

# 1 What Is Behavioral Neuroscience?

## Chapter Outline

### The Origins of Behavioral Neuroscience

*Prescientific Psychology and the Mind-Brain Problem*

*Descartes and the Physical Model of Behavior*

*Helmholtz and the Electrical Brain*

*The Localization Issue*

#### CONCEPT CHECK

#### Nature and Nurture

*The Genetic Code*

#### APPLICATION: THE PROMISE OF DNA COMPUTING

*The Human Genome Project*

#### RESEARCH SPOTLIGHT: BEYOND THE HUMAN GENOME PROJECT

*Heredity: Destiny or Predisposition?*

#### CONCEPT CHECK

#### In Perspective

#### Summary

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## Learning Objectives

After reading this chapter, you will be able to

1. Define the mind-brain problem in behavioral neuroscience
2. Describe the contributions of philosophers and scientists to the development of behavioral neuroscience as a field of study
3. Identify the role of physiologists in the establishment of modern-day behavioral neuroscience
4. Compare the relative contributions of genes and environment in the development of behavioral characteristics
5. Critique the fixed nature of heredity in shaping behavior

## The Origins of Behavioral Neuroscience

### Summary and Guided Review

After studying this section in the text, fill in the blanks of the following summary.

\_\_\_\_\_ (1) is the multidisciplinary study of the nervous system and its role in behavior. During the 1990s, also known as the Decade of the \_\_\_\_\_ (2), intensive research into the role of biology in behavioral problems led to new treatments for depression, addiction, and age-related memory impairment. Advances were also made in the area of genetics, including a greater understanding of the genes involved in diseases such as \_\_\_\_\_ (3) and a(n) \_\_\_\_\_ (4) of all human genes.

\_\_\_\_\_ (5) neuroscience is the branch of psychology that studies the relationships between behavior and the body, and it attempts to answer questions about the biological basis of diverse phenomena such as mental illness, emotions, perception, cognition, and consciousness. Psychology emerged as a separate discipline in 1879 when \_\_\_\_\_ (6) established the first psychology laboratory, and behavioral neuroscience arose as a distinct subfield of psychology some time after this.

Behavioral neuroscience addresses the \_\_\_\_\_ (7) problem, which concerns the nature of the relationship between the physical brain and the mind. Most modern neuroscientists believe that the \_\_\_\_\_ (8) is not a real thing but rather is a concept we use to explain our awareness of experience. This position is known as materialistic \_\_\_\_\_ (9) and assumes that everything is physical. The position that the mind is nonmaterial and separate from the physical brain is called \_\_\_\_\_ (10). This issue of lack of consensus on the mind-brain problem is not a new one: Among the ancient Greek philosophers, Democritus and \_\_\_\_\_ (11) were monists, whereas \_\_\_\_\_ (12) was a dualist.

Scientists often use \_\_\_\_\_ (13) to help them explain how things work. The hydraulic model of behavior was developed by the 17th-century French philosopher \_\_\_\_\_ (14) to explain the physical basis of behavior. According to this model, when the mind willed the body to action, the \_\_\_\_\_ (15) gland pumped animal spirits through the nerves (believed to be hollow tubes) to the muscles, resulting in movement. The pineal gland, therefore, was considered the seat of the \_\_\_\_\_ (16). This model was ultimately shown to be wrong based on the approach of \_\_\_\_\_ (17), which involves use of the methods of observation and experimentation.

Important principles of nervous system anatomy and physiology were discovered during the 1700s and 1800s. Work by several physiologists showed that nerves operated via \_\_\_\_\_ (18), not "animal spirits." However, the German physiologist \_\_\_\_\_ (19) performed experiments that indicated that nerve conduction was not as fast as electricity conducted through wires, which suggested that something more than just electricity was operating in the nervous system.

In the 1800s, well-documented cases of brain injury suggested that specific parts of the brain have specific functions, a concept known as \_\_\_\_\_ (20). For example, railroad worker \_\_\_\_\_ (21) underwent extreme changes in personality following an accident in which an iron rod was driven through his skull and \_\_\_\_\_ (22) lobes. Another case was reported by the French physician \_\_\_\_\_ (23); his patient was unable to speak, and

after the patient died, it was discovered that he had damage in the \_\_\_\_\_ (24) hemisphere of his brain. Gall took the localization concept to an extreme in his theory of \_\_\_\_\_ (25), which stated that several emotional and intellectual faculties were located in specific areas of the brain based on bumps on the skull. On the other extreme, Lashley's theory of \_\_\_\_\_ (26) argued that brain functions are evenly distributed across the brain. Currently, brain researchers know that brain functions are both localized and \_\_\_\_\_ (27), which means that several brain areas interact to produce specific experiences such as learning or emotion.

While not common, evidence that the mind-brain problem is still debated comes from researchers who are interested in \_\_\_\_\_ (28), which they believe cannot be explained by materialism. These scientists study nonmaterial neuroscience and point to studies in which \_\_\_\_\_ (29) altered brain function in patients as evidence for their position. Material neuroscientists interpret these findings as the \_\_\_\_\_ (30) changing the brain.

### Short Answer and Essay Questions

Answer the following questions.

1. Give two examples of the types of research questions that behavioral neuroscientists might ask. For each, explain how someone from a neuroscience background might approach each research question differently than someone from a behavioral psychology background.
2. Regarding the mind-brain question, compare monism and dualism. What are (or were) the problems with each position? How do most modern neuroscientists explain the relationship between the brain and mind?
3. Why was the case of Phineas Gage important for brain science? What did it reveal about the localization of function issue?
4. Compare the theories of localization and equipotentiality. What is the current position of brain researchers on this issue?

## Nature and Nurture

### Summary and Guided Review

After studying this section in the text, fill in the blanks of the following summary.

The question of \_\_\_\_\_ (31) versus \_\_\_\_\_ (32) asks how important genes and environment, respectively, are in influencing behavior. Evidence is accumulating that many behaviors have a genetic or \_\_\_\_\_ (33) component. \_\_\_\_\_ (34), which direct cellular processes and transmit inherited characteristics, are located mostly on \_\_\_\_\_ (35), which are paired in all cells, with the exception of some in the sex cells. The sex of an individual is determined by the sex chromosomes: Females have \_\_\_\_\_ (36) X chromosome(s), and males have \_\_\_\_\_ (37) X chromosome(s) and one Y chromosome. Most body cells have \_\_\_\_\_ (38) chromosomes,

but \_\_\_\_\_ (39) and egg cells have 23. When conception occurs, the fertilized egg, or \_\_\_\_\_ (40), contains half of each parent's genetic material. For the first eight weeks following conception, the developing baby is considered a(n) \_\_\_\_\_ (41), and then it is called a(n) \_\_\_\_\_ (42) until it is born.

Genes are composed of a double strand of molecules known as \_\_\_\_\_ (43), or deoxyribonucleic acid. The strands are connected by pairs of nucleotides (adenine, \_\_\_\_\_ (44), guanine, and \_\_\_\_\_ (45) that carry instructions for producing \_\_\_\_\_ (46), which are used in the construction of the body or act as \_\_\_\_\_ (47). Researchers are building computers out of \_\_\_\_\_ (48) due to its small size and computing speed. Chemists at North Carolina State University are using DNA to detect genes for \_\_\_\_\_ cells (49).

Different versions of a gene are called \_\_\_\_\_ (50). In some cases the effects of the two alleles blend to produce a combined result; one example of this would be type \_\_\_\_\_ (51) blood. A(n) \_\_\_\_\_ (52) allele will produce its effects regardless of which allele it is paired with. In order for a(n) \_\_\_\_\_ (53) trait to be expressed, there must be a copy of the same allele on each chromosome. Individuals who possess two copies of a dominant allele are \_\_\_\_\_ (54) for that gene, and will have the same \_\_\_\_\_ (55), or appearance, as those who possess one dominant and one recessive allele, who are \_\_\_\_\_ (56). An X-linked trait is produced by a gene on the X chromosome that is not paired with one on the Y chromosome. If a recessive gene is located on the X chromosome, the trait it influences is more likely to be seen in \_\_\_\_\_ (57); red-green color blindness is an example of a(n) \_\_\_\_\_ (58) trait. Traits such as height and intelligence are \_\_\_\_\_ (59), meaning they are influenced by more than one gene.

For some time, psychologists focused on \_\_\_\_\_ (60) as the main source of behavior, rather than genes. This emphasis on the role of the environment began changing in the 1960s, and a more balanced view was adopted. Psychologists now believe that genes influence many human behavioral traits, and \_\_\_\_\_ (61) is the behavioral trait whose genetic origins have received the most research attention. However, it is important to remember that genes control only the production of proteins, so they influence behavior indirectly through physiological systems.

Locating genes that influence traits is difficult and time-consuming. However, in 2000, several genetics laboratories published a rough draft of the human \_\_\_\_\_ (62), which will be useful in locating specific genes. This effort, known as the International Human Genome Project, has revealed that humans have only \_\_\_\_\_ (63) individual genes that encode proteins, and that 97% of the genome is made up of "\_\_\_\_\_ (64) DNA, which are sections of chromosomes whose function is uncertain, though 80% of them control \_\_\_\_\_ (65). Although the map does not tell scientists what each gene does, it will allow them to more easily locate specific genes that contribute to specific traits. For example, although researchers in the 1980s knew that the gene for Huntington's disease was located on chromosome 4 near two \_\_\_\_\_ (66) genes, it took them 10 more years to locate the specific gene. Scientists now predict that they can locate important genes much more quickly because of the map. Such knowledge is expected to lead to genetic-based treatment of many more disorders.

The \_\_\_\_\_ (67) (ENCODE) Project began after completion of the Human Genome Project and is focused on determining the function of the human genome.

Scientists at 32 different international institutions are now working to identify the short sequences of DNA, or \_\_\_\_\_ (68), that are responsible for protein creation and are likely areas where mutations result in conditions such as blindness and movement disorders.

The notion that offspring are like clones of their parents is incorrect. Children inherit \_\_\_\_\_ (69) of each parent's DNA, and because of the 60–70 trillion possible \_\_\_\_\_ (70) of genes resulting from sexual reproduction, no two individuals are genetically exactly alike (unless they are identical twins). This variability of traits is the cornerstone of Darwin's theory of \_\_\_\_\_ (71), which states that organisms possessing traits that are most conducive to survival are more likely to pass their genes on to offspring. In addition, the effects of genes are not \_\_\_\_\_ (72). They are not all active at the same time, and they may produce more proteins at some times than at others. They may also become active during certain \_\_\_\_\_ (73), such as when an organism is learning. Clearly genes are not the sole dictators of behavior. Instead, they give us predispositions for certain characteristics.

Comparisons between identical and \_\_\_\_\_ (74) twins allow researchers to estimate the percentage of variation in characteristics due to heredity, or \_\_\_\_\_ (75). It appears that heritability for intelligence is about \_\_\_\_\_% (76). Personality characteristics show a heritability of \_\_\_\_\_% – \_\_\_\_\_% (77). If half of the variation in behaviors is due to genetics, then the other half must be due to \_\_\_\_\_ (78). However, it is important to understand that the more similarity there is between people's environments, the \_\_\_\_\_ (79) the degree of heritability.

Scientists now argue that genes contribute to our predisposition or \_\_\_\_\_ (80) for certain traits. The genes we inherit may result in a predisposition for a disorder such as schizophrenia, but the disorder will emerge only under certain environmental conditions. Clearly both factors are important.

### Short Answer and Essay Questions

Answer the following questions.

5. What is the immediate function of genes? Explain how genes can indirectly influence behavior. Describe the ways in which the actions of genes can be variable.
6. What is the rationale for comparing identical and fraternal twins in order to measure the heritability of traits?
7. Angelina Jolie tested positive for a defective gene (*BRCA1*) that triggers breast cancer in 87% of women with that particular defect. As a result, she removed all of her natural breast tissue through a procedure called a double mastectomy despite not having any symptoms of cancer. Do you agree with her decision? Using information gleaned in this section, explain both points of view.
8. Janet and Charles are expecting their first baby. They are both highly intelligent, and they assume that their child will inherit their intelligence through the genes it shares with them. They feel that the environment has little or no impact on intelligence. After having read the section "Heredity: Destiny or Predisposition?" what would you tell this couple about the scientific evidence for their claim? (Be sure to address the concept of *predisposition* in your answer.)

## Post-test

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Use these multiple-choice questions to check your understanding of the chapter.

1. Which of the following did NOT occur during the Decade of the Brain (1990s)?
  - a. Genes contributing to the development of schizophrenia were identified.
  - b. It was discovered that neurons conduct electricity.
  - c. Drugs that block addiction were discovered.
  - d. New treatments for depression were developed.
2. Who among the following is credited with establishing the first psychology laboratory in Germany in 1879?
  - a. Wilhelm Wundt
  - b. Hermann von Helmholtz
  - c. Gustav Fritsch
  - d. Franz Gall
3. Dr. Locke is a philosopher who believes that there is no distinction between the physical brain and the mind. This position is known as
  - a. materialistic monism.
  - b. idealistic monism.
  - c. dualism.
  - d. materialistic dualism.
4. \_\_\_\_\_ was a dualist.
  - a. Aristotle
  - b. Plato
  - c. Democritus
  - d. Descartes
5. According to the hydraulic model of the nervous system,
  - a. nerves were like electrical wires that conducted electricity.
  - b. nerves were hollow tubes that allowed animal spirits to flow through them.
  - c. nerves were not responsible for behavior.
  - d. none of the above
6. Descartes believed that the "seat of the soul" was located in
  - a. the frontal lobes of the brain.
  - b. animal spirits.
  - c. the pineal gland.
  - d. the left hemisphere.
7. Through their experiments, Fritsch and Hitzig showed that
  - a. the muscle in a frog's leg can be made to move by stimulating the nerve connected to it.
  - b. the rate of nerve conduction is about 90 feet per second.
  - c. the left hemisphere controls speech.
  - d. muscle movement is the result of brain stimulation.
8. Who discovered that nerves conduct electricity at a rate significantly slower than the speed of light?
  - a. Hermann von Helmholtz
  - b. Rene Descartes

- c. Luigi Galvani
  - d. Phineas Gage
9. Broca's mute patient had damage to his
- a. pineal gland.
  - b. frontal lobes.
  - c. left hemisphere.
  - d. motor cortex.
10. Which of the following can be taken as evidence for the idea that different functions are localized in different portions of the brain?
- a. Lashley's theory of equipotentiality
  - b. Phineas Gage's personality change following frontal lobe damage
  - c. Gall's theory of phrenology
  - d. Galvani's demonstration that electricity could move the leg of a dead frog
11. With the exception of egg and sperm cells, all human body cells have
- a. 23 chromosomes.
  - b. 46 chromosomes.
  - c. 23 genes.
  - d. 46 genes.
12. If you underwent a procedure to test for a particular disease that is triggered by a defective protein inherited from your parents, what SPECIFIC genetic component will they be looking for?
- a. a particular chromosome in your genome
  - b. a particular gene on a chromosome
  - c. a particular allele of a gene
  - d. a particular base in an allele
13. Female humans have
- a. two X chromosomes.
  - b. two Y chromosomes.
  - c. one X and one Y chromosome.
  - d. one X chromosome.
14. At six weeks after conception, a developing human is known as a(n)
- a. zygote.
  - b. ova.
  - c. embryo.
  - d. fetus.
15. How many different bases make up DNA?
- a. 20
  - b. 10
  - c. 5
  - d. 4
16. Enzymes
- a. are proteins.
  - b. are produced as a result of genetic mechanisms.
  - c. modify chemical reactions in the body.
  - d. all of the above

17. John has type B blood, and Sue has type A blood. If they have a child, what blood type is impossible for that child to have?
- type A
  - type O
  - type AB
  - All of the above are possible types.
18. If John and Sue have a baby with type A blood, which of the following statements is TRUE?
- The baby is homozygous for the dominant A allele
  - The baby is heterozygous for the dominant A allele.
  - The baby has a recessive B allele.
  - The baby has a dominant O allele.
19. Which of the following is FALSE regarding red-green color blindness?
- It is an X-linked trait.
  - A female cannot be red-green color blind.
  - Males are more likely to have it.
  - It is a recessive trait.
20. A trait is polygenic if
- it is influenced by a gene on the X chromosome.
  - it is influenced by a gene on the Y chromosome.
  - it is influenced by more than one gene.
  - it is influenced only by a single gene.
21. Which of the following is believed to have a genetic basis?
- sexual orientation
  - drug addiction
  - personality
  - all of the above
22. Which of the following is TRUE of the human genome?
- Nearly all of the base-pair sequences have been mapped.
  - Most of our DNA is directly involved in coding for proteins.
  - The functions of all genes are well documented.
  - There are about 80,000 genes.
23. The differential survival of organisms with more adaptive traits is known as
- sexual reproduction.
  - predisposition.
  - natural selection.
  - heritability.
24. Which of the following is NOT true of gene activity?
- Once a gene becomes inactive, it remains inactive.
  - Genes may fluctuate in the amount of protein they code for at different times.
  - A gene may become active at only a certain time of the life cycle.
  - The activity of a gene may be influenced by experience.
25. Which of the following traits has the HIGHEST degree of heritability?
- intelligence
  - personality
  - height
  - occupational interests



26. If people from similar environments are sampled, estimates of heritability for traits will be \_\_\_\_\_ people from different environments are sampled.
- lower than if
  - higher than if
  - the same as when
  - either a or b
27. The BEST way to think about the relationship among genes, environment, and intelligence is that
- environment is more important than genetic inheritance.
  - our genes are more important than the environment.
  - a person's intelligence is equally influenced by each parent's genes.
  - genes set the potential range and environment determines the actual capacity.

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## Answers

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### Guided Review

1. Neuroscience
2. Brain
3. schizophrenia
4. map
5. Behavioral
6. Wilhelm Wundt
7. mind-brain
8. mind
9. monism
10. dualism
11. Aristotle
12. Plato
13. models
14. Descartes
15. pineal
16. soul
17. empiricism
18. electricity
19. Helmholtz
20. localization
21. Phineas Gage
22. frontal (or prefrontal)
23. Broca
24. left
25. phrenology
26. equipotentiality
27. distributed
28. conscious experience
29. behavior therapy
30. brain
31. nature
32. nurture
33. hereditary
34. Genes
35. chromosomes
36. two
37. one
38. 46
39. sperm
40. zygote
41. embryo
42. fetus
43. DNA
44. thymine or cytosine
45. cytosine or thymine
46. proteins
47. enzymes
48. DNA
49. cancer
50. alleles
51. AB
52. dominant
53. recessive
54. homozygous
55. phenotype
56. heterozygous
57. males
58. X-linked (or sex-linked)
59. polygenic
60. learning
61. intelligence
62. genome
63. 21,000
64. junk
65. gene expression
66. marker
67. Encyclopedia of DNA Elements
68. exons
69. half
70. combinations
71. natural selection
72. rigid
73. experiences
74. fraternal
75. heritability
76. 50
77. 40–50
78. environment
79. higher
80. vulnerability

## Short Answer and Essay Questions

1. There are several possible answers, but all must mention that behavioral neuroscientists look for a connection between the nervous system and a specific behavior or set of behaviors. Though not completely separate in approaches, neuroscientists will tend to approach questions using molecular, genetic, functional, mechanistic, or physiological methods, whereas behavioral psychologists might use interviews, questionnaires, or therapeutic or cognitive methods.

2. Monism assumes that the mind and brain are composed of the same thing or substance. Most monists are materialistic, meaning that they believe everything, including the mind, is physical and therefore has no separate existence. Dualists, however, believe that while the brain is physical, the mind is also real, although not material, and exists separately from the brain. The problem with dualism is that it cannot explain how something nonphysical (the mind) can affect something physical (the body). The problem with materialistic monism is explaining how the brain causes subjective, mental experience. Most modern neuroscientists are materialistic monists. They believe that the mind is not a real entity but rather a concept we use to describe what our brains are doing. Therefore, the mind really is the brain or, more precisely, the activity of the brain. However, nonmaterial neuroscientists are keeping the brain-body debate alive by arguing that if behavior therapy can change brain function, then the mind must exist to have an impact on the brain. Material monists would argue that this phenomenon demonstrates that the brain affects the brain.

3. It was important because it showed that damage to a particular part of the brain resulted in disruption of some types of functions but not others. Following his accident, Gage was still able to speak and move normally, and he showed no change in memory or intelligence, but his personality changed, and he became impulsive and hard to deal with. This suggested that the part of the brain damaged by his injury was involved in some types of behaviors but not in others.

4. Localization is the theory that different brain areas are in control of different functions. Equipotentiality assumes that the brain as a whole contributes to all functions. Most brain researchers now believe that while specific functions are located in specific brain regions, several different brain areas work together to produce behaviors and experiences; thus, the brain's functions are both localized and distributed.

5. Genes direct the production of proteins. Those proteins can then influence behavior through their role as enzymes or in creating parts of the body. Genes are variable in their effects, because they may not always be active and because they can vary the amount of a protein that is produced. They may also change functioning as the body ages. Alleles are different forms of genes, which necessarily make different proteins. An allele that encodes for an abnormal or nonfunctional protein (such as sickle cell anemia and its characteristically misshapen hemoglobin molecule) is what we look for when performing a genetic screening test on an individual.

6. Identical twins have the same genes, whereas fraternal twins have about 50% of their genes in common. If we compare identical twins and fraternal twins on some trait such as intelligence, and we find that identical twins are more similar than fraternal twins, then we can assume that genes are responsible for some of the similarity between the identical twins.

7. Individual answers will vary, but the following points need to be understood: (a) the presence (or absence) of a particular allele never completely corresponds with the presence (or absence) of a particular disorder. (b) Environmental factors play a key role in expression of defective genes. (c) Removing potentially cancerous tissue (that is currently healthy) does not completely remove the risk of developing the disease. (d) Surgical procedures carry their

own inherent risks—does the benefit gained through surgery outweigh the risks or costs of that procedure?

8. The evidence suggests that genes and environment are both important. The heritability of intelligence is around 50%, so this means that the environment contributes just as much as genes do. Furthermore, what genes contribute is better thought of as a predisposition; the environment will always have a significant impact.

#### Post-test

1. b 2. a 3. a 4. b 5. b 6. c 7. d 8. a 9. c 10. b 11. b 12. c 13. a 14. c  
15. d 16. d 17. d 18. b 19. b 20. c 21. d 22. a 23. c 24. a 25. c 26. b 27. d

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