3 The Biological Bases of Behavior

3.1 Study Guide Material

left brain/right brain

depression

neurons individual cells in the nervous system that receive, integrate, and transmit information.

acetylcholine

dopamine

norepinephrine

GABA Another group of transmitters consists of amino acids. One transmitter in this group, gamma-aminobutyric acid (GABA), is notable in that it seems to produce only inhibitorypostsynaptic potentials. Some transmitters, such as ACh and NE, are versatile. They can produce either excitatory or inhibitory PSPs, depending on the synaptic receptors they bind to. However, GABA appears to have inhibitory effects at virtually all synapses where it is present. GABA receptors are widely distributed in the brain and may be present at 40% of all synapses. GABA appears to be responsible for much of the inhibition in the central nervous system. Studies suggest that GABA is involved in the regulation of anxiety in humans and that disturbances in GABA circuits may contribute to some types of anxiety disorders (Garakani et al., 2009). GABA circuits also play a central role in the expression of some types of seizures (Shank, Smith-Swintosky,& Twyman, 2000), and they contribute to the modulation of sleep (Siegel, 2004).

Pituitary Master Gland!

Glutamate

Endorphins

Peripheral nervous system

Spinal cord

Hindbrain

Cerebellum

Forebrain has four main things responsible for — and it's the largest!

1. Thalamus: Sensory infromation
2. Hypothalamus: the four Fs: fight, flight, feeding, mating
3. Limbic system: Pleasure
4. Cerebrum: learning

Hippocampus

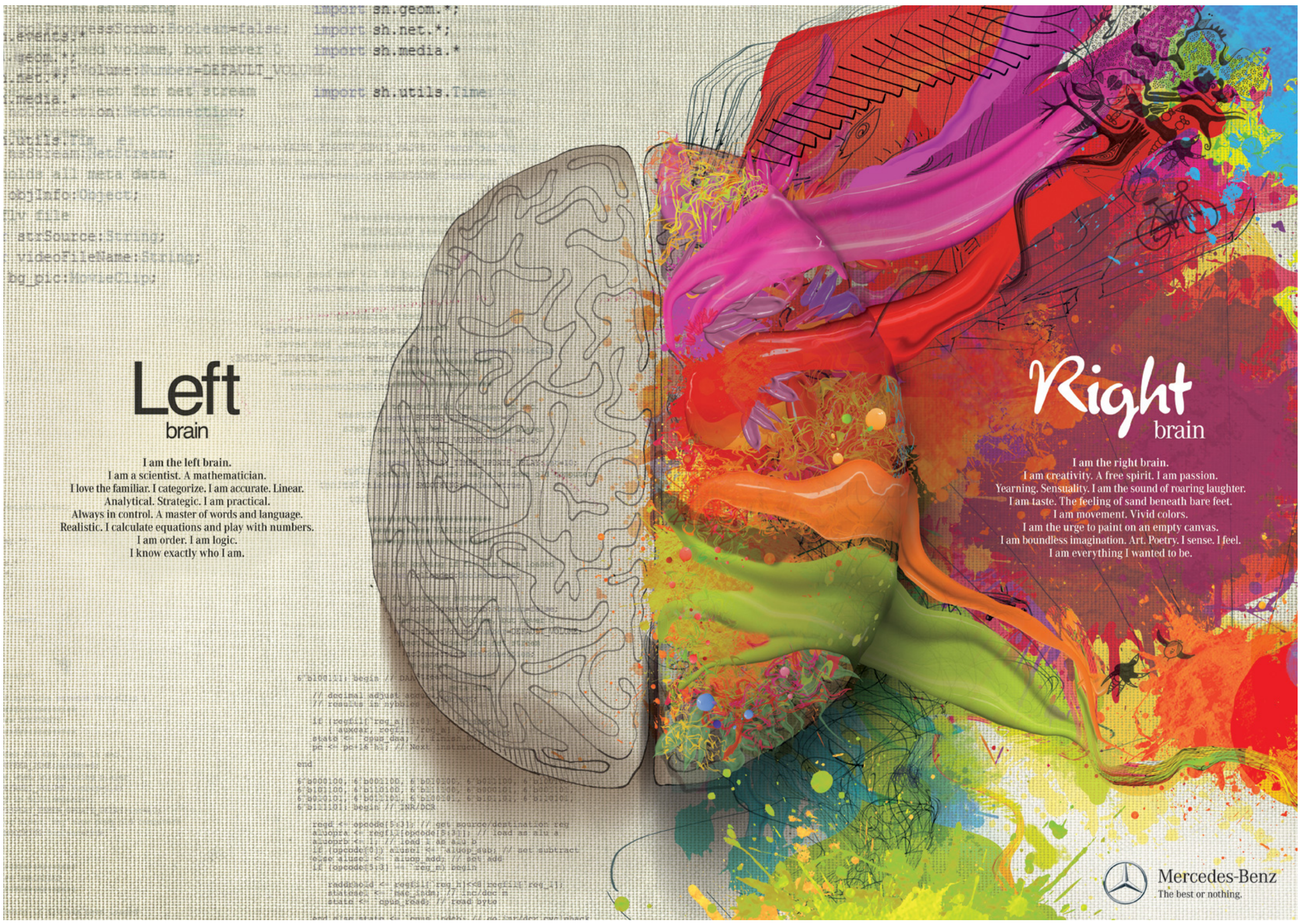
Hormones

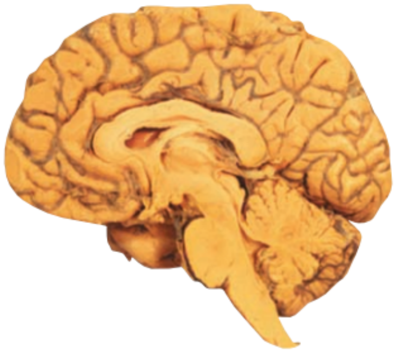
Testosterone Linked to aggression. Steroid hormone from the androgen group and is found in humans and other vertebrates. In humans and other mammals, testosterone is secreted primarily by the testicles of males and, to a lesser extent, the ovaries of females.

Oxytocin love hormone.

Charles Darwin Father of evolution. Proposed survival of the fittest. Natural selection will weed out the weak, the strongest will survive.

3.2 Book Notes





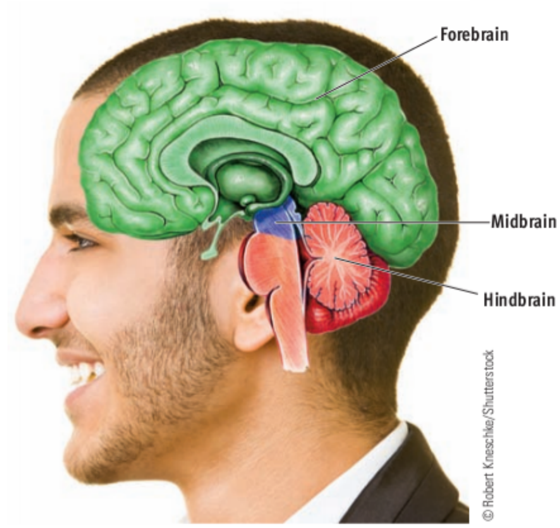


FIGURE 3.10

Structures and areas in the human brain. (Top left) This photo of a human brain shows many of the structures discussed in this chapter. (Top right) The brain is divided into three major areas: the hindbrain, midbrain, and forebrain. These subdivisions actually make more sense for the brains of other animals than those of humans. In humans, the forebrain has become so large it makes the other two divisions look trivial. However, the hindbrain and midbrain aren't trivial; they control such vital functions as breathing, waking, and maintaining balance. (Bottom) This cross section of the brain highlights key structures and some of their principal functions. As you read about the functions of a brain structure, such as the corpus callosum, you may find visualizing it helpful.

PHOTO: Wadsworth collection

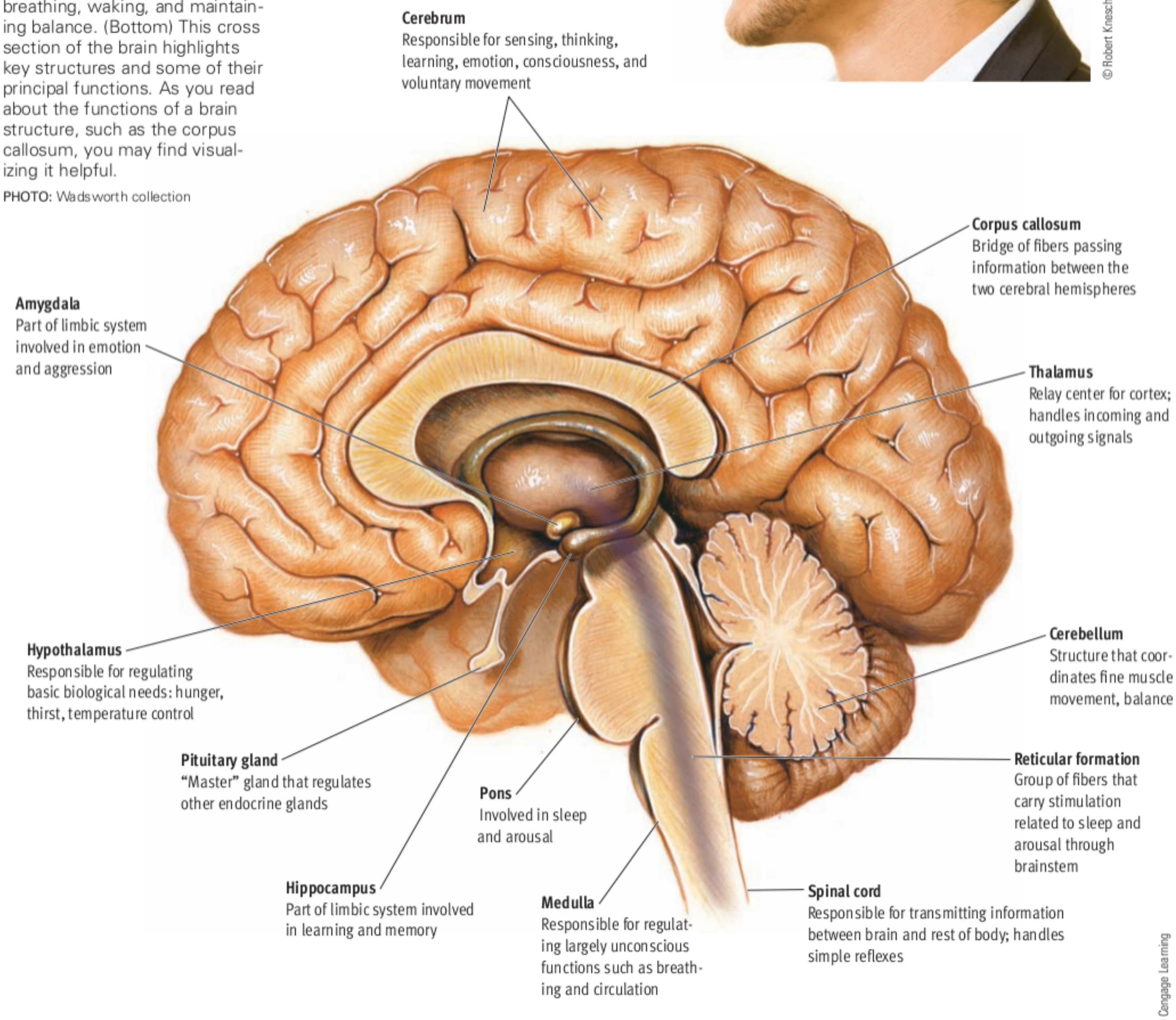


TABLE 3.1 Common Neurotransmitters and Some of Their Relations to Behavior

Neurotransmitter	Characteristics and Relations to Behavior	Disorders Associated with Dysregulation
Acetylcholine (ACh)	Released by motor neurons controlling skeletal muscles Contributes to the regulation of attention, arousal, and memory Some ACh receptors stimulated by nicotine	Alzheimer's disease
Dopamine (DA)	Contributes to control of voluntary movement Cocaine and amphetamines elevate activity at DA synapses Dopamine circuits in medial forebrain bundle characterized as "reward pathway"	Parkinsonism Schizophrenic disorders Addictive disorders
Norepinephrine (NE)	Contributes to modulation of mood and arousal Cocaine and amphetamines elevate activity at NE synapses	Depressive disorders
Serotonin	Involved in regulation of sleep and wakefulness, eating, aggression Prozac and similar antidepressant drugs affect serotonin circuits	Depressive disorders Obsessive-compulsive disorders Eating disorders
GABA	Serves as widely distributed inhibitory transmitter, contributing to regulation of anxiety and sleep/arousal Valium and similar antianxiety drugs work at GABA synapses	Anxiety disorders
Endorphins	Resemble opiate drugs in structure and effects Play role in pain relief and response to stress Contribute to regulation of eating behavior	

3.3 Powerpoint Notes

:: Slide 1 ::

In Chapter 3 we will be learning about:

- How the Nervous System communicates
- How it is organized
- The Brain and Behavior
- Right Brain and Left Brain specializations
- The Endocrine System – The role that our Hormones play in our behavior
- Genetic influences
- And the Evolutionary bases of behavior

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There two major types of cell in the nervous system: glia and neurons.

Neurons are cells that receive, integrate, and transmit information. In the human nervous system, the vast majority are interneurons - neurons that communicate with other neurons. There are also sensory neurons, which receive signals from outside the nervous system, and motor neurons, which carry messages from the nervous system to the muscles that move the body.

The axon ends in a cluster of **terminal buttons** – which are small knobs that secrete chemicals called neurotransmitters. These chemicals serve as messengers that may activate neighboring neurons.

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The **soma**, or cell body contains the cell nucleus and much of the chemical machinery common to most cells.

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Dendrites are the branch-like growths off the soma that are specialized to receive information.

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The long single fiber is the **axon** and it specializes in transmitting information to other neurons or to muscles or glands. It is wrapped in a white, fatty substance that serves as an insulator an helps speed up the transmission of signals. Multiple sclerosis is a degeneration of the myelin sheath and causes a slowing of nerve transmission to muscles.

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Most human axons are wrapped in a myelin sheath. Myelin is a white, fatty substance that serves as an insulator around the axon and speeds the transmission of signals. In people suffering from multiple sclerosis, some myelin sheaths degenerate, slowing or preventing nerve transmission to certain muscles.

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The axon ends in a cluster of **terminal buttons**, which are small knobs that secrete chemicals called neurotransmitters. These chemicals serve as messengers that may activate neighboring neurons.

The points at which neurons interconnect are called synapses. A **synapse** is a junction where information is transmitted from one neuron to another.

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Glia come in a variety of forms. Their main function is to support the neurons by, among other things, supplying them with nutrients and removing waste material. In the human brain, there are about ten glia cells for every neuron.

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The neuron at rest is a tiny battery, a store of potential energy. Inside and outside the axon are fluids containing electrically charged atoms and molecules called *ions*. Positively charged sodium and potassium ions and negatively charged chloride ions are the principal molecules involved in the nerve impulse.

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The **Resting Potential** of a neuron is its stable, negative charge when the cell is inactive. This charge is about -70 millivolts, roughly one-twentieth of the voltage of a flashlight battery.

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An **Action Potential** is a very brief shift in a neuron's electrical charge that travels along an axon.

It moves like a spark travelling down a trail of gunpowder.

After it fires the channels in the cell membrane that opened to let in sodium close up, and it needs some time before it can fire again, this is called the *absolute refractory period*.

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The size of an action potential is not affected by the strength of the stimulus—a weaker stimulus does not produce a weaker action potential. If the neuron receives a stimulus of sufficient strength, it fires, but if it receives a weaker stimulus, it doesn't. This is referred to as the "all-or-none law."

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The synapse. When a neural impulse reaches an axon's terminal buttons, it triggers the release of chemical messengers called neurotransmitters. The neurotransmitter molecules diffuse across the synaptic cleft and bind to receptor sites on the postsynaptic neuron. A specific neurotransmitter can bind only to receptor sites that its molecular structure will fit into, much like a key must fit a lock.

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The neurotransmitters are released when a vesicle fuses with the membrane of the presynaptic cell and its contents spill into the synaptic cleft. After their release, neurotransmitters diffuse across the synaptic cleft to the membrane of the receiving cell.

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When a neurotransmitter and a receptor molecule combine, reactions in the cell membrane cause a **postsynaptic potential**, or PSP - a voltage change at the receptor site on a postsynaptic cell membrane.

After producing postsynaptic potentials, some neurotransmitters either become inactivated by enzymes, or drift away. Most neurotransmitters, however, are reabsorbed into the presynaptic neuron through **reuptake** – a process in which neurotransmitters are sponged up from the synaptic cleft by the presynaptic membrane.

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Most neurons are interlinked in complex chains, pathways, circuits, and networks. Our perceptions, thoughts, and actions depend on patterns of neural activity in elaborate neural networks.

Click to see a video that shows how neural networks work.

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Acetylcholine is involved in every move you make – walking, talking, breathing, etc. all depend on it and it is also involved in attention, arousal, and memory functions. Not enough of it in certain parts of the brain are associated with Alzheimer's Disease

Monoamines include three neurotransmitters:
Dopamine, nonrepinephrine, and serotonin.

**Note to Instructor: you can just read the information on the table as it appears for the remainder of this slide.*

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This is an overview, sort of a flow chart of the human nervous system that shows the relationships of all the parts.

We will look at the different systems separately on the next slides.

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The **peripheral nervous system** is made up of all the nerves that lie outside the brain and spinal cord. Nerves are bundles of neuron fibers - or axons - that are routed together in the peripheral nervous system.

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The peripheral nervous system can be divided into two parts.

The **somatic nervous system** is made up of nerves that connect to voluntary skeletal muscles and sensory receptors. They carry information from receipts in the skin, muscles, and joints to the CNS, and from the CNS to the muscles.

The **autonomic nervous system** is made up of nerves that connect to the heart, blood vessels, smooth muscles, and glands. It controls automatic, involuntary, visceral functions that people don't normally think about, such as heart rate, digestions, and perspiration.

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When a person is autonomically aroused, automatic functions speed up. This speeding up is controlled by the sympathetic division of the **autonomic nervous system** - the **sympathetic nervous system** mobilizes the body's resources for emergencies and creates the fight-or-flight response.

The **parasympathetic** nervous system, on the other hand, conserves bodily resources to save and store energy.

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The **central nervous system**, or CNS, consists of the brain and spinal cord.

It is protected by enclosing sheaths called meninges, as well as **cerebrospinal fluid**, which nourishes the brain and provides a protective cushion for it.

The spinal cord houses bundles of axons that carry the brain's commands to peripheral.

The brain is of course the crowning glory of the CNS. It weighs about 3 pounds and is what enables humans to do everything we do. It is what makes us uniquely human.

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Neuroscientists use many specialized techniques to investigate connections between the brain and behavior.

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The CT scan is a computer-enhanced X-Ray of brain structure. Multiple X-Rays are shot from many angles, and the computer combines the readings to create a vivid image of a horizontal slice of the brain.

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The MRI uses magnetic field, radio waves, and computerized enhancement to map out brain structure. They provide a 3-D view with very high resolution.

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PET scans are used to map brain activity rather than brain structure. They provide color-coded maps that show areas of high activity in the brain over time. The PET scan shown here pinpointed areas of high activity (indicated by the red and yellow colors) when a research participant was engaged in the production of speech.

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The brain is divided into three major areas: the hindbrain, midbrain, and forebrain.

These subdivisions actually make more sense for the brains of other animals than for humans. In humans, the forebrain has become so large it makes the other two divisions look insignificant. However, the hindbrain and the midbrain are not minor players; they control such vital functions as breathing, walking and maintaining balance.

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The **Hindbrain** includes three sub-structures:

The **cerebellum** (little brain), located in the lower part of the brainstem that coordinate fine muscle movement, and balance.

The **medulla**, attached to the spinal cord, controls unconscious functions such as breathing and circulation.

The **pons** which is literally a “bridge” of fibers connecting the brainstem with the cerebellum. It is involved in sleep and arousal.

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The midbrain is concerned with certain sensory processes, such as locating where things are in space.

The midbrain is the origin of an important system of dopamine-releasing axons. Among other things, this dopamine system is involved in the performance of voluntary movements. The abnormal movements associated with Parkinson’s disease are due to the degeneration of neurons in this area.

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Running through both the hindbrain and the midbrain is the **reticular formation**. Lying at the central core of the brainstem, the reticular formation contributes to the modulation of muscle reflexes, breathing, and the perception of pain.

It is best known, however, for its role in the regulation of sleep and wakefulness. Activity in the ascending fibers of the reticular formation is essential to maintaining an alert brain.

:: Slide 35 ::

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:: Slide 36 ::

The **thalamus** is a structure in the forebrain through which all sensory information, except smell, must pass to get to the cerebral cortex. This way station is made up of a number of clusters of cell bodies, or nuclei. Each cluster is concerned with relaying sensory information to a particular part of the cortex.

The hypothalamus is made up of a number of distinct nuclei. These nuclei regulate a variety of basic biological drives, including the so-called “four Fs”—fighting, fleeing, feeding, and mating.

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The limbic system is a loosely connected network of structures involved in emotion, motivation, memory, and other aspects of behavior.

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The cerebrum is the largest and most complex part of the human brain. It includes the brain areas that are responsible for our most complex mental activities, including learning, remembering, thinking, and consciousness itself.

The cerebrum is divided into right and left halves, called cerebral hemispheres.

If we pry apart the two halves of the brain, we see that this fissure descends to a structure called the corpus callosum.

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The cerebral cortex consists of right and left halves, called cerebral hemispheres. This diagram provides a view of the right hemisphere.

Each cerebral hemisphere is divided into four lobes (which are highlighted in the bottom inset): the occipital lobe, the parietal lobe, the temporal lobe, and the frontal lobe.

Each lobe has areas that handle particular functions, such as visual processing. The functions of the prefrontal cortex (see the inset) are something of a mystery, but they may include an executive control system that organizes and directs thought processes.

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New research suggests the brain is not “hard wired” the way a computer is. Our brains are flexible and constantly evolving, but it is still limited as evidenced by the decline in plasticity as we age. We used to think that all neurons were present at birth and once dead did not regenerate…but now we are aware that in certain parts of the brain, the hippocampus and olfactory bulbs they can regenerate on a limited basis.

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This view of the left hemisphere highlights the location of two centers for language processing in the brain: Broca’s area, which is involved in speech production, and Wernicke’s area, which is involved in language comprehension.

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Roger Sperry and Michael Gazzaniga were pioneers in split brain research.

In the case of severe epilepsy, the corpus collosum is sometimes severed to stop violent seizures when medications don’t work. This surgery provides a rare opportunity to study how the hemispheres of the brain react when they can no longer communicate with each other.

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Research with split-brain subjects provided the first compelling evidence that the right hemisphere has its own special talents. Based on this research, investigators concluded that the left hemisphere usually handles verbal processing, whereas the right hemisphere usually handles nonverbal processing, such as that required by visual-spatial and musical tasks.

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If a participant stares at a fixation point, the point divides the subject's visual field into right and left halves. Input from the right visual field (the word *cow* in this example) strikes the left side of each eye and is transmitted to the left hemisphere. Input from the left visual field (a picture of a hammer in this example) strikes the right side of each eye and is transmitted to the right hemisphere.

Normally, the hemispheres share the information from the two halves of the visual field, but in split-brain patients, the corpus callosum is severed, and the two hemispheres cannot communicate. Hence, the experimenter can present a visual stimulus to just one hemisphere at a time.

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The **endocrine system** consists of glands that secrete chemicals – known as **hormones** – into the bloodstream that help control bodily functioning.

Some hormones are released in response to changing conditions in the body and act to regulate those conditions.

Hormones are secreted by the endocrine glands in a pulsatile manner – that is, several times per day in brief bursts or pulses. The levels of many hormones increase to a certain level, then signals are sent to the hypothalamus or other endocrine glands to stop secretion of that hormone – a negative feedback system.

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Much of the endocrine system is controlled by the nervous system through the hypothalamus, which also connects with the **pituitary gland**. The pituitary gland stimulates actions in the other endocrine glands. For example, in the fight or flight response, the hypothalamus sends signals through the pituitary gland and autonomic nervous system to the adrenal glands, which then secrete stress hormones.

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Every cell in your body contains information from your parents, found on the chromosomes that lie within the nucleus of each cell.

Each **chromosome** contains thousands of **genes**, which also occur in pairs. Sometimes a member of a pair has a louder voice, always expressing itself and masking the other member of the pair - this is a dominant gene. A recessive gene is one that is masked when the paired genes are different.

When a person has two genes in a specific pair that are the same, the person is **homozygous** for that trait. If the genes are different, they are **heterozygous**.

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Family studies, twin studies, and adoption studies are assess the impact of heredity on behavior.

Family studies and twin studies focus on genetic relatedness and how it affects various traits in order to study the influence of nature on behavior.

Adoption studies are able to assess the influences of both nature and nurture, as adopted children's traits can be evaluated in relation to both their biological and adoptive parents.

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Leading behavioral genetics research in the last decade shows repeatedly that heredity (nature) and the environment (nurture) jointly influence most of our behavior.

The emergent field of **epigenetics** further demonstrates that genetic and environmental factors are inextricably intertwined.

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Evolutionary Theory, based on the work of Charles Darwin who wrote The Origin of Species in 1859 sparked a great deal of controversy, and continues to do so yet today.

It is based on the principle of natural selection that suggests that heritable traits that provide a survival or reproductive advantage are more likely than alternative traits to be passed on to offspring and thus they come to be “selected” over time.

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The behavior that helps this grasshopper hide from predators is a product of evolution, just like the physical characteristics that help it blend in with its surroundings.