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| AP Biology  **Interactive**  **Student**  **Study**  **Guide** | **North Salem University**  **MISSION**: *Engage students to continuously learn, question, define and solve problems through critical and creative thinking.*  Spring 2020 | |
| It is not enough to explain how adaptations evolve in populations (microevolution), a topic covered in the last chapter. Evolutionary theory must also explain MACROevolution, the origin of new taxonomic groups (new species, new gerera, new families, even new kingdoms and domains). Our objective in this chapter is to evaluate the definitions of species and mechanisms of speciation.  ***If you have any problems – please sign up for extra help after school.*** | | **Chapter 24:**  **The Origin of Species** |

**Chapter 24: The Origin of Species**

**OBJECTIVES:**

**What Is a Species?**

\_\_1. Distinguish between anagenesis and cladogenesis.

\_\_2. Define biological species according to Ernst Mayr.

\_\_3. Distinguish between prezygotic and postzygotic isolating mechanisms.

\_\_4. Describe five prezygotic isolating mechanisms and give an example of each.

\_\_5. Explain why many hybrids are sterile.

\_\_6. Explain how hybrid breakdown maintains separate species even if gene flow occurs.

\_\_7. Describe some limitations of the biological species concept.

\_\_8. Define and distinguish among each of the following: ecological species concept, pluralistic species concept, morphological species concept, and genealogical species concept.

**Modes of Speciation**

**\_\_**9. Distinguish between allopatric and sympatric speciation.

\_\_10. Describe examples of adaptive radiation in the Galopagos and Hawaiian archipelagoes.

\_\_11. Explain how reproductive barriers evolve.

\_\_12. Describe an example of the evolution of a prezygotic barrier and the evolution of a postzygotic barrier.

\_\_13. Define sympatric speciation and explain how polyploidy can cause reproductive isolation.

\_\_14. Distinguish between an autopolyploid and an allopolyploid species and describe examples of each.

\_\_15. List some points of agreement and disagreement between the two schools of thought about the tempo of speciation (gradualism versus punctuated equilibrium).

**From Speciation to Macroevolution**

\_\_16. Explain why speciation is at the boundary between microevolution and macroevolution.

**KEY TERMS:**

[adaptive radiation](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/awords/adaptiveradiation.html) [allometric growth](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/awords/allometricgrowth.html) [allopatric speciation](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/awords/allopatricspeciation.html)

[allopolyploid](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/awords/allopolyploid.html) [anagenesis](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/awords/anagenesis.html) [autopolyploid](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/awords/autopolyploid.html)  
[biological species concept](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/bwords/biologicalspeciesconcept.html) [cladogenesis](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/cwords/cladogenesis.html) [ecological species concept](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/ewords/ecologicalspeciesconcept.html)

[macroevolution](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/mwords/macroevolution.html) [morphological species concept](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/mwords/morphologicalspeciesconcep.html) [polyploidy](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/pwords/polyploidy.html)

[postzygotic barrier](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/pwords/postzygoticbarrier.html) [punctuated equilibrium](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/pwords/punctuatedequilibrium.html) [speciation](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/swords/speciation.html)

[sympatric speciation](http://occawlonline.pearsoned.com/bookbind/pubbooks/campbell6e_awl/medialib/assets/interactivemedia/glossary/words/swords/sympatricspeciation.html)

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**WORD ROOTS:**

**allo-** = other; **-metron** = measure (*allometric growth*: the variation in the relative rates of growth of various parts of the body, which helps shape the organism)

**ana-** = up; **-genesis** = origin, birth (*anagenesis*: a pattern of evolutionary change involving the transformation of an entire population, sometimes to a state different enough from the ancestral population to justify renaming it as a separate species)

**auto-** = self; **poly-** = many (*autopolyploid*: a type of polyploid species resulting from one species doubling its chromosome number to become tretraploid)

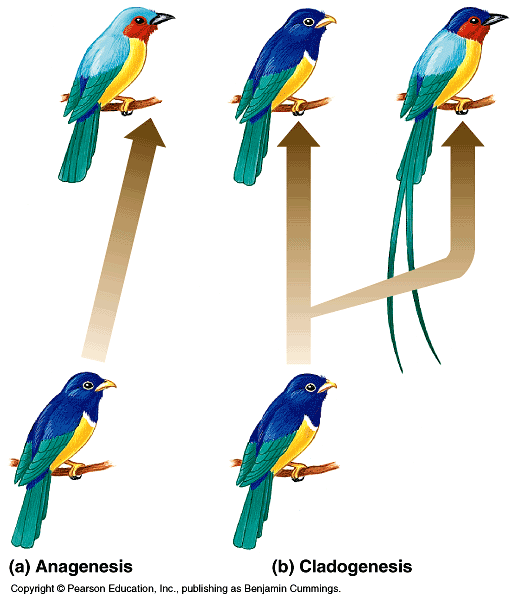
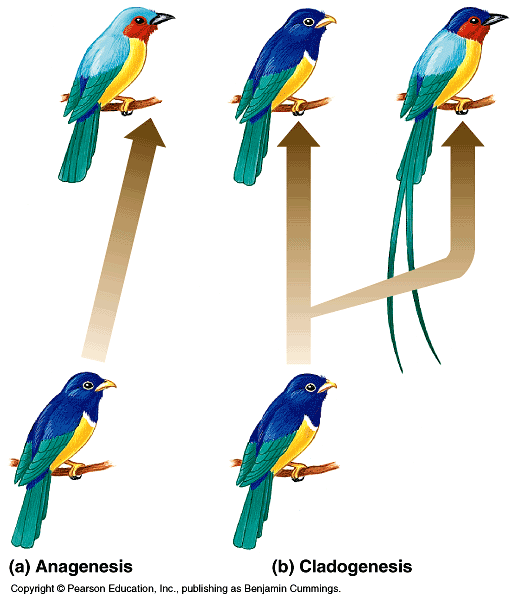
**clado-** = branch (*cladogenesis*: a pattern of evolutionary change that produces biological diversity by budding one or more new species from a parent species that continues to exist)

**hetero-** = different (*heterochrony*: evolutionary changes in the timing or rate of development)

**macro-** = large (*macroevolution*: evolutionary change on a grand scale, encompassing the origin of novel designs, evolutionary trends, adaptive radiation, and mass extinction)

**Guided Reading: Chapter 24**

1. Label the diagrams below and use them to describe the two **patterns** of ***speciation***.



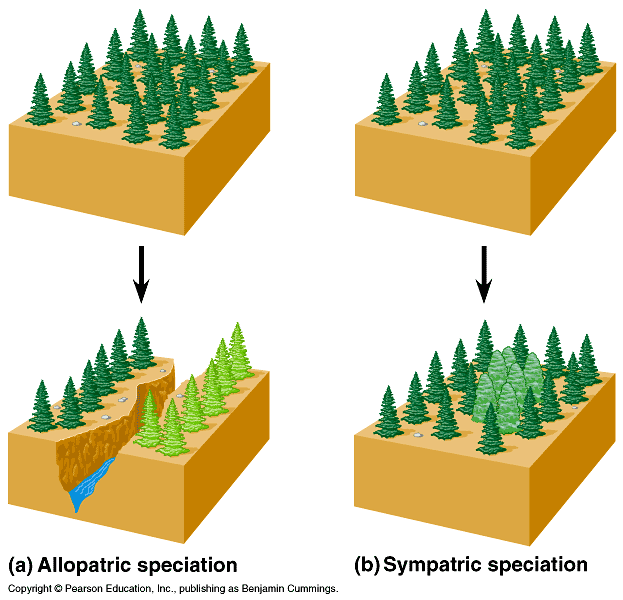
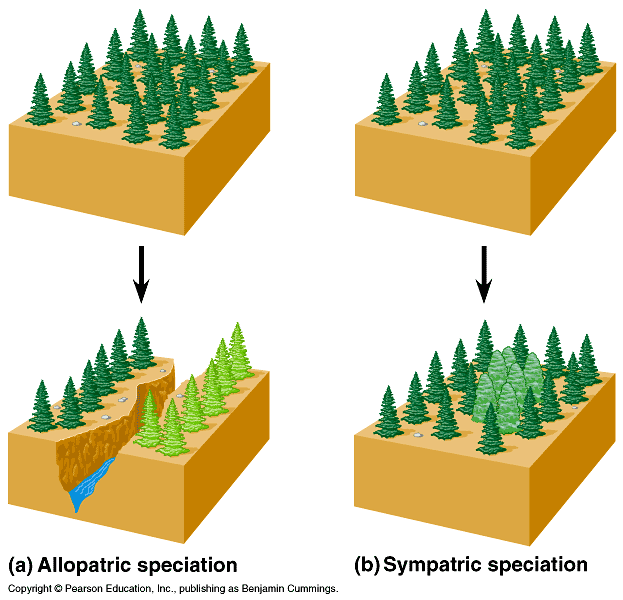
**(a)** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **(b)** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. What was Darwin’s “mystery of mysteries”?
2. Define ***speciation***.
3. Distinguish between **microevolution** and **macroevolution**.
4. Use the biological species concept to define ***species***.

1. What is required for the formation of new species?
2. What are *hybrids*?
3. **Explain** the two types of barriers that maintain *reproductive isolation*.
4. The following charts summarize the various ways that *reproductive isolation* is maintained. Explain and give an example of each type of isolating mechanism.

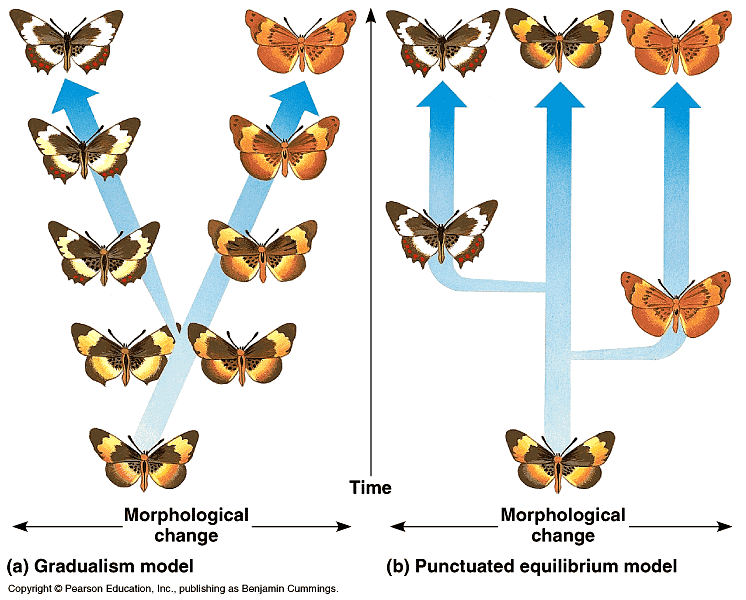
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| **PREZYGOTIC BARRIERS** | **Explanation** | **Example** |
| **Habitat Isolation** |  |  |
| **Behavioral Isolation** |  |  |
| **Temporal Isolation** |  |  |
| **Mechanical Isolation** |  |  |
| **Gametic Isolation** |  |  |
|  |  |  |
| **POSTZYGOTIC BARRIERS** | **Explanation** | **Example** |
| **Reduced Hybrid Viability** |  |  |
| **Reduced Hybrid Fertility** |  |  |

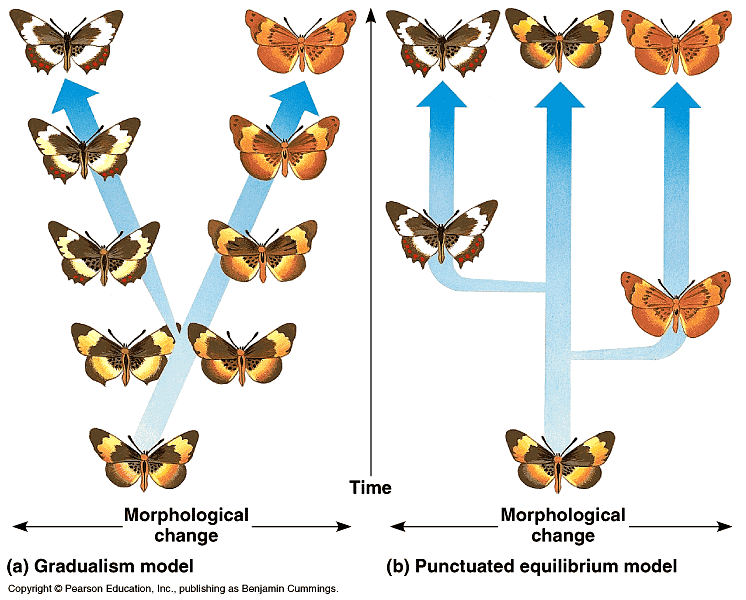
1. Name and briefly explain the concept of species that remains to be the way most biologists distinguish a species.
2. Label the diagrams below and use them to describe the two **modes** of speciation based on how gene flow among populations is initially interrupted.



**(a)** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **(b)** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Using Darwin’s Finches as an example, define a form of ***allopatric speciation*** known as **adaptive** **radiation**.
2. ***Sympatric speciation***occurs in populations that live in the same geographic area. How is this possible?
3. Label the diagrams below and use them to describe the two models for the **tempo** of speciation.





**(a)** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ **(b)** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**15.** What are **homeotic** genes?

**16.** What are ***Hox*** **genes**?

**17.** Changes in ***Hox* genes** can have a profound effect on \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

**Chapter 24: Summary of Key Concepts**

* Macroevolution is the origin of new species and other taxonomic groups. Two patterns of species change chronicled by the fossil record are anagenesis (phyletic evolution), the accumulation of changes associated with the transformation of one species into another, and cladogenesis, branching evolution (FIGURE 24.1).

*Activity24A:*[*Overview of Macroevolution*](javascript:bcPopActivity('24A'))

**WHAT IS A SPECIES?**

* The biological species concept emphasizes reproductive isolation (p. 465 and  FIGURE 24.2) The biological species concept defines a species as a group of populations whose individuals have the potential to interbreed and produce fertile offspring with each other but not with members of other species.
* Prezygotic and postzygotic barriers isolate the gene pools of biological species (pp. 465-467, FIGURE 24.5) Prezygotic barriers prevent mating or fertilization between species. Species that occupy the same geographic area often live in separate habitats (habitat isolation); possess unique, exclusive mating signals and courtship behaviors (behavioral isolation); breed at different times (temporal isolation); and/or have anatomically incompatible reproductive organs (mechanical isolation) or incompatible sex cells (gametic isolation). Even if two different species manage to mate, postzygotic barriers usually prevent the interspecific hybrids from developing into adults, breeding with either parent species, or producing viable, fertile offspring.
* The biological species concept has some major limitations (p. 468) For instance, it is not applicable to fossils or to organisms that reproduce only asexually.
* Evolutionary biologists have proposed several alternative concepts of species (p. 468) Alternative concepts include the ecological species concept, which explains the similarity among members of a species by their adaptation to exploit a particular set of ecological resources (or niche); the morphological species concept, which defines species by phenotypic characteristics; pluralistic species concept, suggesting that different factors operate in different creatures to explain why species exist; and a genealogical species concept, which defines a species by the close genetic relatedness among its members.

**MODES OF SPECIATION**

* Allopatric speciation: Geographic barriers can lead to the origin of species (pp. 469-473, FIGURES 24.6-24.12) Allopatric speciation may occur when two populations of one species become geographically separated from each other. One or both populations may undergo evolutionary change and become reproductively isolated as a consequence of that change.
* Sympatric speciation: A new species can originate in the geographic midst of the parent species (pp. 473-475, FIGURES 24.13-24.16) Many plant species have evolved by polyploidy (multiplications of the chromosome number). Autopolyploids are species derived this way from one ancestral species. Allopolyploids are species with multiple sets of chromosomes derived from two different species. Examples of processes that can result in sympatric speciation in animals are host-switching by parasites and nonrandom mating in polymorphic populations.
* The punctuated equilibrium model has stimulated research on the tempo of speciation (pp. 475-476, FIGURE 24.17) The punctuated equilibrium model suggests that species change most as they bud from an ancestral species, after which they undergo relatively little change for the rest of their existence.

**FROM SPECIATION TO MACROEVOLUTION**

* Most evolutionary novelties are modified versions of older structures (p. 477, FIGURE 24.18) Most novel biological structures evolve in many stages from previously existing structures. In some cases, such as the eye, the function of the organ has probably been constant during all stages of its evolution. In others, such as feathers, the function of the organ has changed.
* "Evo-devo": Genes that control development play a major role in evolution (pp. 477-479, FIGURES 24.19-24.23) Many macroevolutionary changes may have been associated with mutations in genes that regulate development. Such changes can affect the timing of developmental events (heterochrony) or the spatial organization of body parts, as in mutations of homeotic genes.

*Activity24B:  [Allometric Growth](javascript:bcPopActivity('24B'))*

* An evolutionary trend does not mean that evolution is goal oriented (pp. 480-481, FIGURE 24.24) Long-term evolutionary trends may arise because of adaptation to a changing environment. Or, according to the species selection hypothesis, trends may result when species with certain characteristics endure longer and speciate more often than those with other characteristics.

**Chapter 24 - Review Questions**

\_\_\_1) Speciation, or the formation of new species, is -

A) a form of microevolution.

B) responsible for the diversity of life.

C) necessary for natural selection and adaptation.

D) an event that has occurred only a few times in the history of the planet.

\_\_\_2) Which of the following would a biologist describe as microevolution?

A) the formation of new species

B) the extinction of species

C) dramatic biological changes, such as the origin of flight, within a taxon

D) a change in the gene pool of a population from one generation to the next

\_\_\_3) Under the biological species concept, a species is a group of organisms that -

A) are physically similar.

B) share a recent common ancestor.

C) live together in a location and carry out identical ecological roles.

D) have the potential to interbreed in nature and produce fertile offspring.

\_\_\_4) The biological species concept is -

A) applicable to all forms of life, past and present.

B) applicable to all present life forms, but not to fossil organisms whose reproductive behavior cannot be observed.

C) easy to apply to all present sexually reproducing organisms, but harder to apply to asexual organisms and fossils.

D) sometimes difficult to put into practice even for present sexual organisms, and useless for asexual organisms and fossils.

\_\_\_5) Which of the following statements regarding the definition of species is *false*?

A) The ecological species concept identifies species in terms of their ecological niches.

B) The phylogenetic species concept defines a species as a set of organisms that shares a common ancestor and forms one branch on the tree of life.

C) The morphological species concept relies upon comparing the DNA sequences of organisms.

D) Under the biological species concept, the gap between species is maintained by reproductive isolation.

\_\_\_6) Which provides the *most* general and correct description of the idea of a reproductive barrier?

A) any feature (of geography, behavior, or morphology) that keeps one species from mating with another

B) a biological difference between two species that prevents them from successfully interbreeding

C) a geographic barrier that separates two species and prevents gene flow between them

D) a difference in behavior that keeps two species from interbreeding

\_\_\_7) Two populations of organisms belong to the same biological species when they -

A) can't mate with each other, because mating occurs at different times.

B) use different types of behaviors or physical features to attract mates.

C) have anatomical features that make it difficult for organisms from the different populations to mate.

D) encounter each other, mate, and produce viable, fertile offspring under natural conditions.

\_\_\_8) Which of the following types of reproductive barriers separates a pair of species that could interbreed except that one mates at dusk and the other at dawn?

A) temporal isolation C) behavioral isolation

B) habitat isolation D) mechanical isolation

\_\_\_9) Which of the following types of reproductive barriers separates a pair of insect species that could interbreed except that one lives on goldenrod plants and the other on autumn daisies in the same general area?

A) temporal isolation C) behavioral isolation

B) habitat isolation D) gametic isolation

\_\_\_10) Which of the following types of reproductive barriers separates a pair of moth species that could interbreed except that the females' mating pheromones are not attractive to the males of the other species?

A) temporal isolation C) mechanical isolation

B) behavioral isolation D) gametic isolation

\_\_\_11) Which of the following types of reproductive barriers separates two flowering plant species that could interbreed except that one has a deep flower tube and is pollinated by bumblebees, whereas the other has a short, narrow flower tube and is pollinated by honeybees?

A) habitat isolation C) mechanical isolation

B) behavioral isolation D) gametic isolation

\_\_\_12) Which of the following types of reproductive barriers separates two species of sea cucumbers, whose sperm and eggs often bump into each other but do not cross-fertilize because of incompatible proteins on their surfaces?

A) temporal isolation C) mechanical isolation

B) habitat isolation D) gametic isolation

\_\_\_13) Two species that occasionally mate and produce zygotes, but which have incompatible genes that prevent the resulting embryo from developing, are separated by -

A) gametic isolation. C) reduced hybrid viability.

B) reduced hybrid fertility. D) hybrid breakdown.

\_\_\_14) Two species that sometimes mate and produce vigorous but sterile offspring are separated by -

A) gametic isolation. C) reduced hybrid viability.

B) reduced hybrid fertility. D) hybrid breakdown.

\_\_\_15) Two species interbreed occasionally and produce vigorous, fertile hybrids. When the hybrids breed with each other or with either parent species, however, the offspring are feeble or sterile. These species are separated by -

A) gametic isolation. C) reduced hybrid viability.

B) reduced hybrid fertility. D) hybrid breakdown.

\_\_\_16) Frequently, a group of related species will each have a unique courtship ritual that must be performed correctly for both partners to be willing to mate. Such a ritual constitutes a \_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_ reproductive barrier.

A) mechanical . . . postzygotic C) temporal . . . prezygotic

B) behavioral . . . prezygotic D) gametic . . . postzygotic

\_\_\_17) The Monterey pine and the Bishop's pine inhabit some of the same areas of central California. The Monterey pine releases pollen in February, while the Bishop's pine does so in April. This is an example of \_\_\_\_\_\_\_\_ isolation.

A) postzygotic C) habitat

B) temporal D) mechanical

\_\_\_18) The geographic isolation of a population from other members of the species and the subsequent evolution of reproductive barriers between it and the parent species describes \_\_\_\_\_\_\_\_ speciation.

A) punctuated C) allopatric

B) sympatric D) biogeographic

\_\_\_19) Uplift and formation of a mountain range divides a freshwater snail species into two isolated populations. Erosion eventually lowers the mountain range and brings the two populations together again, but when they mate, the resulting hybrids all produce sterile young. This scenario is an example of -

A) sympatric speciation. C) incomplete speciation.

B) allopatric speciation. D) diversifying speciation.

\_\_\_20) Diane Dodd's experiments using fruit flies demonstrated that -

A) the evolution of reproductive barriers occurs much too slowly to produce measurable effects in the laboratory.

B) new species can form in a single generation by the production of new reproductive structures.

C) formation of a reproductive barrier between two populations is more likely if they experience and adapt to different environmental conditions.

D) reproductive barriers usually are absolute - either two populations are fully willing and able to interbreed, or they are strictly separated by a fully effective reproductive barrier.

\_\_\_21) Diane Dodd raised different fruit fly populations on different food sources. She found that after about 40 generations, the evolution of reproductive isolation was under way. The mechanism of evolution responsible for this was -

A) natural selection. C) gene flow.

B) genetic drift. D) mutation.

\_\_\_22) When plants undergo allopatric speciation, an initial reproductive barrier is often -

A) polyploidy. C) temporal isolation.

B) gametic isolation. D) pollinator choice.

\_\_\_23) Speciation without geographic isolation is called \_\_\_\_\_\_\_\_ speciation.

A) sympatric C) incomplete

B) allopatric D) diversifying

\_\_\_24) Organisms that possess more than two complete sets of chromosomes are said to be -

A) haploid. C) diploid.

B) polyploid. D) hybrids.

\_\_\_25) Most polyploid species arise from -

A) a single diploid parent plant. C) a single tetraploid parent plant.

B) a single triploid parent plant. D) the hybridization of two parent species.

\_\_\_26) Which of the following statements about the Galápagos finches is *false*?

A) The Galápagos finch species differ in their feeding habitats.

B) Each island in the Galápagos chain has one and only one isolated, unique species of Darwin's finch.

C) Most speciation events of the Galápagos finches occurred when some finches made it to another island, evolved in isolation, and accumulated enough changes to become a new species.

D) The evolution of the Galápagos finches is an excellent example of adaptive radiation.

\_\_\_27) The emergence of many diverse species from a common ancestor is called -

A) adaptive radiation. C) allopatric speciation.

B) gradualism. D) hybridization.

\_\_\_28) The \_\_\_\_\_\_\_\_ suggests that speciation occurs in brief spurts.

A) adaptive model of the origin of species C) gradual model of the origin of species

B) allopatric speciation model D) punctuated equilibrium model

\_\_\_29) The emergence of a new plant species over a brief period of time, followed by a long period of little change, is consistent with which of the following theories?

A) the gradual model of speciation C) punctuated equilibrium

B) allopatric speciation D) adaptive radiation

\_\_\_30) One of the key contributions of the punctuated equilibrium model is that it helps explain -

A) why transitional fossils are more common than Darwin would have predicted.

B) why transitional fossils tend to be rare and certain common fossil species remain unchanged for long time spans.

C) how new species arise from hybridization events.

D) why large, widespread populations tend to be the ones that evolve most rapidly and unpredictably.

\_\_\_31) Which of the following descriptions *best* represents the gradual model of speciation?

A) Speciation occurs regularly as a result of the accumulation of many small changes.

B) An isolated population differentiates quickly from its parent stock as it adapts to its local environment.

C) Speciation occurs under unusual circumstances and therefore transitional fossils are hard to find.

D) Species undergo little change over long periods interrupted only by short periods of rapid change.

\_\_\_32) One of the finest available sequences of fossils shows how horses have changed slowly and by subtle steps from small shrub-browsing ancestors to the large, grass-grazing modern horse. A large number of fossil species have been named, and it is often difficult to decide on the identity of a fossil horse because transitional forms are common. This record of evolution best fits the idea of -

A) the gradual model of speciation. C) adaptive radiation.

B) punctuated equilibrium. D) hybrid breakdown.