Senses and sensory organs
An Animal’s Senses Guide Its Movements

• The brown bear is able to capture a fast and agile salmon
• Sensory structures of both the bear and salmon gather the information that guides the behaviors involved in this encounter
• Nostrils on each side of the head of the salmon allow water to flow into one and out the other.

• Sensory cells in the nostrils detect specific chemicals in the water:
  - These cells aid the salmon in its homing ability.
• Salmon have a lateral line system, seen here as a blue line along the sides of the fish
  - This enables the salmon to sense the direction and velocity of water currents and thus distinguish which direction is upstream
  - Unfortunately for the salmon, it cannot perceive a bear's paw descending from above
29.1 Sensory inputs become sensations and perceptions in the brain

- **Sensation**
  - Awareness of sensory stimuli (action potentials reaching the brain)

- **Perception**
  - Brain’s full integration of sensory data
29.2 Sensory receptor cells convert stimuli into electrical energy

- Sensory transduction
  - A sensory cell converts a stimulus into an electrical signal called a receptor potential
  - Occurs as a change in the membrane potential of a receptor cell
1. Taste bud anatomy

2. Sugar binding

3. Receptor potential

4. Synapse

5. Action potentials

Figure 29.2A
• Action potentials representing the stimuli are transmitted to the CNS via sensory neurons

• The brain distinguishes different types of stimuli
  - These synapse with different interneurons in the brain
• The strength of a stimulus alters the rate of action potential transmission
  - This communicates information about the intensity of a sensation
  - In sensory adaptation, sensory neurons become less sensitive when stimulated repeatedly
Figure 29.2B

Sugar receptor

BRAIN

Sensory neurons

Interneurons

Salt receptor

TASTE BUD

No sugar

Increasing sweetness

Increasing saltiness

No salt
29.3 Specialized sensory receptors detect five categories of stimuli

- **Pain receptors**
  - Sense dangerous stimuli
- **Thermoreceptors**
  - Detect heat or cold
- **Mechanoreceptors**
  - Respond to mechanical energy (touch, pressure, and sound)
Figure 29.3A

- Heat
- Light
- Pain
- Cold (Hair)
- Light touch
- Epidermis
- Dermis
- Nerve
- Touch
- Strong pressure
- Stretch receptors and hair cells are two types of mechanoreceptors.
• Chemoreceptors
  - Respond to chemicals in the body fluids or external environment
  - A male silkworm moth has chemoreceptors on his antennae that can detect the sex attractant produced by the female silkworm moth
• Electromagnetic receptors
  - Respond to electricity, magnetism, and light
• Photoreceptors
  - Sense light
  - They are the most common electromagnetic receptors
29.4 Three different types of eyes have evolved among invertebrates

- Eye cup
  - Simplest type of photoreceptor
  - Senses intensity and direction of light
  - Found in flatworms
• Compound eye
  - Contains thousands of ommatidia working together to produce a visual image
  - Acute motion detector
  - Provides excellent color vision
  - Found in crabs, crayfish, and nearly all insects

Figure 29.4B
• Single-lens eye
  - Works on a principle similar to that of a camera
  - Found in vertebrates and some invertebrates, such as squids
29.5 Vertebrates have single-lens eyes

- Sclera
- Muscle
- Ligament
- Cornea
- Iris
- Pupil
- Aqueous humor
- Lens
- Vitreous humor
- Choroid
- Retina
- Fovea (center of visual field)
- Optic nerve
- Artery and vein
- Blind spot

Figure 29.5
Eye parts

- **Sclera** - outer surface
- **Cornea** - transparent sclera (focusing)
- **Choroid** - pigmented layer
- **Iris** - eye color, muscular
- **Pupil** - opening in iris
- **Lens** - disk /ligaments
- **Fovea** - center of focus on retina
- **Blind spot** - spot where optic nerve passes
- **Vitreous humor** - large jelly filled chamber
- **Aqueous humor** - smaller fluid filled chamber
• Human eye
  - Cornea and lens focus light on photoreceptor cells in the retina
  - Photoreceptors are most concentrated in the fovea
  - Having two eyes with overlapping fields of view compensates for the blind spot
  - The blind spot is where the optic nerve passes through the retina
29.6 To focus, a lens changes position or shape

- Focusing can occur in two ways
- Moving the lens closer to or farther away from an object is one focusing method
  - It is similar to focusing with a magnifying glass
  - This occurs in squid and some fishes
Accommodation, or changing the shape of the lens, occurs in the mammalian eye:
- Thick and round for near vision
- Thin and flat for distance vision

Figure 29.6
29.7 Connection: Artificial lenses or surgery can correct focusing problems

- Corrective lenses bend light rays to compensate for focusing problems
- There are three common vision problems
  - Astigmatism is a condition involving a distortion of the lens or cornea
• In nearsightedness (myopia), the focal point is located in front of the retina.
• In farsightedness (hyperopia), the focal point is located behind the retina.

Figure 29.7B
29.8 Our photoreceptor cells are rods and cones

- Human photoreceptor cells are named for their shapes
  - Rods
  - Cones
• Rods
  - Function in dim light
  - Contain a visual pigment called rhodopsin
  - There are 125 million in the human retina
• Cones
  - Stimulated by bright light
  - Enable color vision
  - Do not function in night vision
  - There are 6 million in the human retina

• Cones contain visual pigments called photopsins
  - There are three types of cones— blue, green, and red— named for the color absorbed by their photopsin
Figure 29.8B

Retina

Optic nerve fibers

Fovea

Optic nerve

Photoreceptors

Neurons

Cone
Rod
29.9 The ear converts air pressure waves into action potentials that are perceived as sound

- The basic function of the ear is hearing
- The outer ear channels sound waves to the eardrum
- The eardrum passes vibrations to the chain of bones in the middle ear.
- The bones transmit vibrations to fluid in the cochlea, which houses the organ of Corti.

- Vibrations in cochlear fluid move hair cells (mechanoreceptors) against the overlying membrane.

- Bending hair cells trigger nerve signals to the brain via the auditory nerve.
Figure 29.9C

Cross section through cochlea

Bone

Auditory nerve

Upper canal

Lower canal

ORGAN OF CORTI

Overlying membrane

Hair cells

Basilar membrane

Sensory neurons

To auditory nerve
• Louder sounds generate higher amplitude pressure waves
  - These waves result in the vigorous vibration of cochlear fluids
  - There is then a more pronounced bending of hair cells
  - Thus more action potentials are generated
Figure 29.9D
• Pitch depends on the frequency of sound waves
  - High sounds generate high frequency sound waves
  - Low sounds generate low frequency sound waves
  - Sounds of different pitches stimulate hair cells in different parts of the organ of Corti
29.10 The inner ear houses our organs of balance

- Organs of balance are located in the inner ear
  - Semicircular canals
  - Utricle
  - Saccule
- Detection of body position and movement are determined by stimulation of hair cells in the semicircular canals, utricle, and saccule
• Equilibrium structures in the inner ear

Figure 29.10
29.11 Connection: What causes motion sickness?

- Motion sickness is a result of the brain receiving signals from equilibrium receptors in the inner ear that conflict with visual signals from the eyes.
29.12 Odor and taste receptors detect categories of chemicals

- Smell and taste depend on chemoreceptors sending nerve signals to the brain
  - Specific molecules binding to chemoreceptors determine signals
Olfactory (smell) receptors are sensory neurons that line the upper part of the nasal cavity.
• Taste receptors are sensory neurons located in the back of the throat and on the tongue (taste buds)

• There are several types of taste receptors
  - Sweet, sour, salty, bitter, umami
• Insects have taste receptors located in sensory hairs on their feet. They can taste food by simply stepping on it.
• Receptor potential is generated when specific chemical molecules bind with olfactory or taste receptors

• Receptor potential alters the rate of action potentials passing into the brain

• The various odors and tastes we perceive result from the integration of input from a combination of receptors
29.13 Review: The central nervous system couples stimulus with response

- Coupling of stimuli to response by the nervous system
  - Receptor cells receive stimulus
  - Sensory neurons send information to the CNS
  - The CNS integrates information from receptor cells
  - The CNS sends commands to effector cells via motor neurons
  - Response is carried out
Figure 29.13

Motor neuron

Sensory neurons

CNS

Integration

Stimuli

Receptors

Response

Effector

Motor neuron