Chapter 1

What is Behavioral Neuroscience?

**LEARNING OBJECTIVES**



1. Classify the subfields of neuroscience, and explain how behavioral neuroscience fits within the field.

2. Interpret the significance of the major historical highlights in the study of the nervous system.

3. Differentiate the brain imaging technologies, including CT, PET, SPECT, MRI, fMRI, and DTI.

4. Assess the use of microscopic the use of microscopic, recording, stimulation, optogenetic, lesion, and biochemical methods in behavioral neuroscience.

5. Analyze the relative strengths and weaknesses of twin studies, adoption studies, and genetic screens for understanding behavior.

6. Evaluate the ethical standards used to protect human and animal research participants.

Lecture Outline

I. Neuroscience as an Interdisciplinary Field (pp. 2–4)

PowerPoint Slides 1-4 and 1-6

The following film clips provide interesting insights into how and why we study neuroscience and make a good introduction to this unit:

Film Clip #1: Discovering the Human Brain: New Pathways to Neuroscience

Film Clip #2: V.S. Ramachandran at Beyond Belief 2.0

Film Clip #3: Jill Bolte Taylor on T.E.D.

A. **Neuroscience** is an interdisciplinary area of study involving psychology, biology, chemistry, medicine, mathematics, physics, engineering, and computer science.

B. The functions of the brain and nervous system are studied on many different levels.

* 1. The molecular level focuses on DNA, RNA, proteins, and gene expression and includes the subtopics of neural cell physiology and psychopharmacology.
  2. The cellular level is concerned with the structure, physiological properties, and functions of neural cells.
  3. The synapse level defines the connections between neural cells at the synapse. Synaptic neuroscience studies the strength and flexibility of these connections and the implications on complex processes, such as learning and memory.
  4. At the network level, neuroscientists study how interconnected neurons form pathways.
  5. Behavioral neuroscience seeks to understand the biological correlates of behavior, using all of the previous levels of analysis.
  6. All analytical levels use computational neuroscience to develop computational models that can be compared to living systems.

C. Researchers have a specific interest in the relationships between the nervous system and behavior.

1. Neurological illnesses have economic costs. For example, delaying the onset of Alzheimer's disease by five years would save $50 billion annually in health care costs in the United States.
2. Connections between biology and behavior are relevant to neurological diseases and to overall health, as many health conditions (e.g., diabetes, cancer) are tightly linked to behavior.
3. Nervous system responses are linked to behavioral scenarios, such as relationships, parenting, child development, and thinking and learning. Understanding the interaction between the nervous system and behavior can promote well-being.

*Behavioral Neuroscience Goes to Work: What Can I Do with a Degree in Neuroscience?*

II. Historical Highlights in Neuroscience (pp. 5–8)

PowerPoint Slides 1-7 through 1-11

A. Key points

1. Although some periods of enlightenment regarding the relationship between the nervous system and behavior emerged among the Egyptians and Greeks, the major advancements in biopsychology such as the understanding of electrical activity and functional neuroanatomy have been relatively modern and recent, being established within the last 200 years.

2. We take for granted that the brain and nervous system are the sources of intellect, reason, sensation, and movement. This disarmingly simple fact has not been universally accepted throughout human history.

3. The history of neuroscience parallels the development of tools for studying the nervous system.

B. Ancient people's view of the nervous system

1. Trepanation, the drilling of holes in the skull, may represent a prehistoric understanding of the brain’s role in behavior. (p. 5)

*\*See the Supplemental Teaching Strategies and Tools section for additional information regarding the modern day use of trepanation.*

2. The Edwin Smith Surgical Papyrus indicated an understanding that paralysis and lack of sensation were due to damage to the nervous system. In addition, Egyptians discarded the brain during mummification yet provided modern-sounding descriptions of structure and the effects of brain injury, including the irreversible nature of brain trauma. (p. 5)

3. Ancient Greeks understood that the brain was the organ of sensation. (p. 5)

*\* See the Supplemental Teaching Strategies and Tools section for additional information regarding the use of fluid dynamics as the functional model of the nervous system.*

a. Hippocrates understood that epilepsy originated in the brain. (p. 5)

b. Galen made many accurate anatomical observations but continued the misunderstanding of the role of the ventricles and the central nervous system as a fluid-filled network of interconnected tubes. (p. 5)

4. René Descartes (1596–1650) (p. 5)

*\*See the Lecture Enrichment section for additional information regarding the unusual circumstances surrounding the death and burial of René* *Descartes.*

a. Continued the notion that fluids produced movement.

b. Proposed **mind–body dualism**, which maintains that the body is mechanical and the mind is neither physical nor suited to scientific observation as opposed to the modern monism philosophical perspective that the mind is a product of physical neural activity.

Clicker Question #1

5. Discovery of the light microscope by Anton van Leeuwenhoek in 1674. (p. 8)

6. In the late 1700s, Luigi Galvani and Emil du Bois-Reymond established electricity as the mode of communication used by the nervous system. (p. 6)

*Figure 1.4 is an interesting depiction of Galvani’s basement laboratory where he connected wires from a rooftop antenna to the legs of frogs to demonstrate that electrical disturbances could stimulate the leg muscles of the frogs.*

7. Charles Bell (1774–1842) and François Magendie (1783–1855) demonstrated that sensory and motor information travel in separate pathways. (p. 6)

C. Modern neuroscience

1. Camillo Golgi, an Italian neuroanatomist, developed new staining techniques allowing the visualization of the structure of single neurons. Santiago Ramón y Cajal, a Spanish neuroanatomist, made classic trace drawings of neural circuitry leading to the proposal of the Neuron Doctrine, which stated that the nervous system is composed of separate nerve cells rather than the interconnect network of continuous fibers proposed by Golgi. In 1906, Golgi and Cajal shared the Nobel Prize for their neuroanatomical work and theories. (p. 6)

2. **Phrenology**, the correlation of bumps on the skull with personal traits and intellectual abilities, was misguided in most respects, but modern in its acceptance that different cognitive functions may be localized to specific areas in the brain. (p. 6)

3. Work by Paul Broca, who examined the postmortem brains of patients with language deficits, and Fritsch and Hitzig, who observed contralateral muscle movements when stimulating the motor cortex of a rabbit and dog, further established the concept of localization of function in the brain. (p. 7)

4. Hughlings Jackson proposed that the nervous system acted as a hierarchy, with simpler processing carried out by lower levels and sophisticated processing carried out by the cerebral cortex. (p. 7)

5. Charles Sherrington coined the word *synapse* and conducted research on reflexes and the motor systems of the brain. Otto Loewi demonstrated chemical signaling at the synapse. Sir John Eccles, Bernard Katz, Andrew Huxley, and Alan Hodgkin furthered our understanding of electrical signaling. (p. 7)

III. Behavioral Neuroscience Research Methods (pp. 9–22)

These film clips illustrate emerging technologies not covered in the textbook. However, this emphasizes the rapid innovations in neurotechnology and the symbiosis between advances in technology and our understanding of the nervous system.

PowerPoint Slides 1-12 through 1-32

Clicker Question #2

Film Clip #4: Two-Photon Microscope at MIT

Film Clip #5: A Diffusion Spectrum Imaging Tour of the Brain

A. **Histology** refers to the study of microscopic structures and tissues. (pp. 9–11)

1. Tissue to be viewed must be fixed by freezing or formalin and sliced thinly by a **microtome**.

2. Stains are applied to highlight structures of interest, such as the structural analysis of single cells (**Golgi stain**), clusters of cell bodies within a central nervous system nucleus (**Nissl stain**), axonal pathways (**myelin stain** or **horseradish peroxidase**), or specific proteins found in a particular cell (antibodies).

B. Autopsy ("to view for oneself") is the examination of a body after death.

1. Autopsy as a research method has been largely replaced by imaging techniques. (p. 11)

C. Imaging (pp. 11–13)

Clicker Question #3

Film Clip #6: Mind Reading with Imaging

*\*See the Lecture Enrichment section for additional information regarding the use of neuroimaging examples in the classroom.*

1. **Computerized tomography (CT)** uses X-ray technology to provide structural information about the brain and ventricles.

Disadvantages of CT technology include the inability to discriminate between active and inactive regions, and repeated exposures to X-rays.

2. **Positron-emission tomography (PET)** provides information about brain activity based on the utilization of radioactive glucose or oxygen, the two primary nutrients needed to produce neural signals.

Disadvantages of PET technology include a high expense of the machine and the injection of radioactive substances into the participant.

3. **Magnetic resonance imaging (MRI)** uses magnetism and radio frequency waves to provide high resolution images of structure.

Although the use of high-power magnetic fields is generally considered safe, as larger magnets are employed questions arise about their effect on the physiology of the body. MRI technology provides significantly higher resolution images than CT; however, MRI technology is much more expensive than CT technology.

*\*See the Supplemental Reading section for additional information regarding the potential negative effects of exposure to high-power magnetic fields.*

Film Clip #7: How MRI Works

4. **Functional magnetic resonance imaging (fMRI)** uses a series of images taken in a short period of time to analyze brain activity by measuring the flow of blood and oxygen use in the central nervous system.

5. **Diffusion tensor imaging (DTI)** uses MRI machinery to track the movement of water in the fiber pathways of the nervous system. This imaging technique allows scientists to visualize the negative effects of binge drinking on the adolescent brain fiber integrity.

*Connecting to Research: Social Pain and the Brain*

*Thinking Ethically: Can we Read Minds with Brain Imaging?* (p. 14)

D. Recording (pp. 14–17)

Recording methods allow researchers to record the electrical and magnetic output from the brain. Noninvasive recording techniques such as EEG, evoked potentials, and MEG are often used on humans, whereas invasive recording techniques such as single-cell recordings are typically reserved for use in animal research models.

1. **Electroencephalography (EEG)**, useful in examining states of consciousness, such as sleep and epilepsy, is recorded through scalp electrodes. The EEG provides information about the relative activity of large groups of neurons close to the surface of the brain.

Recent advances using computerized EEG recordings have enabled the diagnosis of many disorders, such as schizophrenia, dementias, epilepsy, and attention deficit disorder. Computerized EEG brain tomography generates maps of brain activity, allowing the identification of the source of abnormal activity.

2. **Event-related potentials (ERPs)**, a specialized use of EEG technology, detect the brain’s response to environmental stimuli.

3. **Magnetoencephalography (MEG)**, in which the brain’s tiny magnetic output is assessed, provides information about the activity of particular areas of the brain. Often the activity measured through MEG is superimposed on an MRI structural scan of the brain. Measuring magnetism instead of electrical activity reduces the interference of the skull bones and tissues common with EEG.

4. Single-cell recordings, using surgically implanted microelectrodes, allow researchers to observe the responses of individual neurons and apply electrical stimulation.

E. Brain stimulation (pp. 17–18)

Clicker Question #4

Film Clip #8: Deep Brain Stimulation for Parkinson’s Disease

Film Clip # 9: Repeated Transcranial Magnetic Stimulation

Film Clip #10: Magnetic Brain Boost

Film Clip #11: Jose Delgado and his Bull

1. Stimulation of the brain is used to assess the functions of particular areas, as well as the areas to which they are connected.

2. Surface electrodes used during neurosurgery assess changes in behavior in response to stimulation in the conscious patient. This strategy can identify regions of the brain that participate in certain behaviors (e.g., Penfield).

3. Surgically implanted electrodes allow stimulation of deeper regions of the brain (e.g., Heath, Parkinson's disease treatment).

4. **Repeated transcranial magnetic stimulation** **(rTMS)** can temporarily change brain activity immediately below the stimulation site (e.g., treatment of auditory hallucinations).

5. Optogenetics uses light to turn living neurons on and off. This is done with the use of molecules genetically inserted into specific neurons in the brain and optical fibers either attached to the skull or surgically implanted.

F. **Lesions**, which are also used to assess function, may result from naturally occurring (due to injury or disease) or deliberate brain injury (in laboratory animals).

Electrical or heat lesions destroy small areas of neurons and pathways, whereas chemical lesions destroy small areas of either neural cell bodies or axons, allowing researchers to selectively examine the function of nuclei or pathways in a particular area. The term **ablation** is used instead of lesion when sections of the central nervous system are surgically removed. (p. 19)

G. Biochemical methods (p. 20)

1. Drugs of interest may be administered in a variety of ways, including injection, eating, inhaling, chewing, or direct administration through micropipettes.

2. **Microdialysis**, in which extracellular fluid samples are removed through micropipettes, allows researchers to identify chemicals present in precise areas of the brain.

H. Genetic methods (pp. 20–21)

Film Clip #12: Human Genome Project

1. The effect of genetic concordance on behavior is examined by comparing monozygotic (identical) and dizygotic (fraternal) twins. Studies comparing twins, including those adopted by different sets of parents, provide some insight into relative contributions of genetics and environment.

2. Genetically modified (GM) animals have had a defective gene (**knockout gene**) inserted into their chromosomes, allowing researchers to correlate changes in behavior and physiology with the associated genes affected by the knockout technique.

3. Epigenetics studies the effects of external factors on gene expression; specifically, alteration of gene function due to factors other than changes in the gene sequence, itself.

IV. Research Ethics in Behavioral Neuroscience (pp. 23–25)

A. The ethical use of experimental methodology, including animal and human subjects, is subjected to multiple levels of review (university review boards, national organizational review boards, and peer review at the time of publication) to ensure compliance with federal, state, and local laws and ethical use guidelines. (p. 23)

Clicker Questions #5 and #6

B. Human participant guidelines ensure lack of subject coercion, informed consent of subject, and privacy protection. (pp. 23–24)

*Building Better Health: When is it Appropriate to Use Placebos?*

Clicker Question #7

C. Animal subjects guidelines focus on the necessity of using animals to answer a research question, the provision of excellent housing and health care, and the minimizing of the number of animals used and any pain and suffering that is necessitated by the research protocol. (p. 24)

*\*See the Supplemental Reading section for additional information regarding the protection of animals used in laboratory research.*

Clicker Question #8

*\*See the Supplemental Reading section for additional information regarding the private, U.S. federal, U.S. state, and international public policies and stem cell research.*

# Lecture Enrichment

### II. B. 4. – Unusual Circumstances Surrounding the Death and Burial of René Descartes

René Descartes proposed the mind–body dualism theory in an attempt to clarify the distinction between the physiology and behavior of humans versus other animals. Descartes professed to believe in the existence of God and submitted to the authority of the Catholic Church but was often caught in conflict between the church and his scientific endeavors. Despite his best intentions and efforts, the Catholic Church placed Descartes’ writings on an index of banned books. Discouraged in 1650, Descartes left France accepting a position as the philosopher-in-residence for Queen Christina of Sweden. During the first winter, Descartes caught pneumonia and died. He was subsequently buried as a distinguished foreigner in Sweden. Some 16 years following Descartes’ death, his body was exhumed so that friends and pupils could properly return his body to France as his final resting place. However, the specially constructed transportation casket was too small and Descartes’ head was severed from the body to allow shipment. During the shipping, the head was stolen and traded on the black market amongst collectors. Descartes body was returned to Paris and buried sans Descartes’ head. Eventually over 100 years later, the head of Descartes was returned to the French government and was shelved at the Academie des Sciences. So to this day, the head and body of the mind–body dualism theorist, René Descartes, remain separated.

### Section III. C. – Using Neuroimaging Examples in the Classroom

Using images of the brain from publications, websites, and texts can provide a useful and engaging illustration for many cognitive functions and neurological deficits. It is important when viewing brain sections from neuroimaging techniques such as CT scans to orientate the image of the brain with regard to left versus right and rostral versus caudal poles as often the brain section may be shown as a mirror image.

# Film Clip Suggestions

1. Discovering the Human Brain: New Pathways to Neuroscience (4:04)

Using the resources of the Brain Research Center at UCLA, this film illustrates the development of neuroscience, from its reliance on information from brain injuries and autopsies, through new insights discovered with electronic microscopes, EEG equipment, PET scans, and MRI machines. With Susan Bookheimer, Ph.D. (2006). This is a short version of a 30-minute film.

<http://youtu.be/RREoQJUHSYE>

1. V.S. Ramachandran at Beyond Belief 2.0 (9:23)

V.S. Ramachandran is a neurologist, best known for his work in the fields of behavioral neurology and psychophysics.

<http://www.youtube.com/watch?v=N9hy7oOhHxk&feature=related>

1. Jill Bolte Taylor talks about the results of her stroke (20:11)

Neuroanatomist Jill Bolte Taylor had an opportunity few brain scientists would wish for: One morning, she realized she was having a massive stroke.

<http://www.youtube.com/watch?v=UyyjU8fzEYU&feature=related>

4) Science Tools: Brain Imaging (1:55)

ScienCentral takes you on a visit to the Tonegawa Lab at MIT to see their two-photon microscope and electrophysiology lab, and how they combine to study brain cell growth. <http://www.youtube.com/watch?v=t61h9idEC0Q&feature=channel_page>

5) A Diffusion Spectrum Imaging Tour of the Brain

Technology Review provides a step-through tour of the white matter of the brain using diffusion spectrum imaging (DSI). <http://www.technologyreview.com/player/08/08/06Singer/1.aspx>

6) Mind Reading with Imaging (1:36)

As pollsters have well demonstrated this presidential primary season, reading minds, whether of voters or the person next to you, is close to impossible. However, as this ScienCentral News video explains, scientists are actually one step closer to reading our thoughts.

<http://www.youtube.com/watch?v=jq_nAm4rOu0&feature=channel>

7) How MRI Works (2:26)

Wizard of Schenectady Howard Hart explains how the MRI works. Howard Hart pioneered MRI design with General Electric by the Edison Exploratorium.

<http://youtu.be/pGcZvSG805Y>

8) Deep Brain Stimulation for Parkinson’s Disease (2:30)

You've heard of a pacemaker for the heart, but what about for the head? We'll go under the knife with a Cardington, Ohio farmer who's getting electrodes implanted into his brain to alleviate the debilitating physical effects of a rare neurological disorder.

<http://www.youtube.com/watch?v=EMnfROo7k9A>

9) Repeated Transcranial Magnetic Stimulation (4:15)

Transcranial magnetic stimulation lets you deactivate selected parts of your brain.

<http://www.youtube.com/watch?v=XJtNPqCj-iA&feature=PlayList&p=1E617238454CAA9E&playnext=1&playnext_from=PL&index=6>

10) Magnetic Brain Boost (1:32)

Lack of sleep often comes at times when we need to perform at our best. Now brain researchers studying how sleep deprivation impairs memory have found a potential remedy—rTMS.

<http://www.youtube.com/watch?v=WzYwIs35pPs&feature=channel_page>

11) Jose Delgado and his Bull (0:38)

Jose Delgado implants stimulating electrodes into a Spanish fighting bull.

<http://www.youtube.com/watch?v=be9YlbafKys>

12) Human Genome Project

Introduction (2:37)

How It Started (2:50)

How It Was Paid For (6:11)

Practical Implications (3:58)

Ethics (4:08)

<http://www.nature.com/nature/supplements/collections/humangenome/video>

13) Hair Follicle Stem Cells (1:49)

Non-invasive method for developing stem cells from hair follicles in mice.

<http://www.youtube.com/watch?v=n0UzdYRnMtY&feature=channel_page>

**Additional Videos:**

The Cold Spring Harbor Laboratory Genes to Cognition Online website is a rich source of video material. Simply put “video” into their search engine. There are currently 569 high-quality videos suitable for in-class presentation or homework assignments. Retrieved on December 11, 2014 from <http://www.g2conline.org/>

# Supplemental Reading List

### History of Neuroscience

This text provides an overview of neuroscience history organized by major research area. Stanley Finger, *Origins of Neuroscience: A History of Explorations into Brain Function.* Oxford University Press, 1994. ISBN: 0195146948.

### High-Power Magnets and Aversive Physiological Effects

Recent evidence has shown that exposure to high-power magnetic fields (at least 7 Tesla and stronger) may produce aversive effects. Current MRI technology used in clinical practice is still in the 1–2 Tesla range; however, increasing the magnetic field strength allows better imaging and MRI technology used in research settings are now in the 4–9 Tesla range. The research examining the efficacy and safety of high magnetic field exposure mirrors the studies initially conducted on the effects of exposure to radiation. The following articles describe conditioned taste aversion, vestibular related behaviors, and central nervous system activation induced in rats that received short (15–30 min) exposures to high power magnetic fields.

Lockwood DR, Kwon B, Smith JC, Houpt TA. Behavioral effects of static high magnetic fields on unrestrained and restrained mice. Physiol Behav. 2003 Apr;78(4–5):635–40.

Houpt TA, Pittman DW, Barranco JM, Brooks EH, Smith JC. Behavioral effects of high-strength static magnetic fields on rats. J Neurosci. 2003 Feb 15;23(4):1498–505.

Snyder DJ, Jahng JW, Smith JC, Houpt TA. c-Fos induction in visceral and vestibular nuclei of the rat brain stem by a 9.4 T magnetic field. Neuroreport. 2000 Aug 21;11(12):2681–5.

Nolte CM, Pittman DW, Kalevitch B, Henderson R, Smith JC. Magnetic field conditioned taste aversion in rats. Physiol Behav. 1998 Feb 15;63(4):683–8.

### Handbook of Functional Neuroimaging of Cognition

This text provides a historical account of the development of functional neuroimaging, a detailed explanation of the theory and methods involved in the production of functional neuroimages, and a summary of the latest functional neuroimaging research organized according to system (attention, language, aging, etc.). Publication information: Roberto Cabeza and Alan Kingstone (Editors), *Handbook of Functional Neuroimaging of Cognition.* The MIT Press, 2006. ISBN: 0262032805.

### Ethical Use of Animals in Research

The following websites are good resources of information regarding the legal and ethical use of animals in research.

The Office of Laboratory Animal Welfare: <http://grants.nih.gov/grants/olaw/olaw.htm/>

The Animal Welfare Information Center of the U.S. Department of Agriculture: <http://www.nal.usda.gov/awic>

Public Health Service Policy on Humane Care and Use of Laboratory Animals: <http://grants.nih.gov/grants/olaw/references/phspol.htm>

The American Psychological Association’s Committee on Animal Research and Ethics (CARE): <http://www.apa.org/science/leadership/care/index.aspx>

The Society for Neuroscience’s Policies on the Use of Animals and Humans in Neuroscience Research: <http://www.sfn.org/Advocacy/Policy-Positions/Policies-on-the-Use-of-Animals-and-Humans-in-Research>

### Public Policies and Stem Cell Research

The following websites are good resources of information regarding current governmental public policy on stem cell research and the privatization of stem cell research.

Stem Cells and the Future of Regenerative Medicine: <http://www.nap.edu/books/0309076307/html/>

United States federal policy on funding stem cell research: <http://stemcells.nih.gov/policy/Pages/Default.aspx>

Executive Order E9-5441, March 9, 2009.

Removing Barriers to Responsible Scientific Research Involving Human Stem Cells:

<http://edocket.access.gpo.gov/2009/pdf/E9-5441.pdf>

NIH Stem Cell Basics: <http://stemcells.nih.gov/info/basics/>

Stem cell research regulations in European countries: <http://www.eurostemcell.org/stem-cell-regulations>

California’s Stem Cell Agency: <http://www.cirm.ca.gov/>

# Supplemental Teaching Strategies and tools

### Discussion of Trepanation

Trepanation was likely the first attempt at neurosurgery. Archeological evidence suggests trepanation was employed up to 7,000 years ago. Given our current enlightened view of the brain, trepanation seems a gross and wholly (excuse the puns) procedure by our modern standards. Yet, in the 1970s there was a resurgence of trepanation as a means of achieving mental clarity with some unusual case studies to say the least. The following websites and reports can be used in a classroom discussion of the appropriateness of trepanation:

What’s the story on trepanation? <http://www.straightdope.com/columns/020906.html>

You Need It Like… a Hole in the Head?

<http://www.washingtonpost.com/wp-srv/style/features/trepan.htm>

The skull doctors. Stephanie Pain. New Scientist. September 16, 2000; 167(2256): 32.

<http://www.critpsynet.freeuk.com/skull.htm>

Trepanation.

<http://www.quackwatch.org/01QuackeryRelatedTopics/trepanation.html>

*Neurophilosophy* has found a gory but completely astonishing film of a Kisi medicine man in Tanzania performing a trepanation operation. <http://www.mindhacks.com/blog/2008/02/the_operation_of_the.html>

### Understanding Fluid Dynamics as a Functional Model of the Nervous System

A discussion about the basis for the development of the fluid dynamics model will help the students fully understand and remember the early philosophies of the biology underlying behavior. Given our knowledge base today, it may seem absurd that the Greek and Renaissance philosophers thought that internal fluids were the controlling force underlying human behavior. Students often have a hard time appreciating the perspective of this model given the knowledge base during that time. It is important to remember that prior to the mid-1700s, there was no real understanding of electricity. Physical sources of energy were limited to hydraulic and fire. It became clear to the ancient philosophers that fire was not the source of human energy and that our bodies contained vast amounts of fluids. As evidenced by trauma to the brain, the central nervous system gained importance in sustaining life and behavior. Furthermore, fluid-filled cavities or ventricles were observed in the brain containing a different type of fluid (cerebrospinal fluid) that was not like the circulating blood. Therefore, hydraulic energy became the acceptable model of energy for human behavior. In the early 1600s, René Descartes took up residence in the Paris suburb of St. Germain. In St. Germain, there were a series of fountains and statues that were set in motion, sometimes to accompanying music, by hydraulic power when nearby observers stepped on special flagstones attached to a series of pipes. Descartes observed this phenomenon and applied the concept of plumbing and hydraulic power used to produce complex movements in inanimate objects to the notion of a fluid-filled nervous system being able to produce complex human behavior.

### Discussion of Neuroimaging Techniques

There are many advantages and disadvantages associated with each of the neuroimaging techniques discussed in Chapter 1. Lead a discussion centered on a cost/benefit analysis of using different techniques in the examination of various clinical conditions, such as stroke, car accident victim, or sports-related concussion, and research questions, such as attention, memory, development, or aging.

**Genes to Cognition Online**

The Cold Spring Harbor Laboratory has a rich multimedia site that includes more than 750 items, including animations, interactive experiments, video (<http://www.g2conline.org/>), and a 3-D interactive brain. This site offers multiple opportunities for Lecture Enrichment and Homework. <http://www.g2conline.org/>

# Clicker Questions for Audience Response Systems

1. What do you believe in?
2. Mind–body dualism—there is more to “mind” than just the physical self.
3. Monism—the “mind” is what the brain does.
4. I’m just not sure.

Question type: React

1. Professor Williams wants to check the density of cell bodies in a sample of rat hippocampus. Which type of stain should she use?
2. Horseradish peroxidase
3. **Nissl stain**
4. Myelin stain
5. Golgi stain

Question type: Check Your Learning

1. Which technologies tell us about the activity of the brain?
2. CT and PET
3. CT and MRI
4. **PET and fMRI**
5. PET and MRI

Question type: Check Your Learning

1. Which technique is used to identify the functions of a particular part of the brain?
2. Autopsy
3. Computerized tomography (CT)
4. Evoked potentials
5. **Electrical stimulation**
6. Microdialysis

Question type: Check Your Learning

1. Do you think researchers should be allowed to use PET scans on healthy adult volunteers?
2. Yes
3. No

Question type: React

1. Do you think researchers should be allowed to use PET scans on healthy children with their parents’ consent?

A. Yes

B. No

Question type: React

1. When is animal research ethical?
2. Never
3. When steps are taken to ensure that the animal experiences minimal pain and suffering
4. When human lives can be saved as a result of the knowledge gained
5. When research is conducted at universities rather than by for-profit organizations

Question type: React

1. Is stem cell research ethical?
2. Yes
3. No
4. Only if it uses adult, not embryological stem cells

Question type: React