Lab Activity 1 - Relationships and Biodiversity

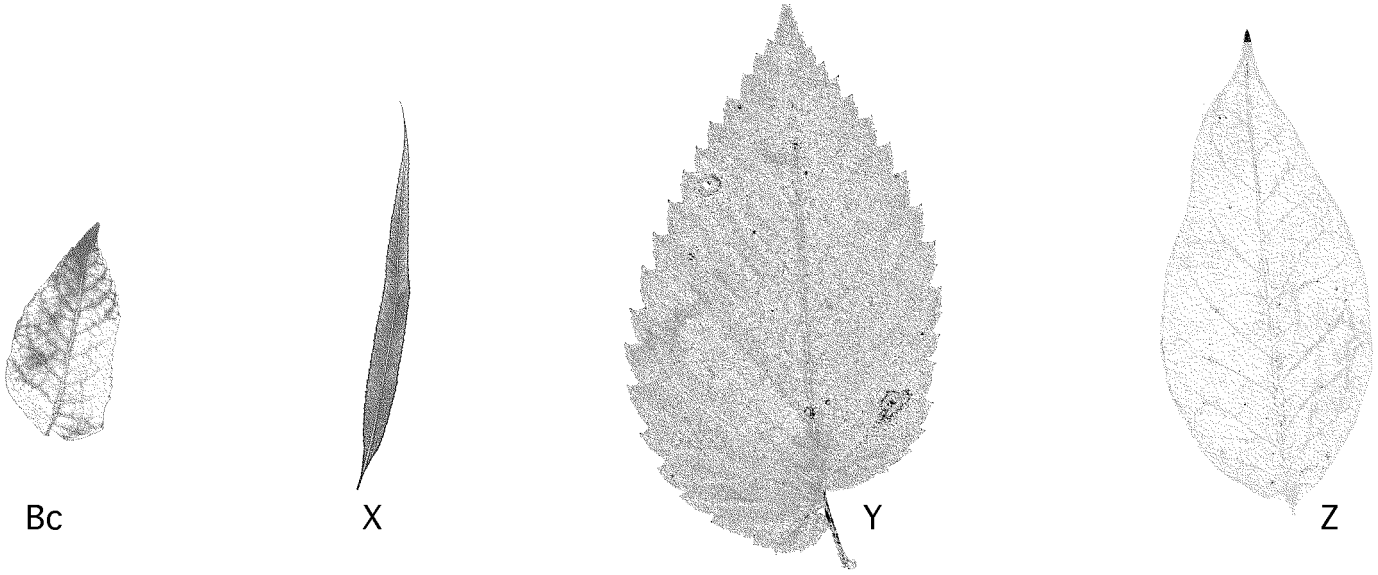
In this lab, students are introduced to classification and the importance of biodiversity. Organisms are classified according to similar characteristics. Some of these characteristics are physical (structural) and others are chemical. Biodiversity is the amount of the different organisms in a given area.

Students learn that an important cancer curing drug is found in *Botana curus*, a slow growing plant that is on the endangered list. They must examine three plentiful similar species to determine which one is most similar to *Botana curus*. It is hoped that this plant will also produce curol, the cancer curing drug.

Lab Procedure:

The students first compared the structural characteristics of the plants to try to determine which species was the closest structurally to *Botana curus*.

- Students examined the structural (physical) characteristics of the leaves of these plants to determine which one is structurally closest to *Botana curus*. (Leaves are actual size.)



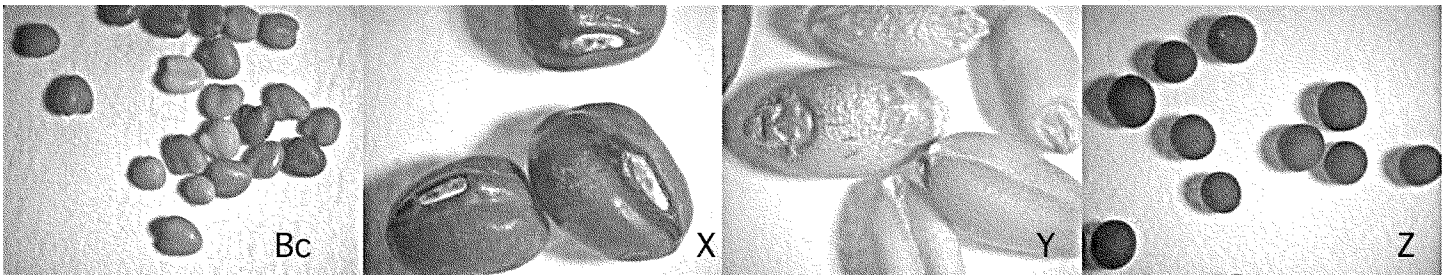
Physical factors deal with the form or structure of the leaf. The physical factors of a leaf include its size & shape, color, and venation (How are the veins organized?).

Fill in the following table:

Leaf	Color	Size & Shape	Venation
Species BC	Light Green		Veins connected to center vein branch off to sub-veins
Species X	Dark Green		All veins are directly connected to center vein
Species Y	Medium Green		All veins are directly connected to center vein
Species Z	Light Green		Veins connected to center vein branch off to sub-veins

Base on the physical characteristics of the leaf, which species appears to be most similar to Botana curus? Explain your answer.

- Students examined the structural (physical) characteristics of the seeds of these plants to determine which one is structurally closest to *Botana curus*. (As viewed under a dissecting microscope at 10X.)



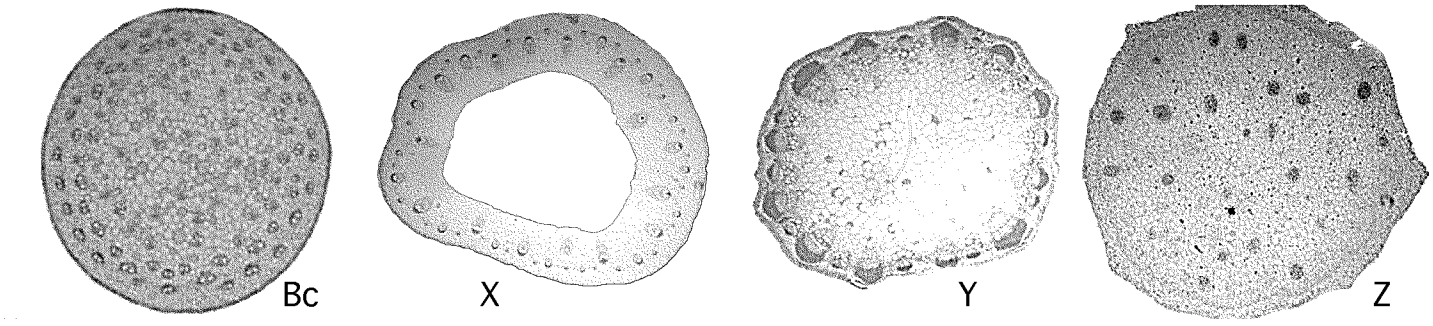
Physical factors of a seed include its size & shape, color, and distinguishing marks such as the scaring where it was attached to the plant.

Fill in the following table:

Seed	Color	Size & Shape	Distinguishing Marks
Species BC	Beige		
Species X	Green		
Species Y	White		
Species Z	Black		

Base on the physical characteristics of the seed, which species appears to be most similar to Botana curus? Explain your answer.

- Students used a microscope to examined the internal structural characteristics of the stems of these plants to determine which one is structurally closest to *Botana curus*. (Viewed under a microscope at 50X power.)



Physical factors of a stem include the size, shape and placement of its vascular bundles. Because these prepared slides of stems were stained to make the vascular bundles more clear, their color is not significant. (Note: Some of the bundle cell walls are so thin, that they are hard to distinguish from the other cells of the stem.)

Fill in the following table:

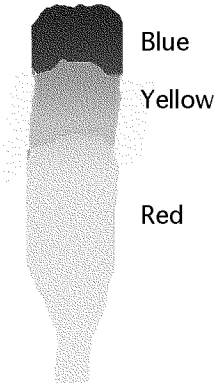
Stem	Vascular Bundle Size & Shape	Vascular Bundle Placement
Species BC		
Species X		
Species Y		
Species Z		

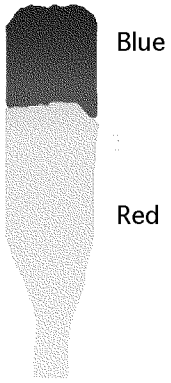
Base on the physical characteristics of the stem, which species appears to be most similar to Botana curus? Explain your answer.

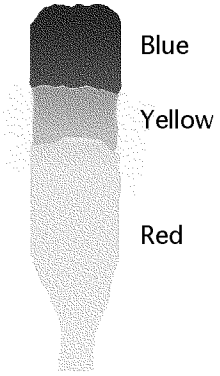
- Based on all of the observed physical (structural) characteristics, hypothesize which plant was most similar to *Botana curus*. Why?

After comparing the physical characteristics of the plants, the students compared the chemical (molecular) characteristics to try to determine which species was the closest molecularly to *Botana curus*.

- Students used paper chromatography to separate the plant pigments to determine which plant has the most similar plant pigments of *Botana curus*.

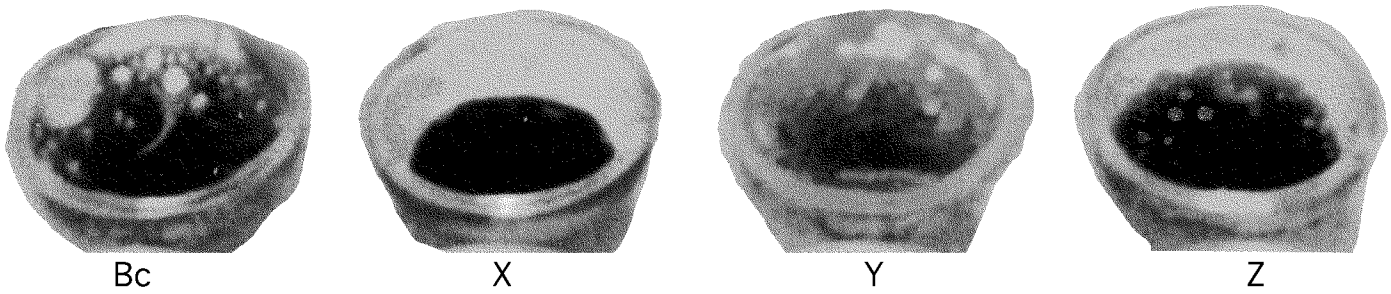






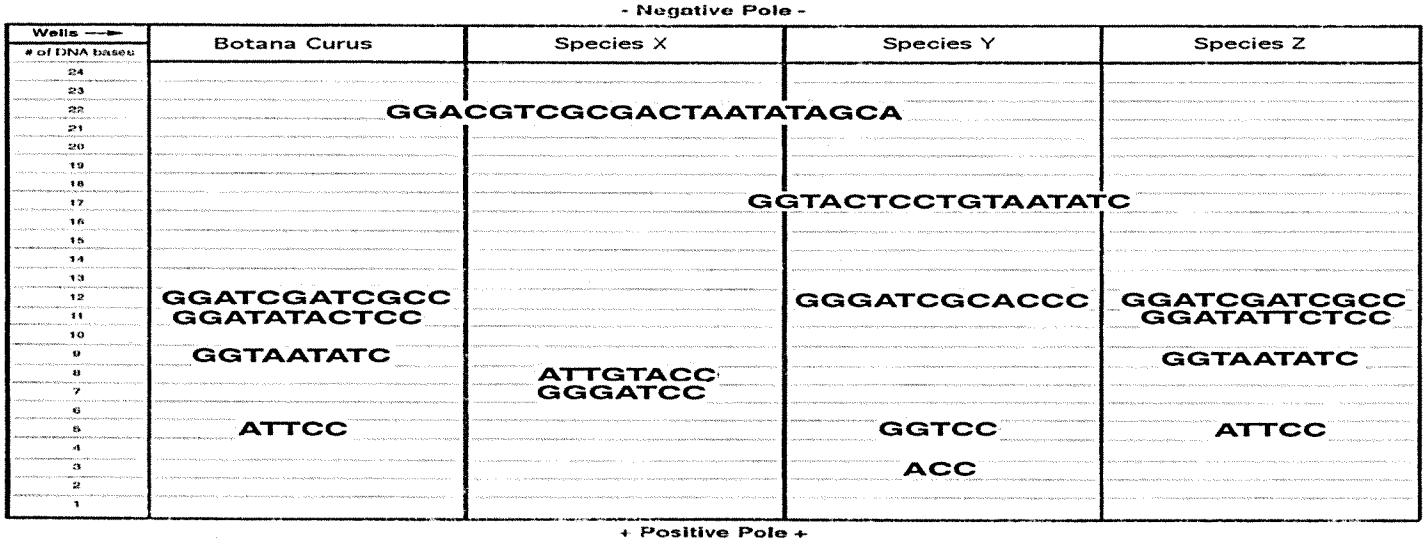
Base on the chromatography results, which species appears to be most similar to Botana curus? Explain your answer.

- Students used an indicator to determine the presence of enzyme M, an enzyme that is usually present when the cancer drug is present. A fizzing action indicates the presence of enzyme M. (An indicator is a chemical that produces an observable change if the substance being tested for is present.)



Base on the indicator results for the presence of enzyme M, which species appears to be most similar to Botana curus? Explain your answer.

- Students simulated gel electrophoresis to determine which plant's DNA is most similar to the DNA of *Botana curus*.



How a gel electrophoresis works:

1. Scientists use a special enzyme that cuts the DNA at specific base sequences. In the above example, the special enzyme cut the DNA in the middle of every C-C-G-G base sequence.
2. The DNA fragments are put into the wells located on top of the device, and then the electricity is turned on.
3. The negative charged DNA fragments move towards the positive plate. The smaller the fragment, the faster it moves through the gel. (The three base fragment of Species Y moved the most while the 22 base DNA fragment of species X moved the least.)

Base on the results of the gel electrophoresis, which species appears to be most similar to Botana curus? Explain your answer.

- Using the DNA sequence, determine the base sequence of its complementary messenger RNA molecule. Then use the universal genetic code to translate the messenger RNA base sequence into the amino acid sequence of the protein being produced.

Botana curus	CAC	GTG	GAC	TGA	GGA	CTC	CTC
Sequence of bases in mRNA produced	*GUG*	*CAC*	*CUG*	*ACU*	*CCU*	*GAG*	*GAG*
Sequence of amino acids in the protein	*VAL*	*HIS*	*LEU*	*THR*	*PRO*	*GLU*	*GLU*

Species X	CAC	GTG	GAC	AGA	GGA	CAC	CTC
Sequence of bases in mRNA produced	*GUG*	*CAC*	*CUG*	*UCU*	*CCU*	*GUG*	*GAG*
Sequence of amino acids in the protein	*VAL*	*HIS*	*LEU*	*SER*	*PRO*	*VAL*	*GLU*

Species Y	CAC	GTG	GAC	AGA	GGA	CAC	CTC
Sequence of bases in mRNA produced							
Sequence of amino acids in the protein							

Species Z	CAC	GTA	GAC	TGA	GGA	CTT	CTC
Sequence of bases in mRNA produced							
Sequence of amino acids in the protein							

Universal Genetic Code Chart

Messenger RNA codons and the amino acids they code for.

FIRST BASE	SECOND BASE: U	SECOND BASE: C	SECOND BASE: A	SECOND BASE: G	THIRD BASE
U	UUU, UUC } PHE UUA, UUG } LEU	UCU, UCC, UCA, UCG } SER	UAU, UAC } TYR UAA, UAG } STOP	UGU, UGC } CYS UGA } STOP UGG } TRP	U C A G
C	CUU, CUC, CUA, CUG } LEU	CCU, CCC, CCA, CCG } PRO	CAU, CAC } HIS CAA, CAG } GLN	CGU, CGC, CHA, CGG } ARG	U C A G
A	AUU, AUC, AUA } ILE AUG } MET or START	ACU, ACC, ACA, ACG } THR	AAU, AAC } ASN AAA, AAG } LYS	AGU, AGC } SER AGA, AGG } ARG	U C A G
G	GUU, GUC, GUA, GUG } VAL	GCU, GCC, GCA, GCG } ALA	GAU, GAC } ASP GAA, GAG } GLU	GGU, GGC, GGA, GGG } GLY	U C A G

How to determine the amino acid sequence from a strand of DNA?

1. Separate the DNA molecule into groups of three bases.
2. Produce your RNA codons by writing the complementary messenger RNA (mRNA) bases.
   - C —> G, G —> C, T —> A, and A —> U (There are no Ts in RNA)
3. Use the mRNA codon to determine the amino acid. (Note: Two different codons can code for the same amino acid. It is therefore possible for two different DNA molecules producing identical proteins.) (Note: The amino acid molecules are represented by the three letters after the parenthesis (}).

Fill in the following table:

How is The DNA and protein molecule of the three species being tested different than Botana curus?

Species	DNA Sequence	Protein Sequence
Species BC		
Species X		
Species Y		
Species Z		

- Based on all the observed structural and molecular characteristics, hypothesize which plant is most similar to *Botana curus*. Why?

_____

_____

_____

_____

This is a very important essay involving Biodiversity. It comes directly from the New York State required lab #1. Read it carefully!

The Biodiversity Crisis

Plant and animal species are being lost at a rate that is unprecedented in the history of life. Human activities are responsible for much of this biodiversity crisis. Some biologists estimate that within the next century, half of Earth's current species may become extinct.

Extinction and the loss of biodiversity occurs when species do not have adaptations that enable them to survive environmental changes. Human activities such as destruction of natural habitats and pollution are thought to be the major environmental factors causing the decline of species, but others are also important. Overhunting, introduction of foreign species that compete with native species, and removal of predators have also played a significant role in endangering some species.

Why should we worry about the loss of biodiversity? We depend on many species for food, clothing, shelter, oxygen, soil fertility—the list goes on and on. Large-scale extinctions of other species may be a warning to us that we are altering the biosphere so rapidly that our species is threatened too.

Biodiversity ensures the availability of a rich variety of genetic material that may lead to future agricultural or medical discoveries having significant value to humankind. Some species have been used as sources for medicines

and other useful products. Scientists now use genetic engineering to transfer desirable genes from one species to another. As diversity is lost, potential sources of these genetic materials may be lost with it.

Biodiversity also increases the stability of the ecosystem. Every population is linked, directly or indirectly, with many others in an ecosystem. Disruptions in the numbers and types of one species can upset ecosystem stability. This means that extinction of one species can accelerate the rate of extinction for other species.

Endangered species hold medicinal, agricultural, ecological, commercial, and aesthetic value. They must be protected so that future generations can experience their presence and value.

All students should have learned:

1. An indicator is a chemical that is used to indicate the present of substance being tested. An observable change will occur if the test substance is present. Some indicators are:

Indicator	Test substance	Observable change
Iodine (amber)	starch	Turns blue-black to black
Benedicts Solution (Blue)	Simple sugar	Turns from blue to orange-red
pH indicator (Bromthymol Blue)	If solution is an acid, neutral or base	Acid - yellow Neutral - green Base - blue

2. Physical characteristics involve the structure or appearance of the organism. They are not as reliable for determining close relationships as comparing DNA or protein. Many unrelated organisms may have some similar structures but will also have many structures that are different. Depending on what structures you are studying, you might establish an evolutionary relationship that does not exist. For example, If the physical characteristic under study was the presence of hair, you might say that a Mexican hairless dog is closer to a Timber Rattlesnake than to a German Shepherd dog. However, if you compared their DNA or proteins, you would find a very close evolutionary relationship exists between a Mexican Hairless dog and the German Shepherd dog.

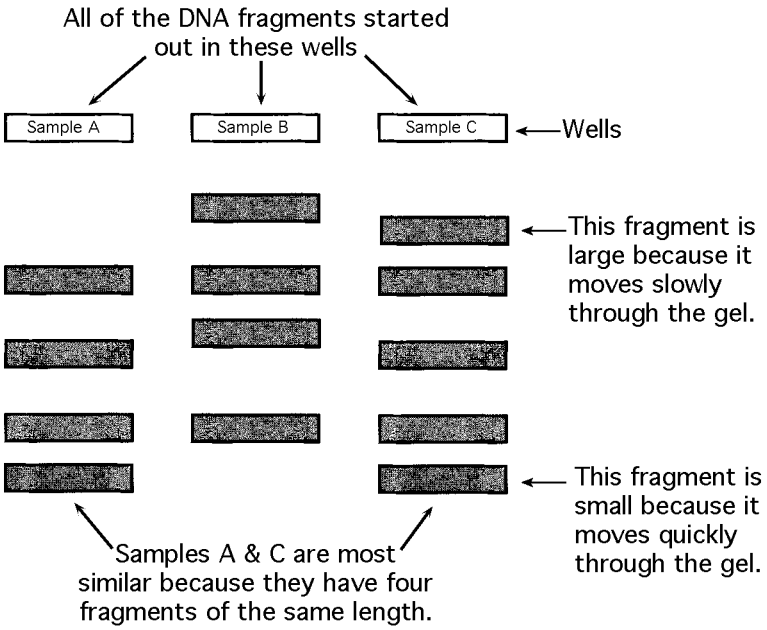
Organism	Presence of Hair
German Shepherd dog	Yes
Mexican hairless dog	No
Timber Rattlesnake	No

3. Chromatography - can separate different substances because their molecules flow through a medium, usually paper, at different rates. They flow at different rates because some molecules stick (adhere) to the paper more than other molecules. The rate of flow depends on the solvent used and the type of paper. The molecules can be identified by comparing the test samples with known substances. Chromatography is often used to separate pigments which are often made up of protein. Similar pigments might indicate an evolutionary relationship.

4. DNA is found in the nucleus of the cell. It contains a code that controls the production of protein by organelles known as ribosomes, which are located outside the nucleus. It is able to do this because the DNA code can be transferred to messenger RNA (mRNA) which can leave he nucleus and travel to the ribosomes. Once at the ribosome, each RNA codon (three bases) will code for a particular amino acid molecule. (See the Universal Genetic Code Chart on page 6 of this booklet.)
   For example:
   DNA molecule: ATGGCACCC...
   mRNA molecule: UACCGUGGG...
   Protein Molecule: TYR - ARG - GLY...

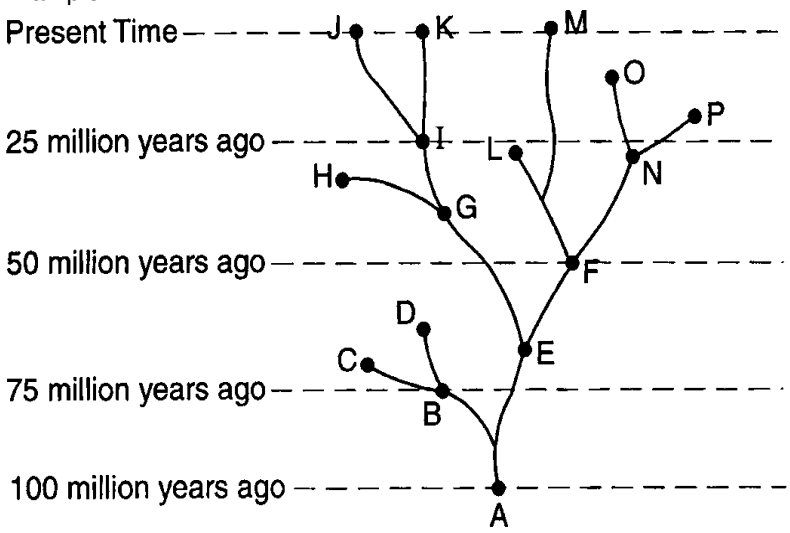
5. Gel electrophoresis is a technique that can be used to determine how similar two or more strands of DNA are to one another. Gel electrophoresis involve the following steps:
   - Obtain a sample of DNA from cells of any type of tissue or from most secretions of the organism.
     - You don't need a lot of DNA because it can be easily duplicated.
   - Use special enzymes to break down the long DNA molecules into smaller fragments.

- Place the DNA fragments of each organism into its own well and turn on the electricity.
- The electricity causes all of the fragments to move towards the positive side of the apparatus.
- Banding is produced because the smaller the fragment the faster it moves.
- The more similar the banding produced between species, the more similar the DNA and the closer the species are related



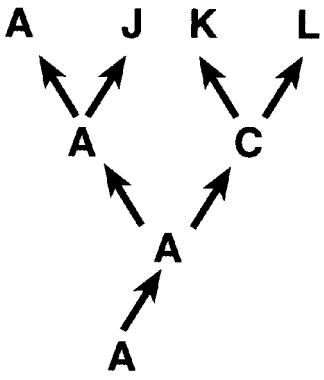
6. Once you have used some or all of the above methods you can draw a diagram representing the evolutionary relationships between organisms.

Example 1:



Notes:
- Species J, K and M are presently alive. All others are extinct.
- Species A is the common ancestor to all others.
- Species I is a common ancestor to species J and K.
- Species E is a common ancestor to all the living species.

Example 2:



Notes:
- Species A, J, K and L are all living in the same time period.
- Organism A has survived the entire duration of the diagram.
- Organism C is extinct
- Organism A is the common ancestor to all of the other organisms.
- Organisms A & J are most closely related.
- Organism C is the common ancestor to organisms K & L.
- Organisms K & L are most closely related.

Name: _____ Topic 10A

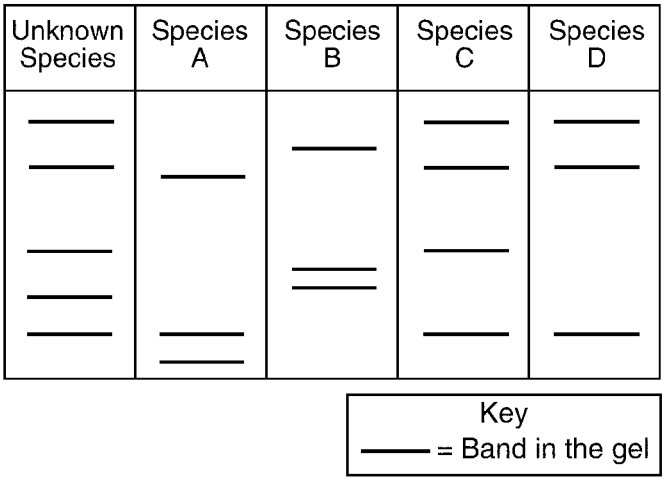
Base your answers to questions 1 through 3 on the information below and on your knowledge of biology.

Scientists found members of a plant species they did not recognize. They wanted to determine if the unknown species was related to one or more of four known species, A, B, C, and D.

The relationship between species can be determined most accurately by comparing the results of gel electrophoresis of the DNA from different species.

The chart below represents the results of gel electrophoresis of the DNA from the unknown plant species and the four known species.

Results of Gel Electrophoresis of DNA from Five Plant Species



1. The unknown species is most closely related to which of the four known species? Support your answer. [1]

_____

_____

2. Identify one physical characteristic of plants that can be readily observed and compared to help determine the relationship between two different species of plants. [1]

Ans: _____

3. Explain why comparing the DNA of the unknown and known plant species is probably a more accurate method of determining relationships than comparing only the physical characteristic you identified in question 2. [1]

_____

_____

4. Scientists hypothesize that cabbage, broccoli, cauliflower, and radishes developed along a common evolutionary pathway. Which observation would best support this hypothesis?

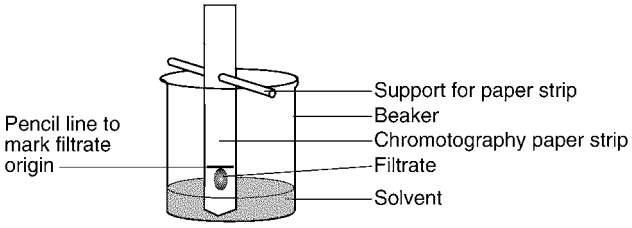
(1) Fossils of these plants were found in the same rock layer.
(2) Chloroplasts of these plants produce a gas.
(3) These plants live in the same environment.
(4) These plants have similar proteins.

Base your answers to questions 5 through 7 on the information below and on your knowledge of biology.

Paper chromatography can be used to investigate evolutionary relationships.

Leaves from a plant were ground and mixed with a solvent. The mixture of ground leaves and solvent was then filtered. Using a toothpick, twenty drops of the filtrate (material that passed through the filter) were placed at one spot on a strip of chromatography paper.

This procedure was repeated using leaves from three other species of plants. A separate strip of chromatography paper was prepared for each plant species. Each of the four strips of chromatography paper was placed in a different beaker containing the same solvent for the same amount of time. One of the laboratory setups is shown below.



5. State one reason for using a new toothpick for the filtrate from each plant. [1]

_____

_____

6. State one way the four strips would most likely be different from each other after being removed from the beakers. [1]

_____

_____

_____

7. State how a comparison of these resulting strips could indicate evolutionary relationships. [1]

_____

_____

Base your answer to question 8 on the portion of the mRNA codon chart and information below.

AUU, AUC, AUA } ILE (Isoleucine) AUG } MET (Methionine)	ACU, ACC, ACA, ACG } THR (Threonine)	AAU, AAC } ASN (Asparagine) AAA, AAG } LYS (Lysine)	AGU, AGC } SER (Serine) AGA, AGG } ARG (Arginine)

Series I represents three mRNA codons. Series II includes a mutation of series I.

Series I AGAUCGAGU

Series II ACAUCGAGU

8. How would the amino acid sequence produced by the mutant strand (series II) compare to the amino acid sequence produced by series I?

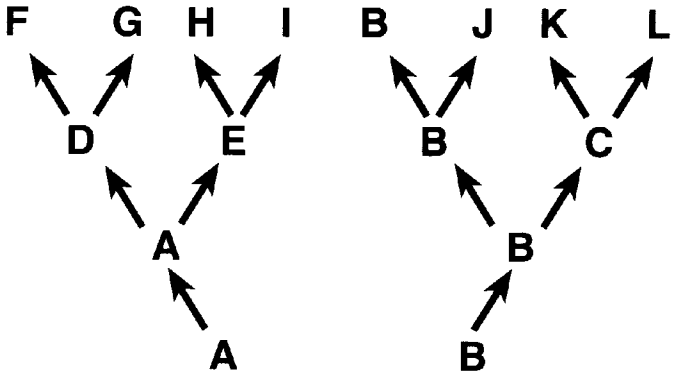
(1) The amino acid sequence would be shorter.

(2) One amino acid in the sequence would change.

(3) The amino acid sequence would remain unchanged.

(4) More than one amino acid in the sequence would change.

Base your answers to questions 9 through 11 on the diagram below and on your knowledge of biology. Letters A through L represent different species of organisms. The arrows represent long periods of geologic time.



9. Which two species are the most closely related?

(1) J and L (3) F and H

(2) G and L (4) F and G

10. Which species was best adapted to changes that occurred in its environment over the longest period of time?

(1) A (3) C

(2) B (4) J

11. Which two species would most likely show the greatest similarity of DNA and proteins?

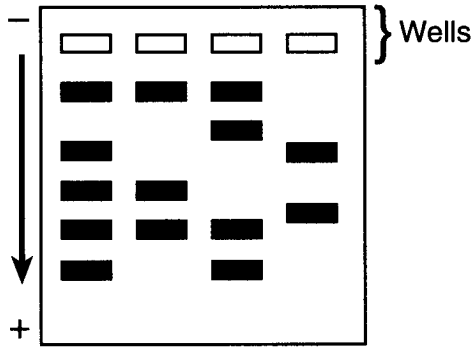
(1) B and J (3) J and K

(2) G and I (4) F and L

12. An indicator for a protein is added to a solution that contains protein and to a solution that does not contain protein. State one way, other than the presence or absence of protein, that the two solutions may differ after the indicator has been added to both. [1]

Base your answers to questions 13 through 17 on the information and diagram below and on your knowledge of biology.

The four wells represented in the diagram were each injected with fragments that were prepared from DNA samples using identical techniques.



13. This laboratory procedure is known as

(1) cloning

(2) gel electrophoresis

(3) chromatography

(4) use of a dichotomous key

14. The arrow represents the direction of the movement of the DNA fragments. What is responsible for the movement of the DNA in this process? [1]

15. The four samples of DNA were taken from four different individuals. Explain how this is evident from the results shown in the diagram. [1]

16. Identify the substance that was used to treat the DNA to produce the fragments that were put into the wells. [1]

Base your answers to questions 17 through 19 on the information provided and on your knowledge of biology.

A student observed the physical characteristics of seven organisms and prepared the data table below.

Organism Comparison

Organism	Internal Skeleton Present	Legs Present	Wings Present	Fur Present	Moist Body Covering Present
Earthworm	no	no	no	no	yes
Fish	yes	no	no	no	yes
Fly	no	yes	yes	no	no
Gorilla	yes	yes	no	yes	no
Jellyfish	no	no	no	no	yes
Parrot	yes	yes	yes	no	no
Snake	yes	no	no	no	no

One of the student's classmates sorted the seven organisms into two groups as shown below.

Group 1	Group 2
fly parrot	earthworm gorilla snake fish jellyfish

17. Which characteristic from the data table did the student use to group the organisms? [1]

_____

18. Another classmate suggested that the earthworm is more closely related to the jellyfish than to any other organism observed. State the evidence from the data table that the student most likely used for this suggested relationship. [1]

_____

_____

_____

19. Fish and snakes are very different organisms, yet they have many similarities. Provide a biological explanation for the fact that fish and snakes have so many characteristics in common. [1]

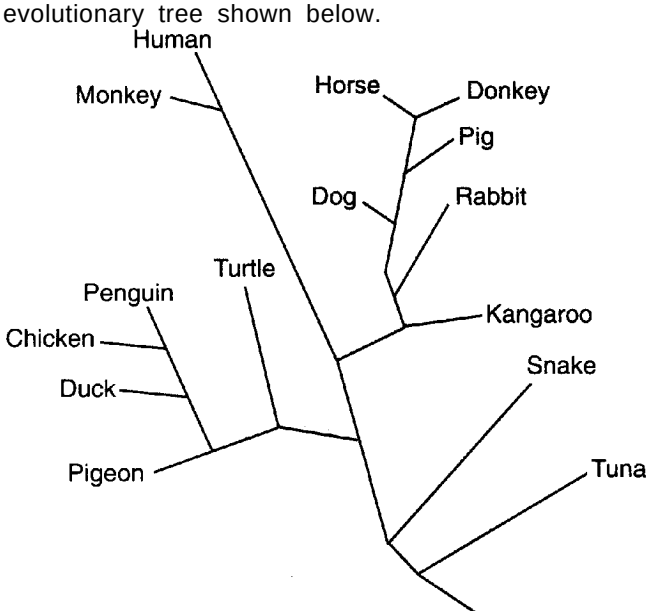
_____

_____

_____

Base your answers to questions 20 through 22 on the information below and on your knowledge of biology.

Based on their analysis of the differences in amino acid sequences of one kind of protein, scientists prepared the evolutionary tree shown below.



20. According to this diagram, the DNA of which pair of organisms would show the greatest similarity?

(1) penguin and turtle (3) snake and tuna
(2) horse and donkey (4) turtle and rabbit

21. Older systems of classification always placed penguins, chickens, ducks, and pigeons in the bird group and turtles and snakes in the reptile group. Does this diagram support the older system of classification? Explain your answer. [1]

_____

_____

_____

22. According to this diagram, is the pig more closely related to the dog or the kangaroo? Justify your answer. [1]

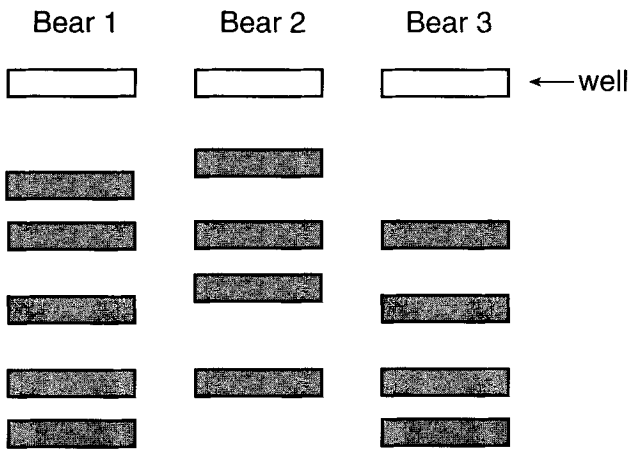
_____

_____

_____

Base your answers to questions 23 through 26 on the information and diagram below and on your knowledge of biology.

The diagram below shows the results of a test that was done using DNA samples from three bears of different species. Each DNA sample was cut into fragments using a specific enzyme and placed in the wells as indicated below. The DNA fragments were then separated using gel electrophoresis.



23. Which two bears are most closely related? Support your answer with data from the test results. [2]

24. Identify one additional way to determine the evolutionary relationship of these bears. [1]

25. Gel electrophoresis is used to separate DNA fragments on the basis of their
(1) size (3) functions
(2) color (4) chromosomes

26. Identify one procedure, other than electrophoresis, that is used in the laboratory to separate the different types of molecules in a liquid mixture. [1]

27. *R*, *S*, and *T* are three species of birds. Species *S* and *T* show similar coloration. The enzymes found in species *R* and *T* show similarities. Species *R* and *T* also exhibit many of the same behavioral patterns.

Show the relationship between species *R*, *S*, and *T* by placing the letter representing each species at the top of the appropriate branch on the diagram below. [1]

Lab Activity 2 - Making connections

In this lab, students are introduced to scientific experimentation by asking them to make connections between patterns that can be observed in the natural world. For instance, when one exercises, the heart rate increases. Is there a connection? — Scientific experimentation can be conducted to see if there is actually a connection.

Lab Procedure:

Students are asked to determine their average resting heart rate by taking their pulses over the course of three trials. For each trial, students counted the number of pulses they felt in their wrists or necks for twenty (20) seconds. This number was multiplied by three (3) to get a good estimate the number of pulses in a minute.

Something is wrong with this number! Each trial should be within 2 heartbeats of one another.

Trial 1 (20 - second count)	36	X3 =	108	per minute	_____ X3 =	_____ per minute
Trial 2 (20 - second count)	24	X3 =	72	per minute	_____ X3 =	_____ per minute
Trial 3 (20 - second count)	25	X3 =	75	per minute	_____ X3 =	_____ per minute

To find the average, add 108 + 72 + 75 = 255 and then divide by 3.

$\frac{255}{3}$ = 85 beats per minute

Fill in your pulse rates and determine your average pulse now.

Your average pulse rate: _____ per minute

Add this number to the data table below.

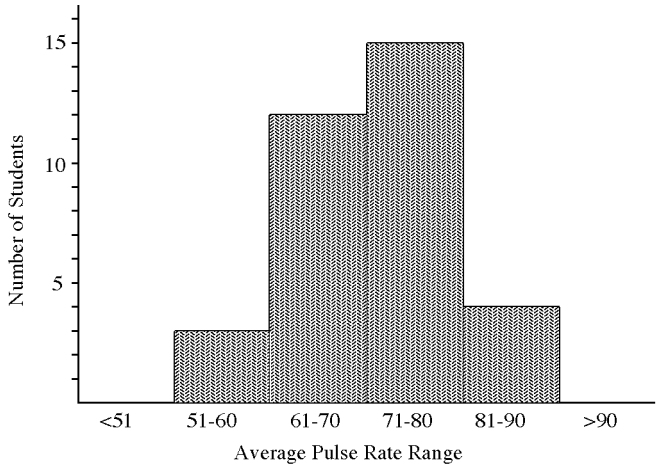
Students organized the data by completing a class data table. Each student put their data in a table that was on the board. It should have looked like the table below.

Class Results: Average Pulse Rates

Pulse rate per minute (range of averages)	<51	51-60	61-70	71-80	81-90	>90
Number of students in this range	0	III 3	𝍸 𝍸 II 12	𝍸 𝍸 𝍸 15	IIII 4	0

Tables are used to organize data!

We can already see a pattern - all of the student heart rates are between 51 and 80! A graph can be drawn to make this pattern even more graphic.

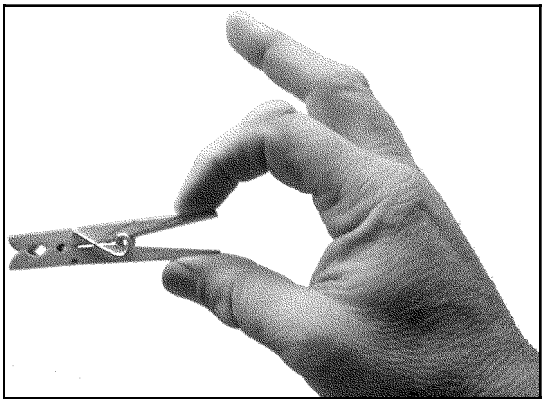


Add your average heart rate to this graph

Some students were asked to exercise. When they did, their pulse (heart rate) increased.

In the second part of Lab Activity #2, the students explored how fatigue affect muscle performance by squeezing a clothespin using only two fingers. Students counted the number of times they could squeeze a clothespin in a minute. Recorded the data and then immediately counted the number of times they could squeeze a clothespin a second minute. Most students could not squeeze the clothespin as many times the second trial as they could the first trial.

Will your muscles become fatigue by squeezing a clothespin? Do the following activity to find out!



Squeeze a clothespin using the two fingers pictured as many times as you can in 1 minute. Record the number in the space provided below and then immediately see how many times you can squeeze the clothespin a second minute. Record that number in the space provided below.

Number of squeezes per minute:

1st minute: _____ 2nd minute: _____

In the last part of Lab Activity #2, the students did an original experiment to determine if exercise could increase one's clothespin squeezing rate. Using family members and friends as subjects, students collected the following data:

- age.
- height.
- weight.
- sex.
- relationship.
- number of times able to squeeze clothespin without exercising.
- number of times able to squeeze clothespin after running in place for 2 minutes.

Every experiment had to have at least 10 subjects. The control data included the number of times the subject could squeeze the clothespin in one minute without exercising, while the experimental data included the number of times the subject could squeeze the clothespin in one minute after exercising. Students constructed a data table for organizing the data. To determine the effect of the exercise, the student compared the data in the control group to the data in the experimental group. There was no consistent conclusion. Some students concluded that exercising before clothespin squeezing increased the number of times the clothespin could be squeezed while other students concluded the opposite. It was obvious that a larger, more controlled study was necessary to determine if exercise enhanced the performance of clothespin squeezing.

All students should have learned:

1. When a person exercises, certain cells such as muscle cells use more energy than when the person is resting. These cells obtain energy by the process of cellular respiration. Cellular respiration occurs in the cell's mitochondria. The energy released by breaking the bonds of glucose (sugar), with the aid of oxygen, is used to make ATP. Carbon dioxide is given off by the cell as a waste product.

2. Homeostasis is the process where the body maintains its chemistry and vital measurements within normal limits. When a person begins to exercise, cells use more energy and therefore begin to remove more oxygen and glucose from the blood while releasing more carbon dioxide to the blood. Internal receptors in the body sense these changes and react by:
   a. Increasing the heart rate in order to increase the flow of the circulating blood that is carrying the oxygen and glucose to the muscle cells and the carbon dioxide from the muscle cells.
   b. Increase the respiratory rate to quicken the exchange of oxygen and carbon dioxide between the air in the lungs and the blood in the circulatory system.
   c. Increase the release of glucose by the liver, as directed by hormones from the pancreas.
   d. If the body becomes warm, blood, carrying heat, will be directed towards the skin and the body will begin to sweat. As the sweat evaporates, heat is carried away from the skin, cooling the body (feedback mechanism).

3. A summary of the body reaction to exercise is in the chart below.

Systems	Responses	Implications
Circulatory	1. Heart rate (pulse) increases 2. Blood flows quicker	1. An increase flow of oxygen and glucose flow to the muscle cells while carbon dioxide is moved away quicker. 2. An increase flow of carbon dioxide to the lungs and oxygen away from the lungs.
Respiratory	1. Breathing rate increases 2. Breathing depth increases	1. An increase supply of air in the lungs. Oxygen diffuses from the air into the blood while carbon dioxide diffused from the blood into the air in the lungs.
Endocrine	1. Pancreas releases a hormone	1. Glucose (sugar) is released into the blood by the liver.
Nervous	1. Increase impulses from brain	1. The heart beats faster. 2. Blood vessels dilate (open) allowing greater blood flow. 3. If the body is warm, sweat begins to flow.

4. Muscle fatigue is mainly caused by two factors, a lack of oxygen and/or glucose, and/or the build up of wastes. When muscle cells do not get enough oxygen, a substance called lactic acid is produced. If a sufficient quantity of lactic acid is present, the muscle will begin to stiffen or cramp. This actually helps the person by preventing damage to the muscle due to over exercising.

5. An hypothesis is a proposed outcome of an experiment. It has to be proved correct by analyzing the data from an experiment. Hypotheses are often written in terms of a cause and effect. If something happens, then something else happens. An example of an hypothesis is: "If students study more, then test grades will increase." The cause is more studying and the effect is higher test grades. Can you write an hypothesis concerning the number of deer in an area?

_____

6. Every experiment must have a control group and an experimental group. Both groups should be the same except that the experimental group will be given the treatment that is being tested. Good experiments will be testing only one variable, called the independent variable. In one experiment you can test the effect of sunlight on the growth of corn plants and in another experiment you can test the effects of sunlight on the growth of corn. However, you cannot test both the effects of water and sunlight on the growth of corn in the same experiment. (Experiments can have more than one dependent variables. The dependent variable is what changes as result of changing the independent variable. For the experiment testing the effects of sunlight on the growth of corn, you could measure the weight of the leaves, stalk, fruit, and roots. That 4 dependent variables for the one independent variable.)

7. When a scientist performs an experiment, he/she must collect data. Most scientists will collect numbers or measurements. In order to indicate growth, a scientist might measure the height, length or weight of the organism. Sometimes, as with bacteria, growth can be determined by simply counting the number of colonies.

8. Scientist will first write the experiment results into data tables. Once complete, the data tables can be organized into graphs. Graphs will often highlight the relationship between the cause and effect of the hypothesis.

9. In order for an experiment to be reliable, it must have a significant number of subjects being studied.
   - One (1) is totally unreliable. It is called a testimonial. If anyone ever tries to sell you a product based on testimonials, avoid the product. There are always exceptions, and advertisers will use these exceptions to sell their product.
   - Ten (10) is a small number and would be unreliable because one or two exceptions would greatly change the data and the results of the experiment.
   - Fifty (50) is an okay number. Fairly good data can be produced at low cost. Exceptions would not have that much effect on the results of the experiment.
   - One hundred (100) is a good number of subjects. It will produces reliable data but at greater cost.
   - Five hundred or more (>500) is aa excellent number of subjects. It will produces very reliable data but at a great cost.

10. **To see if the treatment is effective, the experimental group results must be compared to control group results**.

Name: _____ Topic 10B

Base your answers to questions 1 through 4 on the data table below and on your knowledge of biology.

A group of students obtained the following data:

Data Table

Student Tested	Pulse Rate at Rest	Pulse Rate After Exercising
1	70	97
2	75	106
3	84	120
4	60	91
5	78	122

1. The activity of which body system was measured to obtain these data? [1]

Ans: _____

2. The activity of which other body system would be altered as a direct result of the exercise? [1]

Ans: _____

3. What effect would exercise have on the system you identified in question 68? [1]

_____

_____

4. Explain how this change in pulse rate helps maintain homeostasis in muscle cells. [1]

_____

_____

_____

5. A student hypothesizes that the pulse rate of a person and background music that is playing are related. The student designs an experiment to test this hypothesis. What would be an appropriate control for this experiment? [1]

_____

_____

6 An increase in heart rate will most likely result in

(1) a decrease in metabolic rate
(2) an increase in pulse rate
(3) an increase in cell division
(4) a decrease in body temperature

7. A student squeezed a clothespin as many times as possible in a 30-second time period. The student repeated this procedure nine more times in quick succession. The data obtained are in the chart below.

Trial	Number of Squeezes in 30 Seconds
1	32
2	29
3	28
4	27
5	26
6	25
7	23
8	21
9	19
10	17

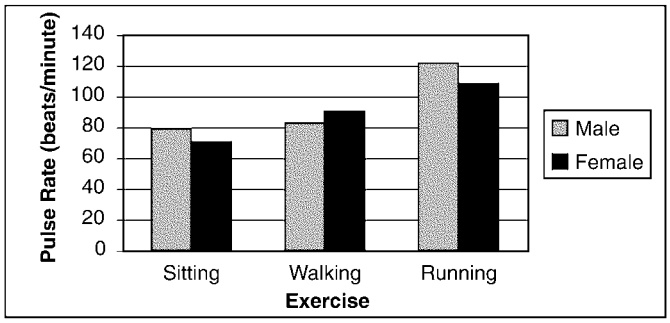
State one hypothesis that this data would support concerning the relationship between number of trials and number of squeezes in 30 seconds. [1]

_____

_____

Base your answers to questions 8 and 9 on the information below and on your knowledge of biology.

In an investigation, 28 students in a class determined their pulse rates after performing each of three different activities. Each activity was performed three times during equal time intervals. The average results are shown in the graph below.



8. Before constructing the graph it would have been most helpful to organize the results of the investigation in

(1) a research plan (3) a data table
(2) an equation (4) a generalization

9. Some students concluded that males always have a higher pulse rate than females. Does the graph support this conclusion? Justify your answer. [1]

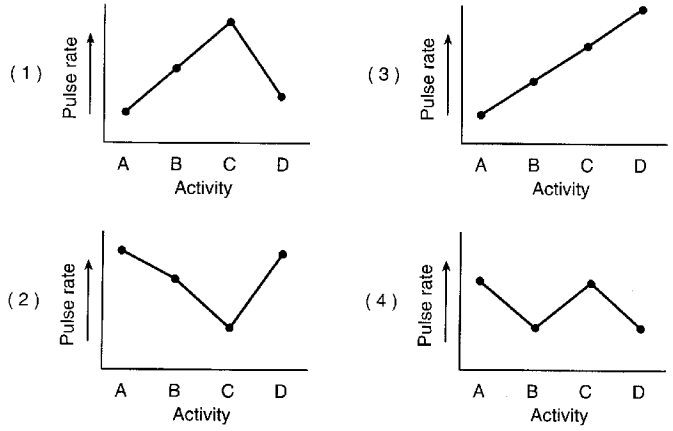
_____

_____

10. A student measures his pulse rate while he is watching television and records it. Next, he walks to a friends house nearby and when he arrives, measures and records his pulse rate again. He and his friend then decide to run to the mall a few blocks away. On arriving at the mall, the student measures and records his pulse rate once again. Finally, after sitting and talking for a half hour, the student measures and records his pulse rate for the last time. Which graph below best illustrates the expected changes in his pulse rate according to the activities described to the right?

Key:Activity

A = after watching television
B = after walking to a friend's house
C = after running to the mall
D = after sitting and talking



11. An experiment was designed to see what effects ibuprofen would have on laboratory mice. Large numbers of male mice and an equal number of female mice were used in this investigation. The male mice were placed in an area with food and water. The female mice were placed in a separate area of the same size. The female mice were given additional food and water. The males were each given 100 milligrams of ibuprofen each day, mixed with their food, and the females were each given 50 milligrams of ibuprofen each day, mixed with their food.

Identify two errors in the design of this investigation. [2]

(1) _____

_____

_____

(2) _____

_____

_____

12. On a television talk show, a guest claims that people who exercise vigorously for 15 minutes or more every day are able to solve math problems more rapidly than people who have no vigorous exercise in their daily routine.

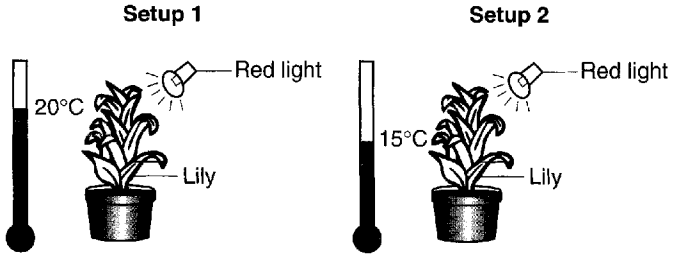
Describe a controlled experiment that could be conducted to test this claim. In your description be sure to:

- state the purpose of the experiment [1]
- state why the sample to be used should be large [1]
- describe how the experimental group will be treated and how the control group will be treated [2]
- state the specific data to be collected during the experiment [1]
- state one way to determine if the results support the claim [1]

13. When a person exercises, changes occur in muscle cells as they release more energy. Explain how increased blood flow helps these muscle cells release more energy. [1]

Base your answers to questions 14 through 16 on the information and diagram below.

An investigation was carried out using the two setups shown below, Other than the difference shown in the diagram, all other conditions were identical.



14. State one possible hypothesis that could be tested using these setups. [1]

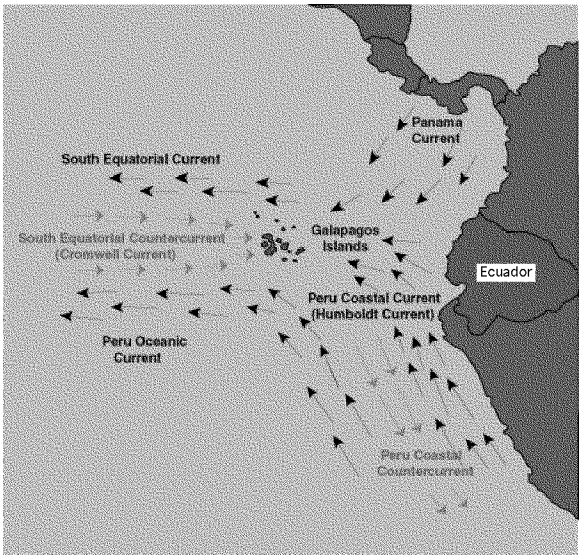
15. What data should be collected in order to test the hypothesis stated in question 68? [1]

16. Describe one change that could be made in the investigation to improve it. [1]

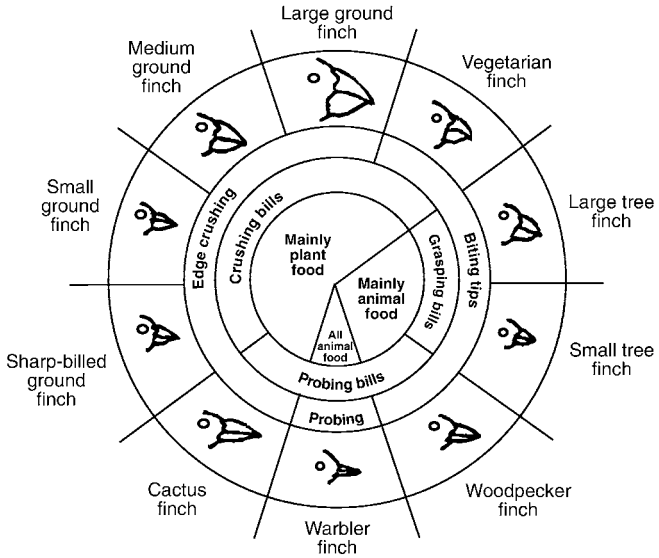
Lab Activity #3 - The Beaks of Finches

In this lab, students are introduced to the topic of evolution. The demonstrate how environmental conditions act as selecting agents. The species or members within a species with variations that make them better adapted to the environment survive and reproduce in greater number than those without the variations. These variations are called adaptations. Offspring will often have the same adaptations as the parents, and they too will have a better chance of survival as long as the environmental conditions remain the same.

Charles Darwin is given credit of first advancing the theory of evolution. He called it natural selection, that is the environment or nature is the selecting agent. Charles Darwin arrived at this theory after studying many organisms including finches that inhabit the Galapagos Islands. Finches are small birds that are found in many areas of the world including Rockaway. The Galapagos Islands are located off the coast of South America. They contain many different species of finches, all descendants of the original finches that were probably blown to the islands by a storm. As the finches radiated (moved outward) to the various islands, they found a varied food supply. The finches that lacked the adaptations to get enough food died while the ones having the adaptations survived and produced offspring with similar adaptations. Over time, the finches evolved into many species that inhabited the islands today. The different species of finches found on the Islands today are arranged in the diversity wheel below.



Finch Diversity



Evolution: What? — Why? — How?

What: Evolution occurs when there is a change in the gene pool of a species. One organism does not evolve, the species evolves.

Why: When a species is very well adapted to an unchanging environment, evolution is usually slow. (That is why many species of sharks, crocodiles and horseshoe crabs have remained virtually unchanged for millions of years.) When an environment begins to change, the beneficial adaptations change also. Species must adapt or face extinction. In the past, most species, such as the many kinds of dinosaurs, have not been able to adapt to a changing environment and have become extinct. In the future, humans may face the same dilemma.

How: Sexual reproduction (genetic recombination) and mutations are the driving forces of evolution. Sexual reproduction and mutations can cause the expression of different variations or adaptations in a given species. If the species is genetically diverse, and the environment begins to change, the species may survive because it may have the variation that will allow it to adapt to the changing environment. As the surviving members of the species reproduce, their offspring inherit these adaptations changing the gene pool of the species causing evolution. Here are all of the steps:

1. All species have variations. These variations are caused by combinations of genes and mutations.
2. There is a struggle for existence. Organisms are always competing for the available resources such as food, light, water, minerals, and space while avoiding to become the food of other organisms.
3. The organisms that are best adapted, the ones with the most favorable adaptations or variations, survive and produce offspring.
4. Overtime, the surviving organisms gene pool will change and evolution occurred.

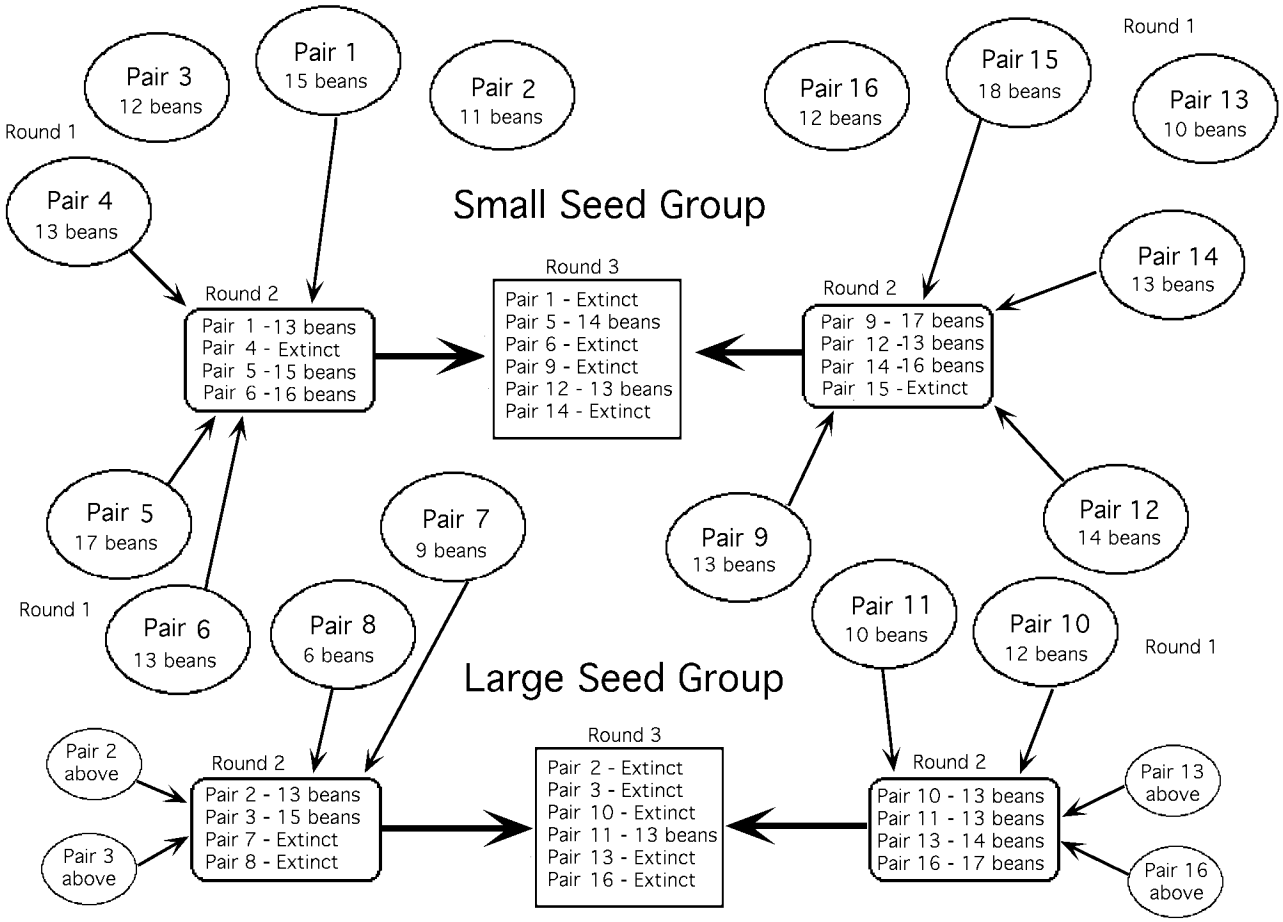
In the above example of the Galapagos' finches, you might ask, "Why so many different species developed from the original species?". The finches on each island was isolated from the other populations of finches on other islands and therefore they did not interbreed. Over time the gene pool became so different, they could no longer breed with each other even if they were on the same island. This indicates that new species were formed. (Definition of species - All the organisms in a group that normally reproduce and produce fertile offspring.)

Lab procedure:

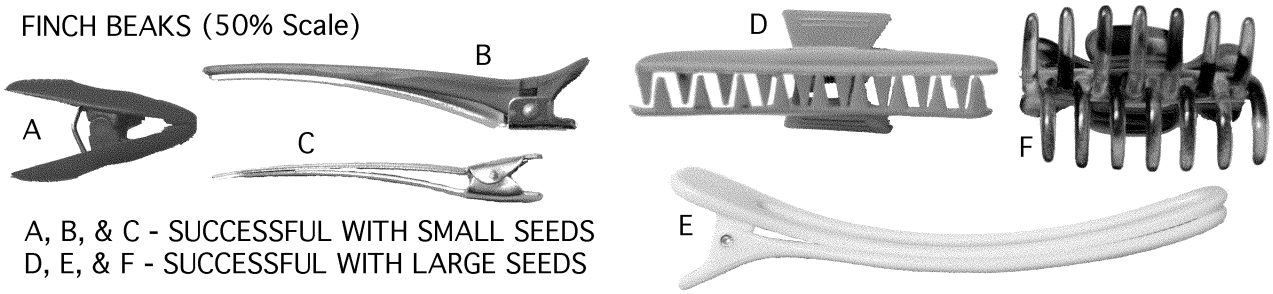
Students in this lab worked in pairs using regular household tools such as pliers, hair clamps, tweezers, and kitchen utensils as the beaks of finches. They competed for food - beans that were placed on a paper plate in the center of the table (island). This lab was divided into three rounds:

- Round 1 — No inter-species competition.
  Students attempt to pick up as many small beans that was placed on a paper plate centered on a table (island) and transfer them to a cup. The idea was to acquire as much food as possible, one bean at a time, in 30 seconds. If the pair using the tool as a finch beak was unable to get the required amount of beans necessary to sustain life (an average of 13 beans), the finch was considered dead. If the finch died, the pair had a second chance by competing in round 2 on a different (table) island using larger seeds as food. The rules are the same. Either get enough food or become extinct.
- Round 2 — Inter-species competition.
  Students with different beaks competed and attempted to pick up as many beans that was placed on a paper plate centered on a table (island) between 2 pairs and transfer them to a cup. They acquired as much food as possible, one bean at a time, in 30 seconds. If the pair using the tool as a beak was unable to get the required amount of beans necessary to sustain life (an average of 13 beans), the finch was considered dead and out of the competition. The finch has become extinct.
  - Note there were two major groups each with a number of subgroups in round 2. The tables with large seeds and the tables with small seeds. Only the pairs of students that collected an average of 13 beans moved to the third round which will again include the two major groups, but no subgroups.
- Round 3 — Inter-species competition.
  All of the pairs of students who survived the second round competed at once and attempted to pick up as many beans that was placed on a paper plate centered on a table (island) between all surviving finches and transfer them to a cup. Each finch acquired as much food as possible, one bean at a time, in 30 seconds. There were so many finches competing, most were not able to get the required average of 13 beans necessary to sustain life and therefore became extinct.

If you can't follow the above description of this Laboratory exercise, here is the flow diagram.



In this class, only 3 pairs of students have finches still "alive". All others have become extinct. Only these three have the adaptations (tools) that allowed them to compete in the changing environment as they competed in all three rounds. Do you think the same results would occur if sunflower seeds was used instead of bean seeds?



- Explain why A, B and C were successful picking up the small seeds while D, E, and F were successful at picking up the larger seeds?

_____

_____

_____

Answer the Following Question:

1. Which finch populations would have a greater chance of survival if the insect populations of the Galapagos islands increased? Explain your answer.

_____

_____

All students should have learned:

1. Evolution is the change in the number and/or type of genes in the gene pool of a population. A population is all of the organisms that normally mate with one another and produce fertile offspring. Evolution is accelerated when environmental conditions change, giving certain members of the population with favorable adaptations or structures an advantage for survival and therefore reproduction.

2. The process of evolution includes:
   a. All species have variations. These variations are caused by combinations of genes and mutations.
   b. There is a struggle for existence. Organisms are always competing for the available resources such as food, light, water, minerals, and space while avoiding to become the food of other organisms.
   c. The organisms that are best adapted, the ones with the most favorable adaptations or variations, survive and produce offspring.
   d. Overtime, the surviving organisms gene pool will change and evolution occurred.

3. Variations are caused by:
   a. The normal mixing of genes during sexual reproduction.
   b. Mutations or a change in the DNA. If it occurs in the original gametes or in the sex organs, the mutation may be passed to the offspring.

4. Competition only exists between different organisms occupying the same niche or function in the ecosystem. If two organisms have different food supplies, they do not compete with one another.

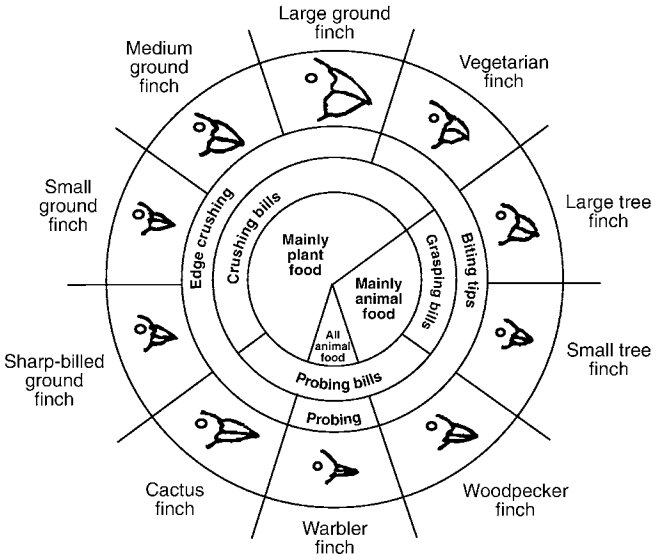
5. The level of competition increases as the populations occupying the same niche increases and/or the food supply decreases.

6. An environment with much food and many niches would have great biodiversity. Not only should there be many different species, but there should be many variations within each population because there is less struggling for survival. (Do you think that Toy poodles, Malteses, Yorkshire terriers and other small dogs would survive in the wild without humans?)

Name: _____ Topic 10C

1. The diagram below shows variations in beak sizes and shapes for several birds on the Galapagos Islands.

Finch Diversity



Using information provided in the chart, identify two birds that would most likely compete for food in times of food shortage and explain why they would compete. [2]

_____ and _____

_____

_____

2. Even though the finches on the various Galapagos Islands require different biotic and abiotic factors for their survival, these finches would most likely be grouped in the same
   (1) species, but found in different habitats
   (2) kingdom, but found in different ecological niches
   (3) species and found in the same biosphere
   (4) population, but found in different ecosystems

3. Galapagos finches evolved partly due to
   (1) cloning and recombination
   (2) migration and selective breeding
   (3) mutation and asexual reproduction
   (4) variation and competition

4. In members of a bird species living on a remote island, the greatest number of beak variations in the population would most likely be found when
   (1) there is a high level of competition for limited resources
   (2) homeostasis is limited by a severe climate
   (3) they have a large and varied food supply
   (4) they are prey for a large number of predators

5. The different tools used during the beaks of finches lab represented
   (1) feeding adaptations in finches
   (2) nest construction adaptations
   (3) variations in seed size
   (4) variations in ecosystems

6. Beak structures differ between individuals of one species of bird. These differences most likely indicate
   (1) the presence of a variety of food sources
   (2) a reduced rate of reproduction
   (3) a large supply of one kind of food
   (4) an abundance of predators

7. A hawk has a genetic trait that gives it much better eyesight than other hawks of the same species in the same area. Explain how this could lead to evolutionary change within this species of hawk over a long period of time. In your answer, be sure to include an explanation of:
- competition within the hawk population [1]
- survival of various individuals in the population [1]
- how the frequency of the better-eyesight trait would be expected to change over time within the population [1]
- what would most likely happen to the hawks having the better-eyesight trait if they also had unusually weak wing muscles [1]

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Laboratory Activity #5 - Diffusion Through a Membrane

Background Information that you need to know:

In this lab activity, students learned about the movement of molecules through the cell membrane. The cell membrane is a very important cell organelle. It separates the cell contents from the external environment, allowing specific chemical activities to occur within the cell.

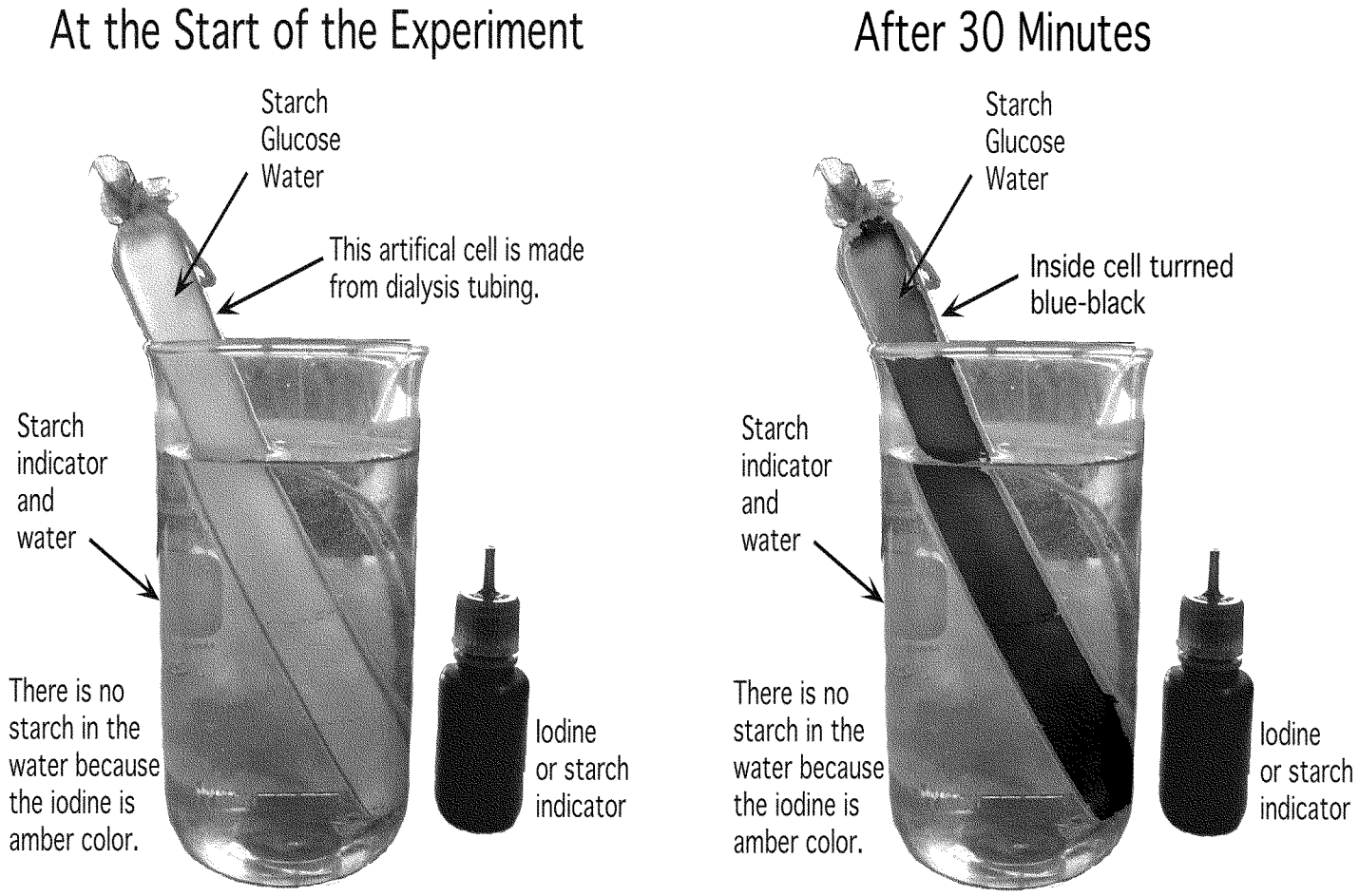
The cell membrane is said to be semipermeable, allowing only certain molecules to pass through it. Movement of molecules through the cell membrane can normally occur by two processes. They are

1. Active Transport - Energy is expanded as molecules are moved from areas of low concentration to areas of greater concentration. Active transport will not be explored in this laboratory activity.
2. Diffusion - Molecules move from areas of greater concentration to areas of lower concentration. Molecules diffuse due their random vibrations. The molecules move in a straight line until they strike another molecule, sending it outward. This process will cause concentrated molecules to spread out or move to areas of lower concentration. That is why everybody in a room will eventually smell a person who is wearing excessive perfume or cologne. (The molecules are jumping off of the person and spreading out to all corners of the room.)

Lab procedure: Part 1 - Building a cell.

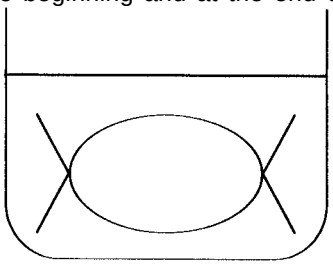
Students followed the below procedure to build an artificial cell.

- One end of an eight inch dialysis tubing was tied closed. Dialysis tubing is made up of a plastic that has many little holes through which only small molecules can pass. The dialysis tubing represents the cell membrane.
- Water, glucose and starch was poured into the tubing.
- The other end of the dialysis tubing was tied closed.
- The "cell" was placed into a beaker half fulled with water.
- Iodine is added to the water in the beaker. Iodine, is an indicator of starch. Normally amber, iodine turns blue-black in the presence of starch.

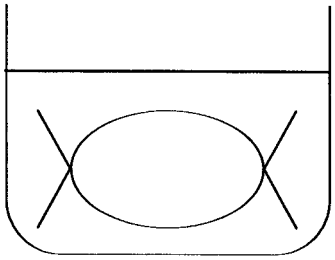


What had to happen for the cell to turn blue-black after 30 minutes?

Based on the pictures and information above, label the contents and note the colors present in both the beaker and the cell at the beginning and at the end of the experiment.



Initial State



Final State

Indicators

A indicator is a substance that is used to test for the presence of another substance. The indicator will react by changing color, fizzing, or reacting in some other obvious way. Two indicators used in this experiment are Iodine and Benedicts solution.

Two common indicators.

Indicator Solution Used	**Materials Tested**		
	Distilled Water	**Starch**	**Glucose**
* Blue color Benedict's Glucose Indicator Solution	Blue	Blue	Orange
Amber-colored Iodine Starch Indicator Solution	Amber	Blue-Black	Amber

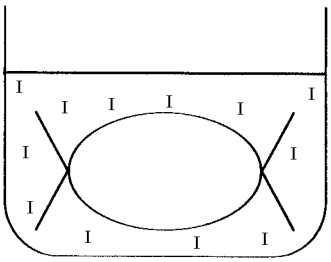
* Must be heated in a hot water bath.

Testing the water in the beaker.

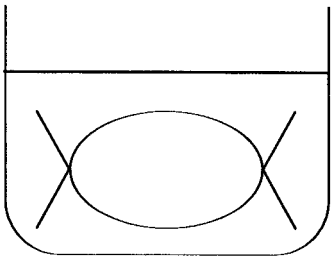
Water in the Beaker	Indicator	
	Glucose Indicator solution (Benedict's)	Starch Indicator Solution (Iodine)
At the beginning of Experiment	Blue	Amber
At the end of Experiment	Orange	Amber

Conclusion of Part 1

In the Initial state diagram below, Iodine is indicated with the letter "I". Using the letters "S" for starch, "G" for glucose and "I" for iodine, indicate the areas where each of these molecules are located in both diagrams.



Initial State



Final State

Which molecules passed through the membrane (dialysis tubing)? Explain your answer.

Which molecules did not pass through the membrane? Explain your answer.

Lab procedure: Part 2 — Diffusion of Water Across a Membrane (Osmosis).

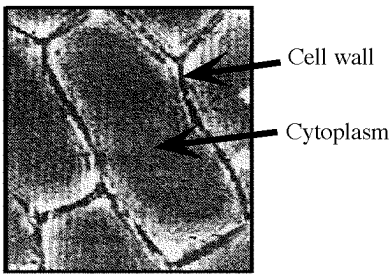
Osmosis is the diffusion of water across a membrane. It moves from areas of greater concentration of water to areas of lower concentration of water.

- Which way will the water move through the membrane in the three examples below?

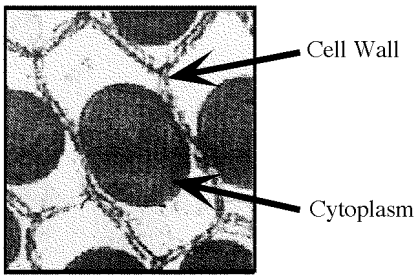
1. Cell	Membrane	2. Cell	Membrane	3. Cell	Membrane
95% water 5% solute	93% water 7% solute	95% water 5% solute	98 % water 2 % solute	95% water 5% solute	95% water 5% solute

The effect of salt and distilled (pure) water on the cell.

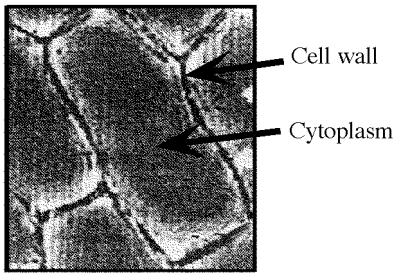
- An onion cell in tap water under high power of microscope looks like:



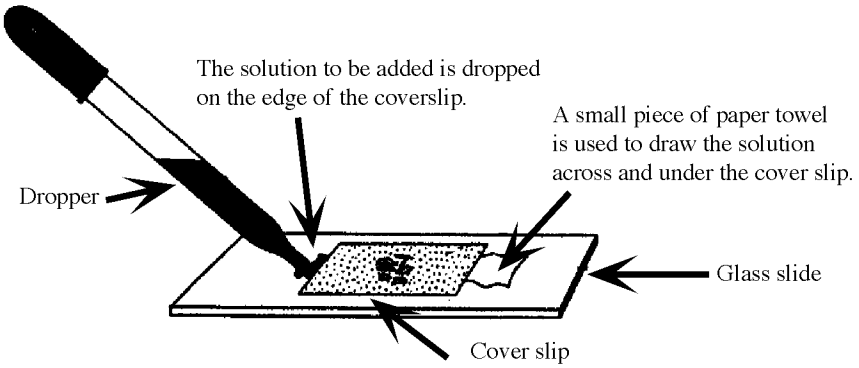
- If this cell is exposed to salt water, water moves from inside the cell to the saltwater environment. This causes the contents of the cell to shrink. This can be clearly seen as the cell contents move away from the cell wall.



- If this cell is exposed to distilled (Pure) or even regular tap water, the water will enter the cell and cause the cytoplasm to expand and it will once again touch the cell wall.



How to change the water without lifting the coverslip?

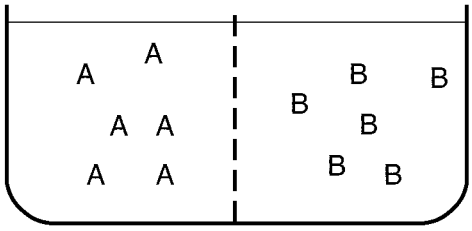


All students should have learned:

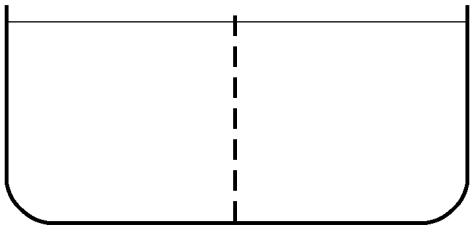
1. Movement of molecules through a membrane by diffusion mostly depend on two factors:
   a. Size of molecule - Small molecules can move through the membrane while large molecules can not.
      - Water, glucose, oxygen and carbon dioxide are small molecules and can move through the cell membrane by simple diffusion.
      - Starch, proteins and DNA are large molecules and cannot move by diffusion through the membrane.
   b. Concentration of molecule: The molecules will move from areas of greater concentration to areas of lower concentration. Three cases concerning water are:
      - Distilled water is 100% water. Distilled water will move through a membrane to a area where there is less than 100% water.
      - 95% Water, 5% salt will draw water out of a cell, causing the cell to shrink because there is a greater concentration of water in the cell. (Putting salt on a slug will cause it to lose water and shrivel up.)
      - If the concentration of water is the same on both sides of the membrane, there is no net movement of water.

Name: _____ Topic 10D

1. The diagram below represents a container of water and two different kinds of molecules, A and B, separated into two chambers by a membrane through which only water and molecule A can pass.



On the diagram of the container below, indicate the distribution of molecules A and B after the net movement of these molecules stops. [2]



Base your answers to questions 2 and 3 on the information below and on your knowledge of biology.

Students prepared four models of cells by using dialysis tubing containing the same blue solution. Each of the model cells originally weighed 10 grams. They then placed each model cell in a beaker containing a different concentration of water. After 24 hours, they recorded the mass of the model cells as shown in the data table below.

Data Table

Concentration of Water Surrounding the Model Cell	Mass of Model Cell
100%	12 grams
90%	11 grams
80%	10 grams
70%	9 grams

2. Why did the model cell that was placed in 100% water increase in mass? [1]

_____

_____

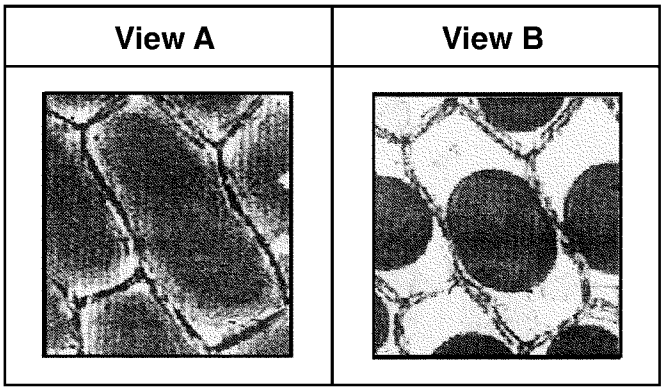
3. What was the concentration of water in the original blue solution? State evidence in support of your answer. [1]

_____

_____

Base your answers to questions 4 through 6 on the information and diagram below.

A student prepared a wet-mount slide of red onion skin and observed it under high power of a compound light microscope (view A). After adding a substance to the slide and waiting one minute, the student observed that there were changes in the cells (view B).



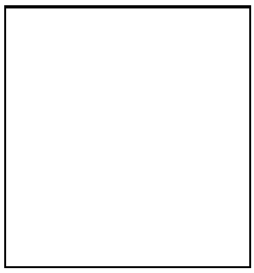
4. Identify one substance that could have been added to the cells on the slide in view A that would make them resemble the cells observed in view B. [1]

_____

5. Identify the specific substance that diffused to cause the change in appearance from view A to view B. [1]

_____

6. In the box below, sketch how view B would appear when viewed under lower power of the same compound light microscope. [1]



7. Molecules A and B are both organic molecules found in many cells. When tested, it is found that molecule A cannot pass through a cell membrane, but molecule B easily passes through. State one way the two molecules could differ, that would account for the difference in the ability to pass through the cell membrane. [1]

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