CHAPTER 3

GENETIC AND EVOLUTIONARY FOUNDATIONS OF BEHAVIOR

QUICK GUIDE TO INSTRUCTOR’S RESOURCES

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CHAPTER OBJECTIVES

After completing Chapter 3, students should be able to:

1. Describe the indirect way in which genes affect behavior, and explain how the effects of environment and genes are intertwined.
2. Explain how meiosis and patterns of genetic dominance and recessiveness contribute to behavioral diversity, and why this diversity is an advantage.
3. Explain what is meant by Mendelian inheritance patterns.
4. Describe the conclusions of Scott and Fuller regarding the genetic basis of fearfulness in dogs, and explain what their research illustrates about the inheritance of behavioral traits.
5. Distinguish between recessive and dominant disorders, and use specific language impairment to illustrate the difference.
6. Explain what is meant by polygenic characteristics, and describe the effects of selective breeding on such characteristics, using Tryon’s study of maze-learning ability in rats as an example.
7. Describe the process of natural selection, particularly in relation to the modern understanding of evolution, and explain how environmental change affects evolution.
8. Explain why evolution lacks foresight, and describe three common misbeliefs that arise when people think of evolution as working toward some planned end.
9. Explain what is meant by functionalism in psychology, and explain how the functionalist approach applies at the evolutionary level.
10. Distinguish between ultimate and proximate explanations of behavior, and describe two ways in which behavioral characteristics may arise that do not involve natural selection.
11. Describe species-typical behavior, and explain how it is determined by biological preparedness, using humans’ ability to walk or talk as an example.
12. Distinguish between homology and analogy in behavior and anatomy, explain the logic underlying comparisons of present-day species to infer an evolutionary pathway, and illustrate this by describing studies on hive building by bees or smiling by primates.

13. Describe the sociobiological account of the relationship between patterns of mating and parental investment.

14. Discuss the sociobiological explanations for the adaptive value of aggression.

15. Discuss two theories that attempt to explain the evolution of apparently altruistic behaviors.

16. Describe two pitfalls to avoid when offering sociobiological explanations for human social behavior.

TEACHING SUGGESTIONS FROM PETER GRAY

The underlying mechanisms of all human physiological processes and characteristics came about in the course of evolution because they promoted survival and reproduction in our ancestors.

An understanding of evolution by natural selection provides, among other things, the foundations for a functionalist perspective in psychology. The underlying mechanisms of all human psychological processes and characteristics—of learning, motivation, emotion, sensation, perception, memory, thought, social interaction, and personality traits—came about in the course of evolution because they promoted survival and reproduction in our ancestors. That is a profound statement, which has profound consequences for theories in psychology. Any psychological theory that cannot account for the evolutionary adaptiveness of a characteristic deemed to be universal in humans is either incomplete or incorrect. For example, an understanding of evolution informs us that Freud's theory of aggression, in which aggression is a component of a “death instinct,” cannot be correct unless by death instinct he meant something very different from what the words imply.

This is the foundation chapter of the book. It establishes the evolutionary theme that runs throughout the book and that brings unity to the otherwise enormously diverse subject matter of psychology. If you wish to reduce the length of this chapter, you might omit the last two major sections—on mating and on helping and hurting. In that case you could use some of the ideas from these sections as lecture elaborations to accompany Chapters 12, 13, and 14 (on social development and social psychology) later in the course.

The first two major sections of the chapter, on genetic mechanisms and inheritance of behavioral traits, are designed to give students a concrete understanding of heredity and how genes influence behavior. I would recommend here a focus not on the molecular details of gene action, but on the general processes by which genetic differences can alter the brain and other organs and thereby alter behavior. If students understand that behavior is a product of bodily structures, then it should be no surprise to them that genetic differences, which alter bodily structures, lead to behavioral differences.

Beyond a basic understanding of gene action and evolution, the most useful concepts in this chapter have to do with cross-species comparison by homology and analogy. To illustrate the value of each of these concepts, and to help drive home the difference between the two, you might devote a separate lecture to each kind of comparison. A potential thesis pertaining to homology is, “Comparison by homology is a valuable tool for learning about the evolutionary origins and proximate mechanisms of species-typical behavior patterns in humans and other species.” I typically focus this lecture on homologies in nonverbal emotional expressions in humans and other primates. A potential thesis pertaining to analogy is, “Comparison by analogy is a valuable tool for learning about the ultimate causes (evolutionary functions) of inborn behavioral biases in humans and other species.” For this lecture I usually focus on aggression, showing how the patterns of aggression in a species can be predicted reasonably well from knowledge of the mating and feeding
patterns of the species. The lecture also includes a subtyping of aggression into somewhat overlapping categories that are defined in terms of their evolutionary functions: mating (or jealous) aggression, maternal aggression, territorial aggression, pain-elicited aggression, and aggression for status.

CLASS ACTIVITIES/DEMONSTRATIONS

Recreating Darwin’s Finches

This hands-on activity helps students understand the concept of adaptation. You can easily recreate Darwin's observation of finches for foods. Give your students a variety of foods that birds would eat (for example, rice, oats, seeds, gummy worms) and kitchen utensils that represent beaks, to attempt to pick up the food. (Recommendations: tweezers, tongs, dropper, chopsticks).

Explain to students that the utensils represent the different types of beaks that birds may have and it is their job to discover what would be the appropriate beak to eat each of the foods. You can also ask students to answer questions such as: What would happen if a bird with a large beak (tongs) lived in an area in which the only food source was oats? Would this bird survive and reproduce?

Sexual Selection and Jelly Belly Jelly Beans

In this activity, students learn about sexual selection through the selection of jelly beans (available at www.jellybelly.com or most supermarkets and pharmacies). In order to do this experiment, you will need to have a couple different “attractive flavors” of jelly beans (such as cotton candy, orange sherbet, juicy pear, and very cherry) and a couple of different “unattractive flavors” of jelly beans (such as booger, barf, pencil shavings, and skunk spray).

Put all of the jelly beans in a bowl (one of each color per student), and have a description of which color is which flavor (it helps to have all the flavors be different colors for simplicity. Have each student come up and choose a jelly bean as a “mate.” Tell students they should choose the flavor they would want to eat because it is attractive, not because they want to try a disgusting flavor. When the student chooses the color, drop in two new jelly beans of that color into the bowl. These new jelly beans represent the “offspring.” At the end of the session, most of the bowl will be filled with “attractive” jelly beans and fewer “unattractive” jelly beans. If for some reason you have a large population of students that enjoy an “unattractive” flavor, you can then discuss how the selection is based on what the species finds attractive; or discuss how culture might affect the selection of mates.

Genetics and the Ability to Taste PTC Materials

Singer (1987) describes an activity, which can be used in conjunction with Gray’s discussion of single-gene traits, and that involves testing students for their ability to taste the compound phenylthiocarbamide (PTC). To some people, PTC has a bitter taste, but to others it is tasteless. The ability to taste PTC is apparently inherited, involving one allele pair (T and t). Nontasters have the genotype tt, while tasters have either the TT or Tt genotype (Bartoshuk, 1991). This is a memorable and effective demonstration because students are surprised that a substance that tastes so very bitter to some people is tasteless to others. The demonstration also reinforces the idea that genes affect behavior only indirectly. In this case, genetic differences among people result in differences in their sensory systems, which in turn leads to differences in how they behave toward certain foods.

Give one PTC strip to each student. Ask students to chew the strip or place it on the tongue, to see if it has any taste. Most students will report a bitter taste, but a few will taste nothing and perhaps wonder if they have received a defective strip of paper. You may
want to let students select and taste a second PTC strip so they can satisfy themselves that they have not been tricked. Although Singer’s procedure mainly demonstrates individual differences in taste, you can easily build on it to make some important points about behavioral genetics. Explain that the ability to taste PTC is determined by one pair of alleles, $T$ and $t$, with the ability to taste PTC being dominant.

For a discussion ask students the following questions:

1. If both parents can taste PTC, is it possible for them to have children who are nontasters? (Answer: Yes, but both parents must carry the recessive allele ($t$), so a child may inherit the $tt$ genotype)
2. If both parents are nontasters, is it possible for them to have children who can taste PTC? (Answer: No, because only people with the $tt$ genotype are nontasters, so their children can only inherit a recessive allele from each parent.)
3. If you can taste PTC, does that mean both of your parents can taste PTC? (Answer: No. In order to inherit a dominant allele ($T$), at least one parent must be a taster of PTC, but one of your parents may be a nontaster.)


ASSIGNMENTS

Explaining the Principles of Genetics

An effective way to ensure that students understand the fundamentals of genetics is to have them explain these ideas in their own words, in reference to situations with which they are familiar. A writing assignment could be made up of one or several of the following items.

1. Write a brief article for a college science magazine that distinguishes between DNA, chromosomes, genes, alleles, phenotype, and genotype. Be sure to include examples to make the differences clear.
2. Suppose an editorial in the newspaper argues that sex causes so many problems for people that asexual reproduction, or cloning, would be much better. Write a letter to the editor that explains how sexual reproduction creates genetic diversity, and how this diversity is an advantage in a changing environment.
3. Write a letter, compose an e-mail, or draw a family tree for your parents explaining what percentage of your genetic information you share with each of them, your grandparents, and your siblings.

What Will Humans Be Like in the Year 10,000?

Students enjoy trying to predict the future, and you can ask them to do this using their knowledge of evolution. Specifically, ask them to describe what they think humans might be like in the year 10,000. One way for them to begin is by considering what traits characterize humans now, and if they expect these to change. Emphasize that each predicted change must be accompanied by an evolutionary explanation. Remind them that evolution has no foresight; so a behavior is not naturally selected to serve some future purpose, but because it is adaptive in the environment in which it occurs. In assigning this essay, emphasize that evolutionary adaptation is measured in terms of the number of viable offspring produced.
One example of a current environmental change that could exert selection pressure on human traits is the thinning of the ozone layer over the South Pole, which allows a greater intensity of ultraviolet light to reach the surface of the Earth over a relatively greater proportion of the year. If this solar radiation in the ultraviolet wavelength is injurious to human reproductive health in the future, there could well be increased adaptive pressures exerted on skin coloration, for example, that serve to protect cells from the deleterious effects of the sun. Another potential example could address natural selection of non-obesigenic genes if the current unhealthy and immoderate self-selection of comfort foods in Western societies results in less viable or less numerous production of offspring.

**Biological Preparedness of Humans for Certain Behaviors**

Gray describes how ethologists have studied fixed action patterns elicited by sign stimuli, and how these studies eventually led to the understanding that many animals are biologically prepared to learn certain behaviors (pp. 72–74). Having students work with these ideas makes a good writing exercise. Specifically, give students a short list of behaviors and ask, “In what ways are humans biologically prepared for these behaviors?” The list might include the use of language, tool use, child care, or complex problem-solving ability.

Gray’s discussion of upright walking and use of language (pp. 73–74) can serve as an example of the type of analysis you are looking for. Be sure your students understand that you are not asking, “Is this behavior species-typical?” but that you want them to consider the ways in which humans are biologically predisposed to learn and exhibit these behaviors.

**MEDIA RESOURCES**

"Return to the Wild" (#4), *Introductory Psychology: Scientific American Frontiers, disc 1* (9 minutes, 46 seconds)  
This video details a program to breed golden lion tamarins in captivity to be released to the wild. These monkeys are native to Brazil, but virtually all of those living in Brazil today were either bred in captivity or born of parents bred in captivity. The importance of learning species-specific skills is presented—the tamarins have poor locomotion skills and mapping skills if they are raised in small cages. The improved ethics of modern zoos is attributed to the fact that they are now viewed as a way to educate the public of the importance of other animals, the redesign of zoos taking into account humane treatment, and a place to breed animals that are endangered.

- What are the behaviors that scientists presumed were species-specific among golden lion tamarins?  
- How does captivity alter what we would consider to be naturally occurring behaviors?

"Remembering What Matters" (#16), *Introductory Psychology: Scientific American Frontiers, disc 2* (8 minutes, 35 seconds)  
This video is detailed in the instructor’s manual notes for Chapter 9. However, it would also work as an introduction for finding evidence for an evolutionary hypothesis. Namely, adrenaline is presented as not only functional for activating the sympathetic nervous system, but also to increase one’s memory to avoid the situation in the future.

- What do the researchers propose is the adaptive function of adrenaline for memory?  
- Would you expect adrenaline to serve this function only in humans, or other animals too? Why?
“Bypass Genes” (#23), Introductory Psychology: Scientific American Frontiers, disc 3 (8 minutes, 14 seconds)

A gene therapy is detailed in its early stages. A woman begins to have difficulty walking because of a blocked artery that supplies blood to her calf muscle. She is not a candidate for standard bypass surgery so opts instead for a gene therapy that will essentially allow her body to build her own bypass of the artery. The results are promising, and indicate possible treatment for coronary artery disease as well. The nucleotides and DNA double helix are quickly presented in picture form without explanation.

What is the process of DNA replication at work for this treatment?

ONLINE DISCUSSION QUESTIONS

Adapted to Environments

You learned that scientists now consider the ways in which humans are behaviorally adapted to their ancestral environment. Think of your favorite wild animal or insect, and explain one way that it is more adapted to its environment than a human would be. If you don’t know enough about another species’ behavior, check out Animal Planet, National Geographic, or other television, Web, or print resources. Then provide an example of a behavior humans have that you think might be an adaptation (therefore something we’ve had for thousands of years, that provides a reproductive advantage).

Unique Human Attributes

Come up with an attribute (behavior, cognitive ability, etc.) that you think no species except humans possess. Given what you’ve learned, come up with an evolutionary explanation of that attribute.

Benefits of Information from Genetic Testing Materials

The increasing availability of genetic tests for specific diseases and behavioral traits raises an important question: Is the knowledge gained from genetic testing always of benefit to the tested individual? How do circumstances—regarding the particular trait or the individual—affect the decision about whether to perform a genetic test?

An example is testing for Huntington’s disease, a debilitating disorder in which brain cells gradually decline in size and number, causing progressive loss of cognitive processing, personality, and muscle control, with death 10–20 years after onset. Symptoms do not appear until the affected individual is 35–45 years old. Huntington’s disease is a single-gene disorder caused by a dominant allele; any individual with the Huntington’s allele will eventually develop symptoms of the disease. Because the allele is dominant, there is at least a 50 percent chance that a child of an affected individual will inherit the disease (the chance is 100 percent if the parent is homozygous for the Huntington’s allele). In part because it is a single-gene disorder, a predictive test for Huntington’s is possible—a test that reveals whether an individual has the Huntington’s allele. If the test is positive, that individual will eventually develop symptoms, but there is no way to determine when the disease will start or how it will progress.

Is the knowledge that one carries the Huntington’s allele—and thus will develop the disease—of benefit to an individual? One reason this knowledge might not be of benefit is the possibility of adverse psychological consequences—depression, possibly suicide. One benefit might be that, given the 50 percent chance of passing the disease to offspring, knowing one’s status would allow an informed decision about whether to have children—recall that the symptoms of the disease do not appear until well into adulthood, when many people have already had children.