Chapter Four
SENSATION AND PERCEPTION

Review of Key Ideas

PSYCHOPHYSICS: BASIC CONCEPTS AND ISSUES

1. Explain how stimulus intensity is related to absolute thresholds and JNDs.

1-1. You are sitting on a secluded beach at sundown with a good friend. You make a bet as to who can detect the first evening star. Since you have just recently covered this chapter in your text, you explain to your friend that doing so involves the detection of a stimulus threshold. In this case, the first star that provides the minimal amount of stimulation which can be detected is said to have crossed the _____. All of our senses have thresholds, but research clearly shows that the minimal amount of stimulation necessary to be detected by any one of our senses (is/is not) always the same. Therefore, the absolute threshold is defined as the stimulus intensity that can be detected _____ percent of the time.

1-2. The smallest difference in stimulus intensity that a specific sense can detect is called the _____. The size of a just noticeable difference (JND) is a constant proportion of the intensity (size) of the initial stimulus. This means that as a stimulus increases in intensity, the JND increases proportionally as well. Therefore, it would be more difficult to detect a slight increase in the length of a (1-inch/20-inch) line, a slight increase in a (quiet/loud) tone, or a slight increase in the weight of a (30-ounce/90-ounce) object.

2. Articulate the basic thrust of signal-detection theory.

2-1. The major idea behind signal detection theory is that our ability to detect signals depends not only on the initial intensity of a stimulus, but also on other sensory and decision processes as well. One factor that is particularly important here is the criterion you set for how certain you must feel before you react (what are the gains from being correct and what are the losses from being incorrect). What other factor is particularly important here?

2-2. Thus, according to signal detection theory, the concepts of absolute thresholds and JNDs need to be replaced by the notion that the probability of detecting any given stimulus will depend on all of the above factors; this is called the concept of _____.

3. Summarize evidence on perception without awareness, and discuss its practical implications.

3-1. Answer the following questions about the study conducted by Jon Krosnick and his colleagues:

(a) What two different kinds of emotion arousing subliminal stimuli accompanied the slides of the target person?

(b) Which group rated the target group in a more favorable manner?

3-2. What general conclusions can be drawn from the research on subliminal perception with respect to its potential persuasive effects?

4. Discuss the meaning and significance of sensory adaptation.

4-1. Which of the following examples best illustrates what is meant by sensory adaptation?

(a) You are unable to clearly hear the conversation at the next table even though it sounds intriguing, and you are straining to listen.

(b) The strawberries you eat at grandma's farm at the age of 20 seem not to taste as good as when you ate them at the age of six.

(c) The wonderful smell you encounter upon first entering the bakery seems to have declined considerably by the time you make your purchase and leave.

4-2. If you answered c to the above question you are right on track and understand that sensory adaptation involves a gradual _____ in sensitivity to prolonged stimulation. This automatic process means that we are not as likely to be as sensitive to the constants in our sensory environments as we are to the _____.

OUR SENSE OF SIGHT: THE VISUAL SYSTEM

5. List the three properties of light and the aspects of visual perception that they influence.

5-1. Before we can see anything, _____ must be present. There are three characteristics of light waves that directly effect how we perceive visual objects; match each of these characteristics with its psychological effect.

_____ (a) wavelength	1. color
_____ (b) amplitude	2. saturation (or richness)
_____ (c) purity	3. brightness

6. Describe the role of the lens and pupil in the functioning of the eye.

6-1. Getting light rays entering the eye to properly focus on the retina is the job of the _____. It accomplishes this task by either thickening or flattening its curvature, a process called _____. Controlling the amount of light entering the eye is the job of the _____. It accomplishes this task by opening or closing the opening in the center of the eye called the _____.

7. Explain how the retina contributes to visual information processing.

7-1. The structure that transforms the information contained in light rays into neural impulses that are then sent to the brain is called the _____. All of the axons carrying these neural impulses exit the eye at a single opening in the retina called the optic _____. Since the optic disk is actually a hole in the retina, this part of the retina cannot sense incoming visual information, and for this reason it is called the _____ spot.

7-2. The specialized receptor cells that are primarily responsible for visual acuity and color vision are called the _____. The cones are mainly located in the center of the retina in a tiny spot called the _____. The specialized receptor cells that lie outside of the fovea and towards the periphery of the retina are called the _____. The rods are primarily responsible for peripheral vision and for _____ vision.

7-3. Both dark and light adaptation are primarily accomplished through _____ reactions in the rods and cones. This chemical reaction occurs more quickly in the _____, so they are quicker to show both dark adaptation and light adaptation.

7-4. Light rays striking the rods and cones initiate neural impulses that are then transmitted to _____ cells and then to _____ cells. From here the visual information is transmitted to the brain via the axons running from the retina to the brain, collectively known as the _____ nerve.

7-5. The processing of visual information begins within the receiving area of a retinal cell called the _____ field. Stimulation of the receptive field of a cell causes signals to be sent inward towards the brain and sideways, or _____, to nearby cells, thus allowing them to interact with one another. The most basic of these interactive effects, lateral antagonism, allows the retina to compare light falling in a specific area against the general lighting. This allows the visual system to compute the (relative/absolute) levels of light.

8. Trace the routing of signals from the eye to the brain and the brain's role in visual information processing.

8-1. Visual information from the right side of the visual field (Figure 4-13 in the text) exits from the retinas of both eyes via the optic nerves and meet at the _____ chiasm, where it is combined and sent to the _____ side of the brain. Visual information from the left side of the visual field follows a similar pattern, meeting at the optic chiasm, and then on to the _____ side of the brain.

8-2. After leaving the optic chiasm on their way to the visual cortex, the optic nerve fibers diverge along two pathways. Fill in the missing parts of the pathways below.

Main pathway

(a) Optic chiasm _____ Visual cortex _____

Secondary pathway

(b) Optic chiasm _____ Visual cortex _____

8-3. The main pathway is subdivided into the magnocellular and parvocellular pathways that simultaneously extract _____ kinds of information from the same input.

(a) Which channel handles the perception of color?

(b) Which channel handles the perception of brightness?

8-4. Because the cells in the visual cortex respond very selectively to specific features of complex stimuli, they have been described as _____ detectors. There are two major types of cells in the visual cortex: simple cells and complex cells. Identify them from their descriptions below.

(a) These cells are particular about the width and orientation of a line but respond to any position in their receptive field.

(b) These cells are very particular about the width, orientation, and position of a line.

8-5. After processing in the primary visual cortex, the signals diverge into two separate streams. The ventral stream processes the details of _____ objects are out there and the dorsal stream processes _____ the objects are located.

8-6. As signals move further along in the visual processing system the neurons become (less/more) specialized as to what turns them on, and the stimuli that will activate them become (less/more) complex. For example, cells in the temporal lobe along the "what" pathway best respond to pictures of human _____.

9. Distinguish the two types of color mixing and compare the trichromatic and opponent process theories of color vision.

9-1. Removing some wavelengths of light, leaving less light than was originally there is called _____ color mixing. Superimposing lights, putting more light in the mixture than exists in any one light by itself is called _____ color mixing.

9-2. The trichromatic theory of color vision, as its name suggests, proposes three different kinds of receptors (channels) for the three primary colors: red, _____, and _____. The opponent process theory of color vision also proposes three channels for color vision, but these channels are red versus _____, yellow versus _____, and black versus _____.

9-3. These two theories of color vision can be used to explain different phenomenon. Use T (trichromatic) or O (opponent process) to indicate which theory best explains the following phenomena.

_____ (a) The color of an afterimage is the complement of the original color.

_____ (b) The different kinds of color blindness suggest three different kinds of receptors.

_____ (c) Any three appropriately spaced colors can produce all other colors.

_____ (d) People describing colors often require at least four different names.

9-4. The evidence is now clear that both theories are (incorrect/correct). Each is needed to explain all of the phenomena associated with color vision. Three different kinds of cones have been found in the retina which are sensitive to each of the three primary colors; this supports the _____ theory. It has also been found that visual cells in the retina, the LGN, and the visual cortex respond in opposite (antagonistic) ways to complementary colors, thus supporting the _____ theory.

10. Discuss the subjectivity of form perception, the phenomenon of inattentional blindness, and the concept of feature analysis.

10-1. The same visual stimulus can result in radically different perceptions, and thus our perceptions of the world are (subjective/objective). We perceive what we expect to perceive (perceptual set) and we may not perceive the unexpected, a phenomenon called _____ blindness.

10-2. The process of detecting specific elements in visual input and assembling them into a more complex form is known as _____ _____.

10-3. Answer the following questions regarding top-down and bottom-up processing:

(a) Which process appears to assume feature analysis?

(b) Which process appears to account for our ability to rapidly recognize and read long strings of words?

(c) What does the text conclude about which theory is correct?

11. Explain the basic premise of Gestalt psychology, and describe Gestalt principles of visual perception.

11-1. The Gestalt view of form perception assumes that form perception is not constructed out of individual elements; rather the form, or whole, is said to be _____ than the sum of its individual elements. The illusion of movement, called the _____ phenomenon, is used to support the Gestalt view of form perception because the illusion of movement (is/is not) completely contained in the individual chunks of stimuli that give rise to it. In other words, the illusion, or whole, appears to be _____ than the sum of its parts.

11-2. Five Gestalt principles of visual perception are illustrated below. Match each illustration with its correct name.

Proximity

Similarity

Continuity

Closure

Simplicity

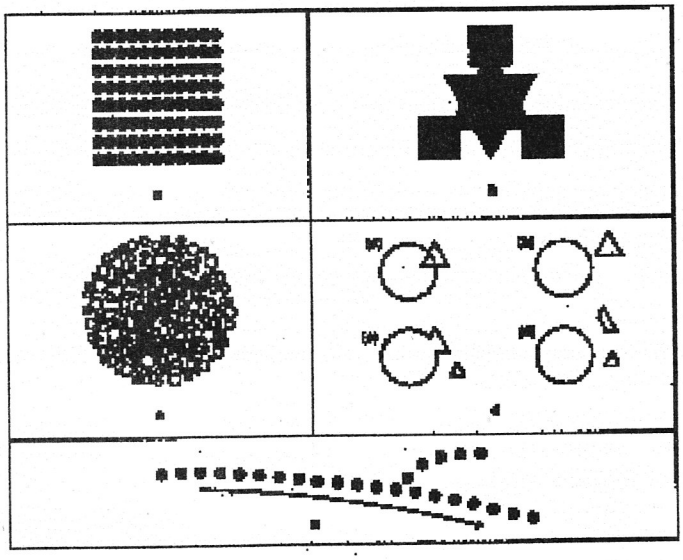
(a) _____

(b) _____

(c) _____

(d) _____

(e) _____



11-3. What Gestalt principle is illustrated by the fact that the words printed on this page appear to stand out from the white paper they are printed on?

12. Clarify how form perception can be a matter of formulating perceptual hypotheses.

12-1. The objects that surround us in the world outside of our bodies are called _____ stimuli; the images the objects project on our retinas are called _____ stimuli. When perceived from different angles or distances, the same distal stimulus projects (similar/different) proximal images on the retina. This forces us to make perceptual _____ about the distal stimulus.

13. Describe the monocular and binocular cues employed in depth perception and cultural variations in depth perception.

13-1. There are two general kinds of cues that allow us to perceive depth. They are easy to remember because one kind involves the use of both eyes and is called _____ cues; the other kind requires the use of only one of the eyes and is called _____ cues. Depth perception (does/does not) require the use of both binocular and monocular cues.

13-2. Here are examples of two different kinds of binocular cues, retinal disparity and convergence. Identify each from these examples:

(a) As a person walks towards you your eyes turn inward.

(b) The images are slightly different on each retina and the differences change with distance.

13-3. There are two general kinds of monocular cues. One kind involves the active use of the eye, such as the accommodation used for focusing the eye. The other general kind is used to indicate depth in flat pictures and thus is called _____ depth cues.

13-4. Identify the following pictorial cues:

(a) Parallel lines grow closer as they recede into the distance.

(b) More distant objects are higher in the field than nearer objects.

(c) When objects appear to be of the same size, closer ones appear larger than more distant ones.

(d) Near objects block or overlap more distant ones.

(e) Texture appears to grow finer as viewing distance increases.

(f) Patterns of light and dark suggest shadows that can create an impression of three-dimensional space.

13-5. What differences have been found in a few cultures without previous experience in viewing two-dimensional figures and photographs?

13-6. Estimates of distance can also be skewed by transient changes in everyday life. For example, persons wearing a heavy backpack estimate that target destinations are (farther/closer) than persons unburdened with backpacks.

14. Summarize the Featured Study and follow-up research on the perception of geographical slant.

14-1. After reading the Featured Study you should be able to answer the following questions:

(a) Which method of judgment of geographical slant, verbal, visual, or haptic (based on touch), was the most accurate?

(b) In what way might overestimates of geographical slant by the visual and verbal methods be of value?

(c) In what way might the better accuracy of haptic estimates be of value?

15. Describe perceptual constancies and illusions in vision, and discuss cultural variations in susceptibility to certain illusions.

15-1. The tendency to experience stable perceptions in spite of constantly changing sensory input is called perceptual _____. For example, even though the retinal image shrinks as a friend walks away, she continues to appear her usual height. This is an example of _____ constancy.

15-2. Being fooled by the discrepancy between the appearance of a visual stimulus and its physical reality is what is meant by an optical _____. Both perceptual constancies and optical illusions illustrate the point that we are continually formulating _____ about what we perceive and also that these perceptions can be quite (subjective/objective).

15-3. What do the variations in cultural susceptibility to certain illusions tell us about our perceptual inferences?

OUR SENSE OF HEARING: THE AUDITORY SYSTEM

16. List the three properties of sound and the aspects of auditory perception that they influence.

16-1. Name the perceived qualities that are associated with the following properties of sound waves.

Physical property	Description	Perceived Quality
(a) purity	kind of mixture	_____
(b) amplitude	wave height	_____
(c) wavelength	wave frequency	_____

17. Summarize the information on human hearing capacities, and describe how sensory processing occurs in the ear.

17-1. Below are questions concerning human hearing capacities. Match the questions with their correct answers.

Answers	Questions
1. 90 to 120 decibels (dB).	___ (a) What is the frequency range of human hearing?
2. 1,000 to 5,000 Hz.	___ (b) How loud do sounds have to be to cause damage to human hearing?
3. 20 to 20,000 Hz.	___ (c) To what frequency range is human hearing the most sensitive?

17-2. Below is a scrambled sequence of events that occurs when a sound wave strikes the ear. Put these events in their correct order using the numbers 1 through 4.

____ Fluid waves travel down the cochlea causing the hair cells on the basilar membrane to vibrate.

____ The pinna directs air to the eardrum.

____ The hair cells convert fluid motion into neural impulses and send them to the brain.

____ The motion of the vibrating eardrum is converted to fluid motion by the ossicles.

18. Compare and contrast the place and frequency theories of pitch perception, and discuss the resolution of the debate.

18-1. One theory of pitch perception assumes that the hair cells respond differentially to pitch depending on their location along the basilar membrane. This is the main idea of the _____ theory of pitch perception. A second theory assumes a one to one correspondence between the actual frequency of the sound wave and the frequency at which the entire basilar membrane vibrates. This is the main idea of the _____ theory of pitch perception.

18-2. Below are several facts uncovered by research. Tell which theory of pitch is supported by each of these facts.

(a) The hair cells vibrate in unison and not independently.

(b) Even when they fire in volleys, auditory nerves can only handle up to 5000 Hz.

(c) A wave pattern caused by the vibrating basilar membrane peaks at a particular place along the membrane.

18-3. The above facts mean that the perception of pitch depends on both _____ and _____ coding.

19. Identify the cues employed in auditory localization.

19-1. The sound shadow cast by the head is in a large part responsible for enhancing two important cues used for auditory localization. What are these two cues?

20. Describe the stimuli and receptors for taste, and discuss some determinants of taste perception.

20-1. The stimuli for taste perception are _____ absorbed in the saliva that stimulate taste cells located in the tongue's _____ _____. It is generally thought that there are four fundamental tastes; these are: _____, _____, _____, and _____.

20-2. What accounts for much of the wide variations in taste preferences among people?

21. Review research on individual differences in taste sensitivity and explain what is meant by the perception of flavor.

21-1. Although taste preferences are highly influenced by the tastes people have been exposed to, taste sensitivity is highly influenced by _____ factors. Nontasters, for example, have a much (higher/lower) density of taste buds on their tongues.

21-2. The differences in taste sensitivity (do/do not) influence eating habits. Supertasters, for example, are (more/less) attracted to sweet and fatty foods than other people.

21-3. What two senses interact to produce the perception of flavor?

22. Describe the stimulus and receptors for smell and discuss odor identification and how odors can influence behavior.

22-1. The stimuli for the sense of smell are _____ molecules floating in the air. The receptors for smell are hairlike structures located in the nasal passages called _____ _____. If there are any primary odors, they must be (large/small) in number. Humans have about 350 different types of olfactory receptors which respond to a (wide/narrow) range of odors. Specific odors trigger responses in different _____ of receptors.

22-2. The text lists two studies that demonstrate odors can have a (small/profound) effect on people's mood and cognition. In one study it was found that subliminal exposure to a citrus-scented cleaning solution led participants to keep their immediate environment _____. Another study found that the likeability of a series of faces could be influenced by the subliminal introduction of pleasant versus _____ odors.

OUR SENSE OF TOUCH: SENSORY SYSTEMS IN THE SKIN

23. Describe the processes involved in the perception of pressure on the skin.

23-1. Cells in the somatosensory cortex that respond to pressure are sensitive to specific patches on the _____. Tactile localization of pressure depends on _____ _____ similar to those seen for vision.

24. Trace the two pathways along which pain signals travel, and discuss evidence that the perception of pain is subjective.

24-1. Pain signals travel to the brain by two slightly different pathways. One pathway sends signals directly and immediately through myelinated neurons to the cortex and is called the _____ pathway. The other sends signals to the cortex through unmyelinated neurons and is called the _____ pathway. The _____ pathway mediates lingering, less localized pain.

24-2. Many studies have demonstrated that the perception of pain can be affected by factors such as mood, ethnicity, and culture. Thus, the perception of pain is _____.

25. Explain the gate-control theory of pain perception and recent findings related to it.

25-1. Answer the following questions regarding the perception of pain:

(a) What phenomenon did the gate-control theory of pain perception attempt to explain?

(b) What effect do endorphins have with respect to pain?

(c) What seems to be the role of the descending neural pathway that appears to originate in the periaqueductual gray (PAG) area in the midbrain?

REFLECTING ON THE CHAPTER'S THEMES

26. Explain the three unifying themes that were highlighted in this chapter.

26-1. The fact that competing theories of both color vision and pitch were eventually reconciled attests to the value of theoretical diversity. Why is this?

26-2. Why must our experience of the world always be highly subjective?

26-3. What do cultural variations in depth perception, taste preferences, and pain tolerance tell us about the physiological basis of perception?

27. Discuss how the impressionists, cubists, and surrealists used various principles of visual perception.

27-1. After reading the Application section in your text, try and answer the following questions by only looking at the paintings:

_____ (a) Which cubist painting depends particularly on the Gestalt principles of continuity for its effect?

_____ (b) Which surrealist painting makes use of a reversible figure to enhance a feeling of fantasy?

_____ (c) Which two impressionist paintings make use of color mixing to illustrate how different spots of colors can be blended into a picture that is more than the sum of its parts?

_____ (d) Which cubist painting uses proximity, similarity, and closure to allow you to see its abstract subject (feature analysis applied to canvas)?

28. Discuss how Escher, Vasarely, and Magritte used various principles of visual perception.

28-1. After reading the Application section in your text, try and answer the following questions by only looking at the paintings.

_____ (a) Which painting uses variations in context to make identical triangles appear very different?

_____ (b) Which two paintings incorporate impossible figures to achieve their effect?

_____ (c) Which painting makes particular use of texture gradient and light and dark shadow to convey the impression of depth?

29. Explain how contrast effects can be manipulated to influence or distort judgments.

29-1. Which of the following contrast strategies, the door in the face technique or employing comparitors, is being illustrated in the following situations:

(a) You want to hit the Florida beaches for spring break, but you need extra money from home. Realizing this is going to be a hard sell, you first ask for a week in Paris and then try and settle for the beaches.

(b) When your lover catches you in an indiscretion, you quickly point out many more serious infractions by friends and acquaintances.

29-2. Both of these strategies illustrate the point that our perceptions and judgments are _____.

Review of Key Terms

Absolute threshold
Additive color mixing
Afterimage
Auditory localization
Basilar membrane
Binocular depth cues
Bottom-up processing
Cochlea
Color blindness
Complimentary colors
Cones
Convergence
Dark adaptation
Depth perception
Distal stimuli
Farsightedness
Feature analysis
Feature detectors
Fovea
Frequency theory
Gate-control theory
Gustatory system
Impossible figures
Inattentional blindness
Just noticeable difference (JND)
Kinesthetic system
Lateral antagonism
Lens
Light adaptation
Monocular depth cues
Motion parallax
Nearsightedness
Olfactory system
Opponent process theory
Optic chiasm
Optic disk
Parallel processing
Perception
Perceptual constancy
Perceptual hypothesis
Perceptual set
Phi phenomenon
Pictorial depth cues
Place theory
Proximal stimuli
Psychophysics
Pupil
Receptive field of a visual cell
Retina
Retinal disparity
Reversible figure
Rods
Sensation
Sensory adaptation
Signal-detection theory
Subjective contours
Subliminal perception
Subtractive color mixing
Top-down processing
Trichromatic theory
Vestibular system
Visual illusion

_____ **1.** The stimulation of sense organs.

_____ **2.** The selection, organization, and interpretation of sensory input.

_____ **3.** The study of how physical stimuli are translated into psychological (sensory) experience.

_____ **4.** The failure to see fully visible objects or events because our attention is focused elsewhere.

5. The minimum amount of stimulation that can be detected by an organism for a specific type of sensory input

6. The smallest amount of difference in the amount of stimulation that can be detected in a sense.

7. A monocular depth cue which involves images of objects at different distances moving across the retina at different rates.

8. Proposes that sensory sensitivity depends on a variety of factors besides the physical intensity of the stimulus.

9. Involves a gradual decline in sensitivity to prolonged stimulation.

10. Our sense of smell.

11. The transparent eye structure that focuses the light rays falling on the retina.

12. The opening in the center of the iris that helps regulate the amount of light passing into the rear chamber of the eye.

13. The neural tissue lining the inside back surface of the eye that absorbs light, processes images, and sends visual information to the brain.

14. Specialized receptors that play a key role in daylight vision and color vision.

15. Specialized receptors that play a key role in night vision and peripheral vision.

16. A tiny spot in the center of the retina that contains only cones, where visual acuity is greatest.

17. The process in which the eyes become more sensitive to light in low illumination.

18. The process in which the eyes become less sensitive to light in high illumination.

19. A variety of deficiencies in the ability to distinguish among colors.

20. The retinal area that, when stimulated, affects the firing of a particular cell.

21. A hole in the retina where the optic nerve fibers exit the eye (the blind spot).

22. Neurons that respond selectively to very specific features of more complex stimuli.

23. Works by removing some wavelengths of light, leaving less light than was originally there.

24. Works by superimposing lights, leaving more light in the mixture than in any one light by itself.

25. Proposes that the human eye has three types of receptors with differing sensitivities to different wavelengths.

26. Pairs of colors that can be added together to produce gray tones.

27. A visual image that persists after a stimulus is removed.

28. Proposes that color is perceived in three channels, where an either-or response is made to pairs of antagonistic colors.

29. A drawing compatible with two different interpretations that can shift back and forth.

30. A readiness to perceive a stimulus in a particular way.

31. A process in which we detect specific elements in visual input and assemble these elements into a more complex form.

32. A progression from individual elements to the whole.

_____ **33.** A progression from the whole to the individual elements.

_____ **34.** An inexplicable discrepancy between the appearance of a visual stimulus and its physical reality.

_____ **35.** The illusion of movement created by presenting visual stimuli in rapid succession.

_____ **36.** Stimuli that lie in the distance (in the world outside us).

_____ **37.** The stimulus energies that impinge directly on our sensory receptors.

_____ **38.** An inference about what distal stimuli could be responsible for the proximal stimuli sensed.

_____ **39.** Involves our interpretation of visual cues that tell us how near or far away objects are.

_____ **40.** Clues about distance that are obtained by comparing the differing views of two eyes.

_____ **41.** Clues about distance that are obtained from the image in either eye alone.

_____ **42.** A tendency to experience a stable perception in the face of constantly changing sensory input.

_____ **43.** Locating the source of a sound in space.

_____ **44.** A fluid-filled, coiled tunnel that makes up the largest part of the inner ear.

_____ **45.** A membrane running the length of the cochlea that holds the actual auditory receptors, called hair cells.

_____ **46.** Holds that our perception of pitch corresponds to the vibration of different portions, or places, along the basilar membrane.

_____ **47.** Holds that our perception of pitch corresponds to the rate, or frequency, at which the entire basilar membrane vibrates.

_____ **48.** The perception of contours where none actually exist.

_____ **49.** Our sense of taste.

_____ **50.** Occurs when neural activity in a cell opposes activity in surrounding cells.

_____ **51.** Objects that can be represented in two-dimensional figures but cannot exist in three-dimensional space.

_____ **52.** Holds that incoming pain sensations pass through a "gate" in the spinal cord that can be opened or closed.

_____ **53.** The sense that monitors the positions of the various parts of the body.

_____ **54.** The system that provides the sense of balance.

_____ **55.** The point at which the optic nerves from the inside half of each eye cross over and then project to the opposite half of the brain.

_____ **56.** Clues about distance that can be given in a flat picture.

_____ **57.** The registration of sensory input without conscious awareness.

_____ **58.** Involves simultaneously extracting different kinds of information from the same input.

_____ **59.** A case in which close objects are seen clearly but distant objects appear blurry.

_____ **60.** A case in which distant objects are seen clearly but close objects are blurry.

_____ **61.** A depth cue which refers to the fact that objects within 25 feet project images to slightly different locations on your right and left retinas, so the right and left eyes see slightly different images.