IV. Development

Life is a series of changes. Beginning as tiny, two-celled organisms, people eventually become babies, children, teenagers, and adults. Countless new skills, both simple and complicated, accompany each new stage. Babies learn how to smile and laugh, children learn how to count and spell, and college students learn how to set their own schedules and wash their own clothes.

All the changes that mark our lives make up a process called development, which is the series of age-related changes that happen over the course of a life span. Many factors influence development, including genes, parental upbringing, parents' educational and economic backgrounds, and life experiences. Even historical events over which we have no control can influence our development.

A) Theories of Development

Development is the series of age-related changes that happen over the course of a life span. Several famous psychologists, including **Sigmund Freud**, **Erik Erikson**, **Jean Piaget**, and **Lawrence Kohlberg**, describe development as a series of stages. A **stage** is a period in development in which people exhibit typical behavior patterns and establish particular capacities. The various stage theories share three assumptions:

1. People pass through stages in a specific order, with each stage building on capacities developed in the previous stage.
2. Stages are related to age.
3. Development is discontinuous, with qualitatively different capacities emerging in each stage.

Sigmund Freud's Theory of Personality

The Austrian psychiatrist Sigmund Freud first described personality development as a series of stages. Of these stages, Freud believed that early childhood was the most important. He believed that personality developed by about the age of five.

Freud's theory of personality development is described in more detail on pages 268-–273 of Chapter 13, "Personality."

Erik Erikson's Theory of Psychosocial Development

Like Freud, Erik Erikson believed in the importance of early childhood. However, Erikson believed that personality development happens over the entire course of a person's life. In the early 1960s, Erikson proposed a theory that describes eight distinct stages of development. According to Erikson, in each stage people face new challenges, and the stage's outcome depends on how people handle these challenges. Erikson named the stages according to these possible outcomes:

Stage 1: Trust vs. Mistrust

In the first year after birth, babies depend completely on adults for basic needs such as food, comfort, and warmth. If the caretakers meet these needs reliably, the babies become attached and develop a sense of security. Otherwise, they may develop a mistrustful, insecure attitude.

Stage 2: Autonomy vs. Shame and Doubt

Between the ages of one and three, toddlers start to gain independence and learn skills such as toilet training, feeding themselves, and dressing themselves. Depending on how they face these challenges, toddlers can develop a sense of autonomy or a sense of doubt and shame about themselves.

Stage 3: Initiative vs. Guilt

Between the ages of three and six, children must learn to control their impulses and act in a socially responsible way. If they can do this effectively, children become more self- confident. If not, they may develop a strong sense of guilt.

Stage 4: Industry vs. Inferiority

Between the ages of six and twelve, children compete with peers in school and prepare to take on adult roles. They end this stage with either a sense of competence or a sense of inferiority.

Stage 5: Identity vs. Role Confusion

During adolescence, which is the period between puberty and adulthood, children try to determine their identity and their direction in life. Depending on their success, they either acquire a sense of identity or remain uncertain about their roles in life.

Stage 6: Intimacy vs. Isolation

In young adulthood, people face the challenge of developing intimate relationships with others. If they do not succeed, they may become isolated and lonely.

Stage 7: Generativity vs. Self-Absorption

As people reach middle adulthood, they work to become productive members of society, either through parenting or through their jobs. If they fail, they become overly self-absorbed.

Stage 8: Integrity vs. Despair

In old age, people examine their lives. They may either have a sense of contentment or be disappointed about their lives and fearful of the future.

Erikson's theory is useful because it addresses both personality stability and personality change. To some degree, personality is stable, because childhood experiences influence people even as adults. However, personality also changes and develops over the life span as people face new challenges. The problem with Erikson's theory, as with many stage theories of development, is that he describes only a typical pattern. The theory doesn't acknowledge the many differences among individuals.

Erikson's Theory of Psychosocial Development

Stage	Conflict Faced	Typical Age Range	Major Challenge(s)
1	Trust vs. mistrust	First year of life	Having basic needs met, attaching to people
2	Autonomy vs. shame and doubt	1–3 years	Gaining independence
3	Initiative vs. guilt	3–6 years	Acting in a socially responsible way
4	Industry vs. inferiority	6–12 years	Competing with peers, preparing for adult roles
5	Identity vs. role confusion	Adolescence	Determining one's identity
6	Intimacy vs. isolation	Early adulthood	Developing intimate relationships
7	Generativity vs. self-absorption	Middle adulthood	Being productive
8	Integrity vs. despair	Old age	Evaluating one's life

Piaget's Theory of Cognitive Development

While conducting intelligence tests on children, Swiss psychologist Jean Piaget began to investigate how children think. According to Piaget, children's thought processes change as they mature physically and interact with the world around them. Piaget believed children develop **schema**, or mental models, to represent the world. As children learn, they expand and modify their schema through the processes of assimilation and accommodation. **Assimilation** is the broadening of an existing schema to include new information. **Accommodation** is the modification of a schema as new information is incorporated.

Example:

Suppose a young boy knows his pet parrot is a bird. When he sees a robin outside and calls it a bird too, he exhibits assimilation, since he broadened his bird schema to include characteristics of both parrots and robins. His bird schema might be "all things that fly." Now suppose a bat flaps out at him one night and he shrieks, "Bird!" If he learns it was a bat that startled him, he'll have to modify his bird schema to "things that fly and have feathers." In modifying his definition, he enacts accommodation.

Piaget proposed that children go through four stages of cognitive development:

Stage 1: Sensorimotor Period

In this stage, which lasts from birth to roughly two years, children learn by using their senses and moving around. By the end of the sensorimotor period, children become capable of **symbolic thought**, which means they can represent objects in terms of mental symbols. More important, children achieve object permanence in this stage.**Object permanence** is the ability to recognize that an object can exist even when it's no longer perceived or in one's sight.

Example:

If a three-month-old baby sees a ball, she'll probably be fascinated by it. But if someone hides the ball, the baby won't show any interest in looking for it. For a very young child, out of sight is literally out of mind. When the baby is older and has acquired object permanence, she will start to look for things that are hidden because she will know that things can exist even when they can't be seen.

Stage 2: Preoperational Period

This stage lasts from about two to seven years of age. During this stage, children get better at symbolic thought, but they can't yet reason. According to Piaget, children aren't capable of conservation during this stage. **Conservation** is the ability to recognize that measurable physical features of objects, such as length, area, and volume, can be the same even when objects appear different.

Example:

Suppose a researcher gives a three-year-old girl two full bottles of juice. The girl will agree that they both contain the same amount of juice. But if the researcher pours the contents of one bottle into a short, fat tumbler, the girl will then say that the bottle has more. She doesn't realize that the same volume of juice is conserved in the tumbler.

Piaget argued that children are not capable of conservation during the preoperational stage because of three weaknesses in the way they think. He called these weaknesses**centration**, **irreversibility**, and **egocentrism**:

- **Centration** is the tendency to focus on one aspect of a problem and ignore other key aspects. In the example above, the three-year-old looks only at the higher juice level in the bottle and ignores the fact that the bottle is narrower than the tumbler. Because of centration, children in the preoperational stage cannot carry out **hierarchical classification**, which means they can't classify things according to more than one level.
- **Irreversibility** is the inability to mentally reverse an operation. In the example, the three-year-old can't imagine pouring the juice from the tumbler back into the bottle. If she poured the juice back, she'd understand that the tumbler holds the same amount of liquid as the bottle.
- **Egocentrism** is the inability to take someone else's point of view. **Animism**, or the belief that even inanimate objects are living, results from egocentrism. Children assume that since they are alive, all other things must be too.

Talking Tables and Dancing Dishwashers

Animism explains the popularity of children's movies featuring characters such as talking vegetables or singing candlesticks. Young children can readily believe that objects around them are alive, which means they can be entertained by stories involving living objects. Children and adolescents past the age of seven generally lose interest in heroic toasters and prefer stories about people.

Stage 3: Concrete Operational Period

From the age of seven to about eleven, children become capable of performing mental operations or working through problems and ideas in their minds. However, they can perform operations only on tangible objects and real events. Children also achieve conservation, reversibility, and decentration during this stage:

- **Reversibility** is the ability to mentally reverse actions.
- **Decentration** is the ability to focus simultaneously on several aspects of a problem.

Furthermore, children become less egocentric during this stage as they start to consider simultaneously different ways of looking at a problem.

Stage 4: Formal Operational Period

In this stage, which begins around eleven years of age and continues through adulthood, children become capable of applying mental operations to abstract concepts. They can imagine and reason about hypothetical situations. From this point on, people start to think in abstract, systematic, and logical ways.

Critiques of Piaget's Theories

Although Piaget made important contributions to the research on cognitive development, his theory has come under attack for several reasons:

- Recent research has shown that he greatly underestimated children's capabilities. For example, researchers have shown that babies achieve object permanence much sooner than Piaget said they do.
- Children sometimes simultaneously develop skills that are characteristic of more than one stage, which makes the idea of stages seem less viable.
- Piaget ignored cultural influences. Research has shown that children from different cultures tend to go through Piaget's stages in the same order, but the timing and length of stages vary from culture to culture.
- Some people never develop the capacity for formal reasoning, even as adults.

Piaget's Theory of Cognitive Development

	Stage	Age	Important Features
1	Sensorimotor	First two years of life	Object permanence, symbolic thought
2	Preoperational	2–7 years	Centration, irreversibility, egocentrism, and animism
3	Concrete operational	7–11 years	Reversibility, decentration, decrease in egocentrism, conservation
4	Formal operational	11 through adulthood	Abstract thought

Kohlberg's Theory of Moral Development

Lawrence Kohlberg focused on **moral reasoning**, or why people think the way they do about right and wrong. Influenced by Piaget, who believed that moral reasoning depends on the level of cognitive development, Kohlberg proposed that people pass through three levels of moral development. He divided each level into two stages.

Level 1: The Preconventional Level

At this level, children ascribe great importance to the authority of adults. For children in the first stage of this level, an action is wrong if it's punished, whereas in the second stage, an action is right if it's rewarded.

Level 2: The Conventional Level

In the next level, children value rules, which they follow in order to get approval from others. In the first stage of this level, children want the approval only of people who are close to them. In the second stage, children become more concerned with the rules of the broader society.

Level 3: The Postconventional Level

In the final level, people become more flexible and consider what's personally important to them. In the first stage of this level, people still want to follow society's rules, but they don't see those rules as absolute. In the second stage, people figure out right and wrong for themselves, based on abstract ethical principles. Only a small proportion of people reach this last stage of moral reasoning.

Critiques of Kohlberg's Theories

Research supports key parts of Kohlberg's theory. People do tend to progress in order through Kohlberg's stages, and cognitive and moral development do affect each other. However, critics of Kohlberg's theory have two main concerns:

- People often show the reasoning characteristic of several different levels simultaneously. For instance, in one situation, a person might reason as if he is at a conventional stage, and in another situation, he might use reasoning typical of a postconventional stage.
- Kohlberg's theory of moral development favors cultures that value individualism. In other cultures, highly moral people may base their reasoning on communal values rather than abstract ethical principles.

Kohlberg's Theory of Moral Development

	Level	Stage	What Determines Right and Wrong
1.	**Preconventional**	1	Punishment by adults
		2	Reward by adults
2.	**Conventional**	3	Rules set by close people
		4	Rules set by society
3.	**Postconventional**	5	Rules set by society, judged by what's personally important
		6	Rules based on abstract ethical principles

B) Prenatal Development

Development happens quickly during the **prenatal period**, which is the time between conception and birth. This period is generally divided into three stages: the germinal stage, the embryonic stage, and the fetal stage.

Stage 1: The Germinal Stage

The two-week period after conception is called the **germinal stage**. Conception occurs when a sperm cell combines with an egg cell to form a **zygote**. About thirty-six hours after conception, the zygote begins to divide quickly. The resulting ball of cells moves along the mother's fallopian tube to the uterus.

Around seven days after conception, the ball of cells starts to become embedded in the wall of the uterus. This process is called **implantation** and takes about a week to complete. If implantation fails, as is quite common, the pregnancy terminates. One key feature of the germinal stage is the formation of a tissue called the **placenta**. The placenta has two important functions:

- Passing oxygen and nutrients from the mother's blood into the embryo or fetus
- Removing waste materials from the embryo or fetus

Stage 2: The Embryonic Stage

The **embryonic stage** lasts from the end of the germinal stage to two months after conception. The developing ball of cells is now called an **embryo**. In this stage, all the major organs form, and the embryo becomes very fragile. The biggest dangers are teratogens, which are agents such as viruses, drugs, or radiation that can cause deformities in an embryo or fetus. At the end of the embryonic period, the embryo is only about an inch long.

Stage 3: The Fetal Stage

The last stage of prenatal development is the **fetal stage**, which lasts from two months after conception until birth. About one month into this stage, the sex organs of the fetus begin to form. The fetus quickly grows as bones and muscles form, and it begins to move inside the uterus. Organ systems develop further and start to function. During the last three months, the brain increases rapidly in size, an insulating layer of fat forms under the skin, and the respiratory and digestive systems start to work independently.

Fetal Viability

Around twenty-two to twenty-six weeks after conception, the fetus reaches the age of viability, after which it has some chance of surviving out-side the womb if it is born prematurely. The chances of a premature baby's survival increase significantly with each additional week it remains in the mother's uterus.

Adverse Factors Affecting Fetal Development

Although the womb provides protection, the fetus remains indirectly connected to the outside world through its mother. Several factors that are linked to the mother can harm the fetus:

- Poor nutrition
- Use of alcohol
- Smoking
- Use of certain prescription or over-the-counter drugs
- Use of recreational drugs such as cocaine, sedatives, and narcotics
- X-rays and other kinds of radiation
- Ingested toxins, such as lead
- Illnesses such as AIDS, German measles, syphilis, cholera, smallpox, mumps, or severe flu

Fetal Alcohol Syndrome

Mothers who drink heavily during pregnancy may have babies with fetal alcohol syndrome. Babies with this syndrome may have problems such as small head size, heart defects, irritability, hyperactivity, mental retardation, or slowed motor development. Fetal alcohol syndrome is incurable.

C) Infancy and Childhood

Babies come into the world with many **innate abilities**, or abilities that are present from birth. At birth, they possess motor reflexes such as the sucking reflex and the grasping reflex. Newborns can also hear, smell, touch, taste, and see, and these sensory abilities develop quickly.

Motor Development

Motor development also progresses quickly. **Motor development** is the increasing coordination of muscles that makes physical movements possible. **Developmental norms** tell us the median age at which babies develop specific behaviors and abilities. Babies often deviate a fair amount from these norms.

Researchers used to think motor skill development could be explained mostly by**maturation**, genetically programmed growth and development. According to this view, babies learn to sit up, pull themselves to a standing position, and walk at particular ages because they are hard-wired that way. However, recent research suggests that motor development isn't just a passive process. Although maturation plays a large role, babies also actively develop motor skills by moving around and exploring their environments. Both maturation and experience influence motor development.

It's Not All Maturation

Maturation plays a much greater role in the development of early motor skills, such as crawling and walking, than in development of later motor skills, such as juggling or playing basketball. The development of later motor skills depends on genetic predisposition, exposure to good teachers, and social factors.

Cultural differences also affect how quickly motor skills develop, although the timing and sequence of early motor skill development remains similar across all cultures.

Example:

In cultures where babies receive early training in sitting up, standing, and walking, they develop these skills earlier. Conversely, in other cultures, mothers carry babies most of the time, and babies develop these skills later.

Temperament

Some babies have fussy personalities, while others have chirpy or quiet natures. These differences result from **temperament**, the kind of personality features babies are born with. Researchers generally agree that temperament depends more on biological factors than on environment. In the 1970s, **Alexander Thomas** and **Stella Chess**, two researchers who study temperament, described three basic types of temperament: easy, slow to warm up, and difficult. In their research, 40 percent of the children were easy, 15 percent were slow to warm up, and 10 percent were difficult. The remaining 35 percent of the children displayed a mixture of these temperaments:

- **Easy** children tend to be happy and adapt easily to change. They have regular sleeping and eating patterns and don't upset easily.
- **Slow-to-warm-up** children tend to be less cheerful and less adaptable than easy children. They are cautious about new experiences. Their sleeping and eating patterns are less regular than those of easy children.
- **Difficult** children tend to be glum and irritable, and they dislike change. Their eating and sleeping patterns are irregular.

Attachment

Attachment is the close bond between infants and their caregivers. Researchers used to think that infants attach to people who feed them and keep them warm. However, researchers Margaret and Harry Harlow showed that attachment could not occur without contact comfort. **Contact comfort** is comfort derived from physical closeness with a caregiver.

The Harlows' Baby Monkeys

The Harlows raised orphaned baby rhesus monkeys and studied their behavior. In place of its real mother, each baby monkey had two substitute or surrogate mothers. One "mother" had a head attached to a wire frame, warming lights, and a feeding bottle. The other "mother" had the same construction except that foam rubber and terry cloth covered its wire frame. The Harlows found that although both mothers provided milk and warmth, the baby monkeys greatly preferred the cloth mother. They clung to the cloth mother even between feedings and went to it for comfort when they felt afraid.

Responsive Mothering

Psychologist **Mary Ainsworth** and her colleagues found that attachment happens through a complex set of interactions between mothers and infants. The infants of sensitive, responsive mothers have stronger attachments than the infants of insensitive mothers or mothers who respond inconsistently to their infants' needs. However, an infant's temperament also plays a role in attachment. Difficult infants who fuss, refuse to eat, and sleep irregularly tax their mothers, which makes it hard for the mothers to be properly responsive.

Attachment Styles

Ainsworth devised an experiment called the **Strange Situation** in order to study attachment behavior. She asked each mother in the sample to bring her infant to an unfamiliar room that contained various toys. After the mother and infant had spent some time in the room, a stranger entered the room and tried to play with the infant. A short while later, the mother left the room, leaving the infant with the stranger. Then the mother returned to the room, and the stranger left. A little later, the mother left the room again, briefly leaving the infant alone. Finally, the mother returned to the room.

Based on her observations of infants' behavior in the Strange Situation, Ainsworth described three types of attachment patterns:

1. **Secure attachment:** Most infants in the sample had a secure attachment to their mothers. These infants expressed unhappiness when their mothers left but still played with the stranger. When their mothers returned, the infants looked happy. The infants displayed greater attachment to their mothers than to the stranger.
2. **Anxious-ambivalent attachment:** Some infants showed a type of insecure attachment called an anxious-ambivalent attachment. These infants became upset when their mothers left but resisted contact with their mothers when they returned.
3. **Avoidant attachment:** Other infants showed a type of insecure attachment called an avoidant attachment. These infants didn't seem upset when their mothers left and avoided their mothers when they returned. Researchers did not see a significant difference in the way these infants treated their mothers and the stranger.

Culture and Attachment Style

Culture can influence attachment style because different cultures have different child-rearing practices. Ainsworth's research in the United States showed that most of her white, middle-class sample of infants had a secure attachment to their mothers. However, in Germany, where parents encourage independence from an early age, a much higher proportion of infants display an avoidant attachment, according to Ainsworth's classification. In Japan, where infants rarely separate from their mothers, the avoidant style is nonexistent, although a higher proportion of anxious-ambivalent attachments occurred than in the United States.

Separation Anxiety

Whether they are securely attached or not, most babies do experience separation anxiety. **Separation anxiety** is the emotional distress infants show when they separate from people to whom they are attached. Separation anxiety typically begins at about six to eight months of age and reaches peak intensity when an infant is about fourteen to eighteen months old.

Day Care

Controversy surrounds the question of whether or not to place children in day care. Some research has suggested that babies have a greater chance of developing insecure attachments if a nonparental figure cares for them for more than twenty hours per week. However, most of the evidence suggests that day care doesn't create poor attachment. Studies have even shown that day care can have positive effects on social development.

Gender Development

Sex isn't the same as gender. **Sex** refers to a biological distinction between males and females. An example of sex difference is the timing of puberty. Because of biological processes, girls' sexual organs mature before those of boys. **Gender** refers to a learned distinction between masculinity and femininity. An example of gender difference is girls' and boys' attitudes toward dolls. Very early on, American society teaches boys that playing with dolls is considered a girlish thing to do. **Gender stereotypes** are societal beliefs about the characteristics of males and females.

Gender Differences

Some gender differences exist, although certainly not as many as stereotypes suggest. For example, starting in preschool, gender differences arise in play behavior. Boys prefer playing with boys and girls with girls. Boys prefer to play with boyish toys like trucks and girls with girlish toys like dolls. Different people give different answers for why this is so:

- Researchers who emphasize biological differences between the sexes say that these preferences arise from biological factors such as genetics and evolution, prenatal hormones, or brain structure.
- Researchers who focus on cognitive development believe that these preferences exist because boys and girls develop different gender schemas or mental models about gender.
- Researchers who study learning think that environment produces these preferences. They point out that almost from the moment of birth, girls and boys receive different treatment. Gender preferences, these researchers say, simply reflect what society teaches children about gender.

D) Adolescence

Adolescence used to be automatically associated with trouble. Recently, however, researchers have found that adolescence is not always so difficult, even with all the changes that occur during this period.

Physical Changes

Pubescence refers to the two years before puberty. The adolescent growth spurt actually begins during pubescence, at about age eleven in girls and about age thirteen in boys. At this time, children get taller and heavier and develop secondary sex characteristics. **Secondary sex characteristics** are sex-specific physical characteristics that are not essential for reproduction. Girls develop breasts, widened pelvic bones, and wider hips. Boys develop facial hair, broader shoulders, and deeper voices.

After pubescence and at the beginning of adolescence, **puberty** occurs. Puberty is the point at which sexual organs mature. Sexual organs include the ovaries in girls and the penis and testes in boys.

Menarche, or the first menstrual period, marks the onset of puberty in girls. The average age of menarche for American girls is about twelve and a half. The beginning of**nocturnal emissions**, so-called wet dreams, marks the onset of puberty in boys. American boys typically begin to produce sperm by fourteen years of age. Girls reach full sexual maturation around age sixteen, and boys reach sexual maturity at around eighteen.

Earlier Onset of Puberty

Girls and boys in the United States reach puberty earlier now than they did a few generations ago, possibly because nutrition and medical care have changed over the years. In Western Europe and the United States, girls have their first menstrual periods at around age twelve or thirteen. In poorer regions of Africa, which lack proper nutrition and health care, girls may not begin to menstruate until they are between the ages of fourteen and seventeen.

Varying Maturation Rates

Puberty occurs at different rates for different people. In girls, puberty usually happens between ages ten and fifteen and in boys between ages eleven and sixteen. Early or late maturation can have the following consequences:

- Early-maturing girls and late-maturing boys tend to have more psychological and social problems than their peers.
- In girls, a correlation exists between early maturation and poorer school performance, earlier sexual activity, more unwanted pregnancies, and a higher likelihood of eating disorders.
- Both boys and girls who mature early use more alcohol and drugs and have more problems with the law than their peers.

Identity

As Erik Erikson pointed out, the search for identity marks an important step in adolescence. Adolescents may go through an identity crisis, during which they struggle to understand themselves and decide their future. The psychologist **James Marcia**described four identity states, based on where people stand on the path to identity:

- **Identity foreclosure** happens when a person prematurely commits to values or roles that others prescribe.
- **Identity moratorium** happens when a person delays commitment to an identity. He or she may experiment with various values and roles.
- **Identity diffusion** occurs when a person lacks a clear sense of identity but still hasn't explored issues related to identity development.
- **Identity achievement** occurs when a person considers alternative possibilities and commits to a certain identity and path in life.

E) Adulthood

Certain experiences tend to occur in adulthood, including:

- Marriage
- Parenthood
- The empty nest
- The midlife crisis
- Menopause (for women)
- Aging

Not all adults go through all these experiences, and the timing of particular experiences can vary greatly from person to person. However, average ages for major life events do exist. **Social clocks** indicate the typical life events, behaviors, and issues for a particular age. Each culture and historical period has a specific social clock. A middle-class white woman living in contemporary U.S. culture may be "off time" for motherhood if she had her first child at age fifteen. In another cultural context or another historical period, however, motherhood at age fifteen may have been "on time."

A **midlife crisis** is a time of doubt and anxiety in middle adulthood. Research suggests, however, that midlife crises don't automatically happen when people reach middle age. The **empty nest** refers to the time in parents' lives when their children have grown up and left home. Parents who have other roles in addition to parenting usually find this period less difficult.

Menopause is the gradual, permanent cessation of menstruation and usually begins between ages forty-five and fifty-five. Though many women suffer uncomfortable physical symptoms during menopause, such as hot flashes, emotional reactions to menopause are far from universal: many women have strong emotional reactions, while just as many others may not. Though men don't experience menopause, they do experience a gradual decline in testosterone production and sperm count as they age.

Aging

Researchers now know quite a bit about the process of growing old. Some abilities and functions decline:

- As people age, they usually lose neurons in the brain, but this loss rarely causes problems such as **dementia**, which is a condition characterized by several significant psychological deficits.
- Vision and hearing tend to decline as people grow older.
- Some aspects of memory decrease in old age. This results from a decline in the speed of mental processing. Decrease in memory capacity is normal and is not necessarily related to dementia.

Other abilities and functions stay the same or even improve as people age:

- **Crystallized intelligence**, which is intelligence based on a life span of knowledge and skills, remains constant or increases.
- Physical exercise and mental stimulation can form new connections between neurons in the brains of older adults.
- Most people's overall sense of well-being increases as they get older.

V. Sensation and Perception

Thanks to the nose, ears, eyes, tongue, and skin, we can imagine a day at the beach: glimmering blue sky, salty water, warm sand, and crying seagulls. Our knowledge of the world depends on the senses: vision, hearing, taste, smell, position, movement, balance, and touch. If someone bounces a basketball, our eyes and ears pick up stimuli such as light and sound waves and send neural signals to the brain. This process called sensation occurs when physical energy from objects in the world or in the body stimulates the sense organs.

However, only when the signals come together meaningfully do we actually perceive a bouncing basketball. Perception happens when the brain organizes and interprets sensory information. Sensation and perception occur together, and normally we don't distinguish between the two separate processes. We use all five of our senses and organize the information we get from them every day of our lives.

A) The Senses

Sensation is the process by which physical energy from objects in the world or in the body stimulates the sense organs. The brain interprets and organizes this sensory information in a process called **perception**. **Psychophysics** is the study of how the physical properties of stimuli relate to people's experience of stimuli. Research in psychophysics has revealed much information about the acuity of the senses.

Measuring the Senses

Psychologists assess the acuity of the senses in three ways:

1. Measuring the absolute threshold
2. Measuring the difference threshold
3. Applying signal detection theory

The **absolute threshold** is the minimum amount of stimulation required for a person to detect the stimulus 50 percent of the time. The **difference threshold** is the smallest difference in stimulation that can be detected 50 percent of the time. The difference threshold is sometimes called the **just noticeable difference** (**jnd**), and it depends on the strength of the stimulus.

Example:

If someone were comparing two weak stimuli, such as two very slightly sweet liquids, he'd be able to detect quite a small difference in the amount of sweetness. However, if he were comparing two intense stimuli, such as two extremely sweet liquids, he could detect only a much bigger difference in the amount of sweetness.

Weber's Law

Nineteenth-century psychologist Ernst Weber proposed a principle demonstrating the fact that we can't detect the difference between two stimuli unless they differ by a certain proportion and that this proportion is constant. In other words, the just noticeable difference for a stimulus is in a fixed proportion to the magnitude of a stimulus. Weber's Law holds true except in the most extreme kinds of stimulation.

Researchers use **signal detection theory** to predict when a weak signal will be detected. This theory considers the fact that the ability to detect a signal depends not only on the strength of the signal but also on the perceiver's experience, motivation, expectation, and degree of alertness. Different people respond differently to the same signal, and the same person may detect a particular signal at one time but not another. Furthermore, people can often detect one type of signal in a sensory modality such as hearing or vision but be oblivious to other types of signals in the same sensory modality.

Sensory Adaptation

When people walk into a restaurant, they probably notice food smells right away. However, as they sit in the restaurant, the smells gradually become less noticeable. This phenomenon occurs because of sensory adaptation. **Sensory adaptation** is the decrease in sensitivity to an unchanging stimulus. The smells don't disappear—the people just become less sensitive to them.

Development of the Senses

Babies have all the basic sensory abilities and many perceptual skills, but these abilities develop and grow more sensitive over time. Babies can recognize the difference between a human voice and other sounds, and they can locate a sound's origin. They can recognize the difference between smells and, very early on, can recognize their mother's particular smell. As for taste, they can differentiate between sweet and salty. Babies also have fairly adept visual abilities. Soon after birth, they can distinguish objects of different colors and sizes. When they are just a few weeks old, they begin to differentiate among contrasts, shadows, and patterns, and they can perceive depth after just a few months.

Sensitive Periods

Even innate perceptual skills need the right environment to develop properly. A lack of certain experiences during sensitive periods of development will impair a person's ability to perceive the world.

Example:

People who were born blind but regain their vision in adulthood usually find the visual world confusing. Since these adults were blind in infancy, they missed the sensory experiences necessary for their visual system to develop fully.

B) Vision

Researchers have studied **vision** more thoroughly than the other senses. Because people need sight to perform most daily activities, the sense of sight has evolved to be highly sophisticated. Vision, however, would not exist without the presence of light. **Light** is electromagnetic radiation that travels in the form of waves. Light is emitted from the sun, stars, fire, and lightbulbs. Most other objects just reflect light.

People experience light as having three features: **color**,**brightness**, and **saturation**. These three types of experiences come from three corresponding characteristics of light waves:

- The color or hue of light depends on its **wavelength**, the distance between the peaks of its waves.
- The brightness of light is related to intensity or the amount of light an object emits or reflects. Brightness depends on light **wave amplitude**, the height of light waves. Brightness is also somewhat influenced by wavelength. Yellow light tends to look brighter than reds or blues.
- Saturation or colorfulness depends on light **complexity**, the range of wavelengths in light. The color of a single wavelength is pure spectral color. Such lights are called fully saturated. Outside a laboratory, light is rarely pure or of a single wavelength. Light is usually a mixture of several different wavelengths. The greater number of spectral colors in a light, the lower the saturation. Light of mixed wavelengths looks duller or paler than pure light.

Wavelength ——> Color
Amplitude ——> Brightness
Complexity ——> Saturation

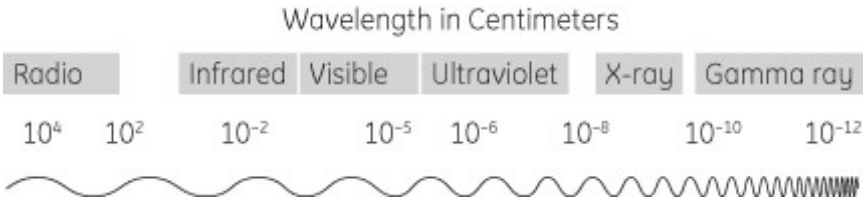
Rainbows and Lights

***White light**: Completely unsaturated. It is a mixture of all wavelengths of light.*

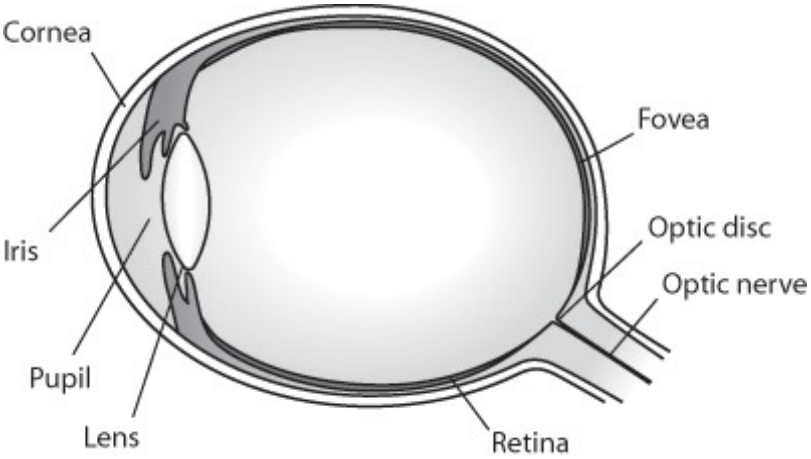
***The visible spectrum**: Includes the colors of the rainbow, which are red, orange, yellow, green, blue, indigo, and violet.*

***Ultraviolet light**: The kind of light that causes sunburns. It has a wavelength somewhat shorter than the violet light at the end of the visible spectrum.*

***Infrared radiation**: Has a wavelength somewhat longer than the red light at the other end of the visible spectrum.*



Structure of the Eye



The process of vision cannot be understood without some knowledge about the structure of the eye:

- The **cornea** is the transparent, protective outer membrane of the eye.
- The **iris**, the colored part of the eye, is a ring of muscle.
- The iris surrounds an opening called the **pupil**, which can get bigger or smaller to allow different amounts of light through the lens to the back of the eye. In bright light, the pupil contracts to restrict light intake; in dim light, the pupil expands to increase light intake.
- The **lens**, which lies behind the pupil and iris, can adjust its shape to focus light from objects that are near or far away. This process is called **accommodation**.
- Light passing through the cornea, pupil, and lens falls onto the retina at the back of the eye. The **retina** is a thin layer of neural tissue. The image that falls on the retina is always upside down.
- The center of the retina, the **fovea**, is where vision is sharpest. This explains why people look directly at an object they want to inspect. This causes the image to fall onto the fovea, where vision is clearest.

Eye Trouble

Nearsightedness is the inability to clearly see distant objects. Farsightedness is the inability to clearly see close objects. A cataract is a lens that has become opaque, resulting in impaired vision.

Rods and Cones

The retina has millions of photoreceptors called rods and cones. **Photoreceptors** are specialized cells that respond to light stimuli. There are many more rods than cones. The long, narrow cells, called **rods**, are highly sensitive to light and allow vision even in dim conditions. There are no rods in the fovea, which is why vision becomes hazy in dim light. However, the area just outside the fovea contains many rods, and these allow peripheral vision.

Because rods are so sensitive to light, in dim lighting conditions peripheral vision is sharper than direct vision.

Example:

People can often see a star in the night sky if they look a little to the side of the star instead of directly at it. Looking to the side utilizes peripheral vision and makes the image of the star fall onto the periphery of the retina, which contains most of the rods.

Cones are cone-shaped cells that can distinguish between different wavelengths of light, allowing people to see in color. Cones don't work well in dim light, however, which is why people have trouble distinguishing colors at night. The fovea has only cones, but as the distance from the fovea increases, the number of cones decreases.

Feature	Rods	Cones
Shape	Long and narrow	Cone-shaped
Sensitivity to light	High: help people to	Low: help people to see

	see in dim light	in bright light
Help color vision	No	Yes
Present in fovea	No	Yes
Abundant in periphery of retina	Yes	No
Allow peripheral vision	Yes	No

Adaptation to Light

Dark adaptation is the process by which receptor cells sensitize to light, allowing clearer vision in dim light. **Light adaptation** is the process by which receptor cells desensitize to light, allowing clearer vision in bright light.

Connection to the Optic Nerve

Rods and cones connect via synapses to bipolar neurons, which then connect to other neurons called ganglion cells. The axons of all the ganglion cells in the retina come together to make up the **optic nerve**. The optic nerve connects to the eye at a spot in the retina called the **optic disk**. The optic disk is also called the blind spot because it has no rods or cones. Any image that falls on the blind spot disappears from view.

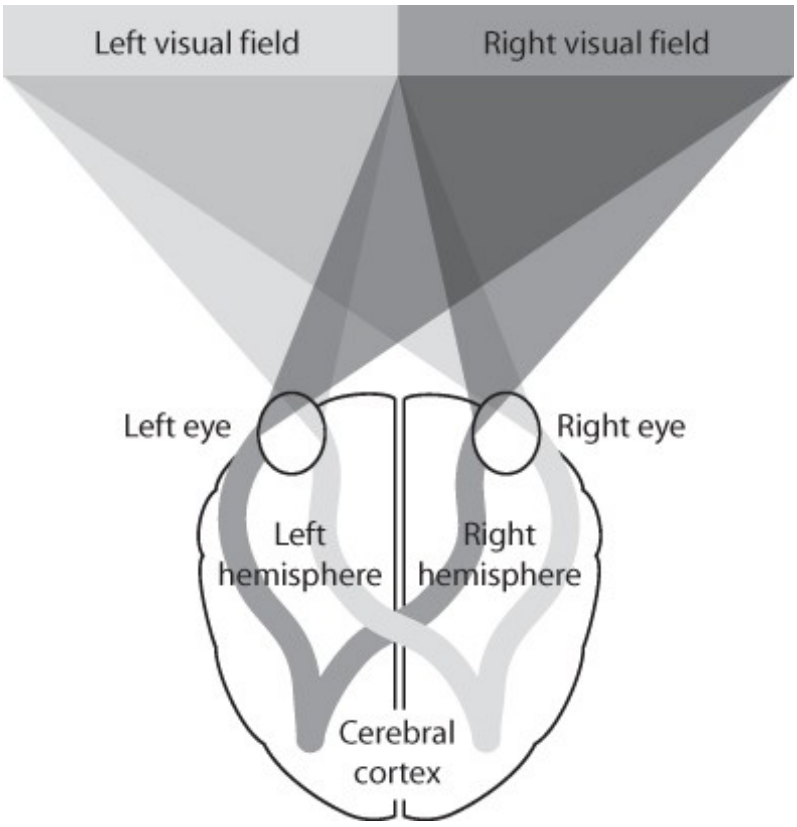
Transmission of Visual Information

Visual information travels from the eye to the brain as follows:

- Light reflected from an object hits the retina's rods and cones.
- Rods and cones send neural signals to the bipolar cells.
- Bipolar cells send signals to the ganglion cells.
- Ganglion cells send signals through the optic nerve to the brain.

Bipolar and ganglion cells gather and compress information from a large number of rods and cones. The rods and cones that send information to a particular bipolar or ganglion cell make up that cell's receptive field.

Ganglion cell axons from the inner half of each eye cross over to the opposite half of the brain. This means that each half of the brain receives signals from both eyes. Signals from the eyes' left sides go to the left side of the brain, and signals from the eyes' right sides go to the right side of the brain. The diagram below illustrates this process.



Visual Processing in the Brain

After being processed in the thalamus and different areas of the brain, visual signals eventually reach the primary visual cortex in the occipital lobe of the brain's cerebrum. In the 1960s, David Hubel and Torsten Wiesel demonstrated that highly specialized cells called **feature detectors** respond to these visual signals in the primary visual cortex. Feature detectors are neurons that respond to specific features of the environment, such as lines and edges.

From the visual cortex, visual signals often travel on to other parts of the brain, where more processing occurs. Cells deeper down the visual processing pathway are even more specialized than those in the visual cortex. Psychologists theorize that perception occurs when a large number of neurons in different parts of the brain activate. These neurons may respond to various features of the perceived object such as edges, angles, shapes, movement, brightness, and texture.

Color Vision

Objects in the world seem to be brightly colored, but they actually have no color at all. Red cars, green leaves, and blue sweaters certainly exist—but their color is a psychological experience. Objects only produce or reflect light of different wavelengths and amplitudes. Our eyes and brains then convert this light information to experiences of color. Color vision happens because of two different processes, which occur in sequence:

- The first process occurs in the retina and is explained by the trichromatic theory.
- The second process occurs in retinal ganglion cells and in cells in the thalamus and visual cortex. The opponent process theory explains this process.

These two theories are explained below.

The Trichromatic Theory

Thomas Young and **Hermann von Helmholtz** proposed the **trichromatic theory**, or**Young-Helmholtz theory**. This theory states that the retina contains three types of cones, which respond to light of three different wavelengths, corresponding to red, green, or blue. Activation of these cones in different combinations and to different degrees results in the perception of other colors.

Color Mixing

Mixing lights of different colors is called additive color mixing. This process adds wavelengths together and results in more light. Mixing paints, on the other hand, is called subtractive color mixing, a process that removes wavelengths so that there is less light. If red,

orange, yellow, green, blue, indigo, and violet light were mixed, the result would be white light. If the same color paints were mixed together, the result would be a dark, muddy color.

The trichromatic theory also accounts for **color blindness**, a hereditary condition that affects a person's ability to distinguish between colors. Most color-blind people are**dichromats**, which means they are sensitive to only two of the three wavelengths of light. Dichromats are usually insensitive either to red or green, but sometimes they cannot see blue.

The Opponent Process Theory

Ewald Hering proposed the **opponent process theory**. According to this theory, the visual system has receptors that react in opposite ways to three pairs of colors. The three pairs of colors are red versus green, blue versus yellow, and black versus white. Some receptors are activated by wavelengths corresponding to red light and are turned off by wavelengths corresponding to green light. Other receptors are activated by yellow light and turned off by blue light. Still others respond oppositely to black and white.

Opponent process theory explains why most people perceive four primary colors: red, green, blue, and yellow. If trichromatic theory alone fully explained color vision, people would perceive only three primary colors, and all other colors would be combinations of these three colors. However, most people think of yellow as primary rather than as a mixture of colors.

Opponent process theory also accounts for complementary or negative afterimages.**Afterimages** are colors perceived after other, complementary colors are removed.

Example:

If Jack stares at a picture of a red square, wavelengths corresponding to red will activate the matching receptors in his visual system. For the sake of simplicity, these matching receptors can be referred to as red receptors. Anything that makes red receptors increase firing will be seen as red, so Jack will see the square as red. Anything that decreases the firing of red receptors will be seen as green. If Jack stares at the square for a while, the red receptors will get tired out and start to fire less. Then if he looks at a blank white sheet of paper, he will see a green square. The decreased firing of the red receptors produces an experience of a green afterimage.

Form Perception

The ability to see separate objects or forms is essential to daily functioning. Suppose a girl sees a couple in the distance with their arms around each other. If she perceived them as a four-legged, two-armed, two-headed person, she'd probably be quite disturbed. People can make sense of the world because the visual system makes sensible interpretations of the information the eyes pick up.

Gestalt psychology, a school of thought that arose in Germany in the early twentieth century, explored how people organize visual information into patterns and forms. Gestalt psychologists noted that the perceived whole is sometimes more than the sum of its parts. An example of this is the **phi phenomenon**, or stroboscopic movement, which is an illusion of movement that happens when a series of images is presented very quickly, one after another.

Example:

The phi phenomenon is what gives figures and objects in movies the illusion of movement. In reality, a movie is a series of still images presented in rapid succession.

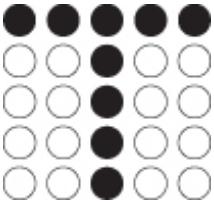
Gestalt Principles

Gestalt psychologists described several principles people use to make sense of what they see. These principles include figure and ground, proximity, closure, similarity, continuity, and simplicity:

- **Figure and ground:** One of the main ways people organize visual information is to divide what they see into figure and ground. **Figure** is what stands out, and**ground** is the background in which the figure stands. People may see an object as figure if it appears larger or brighter relative to the background. They may also see an object as figure if it differs noticeably from the background or if it moves against a static environment.
- **Proximity:** When objects lie close together, people tend to perceive the objects as a group. For example, in the graphic below, people would probably see these six figures as two groups of three.

- **Closure:** People tend to interpret familiar, incomplete forms as complete by filling in gaps. People can easily recognize the following figure as the letter *k* in spite of the gaps.

- **Similarity:** People tend to group similar objects together. In the next figure, people could probably distinguish the letter *T* because similar dots are seen as a group.



- **Continuity:** When people see interrupted lines and patterns, they tend to perceive them as being continuous by filling in gaps. The next figure is seen as a circle superimposed on a continuous line rather than two lines connected to a circle.

- **Simplicity:** People tend to perceive forms as simple, symmetrical figures rather than as irregular ones. This figure is generally seen as one triangle superimposed on another rather than a triangle with an angular piece attached to it.

Depth Perception

To figure out the location of an object, people must be able to estimate their distance from that object. Two types of cues help them to do this: binocular cues and monocular cues.

Binocular Cues

Binocular cues are cues that require both eyes. These types of cues help people to estimate the distance of nearby objects. There are two kinds of binocular cues: retinal disparity and convergence.

- **Retinal disparity** marks the difference between two images. Because the eyes lie a couple of inches apart, their retinas pick up slightly different images of objects. Retinal disparity increases as the eyes get closer to an object. The brain uses retinal disparity to estimate the distance between the viewer and the object being viewed.
- **Convergence** is when the eyes turn inward to look at an object close up. The closer the object, the more the eye muscles tense to turn the eyes inward. Information sent from the eye muscles to the brain helps to determine the distance to the object.

Monocular Cues

Monocular cues are cues that require only one eye. Several different types of monocular cues help us to estimate the distance of objects: interposition, motion parallax, relative size and clarity, texture gradient, linear perspective, and light and shadow.

- **Interposition:** When one object is blocking part of another object, the viewer sees the blocked object as being farther away.
- **Motion parallax** or **relative motion:** When the viewer is moving, stationary objects appear to move in different directions and at different speeds depending on their location. Relatively close objects appear to move backward. The closer the object, the faster it appears to move. Distant objects appear to move forward. The further away the object, the slower it appears to move.
- **Relative size:** People see objects that make a smaller image on the retina as farther away.
- **Relative clarity:** Objects that appear sharp, clear, and detailed are seen as closer than more hazy objects.
- **Texture gradient:** Smaller objects that are more thickly clustered appear farther away than objects that are spread out in space.
- **Linear perspective:** Parallel lines that converge appear far away. The more the lines converge, the greater the perceived distance.
- **Light and shadow:** Patterns of light and shadow make objects appear three-dimensional, even though images of objects on the retina are two-dimensional.

Creating Perspective

Artists use monocular cues to give a three-dimensional appearance to two-dimensional pictures. For instance, if an artist wanted to paint a landscape scene with a straight highway on it, she would show the edges of the highway as two parallel lines gradually coming together to indicate that the highway continues into the distance. If she wanted to paint cars on the highway, she would paint bigger cars if she wanted them to seem closer and smaller cars if she wanted them to seem farther away.

Perceptual Constancy

Another important ability that helps people make sense of the world is perceptual constancy. **Perceptual constancy** is the ability to recognize that an object remains the same even when it produces different images on the retina.

Example:

When a man watches his wife walk away from him, her image on his retina gets smaller and smaller, but he doesn't assume she's shrinking. When a woman holds a book in front of her face, its image is a rectangle. However, when she puts it down on the table, its image is a trapezoid. Yet she knows it's the same book.

Although perceptual constancy relates to other senses as well, visual constancy is the most studied phenomenon. Different kinds of visual constancies relate to shape, color, size, brightness, and location.

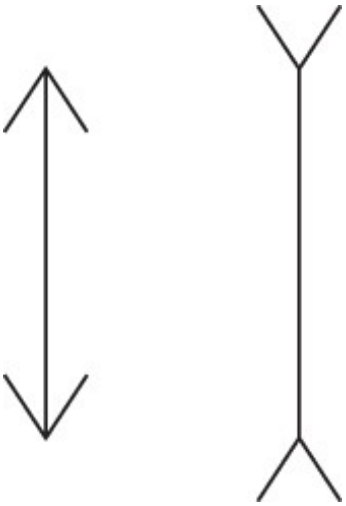
- **Shape constancy:** Objects appear to have the same shape even though they make differently shaped retinal images, depending on the viewing angle.
- **Size constancy:** Objects appear to be the same size even though their images get larger or smaller as their distance decreases or increases. Size constancy depends to some extent on familiarity with the object. For example, it is common knowledge that people don't shrink. Size constancy also depends on perceived distance. Perceived size and perceived distance are strongly related, and each influences the other.
- **Brightness constancy:** People see objects as having the same brightness even when they reflect different amounts of light as lighting conditions change.
- **Color constancy:** Different wavelengths of light are reflected from objects under different lighting conditions. Outdoors, objects reflect more light in the blue range of wavelengths, and indoors, objects reflect more light in the yellow range of wavelengths. Despite this, people see objects as having the same color whether they are outdoors or indoors because of two factors. One factor is that the eyes adapt quickly to different lighting conditions. The other is that the brain interprets the color of an object relative to the colors of nearby objects. In effect, the brain cancels out the extra blueness outdoors and the extra yellowness indoors.

- **Location constancy:** Stationary objects don't appear to move even though their images on the retina shift as the viewer moves around.

Visual Illusions

The brain uses Gestalt principles, depth perception cues, and perceptual constancies to make hypotheses about the world. However, the brain sometimes misinterprets information from the senses and makes incorrect hypotheses. The result is an optical illusion.
An **illusion** is a misinterpretation of a sensory stimulus. Illusions can occur in other senses, but most research has been done on visual illusions.

In the famous **Muller-Lyer illusion** shown here, the vertical line on the right looks longer than the line on the left, even though the two lines are actually the same length.

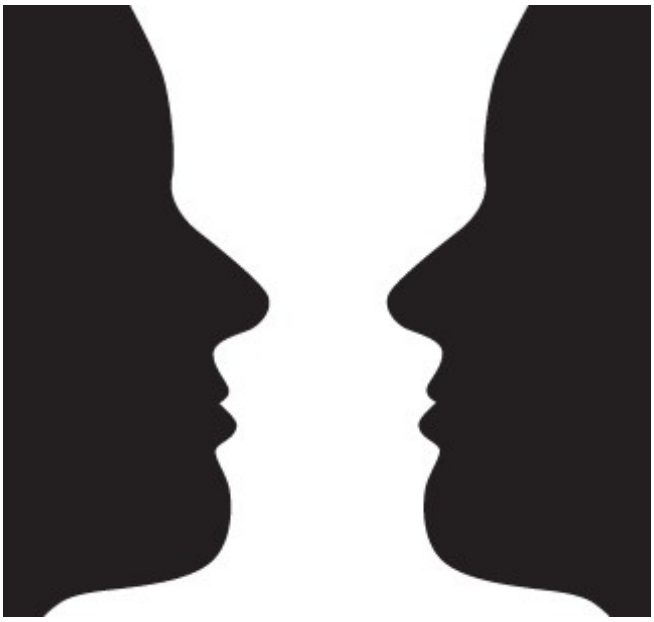


This illusion is probably due to misinterpretation of depth perception cues. Because of the attached diagonal lines, the vertical line on the left looks like the near edge of a building, and the vertical line on the right looks like the far edge of a room. The brain uses distance cues to estimate size. The retinal images of both lines are the same size, but since one appears nearer, the brain assumes that it must be smaller.

Perceptual Set

The Muller-Lyer illusion doesn't fool everyone equally. Researchers have found that people who live in cities experience a stronger illusion than people who live in forests. In other words, city-dwelling people see the lines as more different in size. This could be because buildings and rooms surround city dwellers, which prepares them to see the lines as inside and outside edges of buildings. The difference in the strength of the illusion could also be due to variations in the amount of experience people have with making three-dimensional interpretations of two-dimensional drawings.

Cultural differences in the tendency to see illusions illustrate the importance of perceptual set. **Perceptual set** is the readiness to see objects in a particular way based on expectations, experiences, emotions, and assumptions. Perceptual set influences our everyday perceptions and how we perceive **reversible figures**, which are ambiguous drawings that can be interpreted in more than one way. For example, people might see a vase or two faces in this famous figure, depending on what they're led to expect.



Selective Attention

Reversible figures also illustrate the concept of **selective attention**, the ability to focus on some bits of sensory information and ignore others. When people focus on the white part of the figure, they see a vase, and when they focus on the black part of it, they see two faces. To use the language of Gestalt psychology, people can choose to make the vase figure and the face ground or vice versa.

Selective attention allows people to carry on day-to-day activities without being overwhelmed by sensory information. Reading a book would be impossible if the reader paid attention to not only the words on the page but also all the things in his peripheral vision, all the sounds around him, all the smells in the air, all the information his brain gets about his body position, air pressure, temperature, and so on. He wouldn't get very far with the book.

Context Effects

Another factor that influences perception is the context of the perceiver. People's immediate surroundings create expectations that make them see in particular ways.

Example:

The figure below can be seen either as a sequence of letters, A B C, or a sequence of numbers, 12 13 14, depending on whether it is scanned across or down.

C) Hearing

Hearing, or audition, depends on the presence of sound waves, which travel much more slowly than light waves. **Sound waves** are changes in pressure generated by vibrating molecules. The physical characteristics of sound waves influence the three psychological features of sound: loudness, pitch, and timbre.

- Loudness depends on the **amplitude**,or height, of sound waves. The greater the amplitude, the louder the sound perceived. Amplitude is measured in decibels. The absolute threshold of human hearing is defined as 0 decibels. Loudness doubles with every 10-decibel increase in amplitude.

A Whisper to a Scream

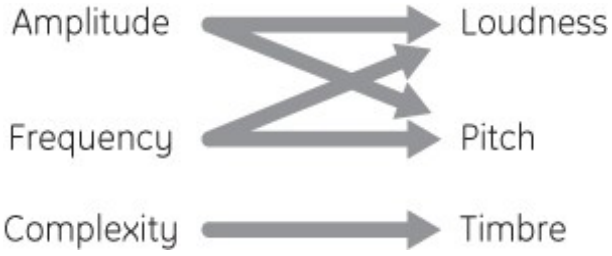
The loudness of normal human conversation is about sixty decibels. A whisper is about twenty decibels. A shout right into someone's ear is about 115 decibels. Being exposed to sounds that are over 120 decibels, even for brief periods, can damage the auditory system.

- Pitch, though influenced by amplitude, depends most on the frequency of sound waves. **Frequency** is the number of times per second a sound wave cycles from the highest to the lowest point.The higher the frequency, the higher the pitch. Frequency is measured in hertz, or cycles per second. Frequency also affects loudness, with higher-pitched sounds being perceived as louder. Amplitude and frequency of sound waves interact to produce the experiences of loudness and pitch.

What's Audible?

Humans can hear sounds that are between 20 and 20,000 hertz.

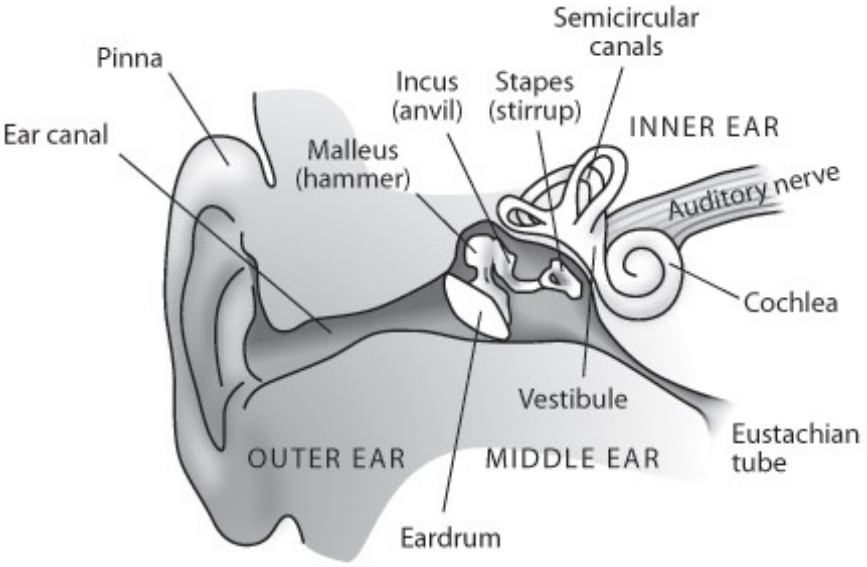
- **Timbre**, or the particular quality of a sound, depends on the **complexity** of a sound wave. A pure tone has sound waves of only one frequency. Most sound waves are a mixture of different frequencies.



The Structure of the Ear

Knowing the basic structure of the ear is essential to understanding how hearing works. The ear has three basic parts: the outer ear, the middle ear, and the inner ear.

The visible part of the ear is the **pinna**, which collects sound waves and passes them along the auditory canal to a membrane called the eardrum. When sound waves hit the eardrum, it vibrates. The eardrum transmits the vibration to three bones, or**ossicles**, in the middle ear, which are called the hammer, the anvil, and the stirrup. The diagram of the ear shows how they got these names: they actually look like a hammer, an anvil, and a stirrup. In response to the vibration, these ossicles move one after another. Their function is to amplify the sound vibrations.



From the ossicles, vibrations move through a membrane called the oval window to the cochlea of the inner ear. The **cochlea** is a coiled, fluid-filled tunnel.

Inside the cochlea are receptors called **cilia** or hair cells that are embedded in the**basilar membrane**. The basilar membrane runs along the whole length of the coiled cochlea. Vibrations that reach the inner ear cause the fluid in the cochlea to move in waves. These waves in turn make the hair cells move.

The movement triggers impulses in neurons that connect with the hair cells. The axons of these neurons come together to form the **auditory nerve**, which sends impulses from the ear to the brain. In the brain, the thalamus and the auditory cortex, which is in the temporal lobe of the cerebrum, receive auditory information.

Pitch Perception

Two theories explain how people distinguish the pitch of different sounds: place theory and frequency theory.

Place theory explains how people discriminate high-pitched sounds that have a frequency greater than 5000 Hz. Place theory states that sound waves of different frequencies trigger receptors at different places on the basilar membrane. The brain figures out the pitch of the sound by detecting the position of the hair cells that sent the neural signal.

Frequency theory explains how people discriminate low-pitched sounds that have a frequency below 1000 Hz. According to frequency theory, sound waves of different frequencies make the whole basilar membrane vibrate at different rates and therefore cause neural impulses to be sent at different rates. Pitch is determined by how fast neural signals move along to the brain.

The detection of moderately pitched sounds, with a frequency between 1000 and 5000 Hz, is explained by both place theory and frequency theory. To discriminate among these sounds, the brain uses a code based both on where the neural impulses originated and how quickly neural impulses move.

Locating Sounds

In the same way that people use two eyes to perceive depth, people use two ears to locate the origin of sounds. The left ear receives sound waves coming from the left slightly faster than the right ear does. The signal received by the left ear may also be a little more intense than that received in the right ear, because the signal has to go around the head to enter the right ear.

Locating a sound is difficult if both ears receive a signal of exactly the same intensity at exactly the same time, as when a sound originates from directly in front, directly behind, or directly above. Turning the head or cocking it to one side can help circumvent this difficulty.

D) Taste and Smell

Taste and smell are chemical senses. As light waves stimulate vision and sound waves stimulate sound, chemicals stimulate taste and smell.

Taste

Taste, or gustation, happens when chemicals stimulate receptors in the tongue and throat, on the inside of the cheeks, and on the roof of the mouth. These receptors are inside taste buds, which in turn are inside little bumps on the skin called **papillae**. Taste receptors have a short life span and are replaced about every ten days.

For a long time, researchers believed in the existence of four tastes: salty, sweet, sour, and bitter. Recently, researchers have suggested the presence of a fifth taste called umami. The spice monosodium glutamate (MSG) has an umami taste, as do many protein-rich foods. Taste is also strongly influenced by smell.

Smell

Smell, or olfaction, happens when chemicals in the air enter the nose during the breathing process. Smell receptors lie in the top of the nasal passage. They send impulses along the olfactory nerve to the olfactory bulb at the base of the brain. Researchers theorize that there are a great many types of olfactory receptors. People perceive particular smells when different combinations of receptors are stimulated.

Remembrance of Smells Past

The sense of smell is closely connected with memory. Most people have had the experience of smelling something, maybe a certain perfume or spice, and suddenly experiencing a strong emotional memory. Researchers don't know exactly why this happens, but they theorize that smell and memory trigger each other because they are processed in neighboring regions of the brain.

E) Position, Movement, and Balance

Kinesthesis is the sense of the position and movement of body parts. Through kinesthesis, people know where all the parts of their bodies are and how they are moving. Receptors for kinesthesis are located in the muscles, joints, and tendons.

The sense of balance or equilibrium provides information about where the body exists in space. The sense of balance tells people whether they are standing up, falling in an elevator, or riding a roller coaster. The sensory system involved in balance is called the **vestibular system**. The main structures in the vestibular system are three fluid-filled tubes called**semicircular canals**, which are located in the inner ear. As the head moves, the fluid in the semicircular canals moves too, stimulating receptors called hair cells, which then send impulses to the brain.

F) Touch

The sense of touch is really a collection of several senses, encompassing pressure, pain, cold, and warmth. The senses of itch and tickle are related to pressure, and burn injuries are related to pain. Touch receptors are stimulated by mechanical, chemical, and thermal energy.

Pressure seems to be the only kind of touch sense that has specific receptors.

The Gate-Control Theory of Pain

Researchers don't completely understand the mechanics of pain, although they do know that processes in the injured part of the body and processes in the brain both play a role.

In the 1960s, **Ronald Melzack** and **Patrick Wall**proposed an important theory about pain called the gate-control theory of pain. **Gate-control theory** states that pain signals traveling from the body to the brain must go through a gate in the spinal cord. If the gate is closed, pain signals can't reach the brain. The gate isn't a physical structure like a fence gate, but rather a pattern of neural activity that either stops pain signals or allows them to pass. Signals from the brain can open or shut the gate. For example, focusing on pain tends to increase it, whereas ignoring the pain tends to decrease it. Other signals from the skin senses can also close the gate. This process explains why massage, ice, and heat relieve pain.

VI. States of Consciousness

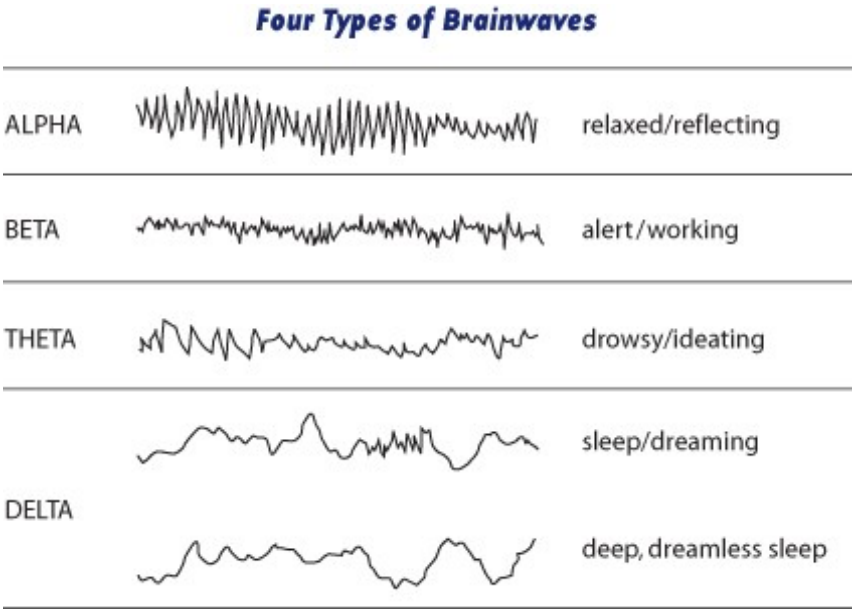
When we sunbathe on a warm day, we notice sensations outside our body, such as the sun shining down, as well as sensations within our body, such as relaxed muscles. Beyond this basic awareness, we are also conscious of ourselves having these experiences. Psychologists define consciousness as the awareness we have of ourselves and our environment.

Consciousness is not static: experiences constantly move in and out of our awareness as our states of mind and environments change. If we fall asleep while sunbathing, we may dream and experience thoughts, feelings, and unconscious desires that aren't always present in our waking state. Drugs and alcohol can also alter consciousness. Alcohol makes us less conscious of our physical sensations and less inhibited, and drugs such as LSD can alter consciousness even more dramatically. Our level of consciousness is, in many ways, both within and out of our control.

A) Consciousness

Consciousness is the awareness we have of ourselves and our environment. Different states of consciousness are associated with different patterns of brain waves. **Brain waves**are tracings of electrical activity that is going on in the brain. Scientists record brain waves using an **electroencephalograph (EEG)**, which monitors electrical activity through electrodes placed on the scalp. There are four main types of brain waves: **alpha**, **beta**,**theta**, and **delta**.

Type of Brain Wave	Corresponding Mental State
Alpha	Very relaxed or meditating
Beta	Awake and alert
Theta	Lightly asleep
Delta	Deeply asleep



B) Sleep

Sleep is just one of many types of consciousness we experience, and sleep itself comprises several states of consciousness. Even when we're sleeping, our brains and bodies continue to work.

Biological Rhythms

Sleep is affected by biological rhythms or periodic physiological changes. Biological rhythms are regular, periodic changes in a body's functioning. There are three types of biological rhythms:

- **Circadian rhythms:** biological cycles that occur about every twenty-four hours. Sleep follows a circadian rhythm. Hormone secretion, blood pressure, body temperature, and urine production also have circadian rhythms.
- **Infradian rhythms:** biological cycles that take longer than twenty-four hours. For example, women's menstrual cycles occur about every twenty-eight days.
- **Ultradian rhythms:** biological cycles that occur more than once a day. Sleep follows an ultradian rhythm of about ninety minutes as well as a circadian rhythm. Alertness and hormone levels also follow ultradian rhythms.

Biological rhythms usually synchronize with environmental events such as changes in daylight. However, experiments have shown that many biological rhythms continue to have the same cycle even without cues from the environment. Such biological rhythms are **endogenous**, which means that they originate from inside the body rather than depend on outside cues.

Biological Clocks

Endogenous rhythms exist because the body has biological clocks that keep time. Biological clocks can be adjusted by environmental cues, such as changes in temperature.

In humans, the **suprachiasmatic nucleus (SCN)** is the main biological clock that regulates circadian rhythms of sleep. The SCN lies in the brain's hypothalamus. When light stimulates receptors in the retina of the eye, the receptors send signals to the SCN. The SCN then sends signals to the nearby **pineal gland**, which secretes **melatonin**, a hormone that regulates the sleep cycle.

Jet Lag

Jet lag is the fatigue and disorientation air travelers feel after a long flight. Although traveling itself drains energy, the time change also contributes to fatigue. People experience jet lag when the events in their environment are out of sync with their biological clocks.

Example:

A traveler leaves New York City at eight in the morning and arrives in London about seven hours later. For her, it's three in the afternoon, but because of the time change, in London it's eight in the evening. Her body, thinking it's mid-afternoon, will be confused by the lack of sunlight, and she'll experience jet lag.

The Function of Sleep

Although everyone sleeps, no one really knows *why* people sleep. Researchers have proposed several theories to explain how sleep evolved to be a necessary behavior:

- People conserve energy by sleeping periodically.
- Sleep has a protective function, as it keeps people tucked away at night, safe from predators.
- Sleep restores body tissues that are depleted during daily activities.

Sleep Research

Sleep research has provided a lot of information about what happens to the brain and body during sleep. Researchers study sleep by monitoring subjects who spend the night in labs, and they use various instruments for different purposes:

- **Electroencephalographs (EEGs):** record brain waves
- **Electromyographs (EMGs):** record muscle activity
- **Electrooculographs (EOGs):** record eye movements
- **Electrocardiographs (EKGs):** record the activity of the heart

Other instruments monitor breathing, body temperature, and pulse.

Sleep Stages

During one night's sleep, people pass through several cycles of sleep, each lasting about ninety to one hundred minutes. There are five distinct stages of sleep in each cycle: 1, 2, 3, 4, and REM.

Stages 1–4

When people are relaxed and ready to fall asleep, their EEG will show mostly alpha waves. When people fall asleep, they enter into stage 1 sleep, which lasts just a few minutes. In stage 1, the EEG shows mostly theta waves. Heart rate, breathing rate, and body temperature drop, and muscles relax. Fantasies or bizarre images may float around in the mind.

After a few minutes of stage 1 sleep, people move into stage 2 sleep. Stage 2 lasts about twenty minutes and is characterized by short bursts of brain waves called **sleep spindles**. People then pass into slow-wave sleep, which occurs during stages 3 and 4. In stages 3 and 4, which together last about thirty minutes, the EEG displays mostly delta waves. People in stage 3 and 4 sleep show slow breathing and pulse rates, have limp muscles, and are difficult to rouse.

Sleepwalking

Most people in stage 4 sleep are still, quiet, and difficult to rouse. Sleepwalkers, however, sometimes become physically active during stage 4. They may get up and walk around their room or even carry on a conversation, take a bath, cook, or go outside and get in their car. Because they are in a deep sleep, most sleepwalkers remember nothing of their actions when they wake up.

REM Sleep

At the end of stage 4, people go back through the stages in reverse, from stage 4 to 3 to 2 to 1. When they reach stage 1, instead of waking up, people go into REM, or rapid eye movement, sleep. A single cycle might look like this:

1	2	3	4	3	2	REM

REM sleep is a stage of deep sleep in which, paradoxically, brain wave activity resembles that of an alert person. REM sleep is also called paradoxical sleep.

During REM sleep, pulse rate and breathing become irregular, eyes move rapidly under closed lids, and muscles remain very relaxed. Genital arousal also happens during REM. In women, the clitoris becomes swollen with blood, and vaginal lubrication increases. In men, the penis becomes erect. EEGs show mostly beta waves during REM sleep. Although dreaming happens in other sleep stages as well, dreams are most vivid and frequent during REM sleep.

People typically go through about four sleep cycles during one night of sleep. The REM stage of sleep gets longer and longer as the night passes, while stage 3 and 4 sleep gets shorter and shorter. During the night's first sleep cycle, the REM stage lasts about ten minutes. During the night's last sleep cycle, people may spend about forty to sixty minutes in REM sleep. Non-REM sleep becomes more shallow as the night goes on, and eventually the sleeper awakens.

Sleep Deprivation

Different people need different amounts of sleep. Some people can function with fewer than six hours of sleep a night, while others can't manage without at least nine hours. Research shows that getting insufficient sleep can have negative effects on health, productivity, and performance.

Researchers have also studied the effects of insufficient REM sleep. Experiment subjects who are intentionally deprived of REM sleep tend to enter the REM stage of sleep more and more frequently during the night. After an REM-deprivation experiment has ended, subjects usually experience a **REM rebound** effect, spending more time in the REM stage on subsequent nights to make up for lost REM time.

Aging and Sleep

Sleep patterns change as people get older. Newborn babies spend about two-thirds of their time in sleep. As people age, they tend to sleep less. The amount of time spent in REM sleep also changes over time. In very young babies, about half of all sleep is REM sleep. As babies get older, the proportion of REM sleep decreases.

Sleep Disorders

Everyone has occasional difficulty sleeping, but some people have **insomnia**, a chronic problem with falling or staying asleep. Another kind of sleep disorder is **narcolepsy**, which is a tendency to fall asleep periodically during the day. Narcolepsy can be dangerous, as people who experience it may fall asleep while driving or operating machinery.

Sleep apnea is another condition that can have negative effects on health and safety. People who have **sleep apnea** stop breathing many times during a night's sleep, and each time they stop breathing, they wake up briefly and gasp for air. This prevents them from getting enough deep sleep, which leads to irritability and sleepiness during the day. Chronic sleep apnea can also result in high blood pressure.

C) Dreams

The function of dreams is as much a mystery as the function of sleep.

Freud's Dream Theory

Psychoanalyst **Sigmund Freud** believed that dreams allow people to express unconscious wishes they find unacceptable in real life. He drew a distinction between the manifest content and the latent content of dreams. The **manifest content** is the plot of the dream: who's in the dream, what happens, and so on. The **latent content** is the dream's hidden meaning. According to Freud, the manifest content is a symbolic representation of the latent content. In other words, the plot acts as a disguise that masks the real meaning of the dream.

Cigars and Tunnels

Freud theorized that many psychological problems stem from repressed sexual urges. In his dream theory, certain objects symbolize sex or genitals. The most famous Freudian symbol is the cigar, which, owing to its shape and association with men, usually represents a penis. Freudian psychiatrists would interpret tunnels and caves as vaginas.

Activation-Synthesis Theory

Another theory, called the **activation-synthesis theory**, proposes that neurons in the brain randomly activate during REM sleep. Dreams arise when the cortex of the brain tries to make meaning out of these random neural impulses. According to activation-synthesis theory, dreams are basically brain sparks.

Problem-Solving Dreams

Some researchers think that dreams express people's most pressing concerns and might help to solve problems in day-to-day life. If someone has an important job interview coming up, for example, he may rehearse scenarios for the interview in his dreams. If someone has relationship difficulties with a significant other, his dreams may give him clues to help solve the problem.

Neural Housekeeping

Some theories argue that dreams arise during the brain's routine housekeeping functions, such as eliminating or strengthening neural connections. Dreams, then, are a way of cleaning up brain files.

During **lucid dreams**, people are aware that they are dreaming and may be able to control their actions to some extent within the dream.

D) Altered States

Some states of consciousness don't occur naturally and must be induced in some way. These include hypnotic states, meditative states, and drug-induced states.

Hypnosis

Hypnosis is a procedure that opens people to the power of suggestion. A hypnotist puts a subject in an altered state by encouraging relaxation and sleepiness and often describing the sorts of physical sensations a subject should be feeling. Once a subject is in the altered state, he or she may act, perceive, think, or feel according to the hypnotist's suggestions. Not everyone can be hypnotized, and some people are more hypnotizable than others. The following chart shows what hypnosis can and can't do.

Hypnosis can:	Hypnosis can't:
Cause people to be relaxed, have a narrowed focus of attention, and be highly engaged in fantasies	Work equally effectively for everyone
Produce anesthesia and treat a range of psychological and medical problems	Force people to do things against their will
Cause hallucinations and distortions in sensory perception	Make people act in ways that would normally be beyond their physical or mental abilities
Reduce inhibitions	Reliably increase the accuracy of memories
Cause changes in behavior after the hypnosis has ended	Allow people to actually reexperience past events or lives

If hypnotized people are instructed to forget what happened during hypnosis, they later claim to have no memory of it. This phenomenon is called **posthypnotic amnesia**.

A hypnotic state isn't sleep—brain waves, for example, do not reliably change during hypnosis as they do during sleep. Researchers don't even agree that hypnosis is an altered state of consciousness. Researchers propose two main theories about hypnosis:

- **Ernest Hilgard** proposed that hypnosis causes people to dissociate or divide their consciousness into two parts. One part responds to the outside world, and the other part observes but doesn't participate. According to this theory, hypnosis can make people not react to pain because hypnosis separates the part of consciousness that registers pain from the part of consciousness that communicates with the outside world.
- Many other researchers, such as Theodore Barber and Nicholas Spanos, think hypnosis happens when a suggestible person plays the role of a hypnotized person. According to this theory, hypnotized people simply behave as they think they are expected to.

Meditation

Meditation is the practice of focusing attention. People meditate to enhance awareness and gain more control of physical and mental processes. Techniques used in meditation vary and include activities such as repetitive chanting and breathing exercises.

Meditative states are associated with an increase in alpha and theta brain waves, and physical indicators of relaxation such as slowed pulse and breathing. Some researchers have found that meditation has long-term effects such as improving physical and mental health and reducing stress. However, researchers disagree about whether meditative states are unique states of consciousness. Some researchers believe relaxation techniques can produce the same kind of state produced by meditation.

Psychoactive Drugs

Psychoactive drugs, as opposed to medicinal drugs, have psychological effects, meaning that they change sensory experience, perception, mood, thinking, and behavior. Psychoactive drugs are sometimes called recreational drugs, though some have legitimate medical uses.

Types of Recreational Drugs

Researchers usually classify recreational drugs into four types: stimulants, sedatives, narcotics, and hallucinogens.

- **Stimulants:** drugs that stimulate the central nervous system
- **Sedatives:** drugs that slow down the central nervous system
- **Narcotics:** also called opiates; drugs that can relieve pain
- **Hallucinogens:** drugs that cause sensory and perceptual distortions

Drugs derived from the cannabis plant, such as marijuana and hashish, have features of more than one of these drug types, so researchers sometimes consider cannabis to be a separate, fifth drug type.

Drug type	Examples	Effects	Negative effects
Stimulants	Nicotine, caffeine, cocaine, amphetamines, crystal meth	Increased alertness and energy, excitation, euphoria, confidence	Anxiety, restlessness, irritability, sleeplessness, paranoia, increased aggressiveness, feelings of panic
Sedatives	Alcohol, Valium, Xanax, barbiturates, such as Seconal	Euphoria, relaxation, less anxiety	Impaired coordination, depression, lethargy, drowsiness, mood swings
Narcotics	Morphine, heroin, opium, codeine, hydrocodone, such as Vicodin	Euphoria, relaxation, less anxiety, less sensitivity to pain	Lethargy, drowsiness, nausea, impaired coordinated, constipation
Hallucinogens	LSD, mescaline, psilocybin	Euphoria, changed perception, hallucinations, insightful moments	Nausea, paranoia, anxiety, feelings of panic, mood swings, impaired judgment, jumbled thoughts
Cannabis	Marijuana, hashish	Euphoria, relaxation, increased awareness, changed perception	Sluggishness, anxiety, impaired memory

How Psychoactive Drugs Work

Psychoactive drugs work by affecting neurotransmitter function. A single drug can affect the function of more than one neurotransmitter. Drugs can:

- Cause more or less of a neurotransmitter to be released at synapses

- Block reuptake of a neurotransmitter by presynaptic cells
- Stimulate or block neurotransmitter receptors on postsynaptic cells

Hallucinations

Hallucinations are sensory or perceptual experiences that happen without any external stimulus. Hallucinogenic drugs fool the brain into perceiving sights, sounds, and tastes that aren't actually present, and they may confuse a person's sense of space and time. For example, a man who takes a hallucinogenic drug may hear voices in his head.

Influences on Psychoactive Drug Effects

A given drug doesn't always have the same effect. If ten people drink beer one evening, they all may have different experiences. The effect of a drug depends on many different factors:

- The amount of the drug
- The potency of the drug
- How the drug is administered
- How much previous experience a user has with the drug
- The user's age and body weight
- The user's mood, personality, and motivation
- The environment in which the drug is used
- The user's expectations about the drug's effects

Chronic Use of Psychoactive Drugs

When people regularly use a drug, they may develop a tolerance to it. As time goes on, people with a **tolerance** need more and more of the drug to get the same effect.

When people stop using a drug after a long period of regular use, they often experience **withdrawal symptoms**. Different drugs produce different kinds of withdrawal symptoms. Not all drugs are addictive.

With chronic use, people can get physically or psychologically dependent on a drug.**Physical dependence** happens when a person must take the drug to avoid withdrawal symptoms. **Psychological dependence** is when a person keeps taking the drug because of cravings. A drug can be both physically and psychologically addictive.

Drug use can be dangerous for several reasons. Heavy or frequent use of drugs can damage body tissues and organs. Overdoses of some drugs, including sedatives, stimulants, and narcotics, can be lethal. Drugs can have dangerous indirect effects by causing people to behave in risky, accident-prone, or unhealthy ways.