Freeman, biological science, 4e, chapter 24

Science, Biology

Freeman, Biological Science, 4e, Chapter 24 24 - Evolution by Natural Selection Learning Objectives: Students should be able to ... - Define evolution, fitness, and adaptation using the biological definitions. - Describe the nature of the evidence regarding (1) whether species change through time and (2) whether they are related by common ancestry. - Assess whether Darwin's four postulates are true in any given example, explain to a friend why evolution must occur if all four are true, and explain whether evolution will occur if any of the four are not true. - Identify common misconceptions about evolution, and give examples to illustrate why they are not true. (For example: Is evolution progressive? Do animals do things " for the good of the species"? Does evolution result in perfection?) Lecture Outline - Evolution is one of the best-supported and most important theories in the history of science. - Evolution is one of the five attributes of life. - Evolution has both a pattern and a process. I. The Evolution of Evolutionary Thought A. Plato and typological thinking 1. Plato saw species as unchanging, perfect " types" created by God. 2. Plato thought individual variation was an unimportant deviation from the true " type." B. Aristotle and the great chain of being (scale of nature) 1. Aristotle, like Plato, thought species were unchanging types. 2. Aristotle thought species could be organized into a sequence or ladder of increasing complexity, with humans at the top. (Fig. 24. 1) C. Lamarck and the idea of evolution as change through time 1. Lamarck noticed that organisms changed over time. 2. Lamarck thought animals progressed over time from " lower" to " higher" forms (like Aristotle's ladder) via inheritance of acquired characteristics. D. Darwin and Wallace and evolution by natural selection 1. Species change over time, but they do not " progress." 2. A species does not have a single true " type." 3. Individual variation is important; variation is what drives evolution. 4. This theory made predictions and was testable; that is, it was scientific. II. The Pattern of Evolution: Have Species Changed through Time? A. Two predictions of Darwin's theory: 1. Species change through time. Freeman, Biological Science, 4e, Chapter 24 2. Species are related by common ancestry. B. Evidence of change through time 1. The fossil record and geologic time a. A fossil is any trace of an organism that lived in the past. (Fig. 24. 2) b. The fossil record was initially organized based on the relative age of the fossils. c. The geologic time scale (1) Sedimentary rocks form layers over long times. These layers form in a chronological sequence (the geologic time scale). (2) From the number of layers and the time it takes to deposit each one, geologists realized that the Earth must be very old. d. Radiometric dating enables us to date rocks directly. (1) The Earth is 4. 6 billion years old. (2) The earliest signs of life are in rocks that are 3. 4âˆ’3. 8 billion years old. 2. Extinction changes the species present over time. a. The fossil record shows that more than 99% of all the species that have ever lived are now extinct. (Fig. 24. 3) b. This is evidence that the species composition on Earth has changed over time. 3. Transitional features link older and younger species. a. Law of succession: Fossils found in a certain geographic region frequently resemble the species currently living in that region. (1) This is evidence that the extinct species are related to existing species. b. Fossils with transitional features (traits intermediate between those of older and younger species) are compelling evidence that species change over time. Example: the fins-to-feet transition.

(Fig. 24. 4) 4. Vestigial traits are evidence of change through time. a. Vestigial traits are traits that have reduced or no function but are clearly related to functioning organs in related species. (Fig. 24. 5) b. The existence of these traits challenges the theory of special creation that organisms were designed by a perfect creator and are static. c. Biologists interpret the existence of these traits as evidence that organisms change over time. 5. Current examples of change through time a. Biologists have documented hundreds of contemporary populations that are changing in response to their environment. © 2011 Pearson Education, Inc. Freeman, Biological Science, 4e, Chapter 24 C. Evidence of descent from a common ancestor 1. Similar species are found in the same geographic area. a. Similar, but distinct, species are often found living close together in the same geographic area, implying that they are linked by a common ancestor. Example: GalÃ¡pagos mockingbirds. (Fig. 24. 6a) b. These similar species are part of a phylogeny (a family tree), and their relationships can be diagrammed on a phylogenetic tree (a branching diagram that indicates genealogy). (Fig. 24. 6b) 2. Homology: the occurrence of similar features in different species because they both inherited the trait from a common ancestor. a. Different kinds of homology: (1) Genetic homology–similarities in DNA sequences (Fig. 24. 7) (2) Developmental homology–similarities in the morphology of embryos and the fate of embryonic tissues (Fig. 24. 8) (3) Structural homology–similarities in the structure of body parts (Fig. 24. 9) b. The three levels of homology interact: Genetic homologies cause developmental homologies, which cause structural homologies. c. Hypotheses about homology can be tested experimentally. (Fig. 24. 10) d. Homology is used extensively in contemporary biology. Examples: use of model organisms, comparative genomics. 3. Current examples of descent from a common ancestor a. Biologists have documented dozens of examples of populations that are undergoing speciation. D. Evolution's " internal consistency" âŽ¯the importance of independent datasets 1. When data from independent sources support a theory, that is powerful evidence that the theory is correct. (Table 24. 1) a. Example: evolution of cetaceans from a terrestrial ancestor. (DNA, morphology, fossil record, and other evidence all agree.) (Fig. 24. 11) 2. The theory of evolution by natural selection is much more consistent with the data than is the pattern predicted by special creation. III. The Process of Evolution: How Does Natural Selection Work? A. Darwin's four postulates, the outcome of which is evolution: 1. Individuals vary. 2. Some variations are heritable. 3. More offspring are produced than can survive. 4. Individuals with traits that confer an advantage are more likely to survive and reproduce. 5. Summary: Evolution by natural selection occurs whenever heritable variation leads to differential success in survival and reproduction. B. The biological definitions of fitness and adaptation 1. Fitness is the ability of an individual to survive and reproduce, relative to other individuals in that population. 2. Adaptation is a heritable trait that increases the fitness of an individual in a particular environment, relative to other individuals lacking the trait. IV. Evolution in Action: Recent Research on Natural Selection A. Case Study 1: How did Mycobacterium tuberculosis become resistant to antibiotics? 1. A patient history a. A patient with active tuberculosis (TB) was given the antibiotic rifampin for 40 weeks and then released when lung cultures showed no bacteria. b. Two months later, the patient had a relapse and died of rifampin-resistant TB. 2. A mutation in a bacterial gene confers resistance. (Fig. 24. 12) a. DNA analysis showed that the patient's TB bacteria had acquired one new mutation in the gene for RNA polymerase, the same enzyme that is the target of rifampin. b. These bacteria were likely present at low frequency before the rifampin treatment. c. When the rifampin treatment began, bacteria without the mutation were killed off, and only the bacteria with the mutation survived. (Fig. 24. 14) d. Students should be able to explain why the patient relapsed, and whether a family member who got TB from the patient after the relapse would respond to antibiotics. 3. Testing Darwin's postulates a. Did variation exist in the population? Yes, research shows that populations of TB bacteria do have variation for rifampin resistance. b. Was the variation heritable? Yes, variation in rifampin resistance (the phenotype) is due directly to genotype. c. Was there variation in reproductive success? Yes, once rifampin treatment began, only a few bacteria survived to reproduce. d. Did selection occur? Yes, certain bacteria (those with the drugresistant allele) were much more likely to survive and reproduce. 4. Resistance is a widespread problem. a. Resistance (to drugs, insecticides, etc.) has evolved repeatedly in many species and is a growing public health problem. (Fig. 24. 14) Freeman, Biological Science, 4e, Chapter 24 B. Case Study 2: Why are beak size, beak shape, and body size changing in GalÃ¡pagos finches? 1. The medium ground finch population of the island Daphne Major varies in beak shape and body size, and these traits are heritable. (Fig. 24. 15) 2. Selection during drought conditions a. Drought survivors had deeper beaks. (Fig. 24.

16) b. Deeper beaks allowed those individuals to eat the only remaining seeds, which were tough and difficult to crack. c. In the next generation, the average beak size was considerably larger than it had been before the drought. d. Summary: In only one generation, natural selection had led to a measurable change in the characteristics of the population. 3. Continued evolution a. In a subsequent rainy year, selection favored individuals with small, pointy beaks. b. Over 30 years of study, researchers have documented continued evolution in response to environmental events. (Fig. 24. 17) 4. Which genes are under selection? a. Recent research has identified several genes that affect beak length in development, such as Bmp4. (Fig. 24. 18) V. Common Misconceptions about Natural Selection and Adaptation A. Selection acts on individuals, but evolutionary change occurs in populations. 1. During the evolutionary process, individuals do not change, only the population changes. Examples: GalÃ¡pagos finches, TB bacteria. 2. Acclimation is not adaptation. Individuals may change during their lifetime (acclimation), but these changes are not passed on to offspring. a. Students should be able to explain the difference between the biological definition of adaptation and its use in everyday English, and the difference between acclimation and adaptation. B. Evolution is not goal directed. 1. Mutations occur randomly; they do not occur because organisms " want" or " need" them. 2. Evolution is not " progressive." a. Evolution does not always result in “ better" or " more advanced" organisms. b. Complex traits are often lost in evolution. 3. There is no such thing as a " higher" or " lower" organism. a. Evolution is not a " ladder"; it is more like a tree. (Fig. 24. 19) b. Evolution simply results in organisms adapted to live in different environments; no

organism is “ higher" than another. © 2011 Pearson Education, Inc. Freeman, Biological Science, 4e, Chapter 24 C. Organisms do not act for the good of the species. (Fig. 24. 20) 1. Individuals with alleles for self-sacrificing behavior die, while individuals with alleles for selfish behavior survive. 2. No instance of purely self-sacrificing behavior has ever been recorded in nature. D. Limitations of natural selection 1. Not all traits are adaptive; evolution does not lead to perfect organisms. Examples: vestigial organs, silent mutations. 2. Genetic constraints: a. Sometimes nonoptimal traits are propagated because they are genetically linked with an optimal trait (genetic correlation). b. One example is finch beaks. The best beak would have been a narrow deep beak, but what evolved was a wide deep beak, because beak depth and beak width are genetically linked. c. Lack of genetic variation can also limit evolution. 3. Fitness trade-offs: Natural selection often results in a compromise between traits with different effects. 4. Historical constraints: Natural selection can act only on traits that existed in the ancestral population. Chapter Vocabulary To emphasize the functional meanings of these terms, the list is organized by topic rather than by first occurrence in the chapter. It includes terms that may have been introduced in earlier chapters but are important to the current chapter as well. It also includes terms other than those highlighted in bold type in the chapter text. evolution special creation great chain of being inheritance of acquired characters typological thinking population thinking population descent with modification fossil fossil record sedimentary rocks geologic time scale relative dating absolute dating radiometric dating extant extinct transitional features law of succession vestigial traits phylogeny phylogenetic tree homology genetic homologies developmental homologies morphology structural homologies vertebrates cetaceans internal consistency natural selection heritable traits heritable variation allele frequencies biological fitness adaptation tuberculosis antibiotic resistance natural experiment acclimation selfish allele genetic constraint genetic correlation fitness trade-off historical constraint