Sense organs
– Specialized nerves that detect changes in external environment
– Translate via nerve impulses to CNS

Classifying receptors
• Chemoreceptors
• Electroreceptors
• Mechanoreceptors
• Photo (radiation) receptors

Chemoreceptors
• Chemoreceptors bind with dissolved molecules
  
Gustation

Olfaction
• Each receptor has cilia with specific protein (around 1000 different receptor proteins)
• Different protein receptors detect parts of an odorant
• The pattern of receptors stimulated corresponds with a particular “smell”
  – i.e. receptors 3, 57 and 378 = bacon

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• In most fish, nares lead to olfactory sac
• **Choanates** - nares lead to nasal cavity and open into mouth

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**Olfaction**

• In mammals, area of olfactory epithelium is increased with turbinate bones

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• **Vomernasal organ** - separate area of olfaction (above vomer)
  – in amphibians, squamate reptiles, most mammals

  Absent in aquatic organisms

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Figure 12-4
• Flehmen – performed by ungulate and carnivore males when in presence of female pheromone
  – blocks nostrils and opens incisive duct

• Humans – Sensation of pheromones is more associated with traditional olfaction but neural pathways go to different areas

• Humans are shown to produce and respond to pheromones
  – Menstrual cycles can be changed with exposure to pheromones
  – Male pheromone (androstadienone) and female pheromone (estratetraenol) can enhance mood

• Taste buds – contain about 50 - 100 receptors in small groups at a taste pore
• Receptors have cilia that extend into pore

Gustation
Variety of taste receptors

Gustation

- Taste buds can be located along palate, pharynx and skin

Cutaneous mechanoreceptors

- Free nerve endings, slow vs. rapid adapting

Mechanoreceptors - neuromast

- Detect currents, body orientation, sounds via mechanical stimulation
- Neuromast - collection of “hair” cells

Fig. 12-8
Orientation of hair cell affects its response to mechanical stimulation

- Kinocilium
- Stereocilia

Hair cell

increases potential

hyperpolarizes

Lateral line- neuromasts located within pores or a canal
- Present in fish, larval amphibians
- Not in aquatic tetrapods

Electroreceptors
- Found in fish, some amphibians, platypus

Electroreceptors
- Ampullary organs contain clusters of modified neuromast cells
  - No cupula – jelly in canal acts as a capacitor
Mechanoreceptors: equilibrium and hearing

Inner ear anatomy

**Gnathostomatans** - 3 ducts, each at right angles to each other

Hair cell groups are dark blue

Inner ear anatomy

endolymphatic duct - in chondrichthyes

Endolymph and perilymph

Cupula

Cristae

Hair cells

Anterior vertical semicircular duct (AVSD)

Posterior vertical semicircular duct (PVSD)

Semicircular canal

Utricle

Utricle

Crista neglecta

Crista of AVSD

Amphull of AVSD

Crista of HSD

Amphull of HSD

Horizontal semicircular duct (HSD)

Sacculus

Lagena

Membranous labyrinth

Dorsal

Anterior
The semicircular canals detect **angular acceleration** in the body.

**Mechanoreceptors: equilibrium**
- Within the saccus and utriculus are groups of hair cells (maculae) which sense **linear acceleration**

mineral particles

Otoliths or statoconia rest on hair cells

**Why is the room spinning?**
- Alcohol diffuses from blood into endolymph, and endolymph swirls.
- Inner ear passes info. to eye muscles, causing eyes to twitch to right (reverses once liver removes alcohol from blood)

**Mechanoreceptors: hearing**
- Aquatic vs. terrestrial vertebrates
  - For tetrapods, waves in air must be converted to waves in fluid at oval window of inner ear

Ear bones
Hearing high frequencies in fish

Amphibian, Reptiles ear bones

- Some amphibians have an extra ear bone "operculum" that connects to forearm

Columella=ear bone

Tetrapod hearing

Hair cells in lagena or cochlea

Movement of the stapes is transferred to cochlea

Vibrations travel up and down cochlea
Vibrations travel across organ of Corti

Sensations of different sound frequencies are detected at different areas of the cochlea

Width and stiffness of basilar membrane changes

- Median eye – also develop as outgrowths of brain
  - pineal secretes melatonin at night

Opening for median eye
Vertebrate eye anatomy

- Iris contains smooth muscle
- Pupil
- Cornea cells specialized to admit light
- Sclera supports eye, can have bones

Vertebrate eyes develop as extensions of the brain

Lens refracts light to focus images to back of retina
• With age, the lens becomes more stiff and unable to ‘bulge’ to focus on close objects

• **Myopia** (near-sightedness) shown below

<table>
<thead>
<tr>
<th>Far object out of focus</th>
<th>Close object in focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eye is too long</td>
<td></td>
</tr>
</tbody>
</table>

Eyesight corrected with a concave lens
Rods - sense grayscale images, function in low light (all vertebrates)

Cones - red, blue, green wavelengths
(birds, primates, some fish, amphibians and reptiles)

Phototransduction: light stimuli transduced into neural signals

- Photopigment “rhodopsin” (rods).

Fovea of retina
- Fovea
  - center of retina
  - only cones, no other neurons
Modifications in design

• Enhancing night vision
  – large eye size
  – mostly rods
  – tapetum lucidum in choroid
  – pupil is vertical slit (for day)

Fig. 12-29

Thermoreceptors

• Infrared detection
  – info projected to optic lobe of brain