

*This is a closed book exam. Please turn off and put away all electronic devices (cell phones, iPods, etc.).*

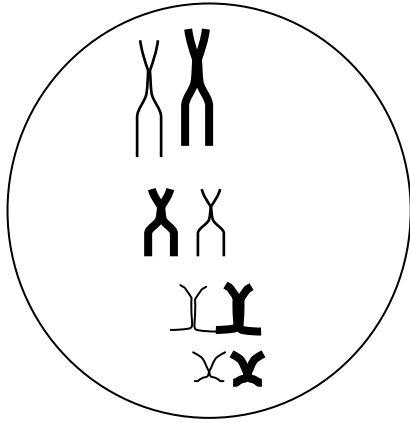
**I. Multiple choice (30 points).** Circle the letter for the SINGLE BEST ANSWER from the options given.

11) A hypothetical medical study followed the diets of 150 volunteers for a year, then measured the elasticity of their blood vessels at the end of that time. Those people who frequently ate dark chocolate had more elastic (healthier) blood vessels than those who ate milk chocolate or no chocolate. This study showed that

- A) dark chocolate is healthier than milk chocolate
- B) if a little dark chocolate is good for you, a lot of dark chocolate must be better.
- C) while patterns of chocolate consumption are correlated with healthier blood vessels, we cannot conclude that chocolate was the causal factor.**
- D) people who ate milk chocolate also tended to smoke more, which outweighed the benefits of chocolate consumption.

12) Species that are in the same \_\_\_\_\_ are more closely related than species that are only in the same \_\_\_\_\_.

- a) phylum ... class
- b) family ... order**
- c) class ... order
- d) family ... genus



13) The figure above shows a cell immediately before separation of the chromosomes in meiosis I. Thin lines are the paternally derived chromosomes, thick lines are the maternally derived chromosomes. The typical adult individual of this species has a chromosome number of \_\_\_\_ and a ploidy of \_\_\_\_.

- a) 4, 2**
- b) 2, 4
- c) 4, 4
- d) 8, 2

14) The meiosis figure above is not actually correct, because all the maternal homologs should segregate together and all the paternal homologs should segregate together.

- a) True
- b) False**

15) Mitosis and meiosis are similar and different in that

- A. mitosis reduces the chromosome number in half, but meiosis keeps the chromosome number the same.
- B. daughter cells in mitosis are genetically identical to parental cells, whereas daughter cells in meiosis are genetically different from parent cells.**
- C. both mitosis and meiosis reduce ploidy by half.
- D. all of the above

- 16) Unless you have an identical twin, you are genetically unique. This is at least in part a result of
- A) genetic recombination.
  - B) random fertilization.
  - C) independent assortment of chromosomes.
  - D) all of the above**
- 17) The four-chambered hearts of birds and the four-chambered hearts of mammals evolved independently of each other. If one were unaware of this independence, then one might logically assume that
- A) early mammals possessed feathers.
  - B) birds and mammals should be placed in the same class.
  - C) the common ancestor of birds and mammals had a four-chambered heart.**
  - D) the common ancestor of birds and mammals had a three-chambered heart.
- 18) The  $F_1$  offspring of Mendel's classic pea cross always looked like one of the two parental varieties because
- A) one allele was completely dominant over another.**
  - B) each allele affected phenotypic expression.
  - C) of the law of independent assortment
  - D) the traits blended together during fertilization.
- 19) Which of the following is the unit of evolution? In other words, which of the following can evolve in the Darwinian sense (e.g., due to the relatively fast effects of natural selection)?
- A) species
  - B) chromosome
  - C) population**
  - D) gene
  - E) individual
- 20) The complex eyes of octopuses and many mammals, including humans, is good evidence for intelligent design because they can only work with all the pieces intact and because no transitional forms are known.
- A. True
  - B. False**
- 21) Because scientific hypotheses are frequently modified to fit new evidence,
- A) pursuing natural explanations of phenomena when the evidence doesn't meet our initial expectations can lead to novel scientific insights.**
  - B) Supernatural explanations provide simpler testable hypotheses for future investigation.
  - C) contradictory evidence about the mechanisms of evolution indicates that evolution probably does not occur.
  - D) Most of what we currently know about evolution is incorrect.
- 22) The same gene that causes various coat patterns in wild and domesticated cats also causes the cross-eyed condition in these cats, the cross-eyed condition being slightly maladaptive. In one of the environments cats live in, the coat pattern that is associated with crossed eyes is highly adaptive, with the result that both the coat pattern and the cross-eyed condition increase in a feline population over time in that environment. Which statement is best supported by these observations?
- A) Evolution is progressive and tends toward a more perfect population.
  - B) Phenotype is often the result of compromise.**
  - C) Natural selection reduces the frequency of maladaptive genes in populations over the course of time.
  - D) In all environments, coat pattern is a more important survival factor than is having crossed eyes.
- 23) Ichthyosaurs were aquatic dinosaurs. Fossils show us that they had dorsal fins and tails just as fish do, even though their closest relatives were terrestrial reptiles that had neither dorsal fins nor aquatic tails. The dorsal fins and tails of ichthyosaurs and fish are
- A) homologous.
  - B) adaptations to a common environment.
  - C) examples of convergent evolution.
  - D) both B and C are correct.**
- 24) What was the most significant result Gregor Mendel drew from his experiments with pea plants?
- A) An organism that is homozygous for many recessive traits is at a disadvantage.
  - B) Recessive genes occur more frequently in the  $F_1$  than do dominant ones.
  - C) Genes are composed of DNA.
  - D) Traits are inherited in discrete units, and are not the results of "blending."**

25) When we say that one organism has a greater fitness than another organism, we specifically mean that it

- A) lives longer than others of its species.
- B) utilizes resources more efficiently than other species occupying similar niches.
- C) mates more frequently than others of its species.
- D) leaves more viable offspring than others of its species.

26) Evolutionary theory predicts that species are related, not independent. Four of the following examples provide support for this prediction, but one is irrelevant. Which of examples listed below does *not* support the claim that species are related?

- A. Many dinosaurs and other organisms went extinct following a huge asteroid impact at the end of the Cretaceous.
- B. The endostyle of lancelets (invertebrate chordates) and the thyroid gland of vertebrates develop similarly, and both produce iodinated proteins.
- C. All prokaryotes and eukaryotes use DNA to carry their genetic information.
- D. Before synthetic insulin was available, diabetics used injections of purified pig insulin to manage their disease.

27) How does Mendel's law of segregation of alleles relate to meiosis?

- A. Meiosis explains how maternal and paternal alleles for a given trait mix together in each gamete.
- B. Meiosis explains how maternal and paternal alleles for a given trait separate into different gametes.
- C. Meiosis leads to gametes with new alleles for a given trait not seen in either parent.
- D. B and C

28) How does a scientific theory differ from a scientific hypothesis?

- A. There is no difference—the terms are interchangeable.
- B. A theory is an explanation for a very general phenomenon or set of observations; hypotheses treat more specific observations.
- C. A hypothesis is an explanation for a very general phenomenon; theories treat more specific issues.
- D. Theories refer to speculation or a hunch about how a natural phenomenon works; hypotheses are used to explain the results of experiments.

29) Yellow seed color in peas is dominant to green. Assume that Mendel conducted a series of experiments where plants with yellow seeds were crossed among themselves, and the following progeny were produced: 302 yellow and 98 green. (a) What is the most probable genotype of each parent? (b) Based on your answer in (a) above, what genotypic and phenotypic ratios are expected in the progeny? (Assume the following symbols: Y = yellow and y = green.)

- A. (a)  $YY \times yy$ ; (b) genotypic = 3:1, phenotypic = 1:2:1
- B. (a)  $Yy \times Yy$ ; (b) genotypic = 1:2:1, phenotypic = 3:1
- C. (a)  $YY \times Yy$ ; (b) genotypic = 1:2:1, phenotypic = 2:1
- D. (a)  $Yy \times Yy$ ; (b) genotypic = 3:1, phenotypic = 9:3:3:1

30) You are doing genetics with fruitflies, investigating traits related eye color. Red eyes (R) are dominant over white eyes (r). One of your colleagues brings you a female red-eyed fly, wanting to know whether it is homozygous dominant or heterozygous. To figure this out, you breed this fly of unknown genotype with

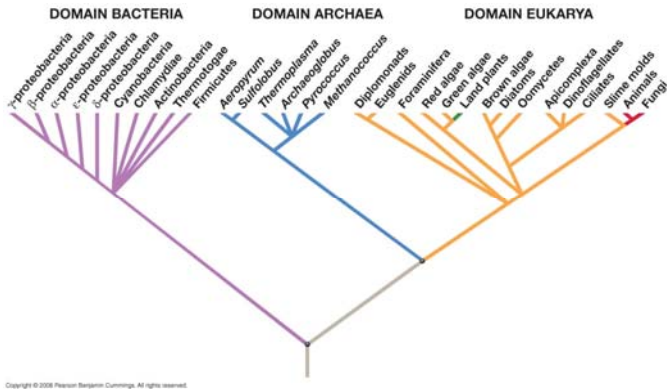
- A. a white-eyed male (rr)
- B. a male that is known to be homozygous red-eye (RR)
- C. a male that is known to be heterozygous red-eye (Rr)
- D. any red-eyed male

31) After doing the fruit fly cross in the experiment above, you get 150 red-eyed offspring. This tells you

- A. Nothing. You need to now breed those offspring with each other to know the answer.
- B. That you have a heterozygous red-eyed female.
- C. That you have a homozygous red-eyed female.
- D. That you really wanted to be an ecologist rather than a geneticist.

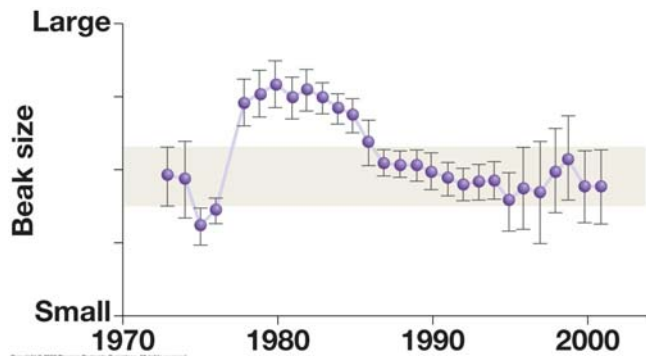
32) What does the term "evolution" mean?

- A. The strongest individuals produce the most offspring
- B. The characteristics of an individual change through the course of its life, in response to natural selection.
- C. The characteristics of a population change through time.
- D. The characteristics of species become more complex over time.



- 33) The modern “tree of life”, above, was revolutionary because
- A. it indicated that Archaea and Eukarya were more closely related than the two prokaryote domains.
  - B. it indicated that the differences between prokaryote domains were much larger than any differences among eukaryotes
  - C. it indicated that differences among common macro-organism kingdoms (plants, animals, and fungi) were much smaller than differences among species commonly grouped together as protists.
  - D. all of the above.**

- 34) The phylogeny in question 23 was deduced from
- A. a careful study of the morphology and behavior of prokaryotes
  - B. the nucleotide sequence of ribosomal RNA**
  - C. genes that code for the nuclear membrane in all organisms.
  - D. a Sherlock Holmes mystery novel



- 35) The graph above shows the changes in beak size of finches in the Galapagos Islands following a drought in 1977 and subsequent wetter years starting in 1983. The change in beak size following the drought does not count as evolution, because when heavy rainfall resumed in later years, beak size returned to what it was before.
- A) True
  - B) False**

**II. Short answer (40 points)**

36. (8 pts). Briefly describe the relationship between traits, alleles, genes, and chromosomes.

*Chromosomes are long strands of DNA (and proteins), each consisting of many genes. Each gene codes for a trait. Alleles are different versions of the SAME gene that lead to different manifestations of that trait (phenotypes). For example, if the trait is hair color, then different alleles (slightly different sequences of DNA for the hair color gene) code for red, brown, blond, or black hair.*

*Note, there seemed to be a lot of confusion about the what an allele is relative to a gene and whether different alleles code for different traits (versus different forms of the same trait). Please make sure you have this straightened out as it is very important for understanding how heredity and natural selection work.*

37. (6 pts) Two true-breeding stocks of garden peas are crossed. One parent had red, axial flowers and the other had white, terminal flowers; all F<sub>1</sub> individuals had red, axial flowers. If 1,000 F<sub>2</sub> offspring resulted from a cross of F<sub>1</sub>'s, approximately how many of them would you expect to have red, terminal flowers? (Assume independent assortment.) Show your work, including any calculations or equations used.

*Note: the key to this problem is that there are TWO traits: flower color and flower position*

*Color alleles: R = red, r = white. Position alleles: A = axial, a = terminal*

*We know that R and A are dominant because when crossing the parental genotypes, all F<sub>1</sub> offspring are red and axial.*

*P: RRAA x rraa*

*F<sub>1</sub>: RrAa (all offspring will be same genotype)*

*F<sub>2</sub>: Note: there are four potential types of gametes from each parent, and each gamete has an allele for both genes. You are looking for the proportion of red, terminal phenotypes; these are shown below, though you could also have filled in the entire Punnett square, then searched for the correct ones*

	RA	Ra	rA	ra
RA				
Ra		RRaa		Rraa
rA				
ra		Rraa		

*. Red, terminal offspring make up 3/16 of the total possible.  $1000 \times 3/16 = 187.5$ , so ~188 red, terminal flowered offspring. Note: you shouldn't need a calculator to do this simple division (try simplifying  $3 \times 1000/16$  before dividing).*

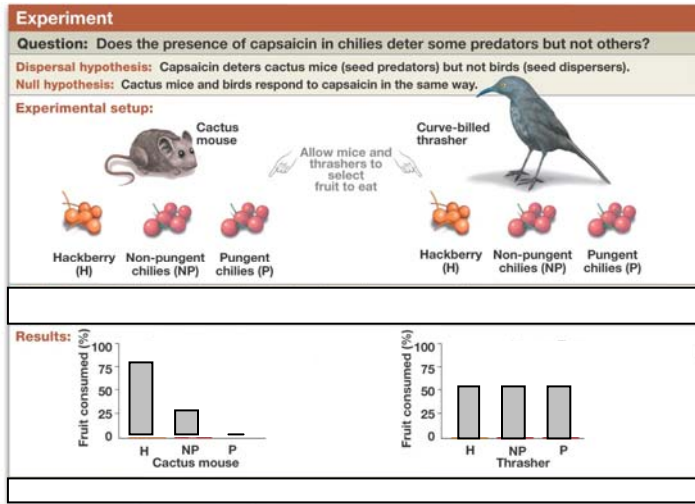
38. (5 pts.) Briefly explain the statement “Selection acts on individuals, but evolution happens in populations.”

*The environment determines which characteristics are advantageous (selection). Individuals with those characteristics contribute more offspring to the next generation (higher fitness), thereby changing the allele frequencies in the population (evolution!!).*

39. (8 pts.) What are the four key steps for evolution by natural selection to happen?

1. Variability in traits
2. Heritability of traits
3. Differential fitness (reproductive output) among individuals as a result of those traits.
4. Offspring with the advantageous traits are a greater proportion of the population in the next generation.

*Note: I also accepted the statement “Organisms must produce more offspring than can survive to reproduce” because that’s in the lab handout for Exercise 2, but #4 above is more accurate.*



40. The above figure indicates the experimental design for testing the directed dispersal hypothesis of why chilies are hot (i.e., contain capsaicin). The directed dispersal hypothesis states that natural selection should favor fruits that taste bad to animal species that act as seed predators, but not to species that act as seed dispersers. The experimenters tested two potential eaters of chili fruits, cactus mice and curve-billed thrashers. They also used three treatments for each disperser: orange non-pungent hackberries, red non-pungent chilies, and red pungent (capsaicin-containing) chilies.

- b. ( 4 pts.) Given this experimental design, state a prediction about the PRIMARY treatment in this experiment that would support the directed dispersal hypothesis.

*Cactus mice will have a smaller percentage of pungent chilies (P) in their diet than will curve-billed thrashers.*

- c. ( 4 pts.) Briefly explain the two control treatments in this experiment: what alternative hypothesis is each meant to test?

- 1) *Hackberries are known to be eaten by both species. Consumption of hackberries by cactus mice would disprove the alternative hypothesis that the cactus mice didn't eat pungent chilies just because they weren't hungry.*
- 2) *Consumption of non-pungent chilies (NP) tests the alternative hypothesis that cactus mice avoid pungent chilies just because their color differs from that of hackberries.*

- d. ( 5 pts) Sketch in hypothetical results for this experiment in the graph above and briefly explain whether or not they support the directed dispersal hypothesis. NOTE: I'm not expecting you to be able to regurgitate the actual results of this experiment from the book (though you can if you want). Rather, I'm looking for logical consistency in interpreting whatever potential results you want to make up.

*This could be anything, but your interpretation had to be consistent with the pattern you drew in the graph. The most common pattern people drew was similar to the one above. This supports the directed dispersal hypothesis because thrashers ate more pungent chilies than did mice. Also, the mice's avoidance of pungent chilies was not apparently caused only by fruit color or lack of hunger, since they ate plenty of hackberries and nonpungent chilies. In contrast, thrashers ate similar amounts of all three fruits.*

**Extra Credit.** (2 points) What is your favorite adaptation of your favorite organism?