Name: ___________________________________ Date:____________ Score: _____ / 40 pts

Speciation Activity

Introduction: This activity is designed to explore speciation. **Speciation** *is the process through which new species arise on our planet*. The most commonly used definition of species is the **biological species definition**: *a species is a group of organisms that can breed with one another*. By this definition, organisms that cannot breed with one another are separate species. For example, although the various dog breeds appear very different from another, they are able to interbreed. Therefore, all dogs are part of the same species. However, brown bears, panda bears, and polar bears cannot interbreed, making them separate species.

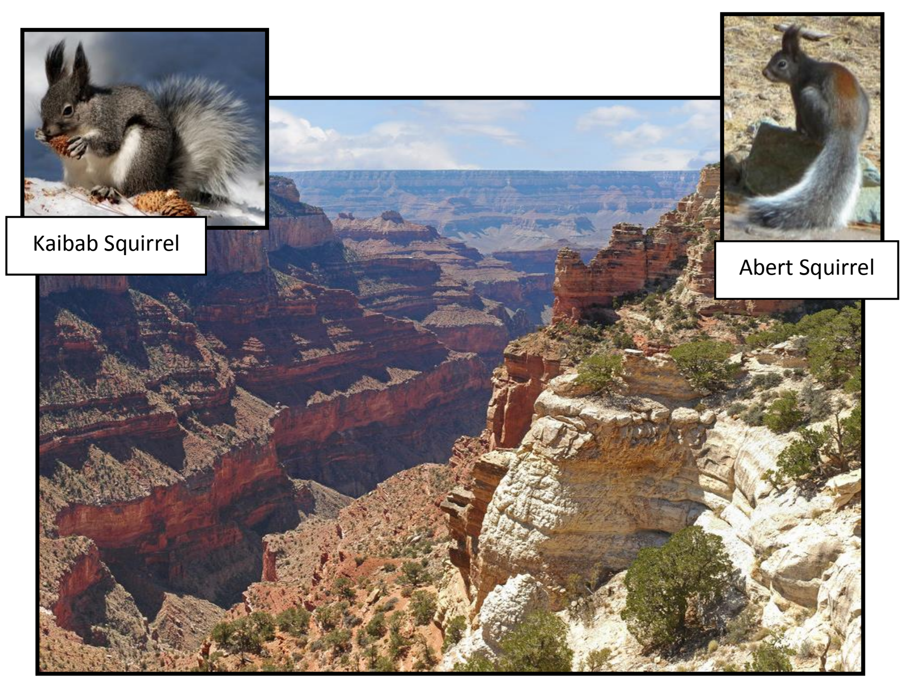
Microevolution studies how mutation, and natural selection acts on populations of organisms (small scale). **Macroevolution** focuses on large evolutionary changes, like how a dinosaur species evolved into modern birds over tens of millions of years. The small, gradual changes that occur during microevolution lead to speciation, and macroevolutionary change.

So, how does a population, consisting of individuals of the same species, become a new species?

There are several ways that speciation can occur, but there is one main phenomenon underlying all speciation: reduced **gene flow**.

Gene flow is a fancy term to describe the fact that a population of interbreeding organisms share genes within their group as they mate. Parents share/mix genes during sexual reproduction, making offspring with a combination of mom and dad's genes. The offspring then find mates, mixing their genes with a mate to make another generation of offspring. The genes within the population are regularly being mixed, hence the term "gene flow".

Let's read an example: A squirrel species lived in Arizona for tens of thousands of years. During the formation of some of the Grand Canyon, the population of squirrels became geographically isolated, or separated on the two sides of the Grand Canyon. At this point, the two separate populations could no longer come in contact with one another to mate. Over thousands of years, mutations occurred randomly in both sub-populations. Natural selection acted on both populations. As a result, the sub-populations gradually became more genetically different from one another. Eventually, when individuals from both populations were reintroduced, they were unwilling, or unable to make offspring. The two populations are now considered to be separate species. We call the species that lives on the North side the Kaibab squirrel, and the species on the South side is named the Abert squirrel.



When speciation occurs due to a population becoming geographically isolated, as in this example, it is called **Allopatric Speciation.**
(https://www.nationalgeographic.org/encyclopedia/speciation/)

<u>Intro Questions</u>: Answer in complete sentences (except for the list).

1. What is speciation? (1 pts)

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2. How is a "species" defined? (1 pts)

   ____

3. List at least three examples of species. (3 pts)

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4. What is the relationship between microevolution and macroevolution? Elaborate. (4 pts)

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5. In your own words, describe how reduced gene flow can lead to new species. (3 pts)

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<u>Simulating Speciation</u>: Now, you will be simulating speciation within a population of hypothetical frogs using dice, and the lists of mutations on the following pages. In this scenario, a hypothetical species of frog, name the "Brown Frog", thrives on the moist floor of a forest, at the base of a mountain range (the habitat's location is indicated in the photo at the bottom of the black arrow.) As the population of brown frogs expands over the landscape, they are divided by the mountain range that is several hundred miles long. Some of the population continues to grow on the left side of the mountain ridge, and the other side continues to spread down the right side of the mountain (indicated by the rounded arrows). You will now simulate random mutation and natural selection using dice. Continue reading on the next page.

Round 1:

1. Before rolling the dice, simply color in one of the blank frogs **brown** on the page at the end of this packet. This frog represents your original population. Cut the frog out, and glue it to the disc numbered "0" on the top of diagram of the mountain range.
2. Working with a partner, obtain two dice. First, Person 1 will roll both dice. Add the numbers on both dice together, which indicates the random mutation that occurs in the population. Use the list for Person 1 to identify the mutation that occurred. For example, if one dice lands on 3, and the other on 5, then you rolled an "8" in total: Which corresponds to a mutation that produces a **black-headed frog**.

3. Both person 1 and person 2 must color in a blank frog from the page provided (because you must both represent each other's mutations on your diagram). In this case, you would color the frog brown, with a black head. Cut the frog out, and glue it on to the disc numbered "1" on Person 1's Side of the diagram. (blank frogs located at the end of the packet).
4. Repeat this step for Person 2. Be sure that Person 2 refers to the other set of mutations after adding the dice numbers together.

Round 2:

1. Person 1 will roll the dice again, and add the numbers to identify the new mutation. However, for Round 2, you will be including the trait from round 1 in the coloring. For example, let's say that Person 1 rolls a "4" and a "5" for this round. This corresponds to a mutation that introduces **blue legs** into the population. So, both person 1 and person 2 will color the new frog **brown, with a black head, and blue back legs**.
2. Color in a blank frog from the page provided. Cut the frog out, and glue it on to the disc numbered "2" on Person 1's Side of the diagram.
3. Repeat this step for Person 2. Be sure that Person 2 refers to the other set of mutations after adding the dice numbers together.

Round 3:

1. Person 1 will roll the dice again, and add the numbers to identify the new mutation. However, for Round 3, you will be including the trait from Round 1 and 2 in the coloring. For example, let's say that Person 1 rolls a "3" and a "1" for this round. This corresponds to a mutation that introduces **yellow spots** into the population. So, Person 1 and Person 2 will color the new frog **brown, with a black head, with blue back legs**, **and yellow spots**.
2. Color in a blank frog from the page provided. Cut the frog out, and glue it on to the disc numbered "3" on Person 1's Side of the diagram.
3. Repeat this step for Person 2. Be sure that Person 2 refers to the other set of mutations after adding the dice numbers together.

PERSON 1's MUTATIONS: Add the numbers on both dice to determine the new trait

2. Introduces gene for maroon body
3. DNA mutates, but causes no change in the frog's traits
4. Introduces gene for yellow spots all over body
5. Introduces gene for black feet
6. Introduces gene for orange spots on back
7. Introduces gene for orange underbelly
8. Introduces gene for black head
9. Introduces gene for blue back legs
10. DNA mutates, but causes no change in the frogs traits
11. Introduces gene for green stripes
12. DNA mutates, but causes no change in the frogs traits

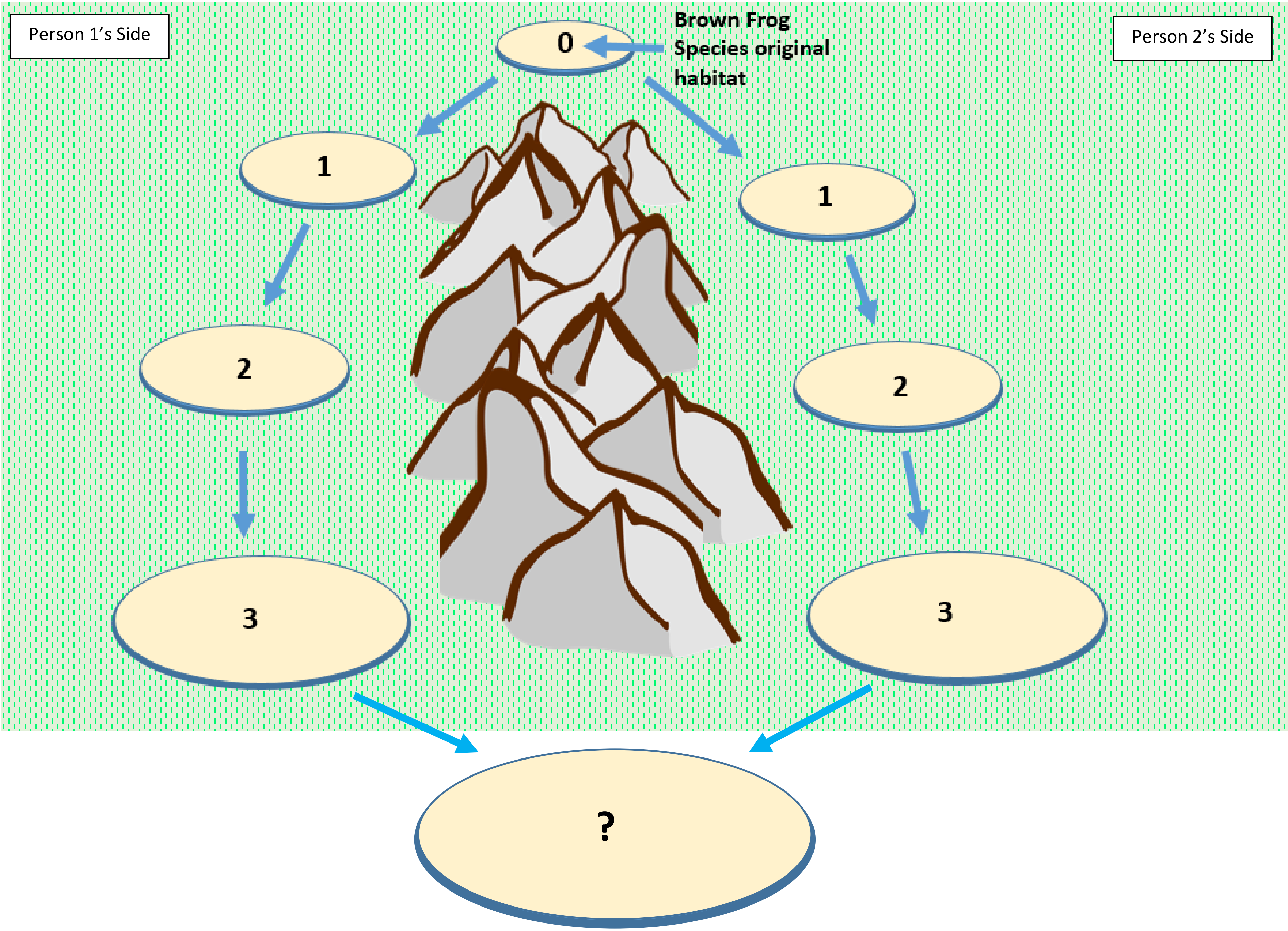
PERSON 2's MUTATIONS: Add the numbers on both dice to determine the new trait

2. Introduces a gene for orange spots all over body
3. The DNA changes, but doesn't affect the frog's traits
4. Introduces gene for gray body with orange underbelly
5. Introduces gene for black body with orange stripes
6. Introduces gene for maroon feet
7. Introduces gene for tan stripes on sides
8. DNA changes, but doesn't affect the frog's traits
9. Introduces gene for yellow body
10. DNA changes, but doesn't affect the frog's traits
11. Introduces gene for purple stripes
12. Introduces gene for blue spots on legs

<u>Misconception alerts:</u>

1. In reality, mutations are random, and most likely produce no change, or negatively affect an organism.
2. In this simple activity, it is easy to represent different colors. In reality, mutations can affect the size, shape, behavior, biochemistry, or any other traits of organisms.

Glue the colored frogs onto the appropriate numbered discs according to the directions. (8 pts – 1 points for each colored in frog glued onto the correct disc)



The disc with the question mark represents a habitat that the frogs share at the end of the mountain range. Let's imagine that the frog populations spread along the sides of the mountain range over the course of tens of thousands of years. During that time, mutations occurred randomly in both of the separated populations. Both populations spread into habitats with different conditions on either side of the mountain. All the while, natural selection is acting upon the frog populations, selecting for the most beneficial traits for each population.

This may lead the two populations of frogs to be very genetically different from one another. There are two possible outcomes if the two populations become quite genetically different from one another:

	SUBSPECIES	**SEPARATE SPECIES**
Definition	-Subspecies are part of the same species: -Subspecies have distinct genetic differences, but can still interbreed	- Separate species cannot, or will not, breed with one another *in nature*
Other Information	-Bengal tigers and Siberian Tigers are an example of subspecies of tigers -It is possible, but not guaranteed, that subspecies can eventually evolve into separate species	There are a few causes that lead to the inability of species to interbreed, including: 1. Subpopulations evolve different mating locations, times, or rituals 2. Subpopulations evolve differently shaped sexual organs, which cannot function with other subpopulations 3. Subpopulations cannot make offspring, due to differing number of chromosomes, for example

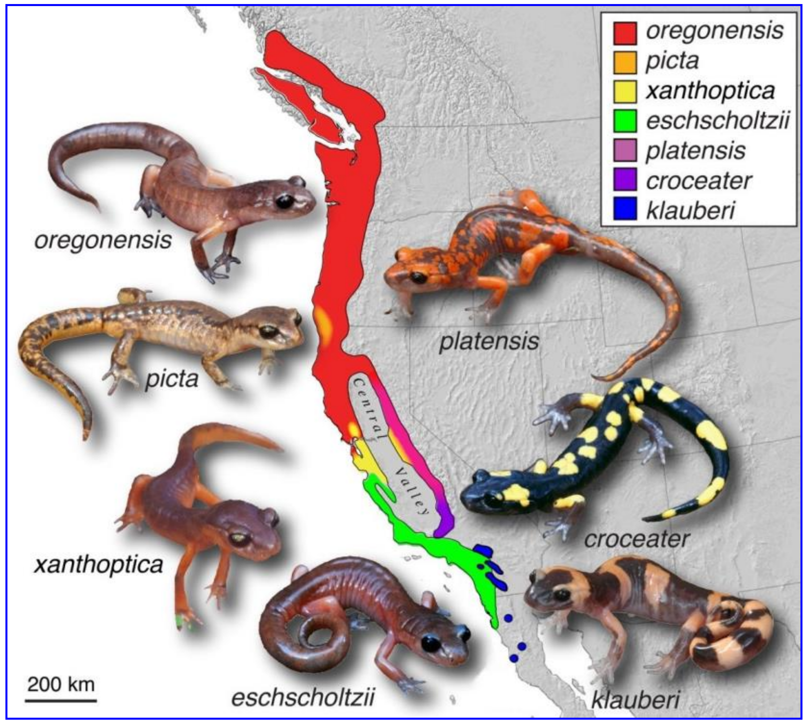
Now, let's see if subspecies, or separate species, evolved in your simulation. If the frogs in discs 3 possess the trait listed below for each person, then they are unable to interbreed, and therefore they have evolved into separate species. *For example, Row 1 tells you that if Person 1's frog has yellow spots all over, and Person 2's frog has maroon feet, then they are two different species*. **Circle "Yes" or "No"** to indicate if they are separate species. Understand that if they are not a new species, then they are a subspecies. (5 pts)

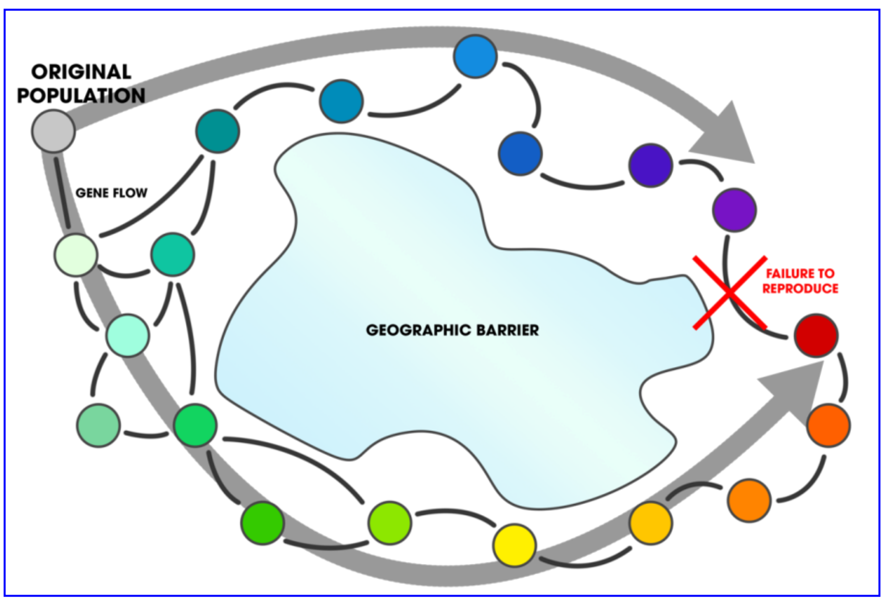
Trait of Person 1's Frog	Trait of Person 2's Frog	Are they Separate Species?
Yellow spots on body	Maroon feet	**Yes or No**
Orange underbelly	Blue spots on legs	**Yes or No**
Black head	Maroon feet	**Yes or No**
Yellow Spots	Tan stripes on sides	**Yes or No**
Blue back legs	Yellow body	**Yes or No**

Ring Species: A Real-World Example

The above activity was modeled after salamanders that evolved in California. Running down the center of California is a very large valley. A species of Salamander (*picta*) originated in Northern California. As the population spread south, subpopulations spread to the east rim and west rim of the valley, becoming geographically isolated. Mutation and evolution shaped the subpopulations as they spread south, generating several subspecies. However, when the two subpopulations met in the Southern part of California, they looked very different from one another, and would not interbreed. They are considered, in nature, to be separate species.

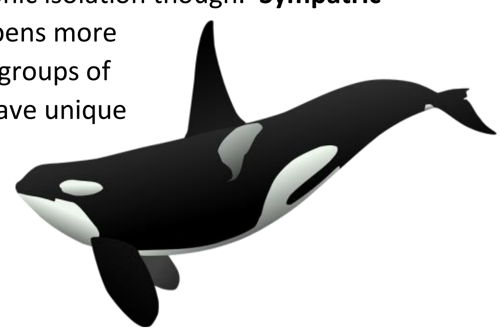




These salamanders are an example of a **ring species**; referring to the shape that they spread out (like a circle). Illustrated by the diagram below, all subspecies in the ring can interbreed with at least their immediate "neighbors", as they are not very genetically distinct from their closest geographic neighbors. However, the subpopulations that met back up at the end of a geographic barrier (mountain, valley, lake) are so genetically different that they are separate species.

__Reality Check:__ In reality, there is no way to predict whether or not two subpopulations will evolve into separate species. Just because subpopulations appear differently from another does not mean they can't interbreed (the opposite is true too).

Subpopulations that have had little or no gene flow for very long periods of time, that live in very different environments are more likely to evolve into separate species. Not all speciation requires geographic isolation though. **Sympatric speciation** occurs when species arise within the same geographical region. It happens more commonly within plants, but one interesting potential example in animals are two groups of orca whales that live in the Northeast Pacific. They prey on different food items, have unique "languages", and distinct mating rituals. The two groups of orcas do not breed with one another. Although scientists are not certain as to whether the groups are capable of producing offspring, they do not observe them mating with one another in nature, where they share a habitat.



Post Activity Questions

Directions: Answer the Questions below in complete sentences.

1. What did rolling the dice represent? Why is the process so important to speciation? (2 pts)

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2. If the 2 populations of frogs were to evolve into separate species, what type of speciation has occurred . (2 pts)

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3. New studies suggest that there are two, genetically distinct groups of rats in New York City (Uptown rats and downtown rats). Although the two rat populations are capable of making offspring with one another, they prefer to stay separated.

A. Are the rats subspecies, or separate species? Explain. (2 pts)

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B. Use the term "gene flow" to describe how the rats could become genetically distinct. (2 pts)

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C. What might eventually result, if the two groups of rats continue to prefer not to reproduce with one another? Elaborate. (2 pts)

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4. What is **Sympatric Speciation**? Provide an example (either from this activity, or do some research). (2 pts)

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5. Explain why the Californian salamanders are considered to be **ring species**. (3 pts)

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Color, and cut out the blank frogs according to the directions. There is an extra frog in case you make a mistake.