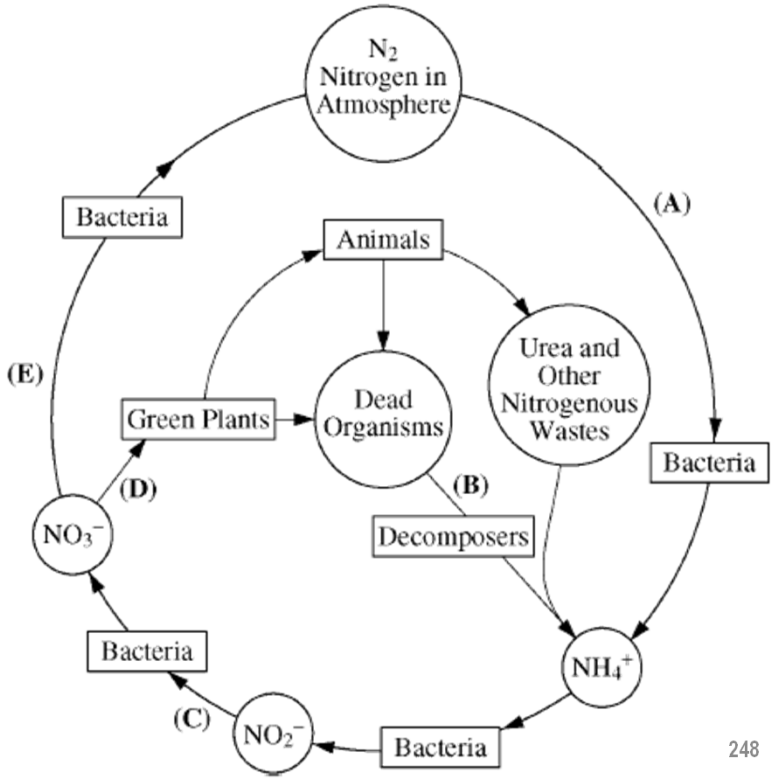
- How does net primary production relate to the concept of **production efficiency**?

Biogeochemical Cycle

- Diagram the **Carbon Cycle** and describe how humans are altering it on a global scale.

Biogeochemical Cycle

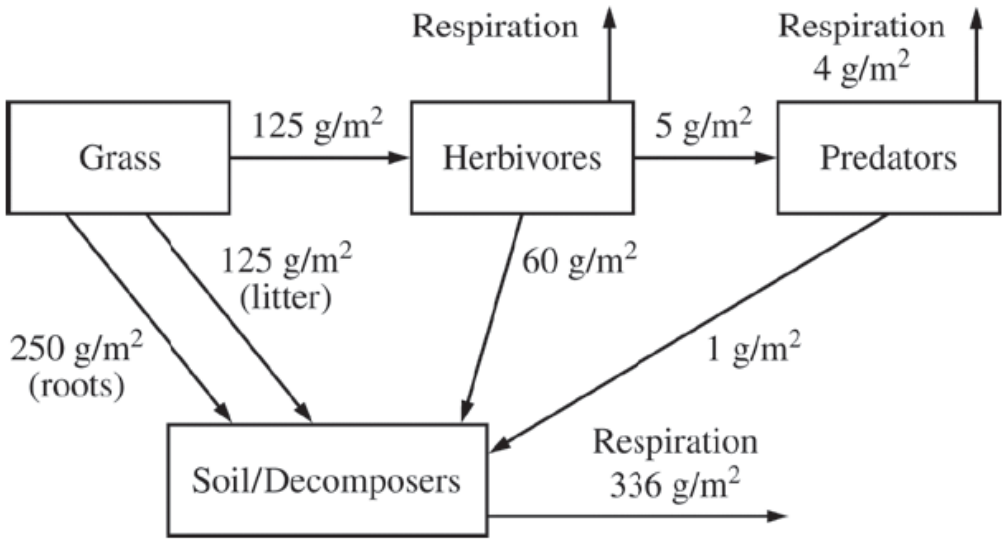
- Explain the labeled sections of the provided **nitrogen cycle** diagram.



Quantitative Skills (Show Work)

- Complete the question and explain your reasoning,

CARBON FLOW IN A GRASSLAND ECOSYSTEM



How much carbon (in g/m^2) is released into the atmosphere as a result of the metabolic activity of herbivores? Give your answer to the nearest whole number.

Population Ecology

- Population ecology is the study of how populations change. Describe the key factors of population ecology listed below:
  - Population Growth
  - Carrying Capacity
  - Population Density

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink

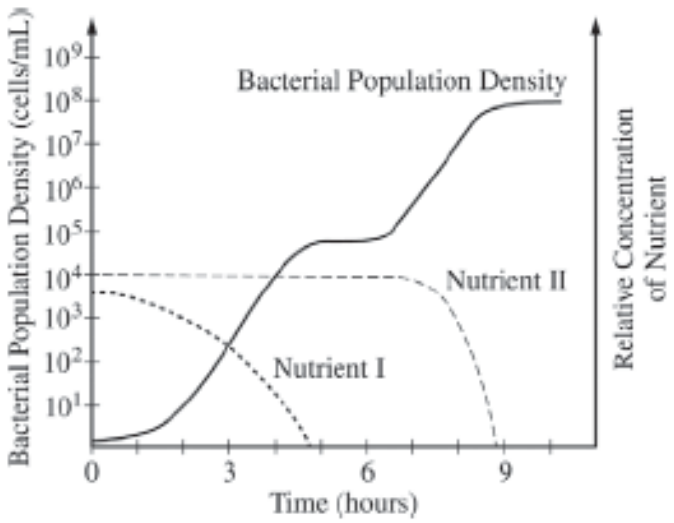


Figure 1. Bacterial population growth in the presence of two nutrients (nutrient I and nutrient II)

Bacteria can be cultured in media with a carefully controlled nutrient composition. The graph above shows the growth of a bacterial population in a medium with limiting amounts of two nutrients, I and II.

(a) **Estimate** the maximum population density in $\frac{\text{cells}}{\text{mL}}$ for the culture. Using the data, **describe** what prevents further growth of the bacterial population in the culture.

(b) Using the data, **calculate** the growth rate in $\frac{\text{cells}}{\text{mL} \times \text{hour}}$ of the bacterial population between hours 2 and 4.

FRQ Practice -Answer

Limiting Factors

- Describe each of the following limits on a population:
  - Density-independent factors
  - Density-dependent factors
  - Biotic factors
  - Abiotic factors

Population Growth

- Describe **exponential population growth**. In what situations is this type of growth likely?

- Describe **logistic population growth**. In what situations is this type of growth likely?

- How do these concepts relate to the idea of **K** and **r-selected species**? Explain.

Quantitative Skills (Show Work)

- There are 300 falcons living in a certain forest at the beginning of 2019. Suppose that every year there are 50 falcons born and 30 falcons that die. What is the **population growth rate** (include units)? Interpret the value.

- What will the population size be after three years assuming **exponential growth**?

- What will the population size be after three years assuming a **carrying capacity** of 1,000 falcons?

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

Many species of bacteria grow in the mouths of animals and can form biofilms on teeth (plaque). Within plaque, the outer layers contain high levels of oxygen and the layers closest to the tooth contain low levels of oxygen. The surface of the tooth is covered in a hard layer of enamel, which can be dissolved under acidic conditions. When the enamel breaks down, the bacteria in plaque can extract nutrients from the tooth and cause cavities.

Certain types of bacteria (e.g., *Streptococcus mutans*) thrive in the innermost anaerobic layers of the plaque and are associated with cavities. Other types of bacteria (*Streptococcus sanguinis*) compete with *S. mutans* but are unable to thrive in acidic environments.

(a) **Identify** the biochemical pathway *S. mutans* uses for metabolizing sugar and **describe** how the pathway contributes to the low pH in the inner layers of plaque.

(b) Normal tooth brushing effectively removes much of the plaque from the flat surfaces of teeth but cannot reach the surfaces between teeth. Many commercial toothpastes contain alkaline components, which raise the pH of the mouth. **Predict** how the population sizes of *S. mutans* AND *S. sanguinis* in the bacterial community in the plaque between the teeth are likely to change when these toothpastes are used.

FRQ Practice -Answer

Ecological Niches

- What is a **niche**?

- How is a niche different from an organism's **habitat**?

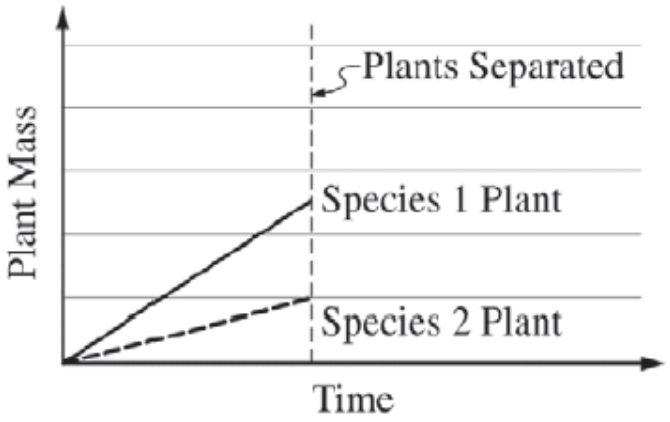
- Describe the relationship between an organism's **fundamental niche** and its **realized niche**.

Species Interactions (Direct)

- Describe the relationship between two organisms if their relationship is:
  - Mutualism
  - Commensalism
  - Competitive
  - Predatory
  - Ammensalism
  - Parasitic

FRQ Practice

- Complete the following short FRQ using complete sentences. Once completed look up the answer key and make corrections in a different color ink.

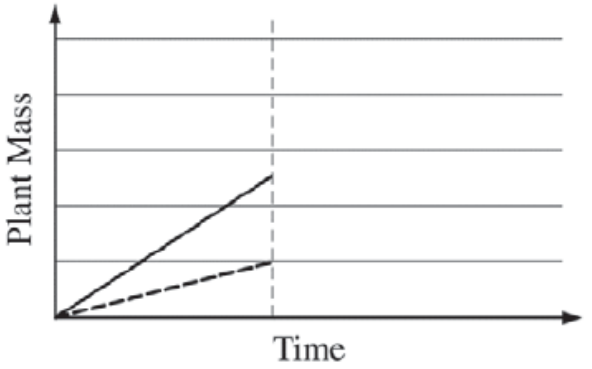


The graph above shows the mass of plants from two different species over time. The plants grew while attached to each other. The plants were separated at the time indicated by the vertical line in the graph.

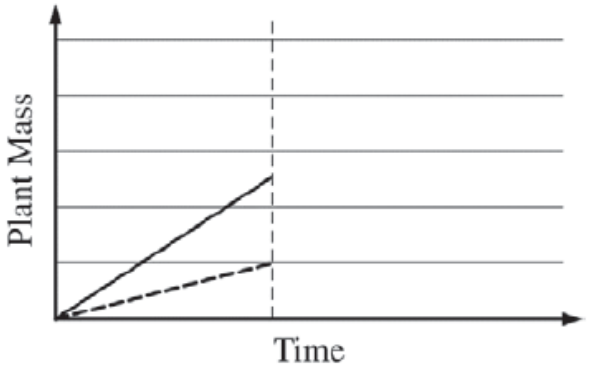
Using template 1, **graph** the predicted shape of the plant-mass lines after separation of the two plants if the plants were in an obligate mutualistic relationship. On template 2, **graph** the predicted shape of the plant-mass lines if the species 2 plant was a parasite of the species 1 plant. **Justify** each of your predictions.

FRQ Practice - Answer

TEMPLATE 1: OBLIGATE MUTUALISM

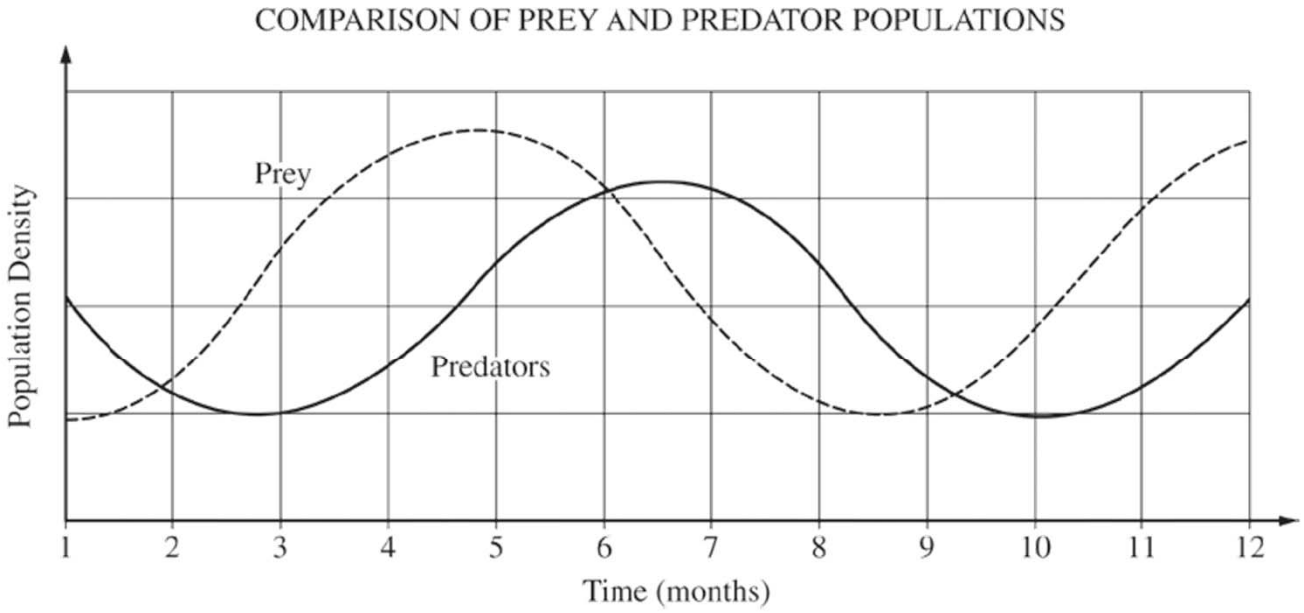


TEMPLATE 2: PARASITISM



Quantitative Skills

- Complete the question and explain your reasoning. What does this tell me about the interactions between predators and their prey?



Use the graph above to calculate the lag time in months between the change in the densities of the prey and the predator populations. Give your answer to the nearest tenth of a month.

Species Interactions (Indirect)

- Describe the concept of a **trophic cascade**.

- How can an understanding of trophic interactions like the trophic cascade and the role of keystone species allow for **biomanipulation** for purposes such as conservation?

Species Diversity

- Define the following terms:
  - Species Richness:
  - Species Evenness:
  - Relative Abundance:
- How do these terms relate to the broader concept of **biodiversity**?

Quantitative Skills (Show Work)

- Calculate the **Simpson's Diversity Index** for the following sample data and then interpret your results:

Species	Location A Quadrat	Location B Quadrat
Couch Grass	21	18
Twitch Grass	1	11
Sea Rocket	8	8
Saltwort	4	3
Lyme Grass	12	8

Simpson's Diversity Index

$$\text{Diversity Index} = 1 - \sum\left(\frac{n}{N}\right)^2$$

n = total number of organisms of a particular species

N = total number of organisms of all species

Disturbance & Succession

- What does it mean to disturb an ecosystem?

- What is the difference between **primary succession** & **secondary succession**?

- Why is an intermediate level of disturbance considered the best for maintaining biodiversity? What does this mean for **climax communities**?

Human Activities Threaten Biodiversity

- Break down the mnemonic HIPPCO and explain its relation to the loss of biodiversity.
  - H
  - I
  - P

Human Activities Threaten Biodiversity

- Break down the mnemonic HIPPCO and explain its relation to the loss of biodiversity.
  - P
  - C
  - O

IE: Disruption to Ecosystems

- The following are illustrative examples provided by CB. Research and explain each of the following and how it connects concept of the disruption of ecosystems.
  - Kudzu
  - Zebra Mussels
  - Dutch Elm Disease
  - Urbanization
  - Mono-cropping

IE: Disruption to Ecosystems

- The following are illustrative examples provided by CB. Research and explain each of the following and how it connects concept that some disruptions to ecosystems come from geological and meteorological events.
  - El Nino
  - Continental Drift
  - Meteor Impact (& Dinosaurs)

Fixing the Damage

- Explain the concepts of **minimum viable** & **effective population size** in relation to the **extinction vortex** in our conservation efforts.

- How do the concepts above relate to the requirements for establishing protected areas such as **nature preserves** and **national parks**?

Fixing the Damage

- Define the following processes:
  - Reclamation
  - Remediation
  - Restoration
- Describe how plants can be utilized in **bioremediation** efforts (i.e. **phytoremediation**).