

Name: \_\_\_\_\_

Date: \_\_\_\_\_

## **AP Biology Exam Review: Genetics, Evolution, and Classification**

### **Helpful Videos and Animations:**

1. Bozeman Biology: Natural Selection (an overview of natural selection and Hardy-Weinberg Equilibrium)
2. Bozeman Biology: Examples of Natural Selection
3. Bozeman Biology: Genetic Drift
4. Bozeman Biology: Evidence of Evolution
5. Bozeman Biology: Essential Characteristics of Life (preserved by natural selection)
6. Bozeman Biology: Natural Selection Unit Review (a review from the previous five videos)
7. Bozeman Biology: Solving Hardy Weinberg Problems
8. Bozeman Biology: Speciation and Extinction
9. Bozeman Biology: Speciation
10. Bozeman Biology: Evolution Continues
11. Bozeman Biology: Classification of Life
12. Bozeman Biology: The Three Domains of Life
13. Bozeman Biology: Mendelian Genetics
14. Bozeman Biology: A Beginner's Guide To Punnett Squares
15. Bozeman Biology: Probability in Genetics - Multiplication and Addition Rules
16. Bozeman Biology: Linked Genes
17. Bozeman Biology: The Genetics of Blood Types
18. Andrew Douch: Pedigree Analysis 1
19. Andrew Douch: Pedigree Analysis 2

### **Relevant Objectives:**

44. Describe Mendel's experiments with peas and how they revealed modern laws of genetics
45. Explain the difference between phenotype and genotype
46. Define homozygous and heterozygous
47. Explain the law of segregation
48. Explain the law of independent assortment
49. Be able to construct a punnett square and use it to predict characteristics of offspring for monohybrid and dihybrid crosses
50. Explain how genetics can be more complicated than simple dominance and recessiveness - can be co-dominance and incomplete dominance
51. Describe what a sex-linked trait is, and be able to complete punnett squares using sex-linked traits
52. Be able to use a chi-squared test to show whether predicted results match actual results
53. Be able to read a pedigree and determine to mode of inheritance from a pedigree
54. Give examples of human genetic diseases and their mode of inheritance
62. Explain the difference between the Lamarckian theory of evolution and the Darwinian theory of evolution
63. Explain how evolution by natural selection occurs
64. Describe the necessary conditions for evolution by natural selection to occur
65. Explain the forces driving evolution, including selection (sexual, predation, etc), genetic drift (founder effect, bottleneck), gene flow, and co-evolution
66. Give examples of how force driving evolution can impact a population
67. Describe the types of selection that can occur (stabilizing, directional and disruptive)
68. Explain what the values represent in the Hardy-Weinberg equilibrium
69. Be able to use the Hardy-Weinberg equilibrium to determine if a population is evolving
70. Define a species
71. Describe the different ways speciation can occur (allopatric vs. sympatric & pre- and post reproductive barriers)
72. Describe the evidence supporting evolution (fossil record, anatomical record, molecular record, artificial selection)
73. Explain the modern evidence supporting evolution (peppered moths, chromosomes, resistance)
74. Explain the leading theory for the origin of life
75. Be able to interpret phylogenetic trees and infer evolutionary relationships from them
76. Be able to create a phylogenetic tree given evolutionary information
77. Be able to interpret cladograms and infer evolutionary relationships from them
78. Be able to create a cladogram given evolutionary information
79. Name the levels of classification
80. Describe the basis of the Linnaean classification system vs. modern classification systems
81. Describe the defining characteristics of each domain

## Topic Outline:

### 1. Mendel's experiments

- Pea plants with distinct dominant vs. recessive traits
- Came up with laws
- Mendel's Laws
  - Law of Dominance – one trait will always be expressed over another; recessive traits are only seen in the absence of dominant traits
  - Law of Segregation – alleles separate from each other, gametes only carry one form of an allele
  - Law of Independent Assortment – genes for different traits can segregate independently from one another; i.e. mom's traits can separate from other mom traits, same with dad

### 2. Basic Genetics Vocabulary

- Gene vs. allele – gene is a section of DNA that codes for a protein, allele is a form of a gene (ex: blonde vs. blue eyes are two different alleles of the same gene)
- Homozygous vs. heterozygous – homozygous = two of the same alleles (AA or aa); heterozygous = two different alleles (Aa), also known as hybrid
- Genotype vs. Phenotype – genotype = genetics of individual (Aa or aa); phenotype = appearance of individual (do they express the dominant or recessive trait)
- Monohybrid Cross vs. Dihybrid Cross – monohybrid = one trait hybrid mating (Aa x Aa); dihybrid = two traits hybrid mating (AaBb x AaBb)
- Testcross or backcross – breeding unknown genotype that expresses the dominant allele with a recessive phenotype

### 3. Setting up & analyzing genetic crosses with Punnett squares

- Know how to set up monohybrid and dihybrid crosses given information regarding parent genotypes and phenotypes and analyze offspring genotype/phenotype ratios
  - Ratios to know:
    - 3:1 = Monohybrid cross; 75% express dominant trait, 25% express recessive
    - 9:3:3:1 = Dihybrid cross; 9/16 express both dominant traits, 3/9 express one recessive trait, 3/9 express the other recessive trait, 1/3 express both recessive traits
- Understand the rules of probability in Punnett Square analysis
  - Rule of Multiplication: when calculating the probability that two or more independent events will occur together in a specific combination, multiply the probabilities of each of the two events
    - For example, the probability of a coin landing face up two times in two flips is  $\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$
    - In genetics, if you cross two organisms with the genotypes AABbCc and AaBbCc, the probability of an offspring having the genotype AaBbcc is  $\frac{1}{2} \times \frac{1}{2} \times \frac{1}{4} = 1/16$
  - Rule of Addition: when calculating the probability that any of two or more mutually exclusive events will occur, you need to add together their individual probabilities.
    - For example, if you are tossing a die, what is the probability that it will land on either the side with four spots or the side with five spots? ( $\frac{1}{6} + \frac{1}{6} = \frac{1}{3}$ )

### 4. Non-Mendelian Patterns of Inheritance

- Sex-linkage is different from autosomal patterns of inheritance – only on sex chromosomes (X or Y – typically X)
  - Do not see normal ratios, typically seen more often in males because males only have one X (if recessive trait)
  - Punnett squares set up the same way, but with trait linked to sex chromosome.
    - Ex: If X linked –  $X^R X^r \times X^r Y$
- Codominance and Incomplete Dominance – codominance = both genes expressed at once (blood type); incomplete dominance = blended phenotype (red & white flowers make pink)
- Multiple Alleles (blood type Punnett squares! Use the alleles i, I<sup>A</sup>, and I<sup>B</sup>)
- Pleiotropy
- Polygenic Inheritance
- Nonnuclear inheritance (traits determined by DNA in mitochondria or chloroplasts, not DNA in the nucleus)
- Traits influenced by the environment (ex: human height)
- Epigenetics

## 5. Analyzing a pedigree of a human inherited condition

- Be able to determine the type of inheritance shown in a pedigree (autosomal dominant, autosomal recessive, sex-linked dominant, and sex-linked recessive)
  - Hints:
    - If there are significantly more males with a condition than females, the trait is sex-linked recessive
    - With an autosomal trait, if a child has a trait but the parents don't, the trait is recessive (both parents are carriers)

## 6. Linked Genes (found on the same chromosome and inherited together during cell division)

- Crossing over between homologous chromosomes during Prophase I of meiosis may separate linked genes onto different chromosomes. The frequency of recombination of linked genes due to crossing over increases if two genes are farther apart on the chromosome
- We can create a linkage map shown the location of genes on a chromosome. The distance between genes is measured in map units. 1 map unit = 1% recombination frequency → those genes are close
- Recombination frequency can be calculated mathematically – # of recombinants/total number of offspring

## 7. Natural Selection

- Major mechanism of change over time – Darwin's theory of evolution
- How natural selection occurs:
  - There is variation among phenotypes – genetic mutations play a role in increasing variation, as does independent assortment, crossing over, and random fertilization
  - Too many offspring are produced than can possibly survive
  - Competition for resources results in differential survival, with individuals with the most favorable traits surviving to reproduce offspring
  - Favorable traits become more common over time, population evolves due to changes in allele frequency
- An adaptation is a genetic variation that is favored by selection and is manifested as a trait that provides an advantage to an organism in a particular environment.
- Fitness is the ability to survive and reproduce
- Different types of selection:
  - Stabilizing selection – selects for average, ex: birth weight
  - Disruptive selection – selects for extremes ex: beak type
  - Directional selection – towards one extreme ex: peppered moth
  - Sexual selection – competition for mates drives evolution
- Artificial selection – humans breed organisms with desired traits

## 8. Evidence for Evolution

- Fossils can be dated by a variety of methods that provide evidence for evolution. These include the age of the rocks where a fossil is found, the rate of decay of isotopes including carbon-14, the relationships within phylogenetic trees, and the mathematical calculations that take into account information from chemical properties and/or geographical data.
- Morphological homologies represent features shared by common ancestry. Vestigial structures are remnants of functional structures, which can be compared to fossils and provide evidence for evolution.
- Biochemical and genetic similarities, in particular DNA nucleotide and protein sequences, provide evidence for evolution and ancestry.

## 9. Genetic Variation

- Be able to describe the basic structure of DNA and its organization in chromosomes in eukaryotic cells
- Be able to describe how chromosomes are divided into gametes (sex cells) during meiosis and how these gametes come together during fertilization to create a zygote
- Be able to describe the mechanisms of creating new genes and combining genes in different ways to increase genetic variation – mutation, crossing over, independent assortment, and random fertilization.
- Be able to explain why genetic variation is important for the survival of a population

10. Hardy-Weinberg Equilibrium - A mathematical model used to calculate changes in allele frequency, providing evidence for the occurrence of evolution in a population.

- 5 conditions must be met for a population to be in HW equilibrium – conditions are seldom met
  - i. Large population/no genetic drift (understand why genetic drift has a more significant effect on the gene pool of small populations; be able to describe both the bottleneck and founder effects)
  - ii. No migration
  - iii. No mutations
  - iv. Random mating
  - v. No natural selection
- Equations
  - $p + q = 1$  and  $p^2 + 2pq + q^2 = 1$ 
    - $p$  = the frequency of dominant alleles in a population
    - $q$  = the frequency of recessive alleles in a population
    - $p^2$  = the frequency of homozygous dominant individuals in a population
    - $q^2$  = the frequency of homozygous recessive individuals in a population
    - $2pq$  = the frequency of heterozygous individuals in a population

11. Speciation

- An evolutionary process by which 2 or more species arise from 1 species and 2 new species can no longer breed and reproduce successfully
- Many mechanisms by which it can occur
  - Geographic isolation; allopatric – different place
    - Species separated by physical barrier
  - Reproductive isolation; sympatric – same place
    - Different behaviors limit mating
    - Different habitats limit mating
    - Different mating seasons limit mating
    - Different anatomical structures limit mating
- Can take place over millions of years or rapidly (after extinction events, for example)
- Divergent evolution/adaptive radiation – species adapt to different environments, end up different; convergent evolution – species adapt similar structures to deal with same problem; co-evolution – two species influence each other's evolution (ex: predator/prey, flower/pollinator)
- Analogous vs. homologous structures
  - Analogous – different structure, evolved separately, deals with same problem (ex: flight, leaves/spines)
  - Homologous structures – similar structure, evolved from common ancestor, can have same function but could be different (ex: bones in forelimb of vertebrates)
- Pacing: gradualism vs. punctuated equilibrium
  - Gradualism – slower and smaller changes
  - Punctuated equilibrium – quicker and more abrupt changes
- Prezygotic and postzygotic barriers to population interbreeding; prezygotic is before fertilization, postzygotic is after
  - Prezygotic (pre-reproductive)
    - Ecological isolation, behavioral isolation, gametic isolation, temporal isolation, mechanical isolation
  - Postzygotic (post-reproductive)
    - Reduced hybrid viability, reduced hybrid fertility, hybrid breakdown

12. Phylogenetic Trees

- Phylogenetic trees and cladograms illustrate the relatedness between two species, in that relatedness of any two groups on the tree is shown by how recently two groups had a common ancestor.
- Phylogenetic trees and cladograms can be constructed from morphological similarities of living or fossil species, and from DNA and protein sequence similarities.
- Phylogenetic trees and cladograms are dynamic, constantly changing due to current and emerging knowledge.
- Be able to analyze an existing cladogram, and create a cladogram from a chart comparing organisms and their traits.
- Be able to explain the development of the six kingdom and three domain classification systems and discuss major characteristics of organisms in each group.

### 13. Origin of Life

- Primitive Earth provided inorganic precursors from which organic molecules could have been synthesized due to the presence of available free energy and the absence of a significant quantity of oxygen.
- Chemical experiments have shown that it is possible to form complex organic molecules from inorganic molecules in the absence of life.
- These complex reactions could have occurred in solution (organic soup model) or as reactions on solid reactive surfaces.
- The RNA World hypothesis proposes that RNA could have been the earliest genetic material.

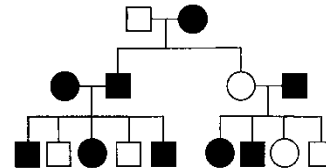
### Practice Multiple Choice Questions:

1. In garden peas, a single gene controls stem length. The recessive allele (*t*) produces short stems when homozygous. The dominant allele (*T*) produces long stems. A short-stemmed plant is crossed with a heterozygous long-stemmed plant. Which of the following represents the expected phenotypes of the offspring and the ratio in which they will occur?

- 3 long-stemmed plants: 1 short-stemmed plant
- 1 long-stemmed plant: 1 short-stemmed plant
- 1 long-stemmed plant: 3 short-stemmed plants
- Long-stemmed plants only

2. In the pedigree below, squares represent males and circles represent females. Individuals who express a particular trait are represented by shaded figures. Which of the following patterns of inheritance best explains the transmission of the trait?

- Sex-linked dominant
- Sex-linked recessive
- Autosomal recessive
- Autosomal dominant



3. In humans, red-green color blindness is a sex-linked recessive trait. If a man and a woman produce a color-blind son, which of the following must be true?

- The father is color-blind.
- Both parents carry the allele for color blindness.
- Neither parent carries the allele for color blindness.
- The mother carries the allele for color blindness.

4. Assume that genes *A* and *B* are not linked. If the probability of allele *A* in a gamete is  $\frac{1}{2}$  and the probability of allele *B* in a gamete is  $\frac{1}{2}$ , then the probability that both *A* and *B* are in the same gamete is

- $\frac{1}{2} \times \frac{1}{2}$
- $\frac{1}{2} + \frac{1}{2}$
- $\frac{1}{2} \div \frac{1}{2}$
- $\frac{1}{2}$

5. In corn, the trait for tall plants (*T*) is dominant to the trait for dwarf plants (*t*) and the trait for colored kernels (*C*) is dominant to the trait for white kernels (*c*). In a particular cross of corn plants, the probability of an offspring being tall is  $\frac{1}{2}$  and the probability of a kernel being colored is  $\frac{3}{4}$ . Which of the following most probably represents the parental genotypes?

- TtCc* x *tTcc*
- TtCc* x *TtCc*
- TtCc* x *ttcc*
- TTCc* x *tTcc*

6. A form of vitamin D-resistant rickets, known as hypophosphatemia, is inherited as an X-linked dominant trait. If a male with hypophosphatemia marries a normal female, which of the following predictions concerning their potential progeny would be true?

- All of their sons would inherit the disease.
- All of their daughters would inherit the disease.
- About 50% of their sons would inherit the disease.
- About 50% of their daughters would inherit the disease.

7. In fruit flies, vermilion eyes are a sex-linked recessive characteristic. If a vermilion-eyed female is crossed with a wild-type male, what proportion of the male offspring should have vermilion eyes?

- a. 0%
- b. 25%
- c. 50%
- d. 100%

8. If red hair, blue eyes, and freckles were consistently inherited together, the best explanation would be that

- a. these traits are recessive characteristics
- b. crossing over has occurred
- c. the genes for these traits are linked on the same chromosome
- d. gene duplications have occurred

**Questions 9-11 refer to the pedigree below.**

9. The genotype of the P<sub>1</sub> male must be

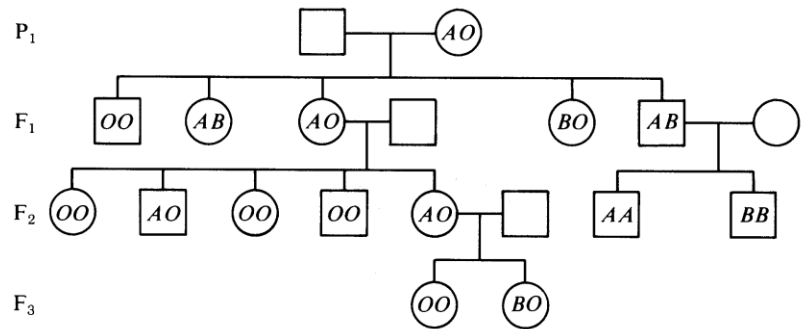
- a. OO
- b. AO
- c. BO
- d. AB

10. The only other possible genotype for children of the F<sub>1</sub> AB male would be

- a. OO
- b. BO
- c. AO
- d. AB

11. The most likely genotype of the mate of the F<sub>1</sub> AO female is

- a. AB
- b. BB
- c. OO
- d. AA



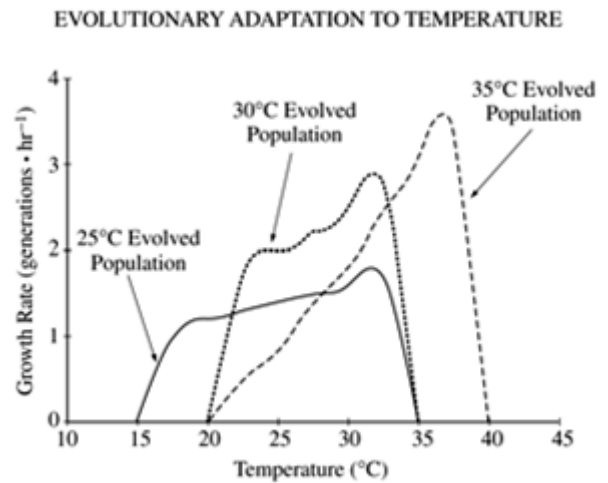
12. Trout in stream A and trout in stream B look similar, but not quite identical. Scientists were unsure if they were two populations of one fish species, or two separate species. To figure this out, they studied the life cycle, habitat, and reproduction of the trout. In a year with a typical amount of rainfall, the trout stay within their own stream and mate with individuals that live nearby. However, in years that include excessive rainfall and flooding, the fish are washed downstream to a larger river, and must swim back up into either stream A or stream B. They choose which stream to swim up randomly, often ending up in a different location than where they themselves were born. When a trout that originated from stream A does breed with a trout from stream B, their offspring are healthy and show no decrease in fertility. Scientists think that flooding in this watershed is happening more and more frequently, due to global climate change. Given this information, predict what is the most likely result for trout A and trout B.

- a. they will become reproductive isolated from each other
- b. they will become more similar in their gene pools
- c. they will go through random changes due to genetic drift
- d. they will adapt to different conditions and look more and more different

13. The Hardy-Weinberg formula is used to estimate the frequency of carriers of alleles that cause genetic disorders and traits. In considering the Hardy-Weinberg equilibrium equation

- a. p represents the number of dominant individuals.
- b. q represents the number of recessive individuals.
- c.  $p^2 + 2pq$  represents the percent of individuals expressing the dominant phenotype.
- d.  $q^2$  represents the number of recessive alleles.

**Questions 14-15.** The graph to the right shows the growth rates of populations of bacteria that have evolved for many generations at different culture temperatures (25°C, 30°C, and 35°C). Each population grows over only a limited range of temperatures (its thermal niche), which are bounded by its critical thermal limits. Within this range, growth rate increases with temperature up to a maximal value and then declines rapidly with increasing temperature. Growth rates are known to be the major determinant of fitness for these bacteria.



14. Which of the following is true concerning the thermal dependence of growth rate between 25°C and 30°C in these populations?

- Thermal dependence is greatest in the population evolved at 25°C.
- Thermal dependence is greatest in the population evolved at 30°C.
- Thermal dependence is greatest in the population evolved at 35°C.
- Growth rates of all populations are equally thermally dependent over this temperature range.

15. If all three populations were mixed together and placed at 37°C, which of the following would be most likely to happen?

- Only the population evolved at 25°C would die and become extinct.
- Only the population evolved at 35°C would survive and reproduce.
- All the bacteria would die and the populations would become extinct.
- All populations would grow, and transfer of genes would create one common population.

**Questions 16-18.** One of the classical examples of evolution occurs on the Galápagos Islands with Darwin's finches. The islands have always been separate from the South American mainland and vary in size and elevation. The lowlands are covered with thorn scrub, while higher elevations (found only on the larger islands) are covered with moist, dense forests. All the organisms living on these islands are descendants of species that have emigrated there, primarily from South America. In studying the finch populations, researchers have identified fourteen species, none of which are found on the mainland.

16. The initial colonizing population of finches most likely exhibited which of the following?

- Hybridization with bird species already existing on the islands
- High rates of interbreeding with mainland populations
- Increased rates of mutation to fill habitats
- A smaller gene pool than that of the mainland populations

17. Initially, one species of finch may have settled on two different islands, maintained this separation over hundreds of years, and eventually followed divergent adaptive pathways. If these now two separate species should migrate onto a new island, they could maintain their individual species identities on this island in all the following ways EXCEPT if one species

- hybridizes successfully with the other species
- lives in the forests and the other in the scrubland
- carries out different stages of its life cycle at different times than the other species
- fails to produce viable young after mating with the other species

18. Although the initial finch species on the islands may have all been seed eaters, which of the following processes minimized competition as the population expanded?

- Selection for niche diversification
- Development of more efficient attack behavior
- Further emigration when carrying capacity was reached
- Genetic drift

19. As many as 60% of people in malaria-infected regions of Africa have the sickle-cell allele, but only about 10% of the U.S. population of African ancestry carries the allele. Malaria remains a major disease in central Africa but has not been a serious problem in the U.S. for many generations. What are the reasons for the difference in the percentages and what is a reasonable statement about future percentages?

- The presence of malaria in Africa maintains the advantage of the heterozygous sickle-cell trait, and the prevalence of malaria will likely continue to preserve the 60% rate in Africa. However, we would predict that the prevalence of the sickle-cell trait will continue to decline in the African-American population.
- The difference is due to lack of interbreeding between the African and African-American populations. We would expect travel and gene flow to increase in human populations, until native Africans and African-Americans both level off at about a 35% rate.
- African-Americans have a lower rate of sickle cell because not all of their ancestors migrated from the regions of Africa infected by malaria. However, now that new therapies are treating sickle-cell anemia among African-Americans, we expect the prevalence of sickle-cell anemia to rise in the African-American population until it reaches the 60% mark.
- Natural selection is affecting the African-American population, reducing the prevalence of a harmful allele, but natural selection is not affecting the African population. We expect the African-American population to continue decreasing the prevalence of the sickle-cell trait, but the African population to remain unchanged until affected by genetic drift.

20. Guppies are small fish found in streams in Venezuela. Male guppies are brightly colored, with black, red, blue and iridescent (reflective) spots. Males cannot be too brightly colored or they will be seen and consumed by predators, but if they are too plain, females will choose other males. Natural selection and sexual selection push in opposite directions. When a guppy population lives in a stream in the absence of predators, the proportion of males that are bright and flashy increases in the population. If a few aggressive predators are added to the same stream, the proportion of brightly-colored males decreases with about 5 months (3-4 generations). The effects of predators on guppy coloration have been studied in artificial ponds with mild, aggressive, and no predators, and by similar manipulations of predators in natural stream environments.

Fitness is a term often used by biologists to explain the evolutionary success of certain organisms. Which feature would a biologist consider to be most important in determining which guppies are "most fit?"

- Large body size and ability to swim quickly away from predators.
- Excellent ability to compete for food.
- High number of offspring that survive to reproductive age.
- High number of matings with many different females.

21. Populations of a plant species have been found growing in the mountains at altitudes above 2,500 meters. Populations of a plant that appears similar, with slight differences, have been found in the same mountains at altitudes below 2,300 meters.

Which of the following describe TWO kinds of data that could be collected to provide a direct answer to the question, do the populations growing above 2,500 meters and the populations growing below 2,300 meters represent a single species?

- Rate of hybrid death, rate of hybrid success.
- Number of differences between the species and the rate of reproductive success.
- Rate of successful interbreeding between the populations, occurrence of hybrid fertility.
- Ability of upper plant species to grow in the altitudes below 2,300 meters, and length of life of hybrids

22. In a certain prairie community, a dominant prairie grass species has an allele frequency of  $P = .7$  and  $q = .3$ . Ten years ago there was a wild fire on the prairie, which resulted in the death of 80% of the prairie grass. Over the past ten years the population has rebounded and currently the allele frequencies are  $P = .1$ ,  $q = .9$  Which of the following justifies this data?

- The new allele frequencies are due to selective pressure placed on the dominant allele.
- The reduction in the dominant allele frequencies is due to a less favorable trait, which resulted in selection against the allele
- The increase in the recessive allele frequency is due to the combined effects of a bottleneck and genetic drift.
- The change in the allele frequencies is due to the migration of new species in the area once the competition was reduced.

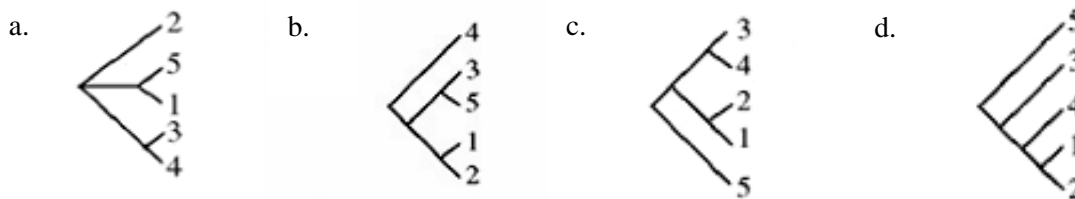


23. The introduction of antibiotics such as penicillin several years ago was immediately effective in combating infections caused by Staphylococcus. In 1958, however, there were several outbreaks of staphylococcal infections. People with the infections did not respond to treatment with any of the antibiotics and there were a large number of deaths. The best explanation for this situation is that

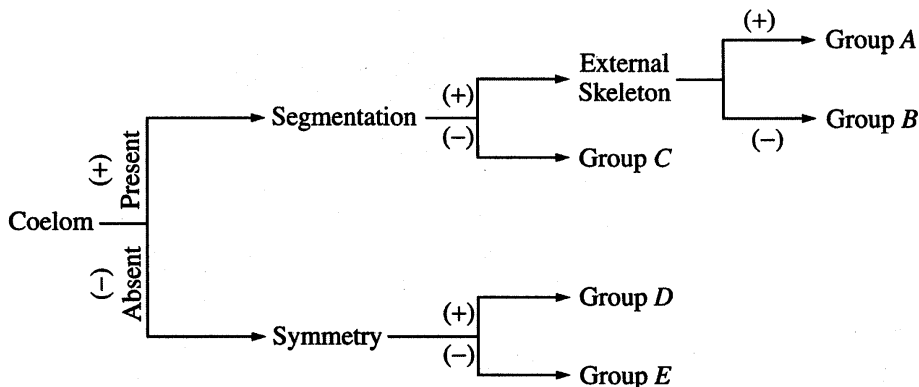
- a. the bacteria from other hosts such as birds, cats, and dogs migrated into human hosts
- b. the bacteria exposed to non-lethal doses of antibiotics quickly learned to avoid them
- c. each generation of bacteria acquired the ability to use antibiotics as nutrients
- d. antibiotic-resistant bacteria survived and multiplied, and these were the forms causing the infections

Species	1	2	3	4	5
1	-	3	19	18	27
2		-	19	18	26
3			-	1	27
4				-	27

24. Which of the following phylogenetic trees is the most consistent with the data above?



**Questions 25-26 Refer to the phylogenetic tree below.**



25. Centipedes and millipedes should NOT be placed in group B because they

- a. have an exoskeleton
- b. display segmentation
- c. have a coelom
- d. are heterotrophic

26. All organisms in this tree have which of the following present, and why?

- a. Prokaryotic cells – because they are the most primitive type of cells
- b. Cilia – because they all move
- c. Glycolysis – because it is conserved across all recognized domains
- d. Mitochondria – because that is where cellular respiration occurs

27. Which of the following is most often associated with the elaborate courtship rituals conducted by many birds?

- a. species recognition
- b. migration
- c. feeding response
- d. altruism
- e. kin selection

28. The differences in cricket calls among sympatric species of crickets are examples of

- a. habitat isolation
- b. temporal isolation
- c. physiological isolation
- d. behavioral isolation
- e. geographical isolation

29. Which of the following statements best expresses the concept of punctuated equilibrium?

- a. Small variations gradually accumulate in evolving lineages over periods of millions of years.
- b. Random mating ensures that the proportions of genotypes in a population remain unchanged from generation to generation.
- c. Stability is achieved when selection favors the heterozygote, while both types of homozygotes are at a relative disadvantage.
- d. Evolutionary changes consist of rapid bursts of speciation alternating with long periods in which species remain essentially unmodified.
- e. Under competition for identical resources, one of the two competing species will be eliminated or excluded.

30. Which of the following principles is NOT part of Darwin's theory of evolution by natural selection?

- a. Evolution is a gradual process that occurs over long periods of time.
- b. Variation occurs among individuals in a population.
- c. Mutations are the ultimate source of genetic variation
- d. More individuals are born than will survive
- e. Individuals that possess the most favorable variations have the best chance of reproducing.

**Questions 31-32.** In a certain flock of sheep, 4 percent of the population has black wool and 96 percent has white wool. Assume Hardy-Weinberg equilibrium.

31. If black wool is a recessive trait, what percentage of the population is heterozygous for this trait?

- a. 4%
- b. 20%
- c. 32%
- d. 64%
- e. 80%

32. What percentage of the population is homozygous for white wool?

- a. 20%
- b. 40%
- c. 64%
- d. 80%
- e. 96%

33.  $A$  represents the dominant allele and  $a$  represents the recessive allele of a pair. If, in 1000 offspring, 500 are  $aa$  and 500 are of some other genotype, which of the following are most probably the genotypes of the parents?

- a.  $Aa$  and  $Aa$
- b.  $Aa$  and  $aa$
- c.  $AA$  and  $Aa$
- d.  $AA$  and  $aa$
- e.  $aa$  and  $aa$

34. Which of the following is the most likely explanation for a high rate of crossing-over between two genes?

- a. The two genes are far apart on the same chromosome.
- b. The two genes are both located near the centromere.
- c. The two genes are sex-linked.
- d. The two genes code for the same protein.
- e. The two genes are on different chromosomes.

**Practice Long Response Questions:** Make an outline of the information you would include in each of these essays.

\*For number one, please do all calculations for part a & b.

1. In fruit flies, the phenotype for eye color is determined by a certain locus. *E* indicates the dominant allele and *e* indicates the recessive allele. The cross between a male wild-type fruit fly and a female white-eyed fruit fly produced the following offspring:

	Wild-type Male	Wild-type Female	White-eyed Male	White-eyed Female	Brown-eyed Female
F1	0	45	55	0	1

The wild-type and white-eyed individuals from the F1 generation were then crossed to produce the following offspring

F2	23	31	22	24	0
----	----	----	----	----	---

- Determine the genotypes of the original parents (P generation) and explain your reasoning. You may use punnett squares to enhance your description, but the results from the punnett squares must be discussed in your answer.
- Use a Chi-squared test on the F2 generation data to analyze your prediction of the parental genotypes. Show all your work and explain the importance of your final answer.
- The brown-eyed female in the F1 generation resulted from a mutational change. Explain what a mutation is, and discuss two types of mutations that might have produced the brown-eyed female in the F1 generation.

2. A new species of fly was discovered on an island in the South Pacific. Several different crosses were performed, each using 100 females and 100 males. The phenotypes of the parents and the resulting offspring were recorded.

Cross I: True-breeding bronze-eyed males were crossed with true-breeding red-eyed females. All the F1 offspring had bronze eyes. F1 flies were crossed, and the data for the resulting F2 flies are given in the table below.

F <sub>2</sub> Phenotype	Male	Female
Bronze Eyes	3,720	3,800
Red Eyes	1,260	1,320

Cross II: True-breeding normal-winged males were crossed with true-breeding stunted-winged females. All the F1 offspring had stunted wings. F1 flies were crossed, and the data for the resulting F2 flies are given in the table below.

F <sub>2</sub> Phenotype	Male	Female
Normal Wings	1,160	1,320
Stunted Wings	3,600	3,820

Cross III: True-breeding bronze-eyed, stunted-winged males were crossed with true-breeding red-eyed, normal-winged females. All the F1 offspring had bronze eyes and stunted wings. The F1 flies were crossed with true-breeding red-eyed, normal-winged flies, and the results are shown in the table below.

F <sub>2</sub> Phenotype	Male	Female
Bronze Eyes, Stunted Wings	2,360	2,220
Bronze Eyes, Normal Wings	220	300
Red Eyes, Stunted Wings	260	220
Red Eyes, Normal Wings	2,240	2,180

- What conclusions can be drawn from cross I and cross II? **Explain** how the data support your conclusions for each cross.
- What conclusions can be drawn from the data from cross III? **Explain** how the data support your conclusions.
- Identify and discuss TWO different factors that would affect whether the island's fly population is in Hardy-Weinberg equilibrium for the traits above.

3. Charles Darwin proposed that evolution by natural selection was the basis for the differences that he saw in similar organisms as he traveled and collected specimens in South America and on the Galapagos Islands.

a. **Explain** the theory of evolution by natural selection as presented by Darwin.

b. Each of the following relates to an aspect of evolution by natural selection. **Explain** THREE of the following.

- Convergent evolution and the similarities among species (ecological equivalents) in a particular biome (e.g., tundra, taiga, etc.)
- Natural selection and the formation of insecticide-resistant insects or antibiotic resistant bacteria
- Speciation and isolation
- Natural selection and behavior such as kinesis, fixed-action-pattern, dominance hierarchy, etc.
- Natural selection and heterozygote advantage

4. Phylogeny is the evolutionary history of a species.

(a) The evolution of a species is dependent on changes in the genome of the species. **Identify** TWO mechanisms of genetic change, and **explain** how each affects genetic variation.

(b) Based on the data in the table below, **draw** a phylogenetic tree that reflects the evolutionary relationships of the organisms based on the differences in their cytochrome *c* amino-acid sequences and **explain** the relationships of the organisms. Based on the data, **identify** which organism is most closely related to the chicken and **explain** your choice.

(c) **Describe** TWO types of evidence—other than the comparison of proteins—that can be used to determine the phylogeny of organisms. **Discuss** one strength of each type of evidence you described.

THE NUMBER OF AMINO ACID DIFFERENCES IN CYTOCHROME *c* AMONG VARIOUS ORGANISMS

	Horse	Donkey	Chicken	Pengiu	Snake
Horse	0	1	11	13	21
Donkey		0	10	12	20
Chicken			0	3	18
Penguin				0	17
Snake					0