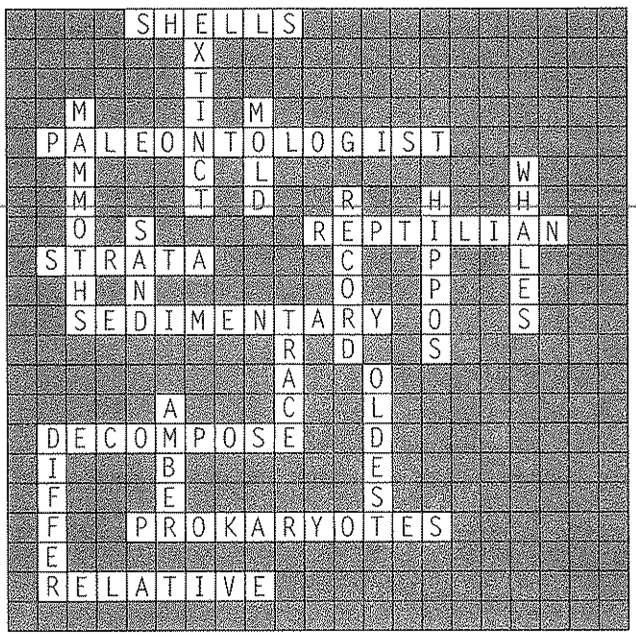
Chapter 13

Review the Concepts

Exercise 1: 1. E 2. D 3. G 4. F 5. B 6. H 7. A 8. C

Exercise 2: 1. Charles Darwin 2. evolution 3. vary 4. heritable 5. environment 6. survive 7. reproduce 8. beneficial 9. natural selection 10. desirable 11. beaks 12. pesticide 13. population 14.alleles 15. environment 16. goal 17. population 18. adapt

Exercise 3:



Exercise 4: 1. comparative anatomy 2. molecular biology 3. molecular biology 4. fossil record 5. comparative anatomy 6. natural selection 7. artificial selection 8. biogeography 9. molecular biology 10. biogeography 11. comparative anatomy 12. comparative anatomy 13. fossil record 14. molecular biology 15. comparative anatomy 16. artificial selection

Exercise 5: The following illustrate homologies: 1, 2, 3, 5, 9, 11, 12, 14, 15

Exercise 6: 1. population 2. individual 3. population 4. gene pool 5. microevolution 6. mutation, sexual reproduction 7. genetic 8. mutation 9. body (somatic) cells 10. mutations in gametes 11. harmful 12. duplication mutation 13. prokaryotes 14. 1/100,000 15. sexual reproduction 16. crossing over, independent assortment, random fertilization

Exercise 7: B. *RR*, *Rr*, *rr* C. 36, 48, 16 D. 0.36, 0.48, 0.16 E. 72, 48, 0 F. 0, 48, 32 G. $p = 0.6$, $q = 0.4$ H. 0.6, 0.4 J. *RR*, *Rr*, *rr* K. 0.36, 0.48, 0.16 L. 72, 48, 0 M. 0, 48, 32 N. $p = 0.6$, $q = 0.4$ O. The genotype and allele frequencies stayed the same in the second generation and will continue to do so in succeeding generations. This illustrates that the frequency of each allele in the gene pool will remain constant unless acted on by other agents. Sexual reproduction alone does not lead to microevolution—the so-called Hardy-Weinberg principle. P. Whether an allele is dominant or recessive has nothing to do with its probability of being inherited, so the frequencies of the *R* and *r* alleles remain constant from generation to generation.

Exercise 8: 1. No gene flow. The population is not isolated; there is gene flow—migration of individuals with yellow alleles into the population. 2. No mutation. A mutation alters the frequency of red and yellow alleles in the gene pool. 3. Very large population. Because the flower population is small, a chance event such as a landslide can significantly alter the gene pool. This is called genetic drift. 4. No natural selection. Individuals differ in reproductive success, changing the relative frequencies of red and yellow alleles in the gene pool. This is natural selection, and it is the only situation in this exercise that results in adaptation to the environment. 5. Random mating. Mating is not random because a yellow plant does not stand an equal chance of mating with every other plant in the population. It is more likely to mate with a yellow plant.

Exercise 9: 1. struggle 2. fittest 3. fitness 4. phenotype 5. phenotype 6. genotype 7. gene pool 8. population 9. allele 10. diploid 11. variation 12. environment 13. balancing 14. heterozygote 15. frequency 16. neutral 17. dimorphism 18. secondary 19. intrasexual 20. intersexual 21. mate 22. genes 23. bell 24. stabilizing 25. directional 26. change 27. diversifying 28. intermediate 29. Natural selection 30. compromises

Test Your Knowledge

Multiple Choice: 1. e 2. b 3. d 4. d 5. c 6. a 7. c 8. e 9. b 10. b 11. e 12. d 13. b

Essay: 1. Because organisms produce more offspring than the resources in their environment can support, only a fraction of these offspring survive and reproduce themselves. Individuals in a population vary in their characteristics, and many of these varying traits are inherited. Those individuals with traits that fit them best to their environment are most likely to survive and reproduce, and thus these individuals leave more offspring than less fit individuals. Over time, the fitter types make up a larger fraction of the population, and through this process of natural selection the population adapts to its environment.

2. There are many well-researched examples of adaptation through natural selection—Galapagos finches, pesticide resistance in insects, antibiotic resistance in bacteria. Biogeography, the geographical distribution of species, suggests that species change when they move into new habitats. Animals on islands resemble those on the nearest land mass more than those in more distant localities. The fossil record shows sequential changes in living things over time. Comparative anatomy shows the relationships among organisms descended from a common ancestor. Molecular biology shows that organisms thought to be more closely related on the basis of other criteria also have a greater proportion of their DNA and proteins in common.

3. A population is a group of individuals of a particular species living in a particular place at a particular time. A species is all the populations whose individuals can potentially interbreed. The white-tailed deer on an island constitute a population; all white-tailed deer are members of a particular species.

4. Homologous structures—anatomical or molecular—are features that often have different functions but are structurally similar because of common ancestry. The forelimbs of humans, cats, bats, and whales are similar in structure but differ in shape and function and show descent of these animals from a common land mammal ancestor. The genes of these animals are more similar to each other than any of their genes are to the genes of fish, also showing common ancestry. Homologous structures enable us to reconstruct the branching sequence of the evolutionary "tree," which species have common ancestors and are on the same branch and how the branches connect.

5. Darwin would have said that both horses and zebras are descended from a common ancestral species that lived in the past. As the descendants of this species spread into different environments, they adapted in different ways to different conditions. Horses and zebras eventually became distinct species, but their homologous structures show that they are related—descended from the same ancestor.

6. In a small population, a chance event might alter the frequency of alleles in the gene pool so as to increase the frequency of an allele that would otherwise be disadvantageous. In a diploid population, a recessive allele affects the phenotype only when two copies of it are present in a homozygous individual. Many harmful recessive alleles in a population might be "hidden" in heterozygous individuals, not exposed to the effects of natural selection. Sometimes natural selection actually favors heterozygotes—a phenomenon known as heterozygote advantage. In this case, heterozygotes might have greater reproductive success than either homozygote, further increasing the frequency of an allele that is harmful in the homozygous recessive state.

7. All these phenomena alter allele and genotype frequencies in the gene pool, but in different ways. In a small population, a chance event could kill some individuals and this random "sampling error" could significantly alter the gene pool. If individuals prefer some types of potential mates to others—that is, if mating is nonrandom—certain alleles are more likely to be passed on than others, and the gene pool can change. Migration of individuals in or out of the population can add new alleles or remove alleles from the gene pool. Mutation creates a new allele, altering allele frequencies. If a certain allele enables individuals with that allele to better survive and reproduce, that allele is more likely to be passed on to the next generation than others, and its frequency in the gene pool will increase. This is natural selection, and it is the only circumstance that leads to adaptation.

Apply the Concepts

Multiple Choice: 1. e 2. a 3. a 4. c 5. b 6. d 7. c 8. b 9. e 10. d 11. d 12. b

Essay: 1. Lamarck would have said that the ancestral butterfly had a shorter proboscis. It stretched the proboscis to reach the nectar deep in the flower, and this change was passed on to its offspring. In this way, the proboscis got longer and longer. Darwin would have said that the ancestral butterflies varied—some had longer proboscises than others—and that proboscis length is inherited. Those butterflies with the longest proboscises were able to get the most food from the flowers and were therefore better able to survive and reproduce. A greater proportion of butterflies in the next generation inherited longer proboscises, and over time, this survival of the fittest resulted in an increase in the average length of the proboscis.

2. Darwin saw that by selecting individuals with desired characteristics as breeding stock, humans play the role of the environment and bring about differential reproduction. If this artificial selection can bring about great change in pigeons in a few hundred years, natural selection must be able to cause even greater changes over millions of years.

3. An individual cannot adapt in an evolutionary sense. Each plant has particular characteristics; it can either stand heat or it cannot. Lindsay recognized that individual plants probably varied in their ability to withstand heat. Perhaps plants with thinner leaves or shallower roots are more likely to

wilt and die. Those with thicker leaves or deeper roots might withstand heat and drought better and are better able to survive and reproduce, passing their genes for the characteristics that enable them to withstand the heat on to the next generation. In the next generation of wildflowers, a greater proportion of individuals will be of the more fit type. Thus individual plants do not adapt, but the population does.

4. Use the formulas $p + q = 1$ and $p^2 + 2pq + q^2 = 1$ to answer these questions. Nine percent (0.09) of the individuals in the population are homozygous recessive (white). If $q^2 = .09$, then $q = 0.3$. Since $p = 1 - q$, $p = 0.7$. Frequencies of homozygous dominant, heterozygous, and homozygous recessive individuals are 0.49, 0.42, and 0.09, respectively. Frequency of the green allele is 0.7. Frequency of the white allele is 0.3. The genotype and gene frequencies will stay the same in the next generation if the population is at Hardy-Weinberg equilibrium.

5. The population could be made to deviate from Hardy-Weinberg equilibrium in several ways. One could randomly scoop out some fish. In such a small population, this could probably alter allele and genotype frequencies by chance—genetic drift. One could cause gene flow by adding white fish to the aquarium. Subjecting the fish to X-rays might cause mutations that would alter the makeup of the gene pool. One could segregate the fish so that mating is nonrandom—only allowing fish of the same color to mate with each other, for example. Putting in a predator that can see and catch the white fish more easily than the green ones would result in natural selection in favor of the green fish and adaptation of the fish population to their environment.

6. The data indicate that the owls are catching a larger proportion of the dark mice than of the light mice. Perhaps the dark mice are easier to see against the white sand. If coloration is inherited, the light mice are more likely to pass their genes on to future generations, so a larger proportion of the mice will be light colored. Directional selection is occurring, and the mouse population is adapting to its environment.

Chapter 14

Review the Concepts

Exercise 1: 1. C 2. D 3. A 4. B

Exercise 2: 1. Because both are extinct, we must rely on appearance rather than the biological species concept. 2. Do tigers and lions interbreed under natural conditions? Is a tiglon fertile? 3. Appearance can be deceptive; they can interbreed. But would a Chihuahua really be able to mate with a Saint Bernard? 4. The criterion of interbreeding is useless for asexual organisms; we have to classify them by appearance and biochemical features. 5. A and C are becoming separate species, but there is still some gene flow between them via B. 6. If it is difficult to distinguish species on the basis of appearance, it might be difficult to know whether isolated populations are of the same or different species. 7. Are the birds the same species if they look alike? If the populations are separated, it might not be possible to determine whether they could interbreed in nature.

Exercise 3: 1. prezygotic, temporal isolation 2. postzygotic, hybrid breakdown 3. postzygotic, reduced hybrid fertility 4. prezygotic, mechanical isolation 5. prezygotic, behavioral isolation 6. prezygotic, gametic isolation 7. prezygotic, habitat isolation 8. postzygotic, reduced hybrid viability

Exercise 4: There are many possible answers for each of these questions, for example: 1. ocean, mountain range 2. mountain range, river 3. separate river basins, dry land between lakes 4. mountain range, ocean 5. ocean, mountain range 6. land bridge, deep water between coral reefs

Exercise 5: 1. yes, yes, 36 2. no, no, 33 3. no, no, 35 4. yes, yes, 36 5. yes, yes, 28 6. no, no, 21

Exercise 6: 1. population 2. species 3. geographical barrier 4. genetic drift 5. natural selection 6. interbreed 7. pre 8. behavioral 9. post 10. reduced hybrid viability 11. reinforce 12. fusion 13. hybrid 14. gene 15. species 16. biological 17. isolating 18. allopatric 19. punctuated 20. polyploid 21. tetraploid 22. meiosis 23. isolated 24. species 25. sympatric

Exercise 7: There are many possible examples, such as the following: 1. As a large lake gradually dries up, fish or frogs could be isolated in smaller ponds or springs. 2. Wildflowers or beetles could evolve on isolated mountains surrounded by lowlands. 3. Insects could evolve in isolated caves. 4. Unique plants could evolve on rock outcrops that have different minerals from the surrounding soil.

Exercise 8: 1. H 2. I 3. E 4. F 5. A 6. B 7. D 8. C 9. G

Test Your Knowledge

Multiple Choice: 1. b 2. b 3. e 4. c 5. a 6. d 7. d 8. a 9. e 10. b

Essay: 1. It is not possible to see whether fossil species could have interbred. Isolated populations may not naturally have the opportunity to interbreed. The interbreeding criterion does not apply to asexual organisms.

2. A splinter population is cut off from the parent population by a geographical barrier such as a mountain range, a canyon, or a stretch of ocean. Changes in allele frequencies occur in the splinter population, caused by mutation, natural selection, and genetic drift. These changes are undiluted by gene flow from the parent population. Finally, the splinter population has diverged so much from the parent population that individuals from the two populations can no longer interbreed. The presence of prezygotic or postzygotic barriers tells us that they have become separate species.

3. Imagine two species of flowers: species A, with a diploid number of 10 ($2n = 10$), and species B, with a diploid number of 12 ($2n = 12$). Two things have to happen to produce a fertile hybrid—hybridization and then an error in cell division. Pollen from species A ($n = 5$) fertilizes an egg from species B ($n = 6$). This produces a zygote with 13 chromosomes. This zygote can develop into a hybrid plant, but the hybrid would be sterile because its chromosomes cannot pair during meiosis. However, an error during cell division could duplicate chromosomes, producing a bud or a plant with 26 chromosomes. Each chromosome would be able to pair in meiosis, producing gametes with 13 chromosomes. Self-fertilization among the gametes would produce a zygote with 26 chromosomes ($2n = 26$). This hybrid would be fertile, because all the chromosomes would be able to pair in meiosis.

4. A small, isolated population is more likely to undergo speciation, because it is more likely to be affected by natural selection and genetic drift in a local area and less affected by gene flow that would make it more like other populations.

5. According to the gradual model, isolated populations gradually evolve differences as they adapt to local environments. There is a smooth, gradual process of change from one species to the next, through an incremental accumulation of microevolutionary differences. The punctuated equilibrium model suggests that evolution occurs in spurts. New species rapidly diverge from the parent stock and then remain unchanged for long periods. The fossil record often suggests the sudden appearance, persistence, and sudden disappearance of species predicted by the punctuated equilibrium model, rather than the gradual transitions predicted by the gradual model (although not all changes show up in fossils).

Apply the Concepts

Multiple Choice: 1. a 2. b 3. e 4. d 5. a 6. e 7. b 8. c 9. b 10. c

Essay: 1. The west has much more rugged terrain than the east. There are many mountain ranges and canyons that would be formidable geographical barriers, isolating populations and promoting allopatric speciation.

2. A cell from a mule would contain 63 chromosomes, 32 from the horse gamete and 31 from the donkey gamete. A mule is sterile because, in meiosis, its chromosomes are unable to pair up and then separate to form haploid cells.

3. This is a gray area, because dogs and coyotes probably would not interbreed under natural conditions in the wild. If dogs and coyotes are different species, this shows us that they are closely related, having recently evolved from a common ancestral species.

4. Dry stretches of desert between streams constitute geographical barriers that isolate fish populations in desert streams, much as stretches of ocean separate land animals on islands. Isolated fish populations might undergo different mutations and genetic drift and be subjected to different kinds of natural selection. They might evolve into different species, like animals isolated on oceanic islands.

5. Flies in newer populations might be less picky because they have not been separated from other populations as long, so they still share some characteristics (courtship signals, and so on) and can be "fooled" by flies of other species. Perhaps females are pickier than males because females only mate once and males can mate repeatedly. Females who make mistakes are not as successful at reproducing, so there is strong selection in favor of reproductive barriers—females who can tell the difference between their own species and other species.

6. According to the punctuated equilibrium model, species evolve rapidly and then remain unchanged for long periods. If the banana-eating moths are native to Hawaii, and bananas have only been there for 1,000 years, this suggests that a new species of moth evolved there in 1,000 years or less. This is a short time by evolutionary standards and is a bit of evidence in favor of the punctuated equilibrium model.

7. This criticism is not valid. Formation of a new species by allopatric speciation might take thousands of years. We have not been able to study species for long enough to see the whole process happen, but there is a lot of circumstantial evidence—Darwin's finches, cichlids in Lake Victoria, and so on. More important, we have seen many species of plants appear virtually overnight, via sympatric speciation—hybridization and polyploidy.