Name: _____ Period: _____ Date: _____

# sciencemusicvideos Adaptation, Natural and Artificial Selection, and Population Genetics Student Learning Guide

**Getting to the tutorials.**

- Go to www.sciencemusicvideos.com; Use the College Bio, AP Bio, or Learning Guide Menus to find "Adaptation, Natural and Artificial Selection, Population Genetics"
- Start with "1. Thinking Like Darwin: Adaptation, Artificial and Natural Selection.
-

***1. Tutorial 1: Thinking Like Darwin***

1a. Read, "Adaptations are traits the help organisms..." ☐

In your own words, define *adaptation*.

1b. In the space below, list three notable adaptations that are not described in this tutorial .

2. Read "Selective Breeding, or artificial selection..." ☐

3. Complete the Adaptation and Selective Breeding Quiz ☐

3a. Define the term *species*:

3b. List and briefly describe some varieties or breeds to accompany the examples in this tutorial (no dogs or members of the Brassica family).

3c. Explain why varieties or breeds are *not* species.

3d. What's a phenotype, and how does it apply to selective breeding?

4. Read "Natural Selection, an interactive reading..." ☐

4a. Natural selection can be summarized as four related steps. List them below.

-
-
-
-

*4b. Natural selection* winds up sitting next to *artificial selection* at a baseball stadium They have a brief conversation where they note how similar they are, while acknowledging their differences. Write down their dialogue below.

4c. What is mutation, and how is mutation important to natural selection?

4d. What's an evolutionary arms race?

5. Read "A few additional ideas related to natural selection..." ☐

6. Take the quiz, "Adaptation, Artificial Selection, and Natural Selection."☐

6a. Explain why populations, and not individuals, are the units of evolution.

6b. Natural selection is sometimes summarized as "survival of the fittest." What is evolutionary fitness?

6c. Pick an organism of your choice. Focus on one adaptation.
1. In the space below, create a speculative hypothesis about how that adaptation might have evolved through natural selection.

6d. Look over your explanation. See if you can design an experiment to test your hypothesis.

***Tutorial 2: Alleles in Gene Pools***

1. Read, "A Population Genetics Case Study: The Cheetah" ☐
**Summarize:** Genetically speaking, what's the cheetah's problem?

2. Complete, "The Gene Pool, Fixed Alleles…" interactive reading ☐
Define *Allele:*

Define *Gene locus:*

Define *Fixed allele:*

3. Take the "Checking Understanding" Quiz ☐
REFLECTION: 3 things you learned from this section:

**Tutorial 3. Follow the link to "Understanding Allele Frequencies in Gene Pools."**

1. Allele Frequency. Complete the reading and interactive table (1.a.), and the quiz (1.b.) ☐
**Summarize:** What is allele frequency?

2. Complete the reading "Allele Frequency Case Study: The Peppered Moth" ☐
**Application:** Use the concept of allele frequency to explain how the color of the peppered moth changed in response to pollution in English forests in the mid-1800s. (Continue this on the next column)

3. Read the section entitled "Misconception Alert! 'Dominant Allele' does not mean 'Most common Allele.'" ☐
4. Complete the reading: "Allele frequencies and fixed alleles in dogs" ☐
5. Complete the "Checking Understanding" Quiz. ☐
Reflection: The three most important things I learned from this section were …

**Tutorial 4. Follow the link to "The Hardy-Weinberg Equation."**

1. Some Population Genetic Analysis to Get Us Started, including *1.a. Population Genetics Analysis Task 1*
*Note that the paper version of the data set is much easier to use: it's been provided to you as a separate handout.*
Read the introduction, complete the activity, and record the results of your analysis below. Then check your results (using the webpage)

| Allele or genotype | fraction | decimal |
|---|---|---|
| a | ____/400 | 0._____ |
| A | ____/400 | 0._____ |
| aa | ____/200 | 0._____ |
| Aa | ____/200 | 0._____ |
| AA | ____/200 | 0._____ |

*1.b. Population Genetics Analysis Task 2*
Now, look back at the table, and note relationships between your results. Write them down, then click "show the answer." As needed, make corrections or additions in the space below.

2. Read "Population Genetic Analysis is about counting…"☐
After reading, complete the "Hardy-WeinbergEquation" Flashcards. ☐

**Total Recall:** From memory, complete the table below:

| Symbol | Represents the frequency of… |
|---|---|
| p | |
| q | |
| $p^2$ | |
| 2pq | |
| $q^2$ | |

3. Read "Use Cross Multiplication Tables."

**More Recall:** From memory, put the symbols from the table above into the cross multiplication table below.

| | | |
|---|---|---|
| | | |
| | | |

4. Complete "Solving Hardy-Weinberg Problems Using Cross Multiplication Tables." Solve the problems in the spaces below, and use the flashcards to check your work.

**PROBLEM 1:** In a population, the frequency of the homozygous recessive phenotype is 36%. Determine the frequency of

- the recessive allele
- the dominant allele
- homozygous dominants
- heterozygotes

| | | |
|---|---|---|
| | | |
| | | |

**PROBLEM 2:** A study in an African nation estimated the frequency of individuals born with sickle cell anemia as 2.1%. What is the frequency of heterozygotes (individuals who don't suffer the symptoms of sickle cell anemia, but, on account of possessing the allele, have some resistance to the parasite that causes malaria)?

| | | |
|---|---|---|
| | | |
| | | |

**PROBLEM 3:** In a population of butterflies, brown (B) is dominant over white (b). 40% of the butterflies are white. What's the percentage of

- the recessive allele
- the dominant allele
- homozygous dominants
- heterozygotes

| | | |
|---|---|---|
| | | |
| | | |

**PROBLEM 4:** Cystic fibrosis is the most common inherited disease among North Americans of European ancestry. The disease is caused by a recessive allele. About 1 in 2500 babies are born with this condition. What percentage of the population are carriers?

| | | |
|---|---|---|
| | | |
| | | |

**PROBLEM 5:** The frequency of two alleles in a gene pool is 0.19 (A) and 0.81 (a). What is the percentage of heterozygotes in the population? What's the percentage of homozygous recessives.

| | | |
|---|---|---|
| | | |
| | | |

**Tutorial 5. Follow the link to "The Hardy-Weinberg Principle."**

1 & 2. Read the introduction and "The Principle, a Starting Definition." ☐

**SUMMARIZE**: Based on the text, write down the Hardy-Weinberg Principle.

3. Read "Factors that Keep Populations in Genetic Equilibrium." ☐

4. Read "Remembering the Hardy-Weinberg Principle…" and take the fill-in-the-blanks quiz.

**Remembering what you've learned:** In the space below, write down the five conditions that keep gene pools in equilibrium.

- 
- 
- 
- 
- 

**Click the link to the next tutorial: "Natural selection in Gene Pools"**

**Tutorial 6. Natural Selection in Gene Pools**

1. Read the introduction ☐

2. Read "Natural Selection Directly Acts on Phenotypes" and complete the "Genotype v. Phenotype" interactive table ☐
Complete the following table

| Term | Definition |
|---|---|
| Phenotype | |
| Genotype | |

3. Read "Natural Selection Increases the Frequency of Beneficial Alleles…" ☐

**CHECKING UNDERSTANDING:** How does natural selection change gene pools?

Complete this sentence: Natural selection selects _____ in individuals. In doing so, it changes the frequency of _____ in populations.

4. Read "Natural Selection in Action…" ☐
Answer the following questions:

4a. People select traits in domesticated animals. Who selected the colors of the peppered moths (and how)?

4b. Summarize how the ice fish evolved its red-blood cell free blood….

4c. Summarize how different phenotypes of pocket mice evolved in the Arizona desert.

5. Read "Natural Selection can Unfold in Three Ways." ☐
Complete the table below, comparing the three modes of selection you just read about:

| Type of selection | Image | Description |
|---|---|---|
| Directional | | |
| Stabilizing | | |
| Disruptive | | |

6. **Checking Understanding.** Read the summary and take the "Natural Selection in Gene Pools Quiz." ☐

**Reflection:** Think about the whole tutorial (all the exercises, readings, and all the questions you've answered). *At this point, what is population genetics? What does it explain?*

**Tutorial 7. Follow the link to the next tutorial "Why Harmful Alleles Don't Disappear"**

1. Read the introduction ☐

2. Complete the interactive reading, "Harmful Recessive Alleles" ☐

REFLECTION: In your own words, explain why harmful recessive alleles stay in gene pools.

3. Read "The persistence of harmful dominant alleles" ☐
REFLECTION: In your own words, explain why harmful dominant alleles stay in gene pools.

4. Take the quiz "Why Harmful Alleles Persist in Gene Pools" ☐

**Reflection:** Despite natural selection, *why aren't gene pools full of perfect genes?*

**Tutorial 8. Follow the link to the next tutorial: Mutation in Gene Pools, and Heterozygote Advantage.**

1. Read "Mutations, DNA, and Protein." You've already learned a lot of this, so it should be easy. ☐
SUMMARIZE: in your own words, explain the genetic and molecular causes of sickle cell anemia.

2. Read "Mutations can have three types of consequences." ☐

**SUMMARIZE** by answering the questions that follow:

2a. When are mutations harmful? Give some specific examples,

2b. What's a silent mutation?

2c. How could a mutation be helpful?

2d. What is heterozygote advantage?

3. Take the Checking Understanding Quiz ☐

**Reflection:** In terms of a population's gene pool, how is mutation important?

**META Reflection:** Think about the whole tutorial (all the exercises, readings, and all the questions you've answered, from the first page to this point). At this point, *what is population genetics*? What does it explain?

Follow the link to the next tutorial ("Genetic Drift…)"

**Tutorial 9. Genetic Drift, the Founder Effect, and Population Bottlenecks.**

1. Read: "Genetic drift can explain…" ☐

SUMMARIZE: in your own words, explain what genetic drift is:

2a. Read about the founder effect: ☐

SUMMARIZE: In your own words, explain what the founder effect is:

2b. Read about population bottlenecks as applied to Elephant seals: ☐

SUMMARIZE: in your own words, explain what a population bottleneck is:

2c. Read about cheetahs: ☐

SUMMARIZE: in your own words, explain why cheetahs have such little genetic variation:

3. Take the "Checking Understanding" Quiz

**Reflection:** In terms of a population's gene pool, why is genetic drift important?

Follow the link to the population genetics cumulative quiz.

**10.Take the cumulative quiz:** ☐

## Population Genetics Review Questions

1. Describe, in terms of allele frequencies and the environment, how the peppered moth changed from mostly light to mostly dark.

2. In terms of fixed alleles and number of heterozygotes, how are dogs with a pedigree different from mutts?

3. Describe two genetic conditions that are caused by dominant alleles, but are exceedingly rare. Why don't these conditions disappear altogether?

4. Describe two recessive genetic conditions that are caused by recessive alleles. Why don't they disappear?

5. In terms of evolution, what happens to phenotypes, and what happens to allele frequencies?

6. Are you going to evolve over the course of your life? What's a better word for what happens to individual organisms?

7. Use the terms "allele," "allele frequency," and "gene pool" to explain the evolution of fur color in the rock pocket mouse.

8. Use the terms "allele," "allele frequency," and "gene pool" to explain how the ice fish evolved its unique, hemoglobin-free type of blood.

9. What is the Hardy-Weinberg equation. Write the equation, and then, much more importantly, explain what the equation *means*.

8. What is the Hardy-Weinberg principle: List, from memory, the five conditions that keep populations in genetic equilibrium, and describe each one.

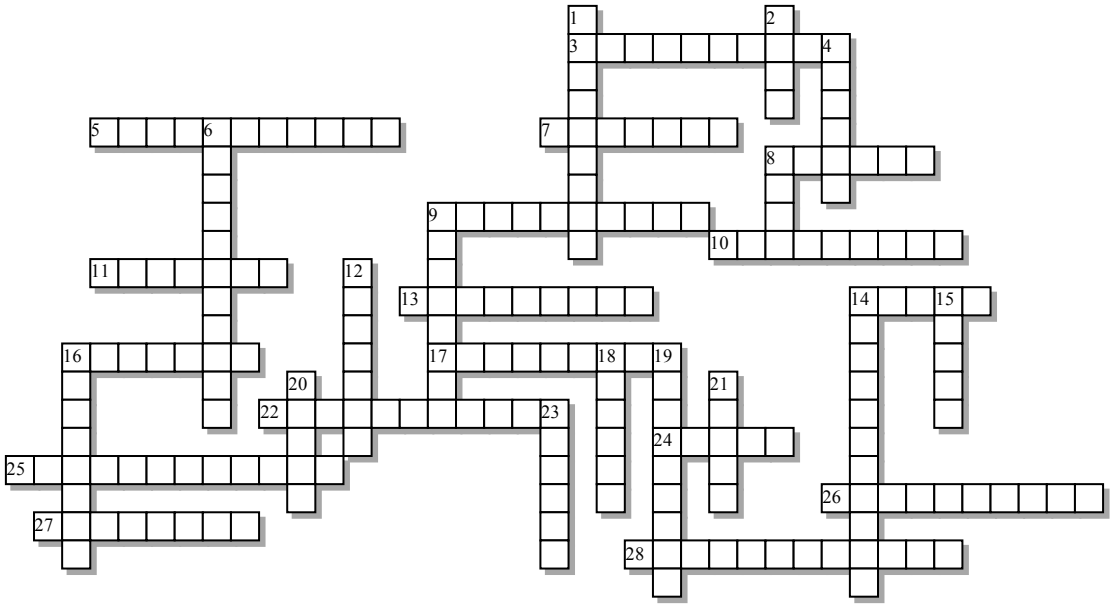
9. What role do mutations play in gene pools?

10. How and when can the sickle cell mutation be beneficial?

11. Search for "heterozygote advantage" on-line. List and briefly describe at least three additional examples of heterozygote advantage

11. Write a short paragraph in which you compare and contrast the founder effect with a population bottleneck.

# Population Genetics



**Across:**

3 - If you can count the number of individuals with a _____ recessive phenotype, you can figure out a lot about a gene pool's structure. "

5 - Selection against the extremes of a trait in a population.

7 - The _____ effect is when a small number of individuals with unusual alleles give rise to a new population.

8 - Mating in genetically stable populations must be

9 - Selection against the average trait in a population

10 - Allele _____ is how common an allele is in a gene pool.

11 - This kind of selection occurs when one phenotype leaves more offspring than other phenotypes

13 - Loss of genetic _____ is associated with genetic drift.

14 - Genetic _____ is a change in allele frequencies caused by random events

16 - If you're a heterozygote for sickle cell, you have a better chance of surviving this disease

17 - Heterozygote _____ is one explanation for the persistence of harmful recessive alleles in gene pools.

22 - Individuals are selected. Only _____ evolve.

24 - For a population to be genetically stable, it must be

25 - 2pq is the frequency of individuals who are _____.

26 - A population _____ is when a population suffers huge mortality, and a few, random survivors give rise to a new population."

27 - The H-W principle states that if five conditions are met, allele frequencies will remain

28 - The gene pool of _____ populations, like specific breeds of dogs or cattle, will have many fixed alleles.

**Down:**

1 - Natural selection can only act on an organism's _____

2 - All the alleles for all the genes in a population make up a population's gene _____

4 - A mutation with no effect on the phenotype

6 - Populations that are genetically stable will have no _____ or emigration

8 - It's possible for a dominant allele to be extremely _____

9 - The allele for Huntington's is an example of a harmful _____ allele that persists in the human gene pool.

12 - _____ recessive alleles, because they can hide out in heterozygotes, don't get selected out of gene pools.

14 - In a graph of a quantifiable trait in a population, this type of selection pushes the average to the left or right.

15 - If there's only one allele for a gene locus, then that allele is

16 - Random change in DNA that brings new alleles into gene pools.

18 - An alternative form of a gene

19 - Change in allele frequencies in a population is

20 - The spot on a chromosome where you find a gene

21 - First part of the name of the most important equation in population genetics.

23 - This kind of selection occurs when one phenotype in one sex gets more matings than other phenotypes.

**Word bank:** Hardy, advantage, allele, bottleneck, constant, directional, disruptive, diversity, domesticated, dominant, drift, evolution, fixed, founder, frequency, harmful, heterozygous, homozygous, immigration, large, locus, malaria, mutation, natural, phenotype, pool, populations, random, rare, sexual, silent, stabilizing

Name: _____ Period: _____ Date: _____

# *Species, Speciation and Extinction, Student Learning Guide*

**Getting to the tutorials**

- Go to www.sciencemusicvideos.com; Use the College Bio, AP Bio, or Learning Guide Menus to find "Species, Speciation and Extinction."

**Tutorial 1: What is a Species?**

1 & 2. Read the introduction, and complete the interactive reading. ☐

Why are all dogs members of the same species?

Why *isn't* the Bengal cat a species?

From memory, complete this definition of a species:

*A group of individuals or populations that share a common _____ _____, and which is _____ from other groups. All members of a species can _____ to produce _____ offspring.*

3. Read "Talking about Species, Subspecies, Breeds, and Varieties. " As you read define the following terms

| | |
|---|---|
| subspecies | |
| breed | |

4. Read "What Keeps Species Apart?..." ☐

Speculate: Why don't grizzly bears breed with black bears?

5. Take the "Reproductive Barriers" Quiz

**Checking Understanding:**

a. Compare and contrast pre-zygotic and post-zygotic isolating mechanisms.

b. List and briefly describe as many specific reproductive isolating mechanisms as you can. You should be able to list 5 pre-zygotic and 3 post-zygotic mechanisms.

6. Read "The Biological Species Concept. Limitations and Alternatives." ☐

7. Take the quiz "What is a Species?" ☐

**Checking Understanding:**

a. Describe the limits to the biological species concepts.

b. Briefly describe these other species concepts:

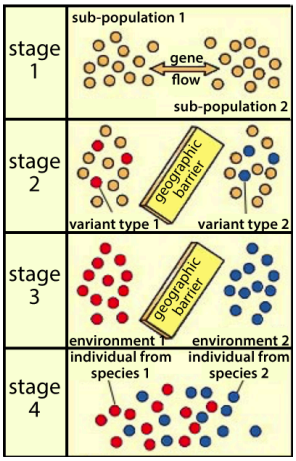
| | |
|---|---|
| morphological species | |
| phylogenetic species | |
| chronospecies | |

Click the link to the next tutorial, "Allopatric speciation."

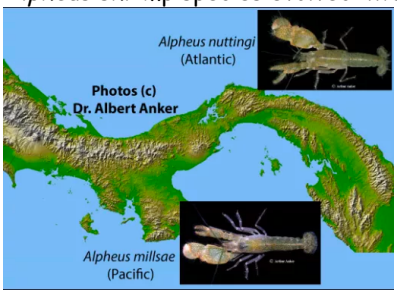
**Tutorial 2: Allopatric Speciation**

1 & 2. Read the introduction, and complete the interactive reading. Start by speculating about how the two *Alpheus* shrimp species evolved into separate species.

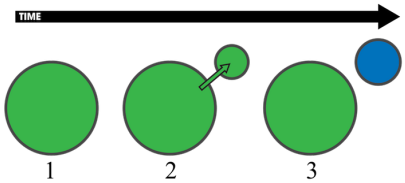
When you're done, write out an explanation of the allopatric speciation model in the space to the right of the diagram below.



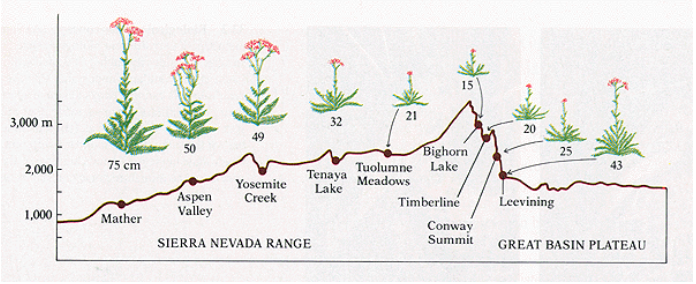

Now, let's return to the example we started with. Using what you know about allopatric speciation, explain how the two *Alpheus* shrimp species evolved into separate species.



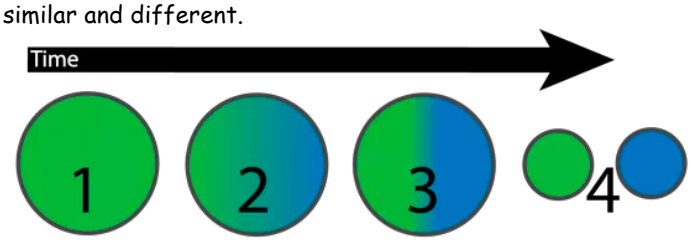

3. Read about "Peripatric Speciation," and take the Peripatric speciation quiz. When you're done, use the diagram below to explain how peripatric speciation works.



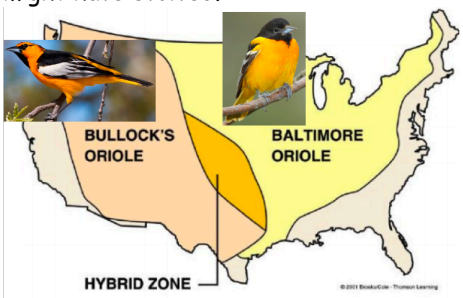

4a. Read about Clines. In the space below the diagram, explain the connection between the height of these yarrow plants and elevation.




4b. Read about "Parapatric Speciation and Hybrid Zones" In the space below the diagram, explain 1) the connection between clines, parapatric speciation, and hybrid zones; and 2) how parapatric speciation and allopatric speciation are similar and different.

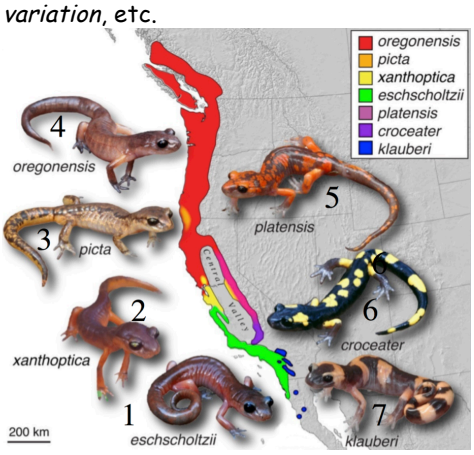



**Checking Understanding.** Explain the hybrid zone between the two species shown below, and speculate about how it might have evolved.



4c. Read about "Ring Species." ☐

In the space to the right and below the diagram, explain how ring species work. Make sure your explanation includes concepts like *reproductive isolation*, *differentiation*, *clinal variation*, etc.




5. Take the "Allopatric Speciation (and its Variations)" quiz.

**SYNTHESIZE** what you've learned.

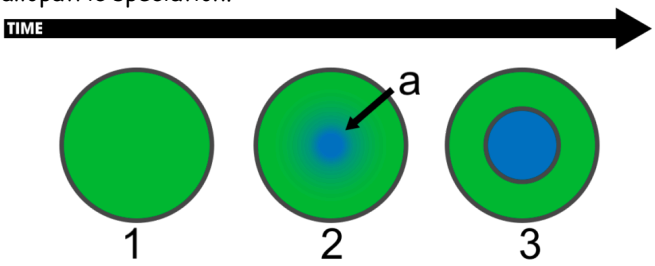
In the space below, explain how allopatric speciation works, and compare it to peripatric and parapatric speciation. Make sure you include an explanation of clines and hybrid zones.

Follow the link to the next tutorial, "Sympatric Speciation."

**Tutorial 3: Sympatric Speciation**

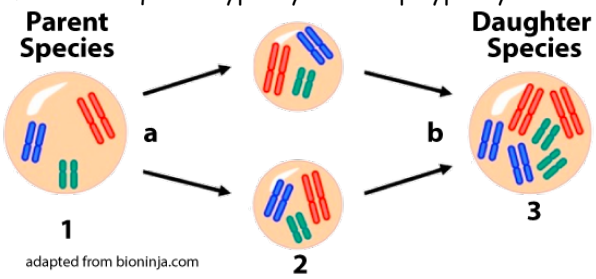
1. Read the introduction. ☐

**Explain**: How is sympatric speciation different from allopatric speciation?




2. Read "In plants, Sympatric Speciation can occur through..."

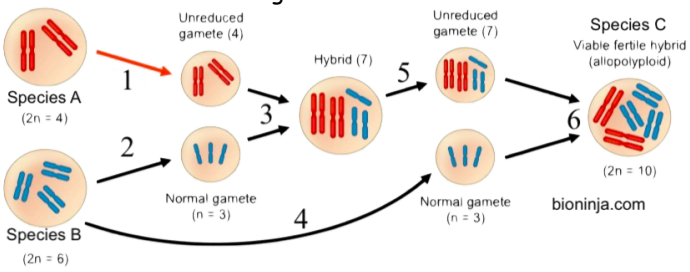
3. Take the quiz: Polyploidy and Allopolyploidy




Create a key to the diagram above. The process is called _____

| | |
|---|---|
| 1 | |
| a | |
| 2 | |
| b | |
| 3 | |

Do the same for this diagram:




The process is called _____

| | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |
| 6 | |

4. Read "Sympatric Speciation in Animals" ☐

5. Take the quiz: Sympatric Speciation ☐

**Checking Understanding**

Explain how each of the following can bring about sympatric speciation in animals.

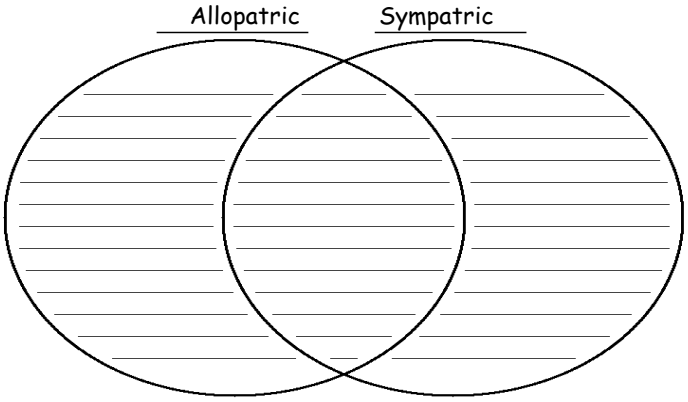
a. Sexual selection

b. Disruptive selection

c. Habitat differentiation.

**Comparing and Contrasting:**

a. Complete the Venn Diagram below




Now, in the space below, write one or two paragraphs comparing and contrasting allopatric and sympatric speciation. Write small.

Click the link for the next tutorial, "Adaptive Radiation."

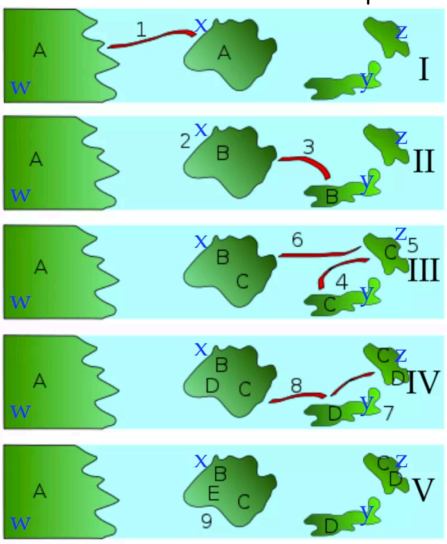
**Tutorial 4: Adaptive Radiation**

1. Read about adaptive radiation ☐

**Checking Understanding**

a. Explain, on a general level, how adaptive radiation works.

b. Use what you've learned about adaptive radiation to explain how, in the hypothetical example below, species "A" could have evolved into 5 descendant species.




**Tutorial 5: Extinction**

1. Read the introduction: "Three Extinct Species."☐

2. Read "Extinction is the Flip Side of Speciation." ☐

3. Read "The Extinction Vortex" ☐

**CONNECT!** Explain how the extinction vortex is connected to the idea of genetic drift (covered in a previous module).

4. Read "The background level of extinction." ☐

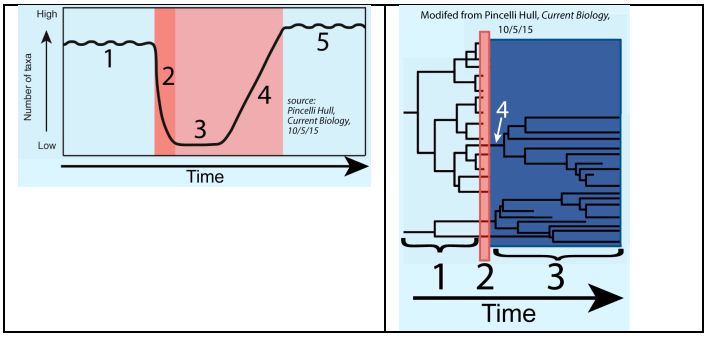
5. Read "Mass Extinction" ☐

**SUMMARIZE**: Imagine that you're at home, explaining to a younger sibling, cousin, or neighbor about what you learned about mass extinction. Explain what you've learned (but make sure not to make it too traumatic). In you explanation, be sure to contrast *mass extinction* with *background level extinction*.

6. Read "What Happens After Mass Extinction" ☐

7. Take "Understanding Extinction" Quiz ☐

**SUMMARIZING TASK 1;** Explain what these diagrams say about what happens before, during, and after a mass extinction.




**Continue on to the Speciation and Extinction Cumulative Quiz**

**Tutorial 6. Species, Speciation, and Extinction Cumulative Quiz.**

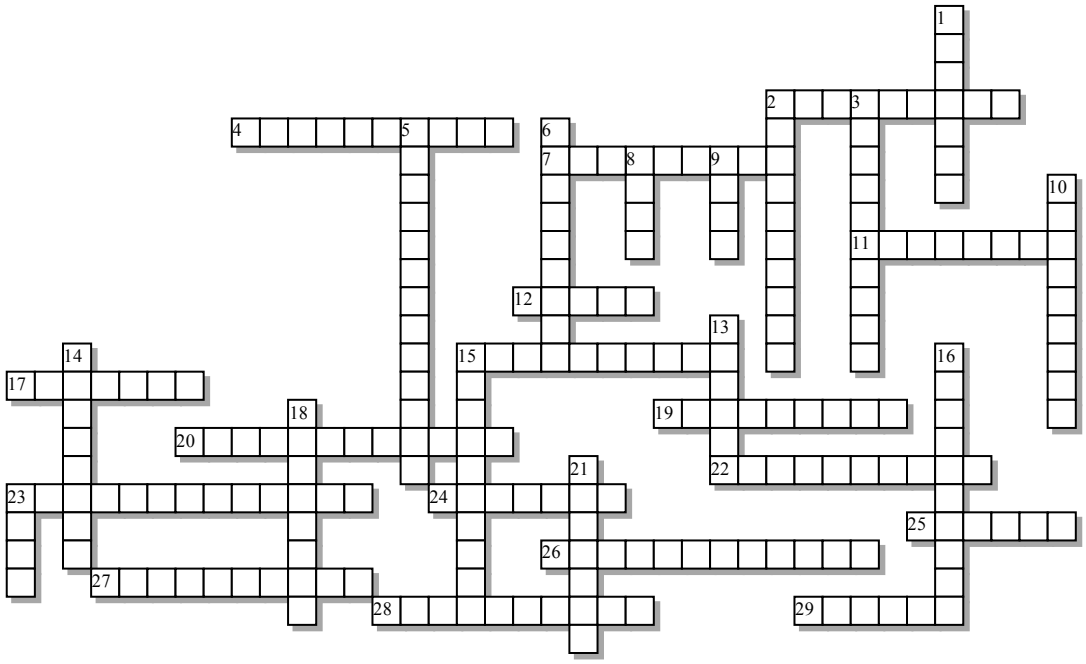
1. Take the Cumulative Quiz.

**2. SUMMATIVE REFLECTION ABOUT SPECIATION**

According to recent estimates of biodiversity, our planet has 8.7 million species (*Nature*, August 24, 2011). In the space below, explain how they got there. Use this as an opportunity to test your understanding of 1) what a species is; 2) allopatric speciation, 3) sympatric speciation, 4) adaptive radiation. End with a brief explanation of why extinction happens, and why it's important in understanding the history of life.

You should have a lot to say. Write small, and fill up the rest of the space below.

**Species, Speciation, and Extinction**



**Across:**

2 - The type of barrier in which the first hybrid generation is fine, but the second won't work

4 - A naturally occurring, differentiated group within a species, often connected to a specific geographical area.

7 - Speciation without a geographical barrier

11 - An _____ impact caused the extinction the dinosaurs

12 - Graded variation in genetic and phenotypic characters along a geographical axis.

15 - A speciation mechanism that involves entire new sets of chromosomes.

17 - A population of interbreeding organisms that is isolated from other such groups

19 - Poodles, Golden Retrievers, and Kerry Blue Terriers are all _____ of the domestic dog.

20 - The _____ species concept sees species as distinct branches on the tree of life

22 - Selection against the average phenotype that can split a species into two.

23 - A species concept that's very useful with fossil species

24 - Where an organism lives; also a cause of speciation, and a reproductive barrier.

25 - Species in disturbed habitats often enter into an extinction ___.

26 - This kind of isolation is at the heart of the biological species concept

27 - This process directly undoes what speciation does

28 - A burst of _____ often follows mass extinctions.

29 - This kind of selection involving female choice can lead to speciation in animals.

**Down:**

1 - Pre-_____ barriers prevent closely related species from breeding.

2 - The _____ extinction rate is about one extinction/million species/year

3 - A speciation process that involves a geographic barrier.

5 - A species that evolves over time into a descendant species.

6 - The biological species concept won't work with species that reproduce this way

8 - One way of thinking about a species is as a distinct, isolated gene _____ .

9 - When a cline folds back on itself, a _____ species can form.

10 - When a species splits into several descendants, it's called adaptive _____

13 - Between closely related species, there's often this kind of zone.

14 - When two closely related species breed in different seasons, the barrier is

15 - When speciation occurs in a small, subpopulation on the periphery.

16 - If courtship rituals don't elicit the desired response in a partner, the barrier is

18 - Huge _____eruptions were associated with the "Great Dying."

21 - If sperm won't fertilize egg, then the barrier is

23 - This kind of extinction is associated with planetary disturbances

**Possible Answers:** allopatric, asexually, asteroid, background, behavioral, breakdown, chronospecies, cline, disruptive, extinction, gametic, habitat, hybrid, mass, morphological, peripatric, phylogenetic, polyploidy, pool, radiation, reproductive, ring, sexual, speciation, species, subspecies, sympatric, temporal, varieties, volcanic, vortex, zygotic

Name: _____ Period: _____ Date: _____

# *sciencemusicvideos* Phylogeny and Classification, Student Learning Guide

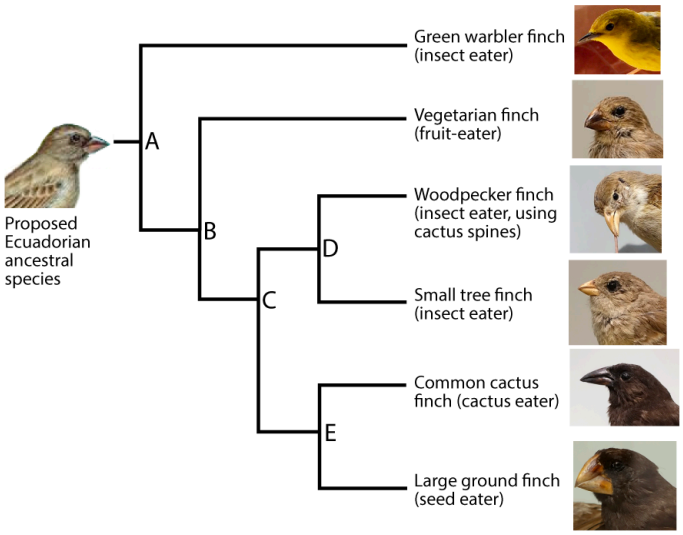
**Getting to the tutorials.**

- Go to www.sciencemusicvideos.com; Use the College Bio, AP Bio, or Learning Guide Menus to find "Phylogeny and Classification"

1. Read "Phylogeny shows evolution's branching pattern." ☐

2. Take the quiz "Phylogeny Introduction: Checking Understanding." ☐

**SUMMARIZING**: Using the phylogenetic tree below, write a paragraph explaining the story of finch evolution on the Galapagos islands. Use terms such as "node," "clade," "speciation," and "common ancestor."




3. Read "Naming and Classifying Species" (both 3a. "Binomial Nomenclature" and 3b. "Classification"☐

4. Take the quiz "Phylogenetic Trees, Binomial Nomenclature, and Classification"

**MASTERING THE TERMS:** In the space below, define each of the following terms

- Clade
- Node
- Lineage
- Taxon
- Terminal taxon
- Binomial

5. Read "Phylogenetic Trees: A Deeper Look" (sections *a*, *b*, and *c*) ☐

5d. Take the Quiz, "Phylogenetic Trees, Checking Understanding." ☐

DRAWING DISTINCTIONS: Write a sentence comparing and contrasting each of the following:

a. Ingroup vs. outgroup

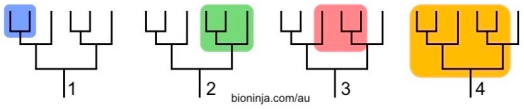
b. Clade vs. taxon

c. Taxon vs. category

d. Shared derived features vs. ancestral feature

e. Common names vs. scientific names.

f. Explain, with reference to the diagram below, the difference between a monophyletic, a polyphyletic, and a paraphyletic taxon.




6. Read and complete, "Using Character Tables to Create Phylogenetic Trees (including all the interactive phylogenies in *a*, *b*, and *c*" ☐

7. Read and complete all the quizzes in "Molecular Clocks."☐

8. Read and complete "Horizontal Gene Transfer"☐

9. Complete the "Phylogeny Cumulative Quiz"☐

**Checking Understanding:** In the spaces below, answer, define or explain.

1. What's a character table?

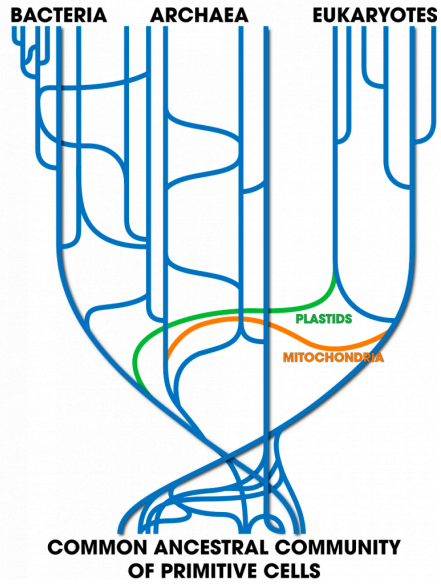
2. What are analogous features? How do they arise? Why must they be avoided in determining phylogeny?

3. *Why* can shared nucleotide or amino acid sequences be used to determine phylogeny?

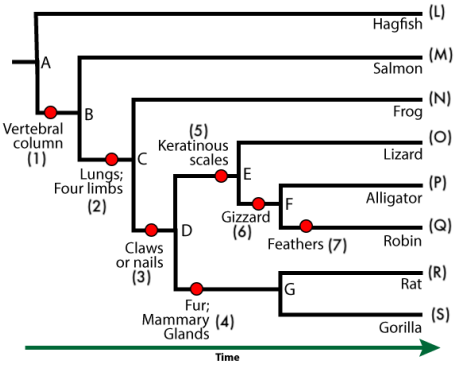
4. What are molecular clocks? How are they calibrated?

5. For a given protein or gene, why would you expect sister taxa to have closely matching amino acid and nucleotide sequences?

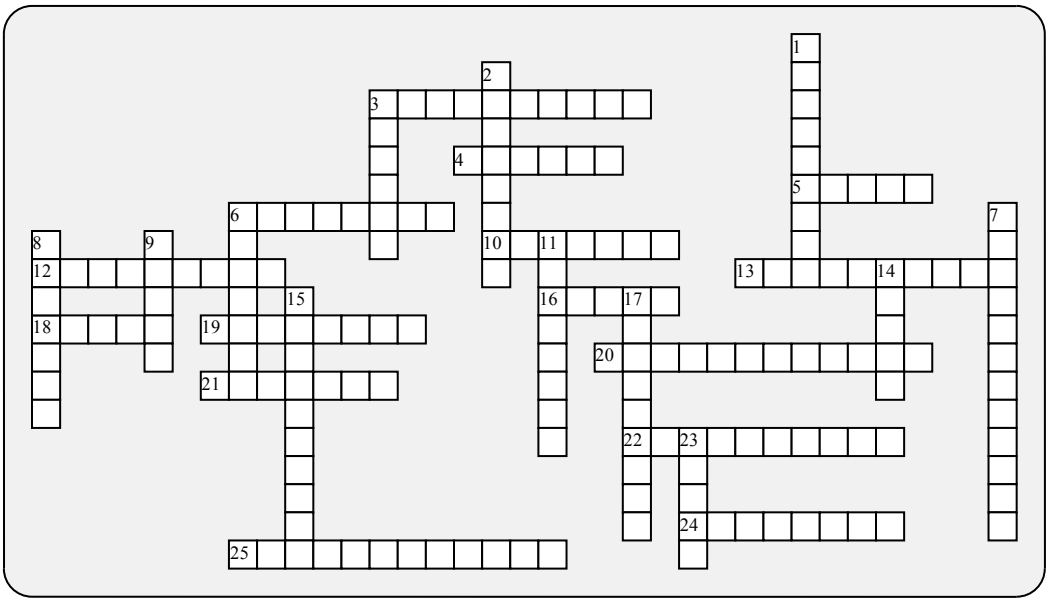
6. Explain the diagram below (with a particular focus on the tangled web on the bottom).




8. You're talking to a friend, who asks you what you're learning in biology. You say "about phylogenetic trees." They say "What are those?" Using the tree below, walk them through how phylogenetic trees work. Make sure your description covers *clades, terminal taxa, sister taxa, ancestral traits, shared derived traits, out-groups, in-groups,* and other terms as needed.



# Phylogeny and Classification



**Across:**

3 - The name for the process that occurs at the branch points in a phylogenetic tree.
4 - The most general of the classification categories
5 - The classification category just above species
6 - The scientist who developed the modern science of classification
10 - Avoid this type of character when creating a phylogeny
12 - The study of evolutionary history
13 – An oxygen-carrying protein widely used in determining phylogenetic relationships
16 - If you can calibrate a molecular _____, you can estimate the time of divergence between two species.
18 - A group that consists of a common ancestor, and all of its descendants.
19 - The science of classification is known as _____.
20 - This kind of taxon excludes some members of its clade.
21 - A feature that unites a clade is a shared _____ feature.
22 - A protein in the electron transport chain widely used as a molecular clock.
24 - A taxon used to identify the common ancestor of an ingroup.
25 - This kind of taxon includes lineages that spring from separate ancestors.

**Down:**

1 - A diagram that shows branching evolution, but the branches have no relationship to time.
2 - The two part name given to every species is known as a _____.
3 - These kind of taxa split off from the same ancestor
6 - A single line of descent within a phylogenetic tree is a _____.
7 - A taxon that's also a clade must be _____.
8 - A group of organisms that can interbreed to produce fertile offspring
9 - In a phylogenetic tree, the ancestors are located at _____.
11 - Every clade is united by a single common _____.
14 - The language used to name species
15 - This type of gene transfer occurs in bacteria, and happened very frequently early in life's history.
17 - Any quantifiable, heritable trait that can be used to determine phylogeny
23 - A named group of organisms.

**Possible Answers:** Latin, Linnaeus, analogy, ancestor, binomial, character, clade, cladogram, clock, cytochrome, derived, domain, genus, hemoglobin, horizontal, lineage, monophyletic, nodes, outgroup, paraphyletic, phylogeny, polyphyletic, sister, speciation , species, taxon, taxonomy

Name: _____ Period: _____ Date: _____

# *sciencemusicvideos* Evidence for Evolution: Student Learning Guide

**Getting to the tutorials:**

- Go to www.sciencemusicvideos.com. Use the College Bio, AP Bio, or Learning Guide Menus to find "Evidence for Evolution."

**Tutorial 1. Evidence for Evolution: Claims and Historical Observations**

1 and 2. Read the introduction and section 2, "Theory and Hypothesis."

After the reading, take the "Theory v. Hypothesis" Quiz. Check this box when you're finished. ☐

3. Read "What claims does the theory of evolution make ."☐

**CHECKING UNDERSTANDING:** In your own words, explain how the scientific meaning of the word *theory* is different from the word *hypothesis*.

**SUMMARIZE**: In the space below, describe the two claims that evolution makes.

•

•

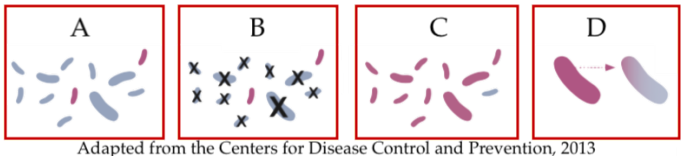
4. Read, "Observations of Evolution in Recent Times." As you do, complete all of the embedded quizzes and interactive readings. ☐

Extension: If you're interested (or if it's assigned by your teacher), read one or more of the suggested readings.

5. Complete the cumulative quiz "Historical Examples of Evolution."☐

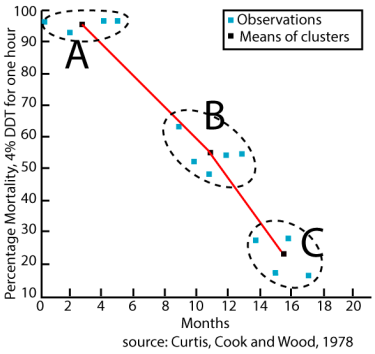
**SUMMARIZE**: In the space below, write brief summarize of the following. As you do, explain each of the diagrams.

a. Antibiotic resistance in bacteria

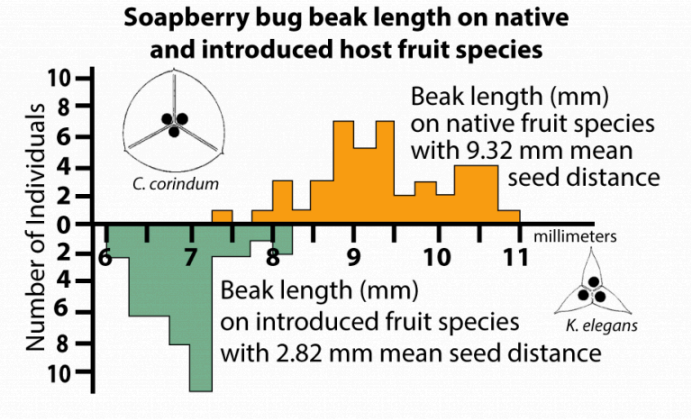



Adapted from the Centers for Disease Control and Prevention, 2013

b. Pesticide resistance in Mosquitoes




c. Evolution of new phenotypes in the soapberry bug




Click the link to *Homologous and Vestigial Structures*

**Tutorial 2. Homologous and Vestigial Structures as Evidence for Evolution**

1a. Read "Adaptive radiation results in differentiation." This includes the interactive reading, "Adaptive radiation and descent with modification." ☐

1b. Read "Differentiation from a common ancestor results in homologous structures."

1c. Take the quiz, "Homologous Traits."

**CHECKING UNDERSTANDING**: Use the space below to explain the evolutionary biology connected with each of the following diagrams. Create a descriptive title for each image.

**Image 1:**_____

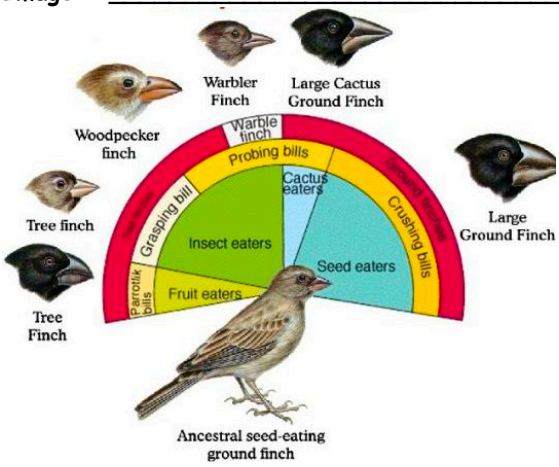



**Image 2:**_____

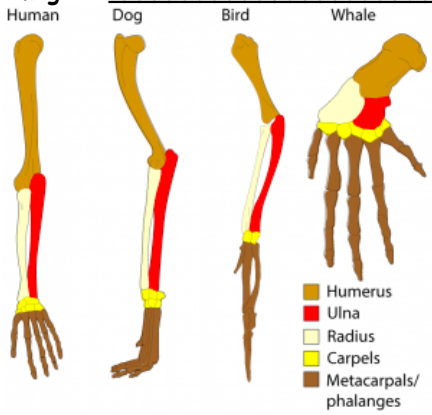



**Image 3:** _____

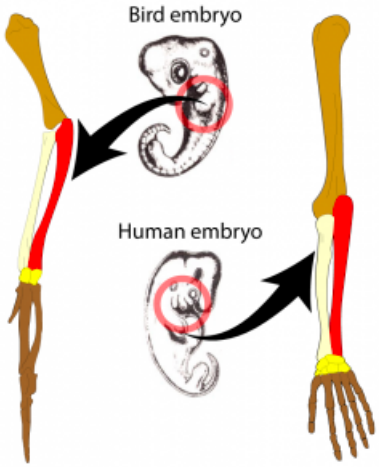
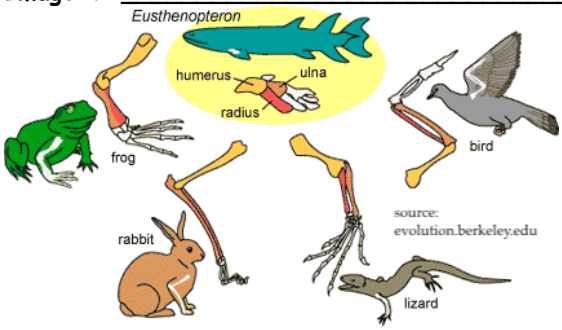



**Image 4:** _____




2a. Read "Vestigial Traits, the Case of the Blind Cave Tetra." ☐

2b. Read "Additional Examples of Vestigial Traits" ☐

2c. Complete the "Vestigial Traits Quiz."

**SUMMARIZING TASK 1:** Respond to the prompts below.

- Explain the evolution of blindness in cave fish.

- Explain the evolution of vestigial leg bones in whales.

- Identify two human vestigial traits. In the space below, explain how they evolved.

**SUMMARIZING TASK 2:** Explain the connection between homologous traits and adaptive radiation.

**SUMMARIZING TASK 3:** Explain why all vestigial traits are also homologous traits, but why the reverse is *not* true.

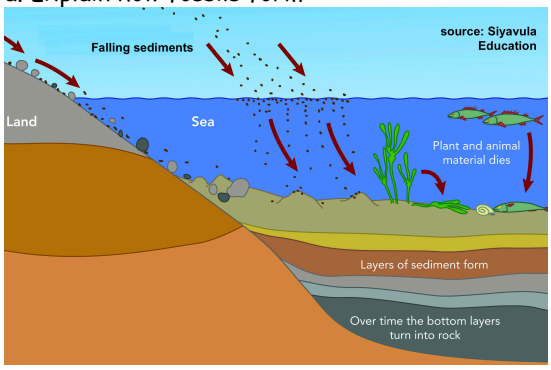
Continue to the next tutorial: *The Fossil Record, Biogeography, and Convergent Evolution*

**Tutorial 3. The Fossil Record and Biogeography**

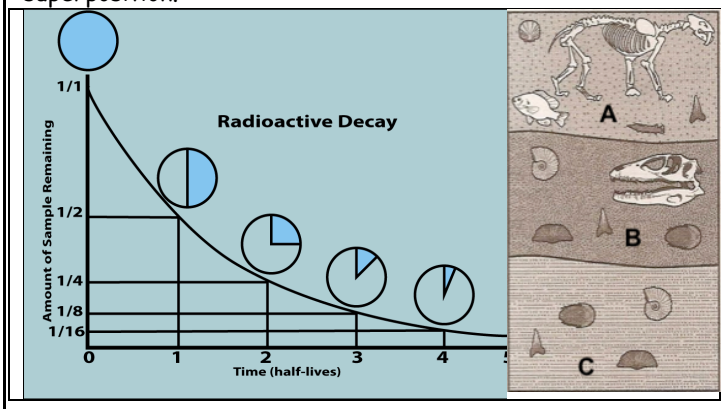
1. Read "How Fossils are Formed." ☐
2. Read "Knowing the Age of a Fossil." ☐
3. Read "The Fossil Record as Evidence for Evolution." ☐
4. Take the quiz "Fossils as Evidence for Evolution." ☐

**CHECKING UNDERSTANDING:**

a. Explain how fossils form:




b. Compare and contrast absolute dating and relative dating. In your answer, explain radiometric dating and superposition.



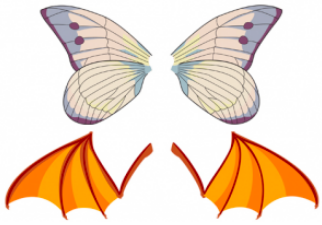
c. Explain how transitional fossils provide evidence for evolution. In your explanation, list 2 specific examples.

5. Read "Biogeography: Convergent Evolution and More Adaptive Radiation." As you do, complete the "Mystery Succulent" Activity (and read the rest of this passage) ☐

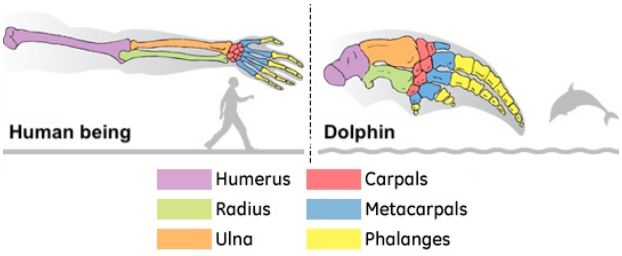
5b. Read "Convergent evolution happens when...." As you do, take the "Homology or Analogy" quiz ☐

**SUMMARIZE**:

Task 1: Are the wings of bats and birds homologous or analogous? Explain.



Task 2: Are the forelimbs of humans and dolphins homologous or analogous? Explain



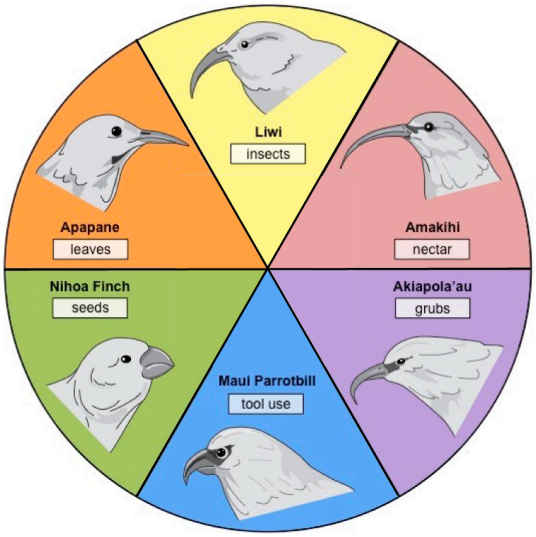

5c. Read "More Biogeography: Life on Oceanic Islands." This includes the interactive reading, "Explaining the biology of Remote Oceanic Islands." ☐

6. Take the quiz: Biogeography and Convergent Evolution."

**SUMMARIZE**

a. How is life on oceanic islands unique?

b. Explain the evolution of the Hawaiian Honeycreepers




c. Explain how the following concepts connect to island biogeography: *adaptive radiation*, *homology*, and *descent with modification*.

Click the link to "Developmental and Molecular Homologies"

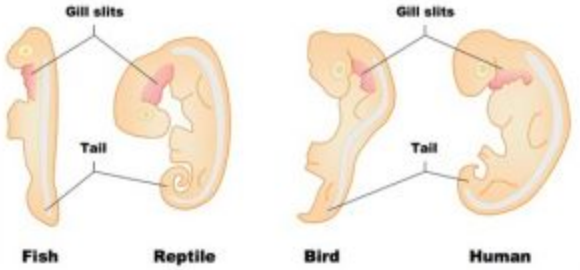
**Tutorial 4. Developmental, Molecular, and Genetic Evidence for Evolution**

1 and 2. Read the Introduction, then continue reading "Embryology as Evidence for Evolution" ☐

3. Read "Molecular Homologies." As you do, complete the interactive reading, "Molecular Homologies and Evolution." ☐

**CHECKING UNDERSTANDING:**

a. Explain how the diagram below is evidence for evolution. Use the terms *adaptive radiation*, *homologous trait*, and *vestigial trait* in your response.




b. Explain how this data about cytochrome *c* is evidence for evolution.

| Cytochrome *c* Evolution | |
|---|---|
| **Organism** | **Number of amino acid differences from humans** |
| **Chimpanzee** | **0** |
| **Rhesus Monkey** | **1** |
| **Rabbit** | **9** |
| **Pigeon** | **12** |
| **Bullfrog** | **20** |
| **Fruit Fly** | **24** |
| **Yeast** | **42** |

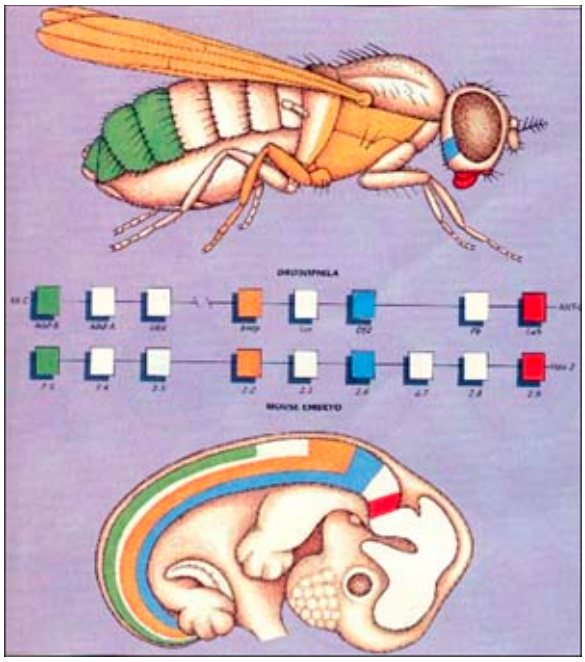
4. Read "Genes can also be homologous and vestigial" ☐

5. Complete the Quiz: "Embryonic and Molecular Evidence for Evolution" ☐

6. Read "The Deepest Homologies." As you do, complete the quiz, "We're all Cousins."☐

**CHECKING UNDERSTANDING:**

a. Explain how the *hox* genes, shown below, serve as evidence for evolution.



b. List and describe the traits that provide evidence for a common ancestry for all life.

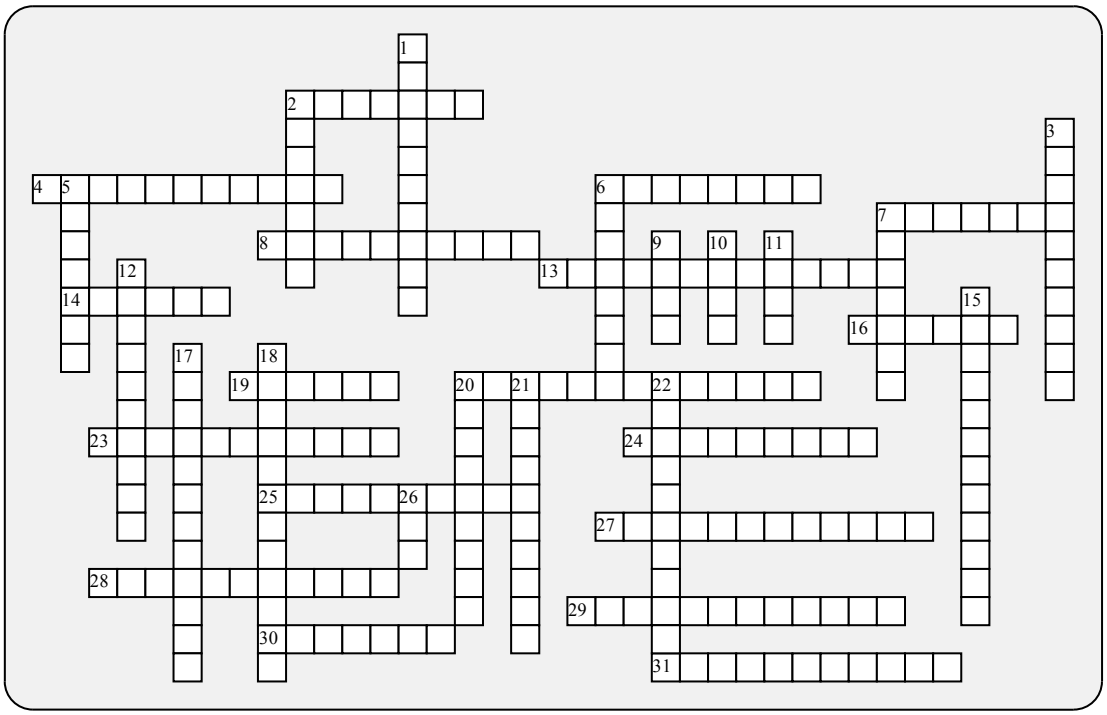
c. List and describe the traits that provide evidence for common ancestry for all eukaryotes.

**TUTORIAL 5: CUMULATIVE QUIZ**
Follow the link to the "Evidence for Evolution Cumulative Quiz," and complete the quiz.

**SUMMARY OF SUMMARIES:** You're at a park, talking to an acquaintance who says "I don't believe in evolution. It's just a theory. There's no evidence for it."
What would you say in response. Take your time, and don't hold back. In your response:
a) Explain what it means for an idea to qualify as a scientific theory.
b) Describe and explain the evidence for evolution. Include a discussion of:
1. Observations of evolution in historical times
2. Homologous and vestigial features
3. Fossils
4. Biogeographical evidence
5. Embryological evidence
6. Molecular evidence
7. Genetic evidence.

 Name:_____

# Evidence for Evolution



**Across:**

2 - The type of species found only in one place. These are very common on islands.

4 - A public health risk has been generated by our overuse of antibiotics in _____.

6 - One of the deepest ideas of biology: all living things share a common _____.

7 - Isolated chains of _____ are great places for adaptive radiation.

8 - Bacteria can transfer genes to others in their population through _____gene transfer.

13 - The principle that the older fossils are in the deeper layers of rock.

14 - A well established, tested principle that's supported by a huge body of evidence

16 - A remnant, impression, or trace of an organism from the past that's preserved in the Earth's crust.

19 - The remnant of our tail, which sometimes becomes irritated when we fall on our behinds.

20 - A famous fossil of an early bird

23 - The kind of dating that's based on the half-life of radioactive elements.

24 - _____traits have lost their original function (and might not have any function at all).

25 - This molecule, part of the electron transport chain, is a great benchmark for evolution.

27 - The study of the distribution of species on our planet.

28 - Many mysteries connected to the distribution of past and present life are solved if one considers this kind of drift.

29 - _____ fossils show an ancestral species in the process of evolving into its descendants.

30 - IIf it looks like a cactus, but it's not, it's probably a _____.

31 - The only type of rock in which fossils form.

**Down:**

1 - Structures derived from a common ancestor, often with different functions.

2 - These often show vestigial features that can't be seen in adults.

3 - This kind of fish is rarely found on islands.

5 - Evolution changes a population's _____ makeup.

6 - This kind of radiation creates new species.

7 - A type of rock that can be used for estimating the age of a nearby fossil.

9 - A bacterial strain that most antibiotics can't stop.

10 - The soapberry bug has quickly evolved new phenotypes as it has adapted to the fruit of new _____ plants.

11 - Tiktaalik is a species that was midway between _____ and tetrapod (four-limbed) vertebrates.

12 - Many insect populations have developed _____ to pesticides.

15 - The endosymbiotic organelle that makes a eukaryote a eukaryote.

17 - Evolution is supported when we see evidence of descent with _____.

18 - A family of birds that's the Hawaiian version of the Galapagos finch.

20 - Features that share the same function, but aren't the result of common ancestry.

21 - Evolutionary change which results in superficially similar forms evolving independently.

22 - Genes that have lost their function, and are no longer expressed.

26 - Highly conserved genes that control aspects of animal development.

**Possible Answers:** Archaeopteryx, Embryos, Euphorb, Horizontal, MRSA, adaptive, agriculture, analogous, ancestor, biogeography, coccyx, continental, convergent, cytochrome, endemic, fish, fossil, freshwater, genetic, homologous, honeycreeper, host, hox, igneous, islands, mitochondria, modification, pseudogenes, radiometric, resistance, sedimentary, superposition, theory, transitional, vestigial