

Animal Phys. Key Words – Blank

Lecture 10

Sensory system: sensory cells, afferent neuron and part of the brain/CNS associated with that sensor

Stimulus modality: the type of stimulus that the cell is sensitive towards. Can be mechanical, chemical, thermal, electrical, magnetic, photo

Sense organ: sensory cell plus associated non-neural cells

Interoceptors: sense internal stimulus

Exteroceptors: sense stimulus outside of the body

Stimulus: activates sensory receptors on cells, triggers a response

Polymodal receptors: cell receptors that are sensitive to more than one stimulus.

Epithelial sensory receptor cell: a sensory cell that is not part of a neuron. Stimuli induce a receptor potential in the cell, and when this receptor potential reaches a certain threshold, neurotransmitters diffuse across the membrane into the soma/dendrites of the adjacent afferent neuron

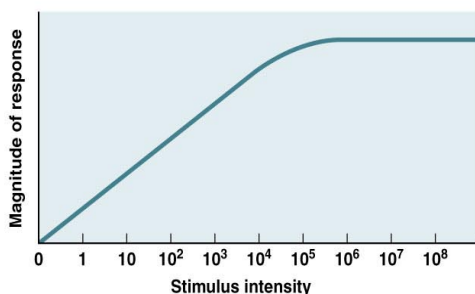
Receptor potential: electrical potential that builds up inside an epithelial sensory receptor cell

Generator potential: electrical potential that builds up inside a sensory neuron that receives the stimulus directly

Dynamic range: the range of stimulus that can be encoded by receptor cells

Range fractionation: different sensory receptors on a cell may have different dynamic ranges; this allows the cell to have a larger total dynamic range, as well as the ability to discriminate more finely

Logarithmic encoding: some sensory receptors respond to stimuli in a logarithmic fashion. Ex: candle in bright room vs. dark room



(d) Logarithmic encoding

Weber-Fechner law: the subjective sensation is proportional to the logarithm of the stimulus intensity

Receptive field: sensory surface that, when stimulated, triggers a response in the primary afferent neuron. Stimulus applied to any part of the receptive field will trigger a response only in one afferent neuron.

Lateral inhibition: in order to increase sensitivity, interneurons connected to afferent neurons will silence the stimulus received by adjacent afferent neurons by excreting neurotransmitters. The neurotransmitters diffuse across the cell membranes of the adjacent afferent neurons and prevent them (to a certain extent) from sending an action potential along to the CNS

Tonic receptors: will continue transmitting action potentials as long as there is continuous stimulus

Phasic receptors: will stop transmitting action potentials even if there is a continuous stimulus

Receptor adaptation: only occurs in phasic receptors; desensitivity of the receptor to stimulus.

Lecture 11- Chemoreception

Chemoreceptors: ligand binds to receptor embedded in membrane, regulates permeability of membrane to other ions

External chemoreceptors: allow for olfaction (smell) and gustation (taste)

Internal chemoreceptors: maintain homeostasis by detecting concentrations of oxygen, CO₂, nitrogen

Olfactory epithelium: tissue layer with layer of mucus on top that dissolves odorants

Vomer nasal cavity: detects dissolved airborne pheromones. Different sensory receptors and transduction pathway than olfaction

Flehmen response: lifting of the upper lip to facilitate entrance of pheromones into the vomeronasal complex

Barbells (catfish): boast mechanoreceptors and chemoreceptors (for both taste and smell)

Agnathans: jawless fish (lampreys) have only one nostril and one olfactory organ

Teleosts: bony fish have two nostrils, each with their own olfactory organ, usually on dorsal side of face

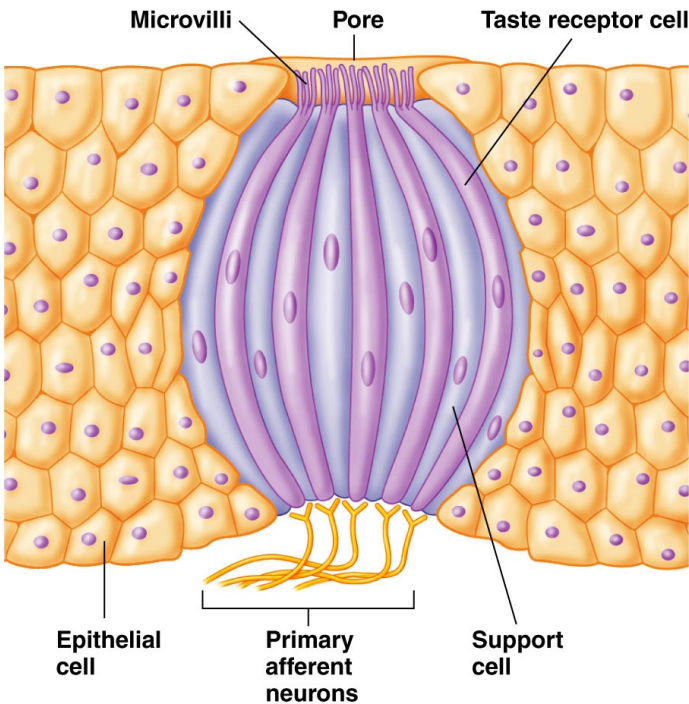
Elasmobranchs: cartilaginous fish have two nostrils, each with their own olfactory organ, usually on ventral side of snout

Gustation: signal is sent to gustatory cortex in frontal cortex. Tastants are generally in high concentrations. 5 different taste qualities, each with their own transduction pathway

Olfaction: signal is sent to olfactory cortex in frontal cortex. Odorants generally in low concentrations, airborne. Odorants bind with odorant binding proteins, dissolve in the olfactory epithelium, where they

are detected by receptors on cilia of olfactory sensory cells (which make up the epithelium). An action potential travels from primary afferent neurons to olfactory bulb (part of brain)

Taste buds: have little craters in them which are each filled with a bulb, made up of numerous taste receptor cells. At the ends of these cells (along the surface of the tongue) are cilia, which house the taste receptors. Each taste receptor cell is connected to its own primary afferent neuron.



Tastants: non-airborne compounds that are generally in high concentrations

5 taste qualities: umami, salty, sweet, sour, bitter

Labelled-line pattern (theory): each receptor cell corresponds to a specific taste (accepted theory)

Across-fibre pattern (theory): taste is the result of the combination of receptors

Taste-receptor proteins: G-protein coupled receptors and “simple” channel proteins

Salty transduction pathway: Na^+ enters cell, depolarization prompts Ca^{2+} to enter, neurotransmitters are released

Sour transduction pathway: eating sour food increases $[\text{H}^+]$ due to intake of HCl . H^+ blocks K^+ channel protein, preventing it from leaving the cell. This prompts Ca^{2+} to enter, causing an action potential, and thus neurotransmitters to be released,

Umami transduction pathway: L-Glutamate... pathway not fully described

Transducin: G-protein present in taste receptor cells that detect bitter tastants

Bitter transduction pathway: bitter taste molecule lands on receptor, changes conformation of G-protein (transducin), activating phospholipase C. PLC catalyzes transformation of PIP₂ to IP₃. IP₃ releases intracellular stores of Ca²⁺, causing action potential, and release of neurotransmitters.

Gustducin: G-protein found in sweet taste receptor cells

Sweet transduction pathway: sweet molecule lands on receptor, changes conformation of G-protein (gustducin), activating adenylate cyclase. Adenylate cyclase catalyzes conversion of ATP to cAMP. cAMP opens K⁺ ion channels, K⁺ rushes in, causing receptor potential. This opens Ca²⁺ channels, allowing Ca²⁺ to enter. Neurotransmitters are released

Olfactory bulb: part of the brain that receives chemosensory information about odour

Odorant binding proteins: present in mucous layer on the olfactory epithelium, makes odorants more hydrophilic

Olfactory sensory cells: make up the olfactory epithelium. Have cilia on the ends which contain the receptors

Odour transduction pathway: odorant lands on receptor (on cilium of olfactory sensory cell), causing conformational change of g-protein (Golf protein), which moves along the membrane. The golf protein then activates adenylate cyclase. AC converts ATP to cAMP, which opens cAMP-gated ion channels. These channels allow Na⁺ and Ca²⁺ to enter. This induces a generator potential. Ca²⁺ also opens Ca²⁺ gated Cl⁻ channels, allowing Cl⁻ to leave the cell. This further increases the generator potential. Na⁺ channels are opened, allowing Na⁺ to enter, causing an action potential.

Combinatorial encoding:

Glomerulus: collection of synapses in the olfactory bulb. Each glomerulus encodes a different smell.

Sensilla: allows invertebrates to smell, taste

*Olfaction and gustation have different sensory organs, receptors, integrating centers and transduction pathways

Lecture 12: Mechanoreception

Mechanoreceptor proteins: includes hair cells. Detect vibration, pressure, displacement

Functions of mechanoreceptors: detect vibration (hearing), pressure (touch), displacement (equilibrium)

Baroreceptor: detect pressure within the body (internal mechanoreceptors), such as blood pressure, blood volume

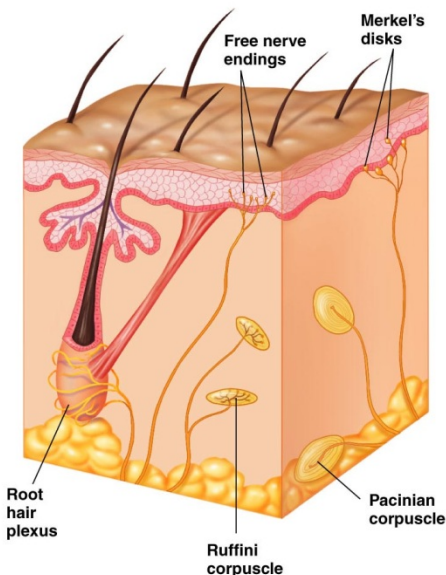
Proprioceptor: detects displacement of the body. These include hair cells, muscle spindles, ruffini corpuscles, golgi tendon organs, joint-capsule receptors and root-hair plexus (in vertebrates); trichoid sensilla, scolopidia and campaniform sensilla in arthropods;

Tactile receptor: detect touch. These include merkel's disks, pacinian corpuscle (detects vibrations)

Merkel's disks (merkel cells): cells associated with free nerve endings in the epidermis. Detect light touch on skin

Root hair plexus: free dendrites of afferent neurons wrap themselves around hair follicles and detect displacement (tactile receptors)

Pacinian corpuscle: large dendrite deep in skin that detects vibrations (tactile receptor)



Ruffini corpuscle: dendrite with elongated capsule, senses movement of epithelium (proprioceptor)

Muscle spindles: receptors that detect stretching in muscles (proprioceptors)

Golgi tendon organs receptors that detect stretching in tendons (located at the interface between muscles and tendons)

Joint capsule receptors: in joints, detect pressure, movement on joints (proprioceptors)

Trichoid sensilla: in arthropods: hair-like structure made of cuticle that bends back and forth and detects motion (receptor cell beneath layer of cutin)

Campaniform sensilla: in arthropods: small bump in cutin that relays information about stress in the joints – guides the arthropod in making synchronized movements

Scolopidium: detects deformation of the cuticle, sensitive to vibrations

Statocysts: micro-organs lined with sensory receptors (lined with cilia) that contain hard calcium-carbonate particles (statoliths) that move back and forth inside a fluid-filled capsule in response to displacement (present in arthropods, cnidarians, more advanced in octopi)

Cristae: along with the macula, makes up the statocysts in octopi. They have paired statocysts that detect forward and torsional acceleration.

Macula: detects forward acceleration in octopi. In vertebrates, it is a membrane with a layer of hair cells (>100,000). On top of the membrane is a gelatinous matrix with otoliths on top. When there is movement, the otoliths move back and forth and pull the gel along with it, causing displacement of the hair cells. The utricle macula detects horizontal motion while saccule macula detects vertical motion.

Subgenual organ: detects vibrations in arthropods (on legs of insects). (tactile receptors)

Johnson's organ: detects sound waves in arthropods

Tympanal organ: aka tympanic membrane. Vibrates in response to sound. In inner ear.

Vertebrate hair cell: used for hearing and equilibrium (vestibular system). When stereocilia move toward the kinocilium (or main, large stereocilium), stretch receptors open, Ca²⁺ rushes in, and an action potential occurs.

Neuromast: pore (cupula) that contains hair cells and filled with viscous gel. Present in fish in pores (ampullae) or along the lateral line. Used as proprioceptors in fish

Electroreceptors: modified mechanoreceptors

Ampulla: pores that contain neuromasts with hair cells

EOD: electric organ discharge. Method used by some fish to detect electrical field of others

Cochlea: responsible for detecting hearing

Vestibular apparatus: responsible for adjusting equilibrium

Ossicles:

Pinna: outer ear, present in mammals but rare in other vertebrates

Endolymph: fluid that fills up the semicircular canals, moves around in response to motion. It passes by the cristae, which lie inside the ampullae at the base of the semicircular canals.

Cristae: layer of hair cells covered by gelatinous mass (cupula). As endolymph moves past the cupula, it deforms the gelatinous mass, which bends the hair cells, causing depolarization or hyperpolarization.

Lecture 13 – Audition

Audition: or hearing; detection of vibrations

Organ of Corti: organ in inner ear with hair cells

Cochlea: extended lagena; detects hearing

Has 3 chambers: Vestibular duct, Tympanic duct, and Cochlear duct.

Lagena: found in the upper ear in humans, but in fish it has otoliths to detect vertical linear acceleration.

Swim bladder: sound amplifier, connected or close to the ear

Otophysic connection: i.e. the swim bladder

Weberian ossicles: bunch of bones that connect the swim bladder to the inner ear

Pinna: the funnel that collect and concentrates sound waves into the ear canal

*sound travels poorly from air to fluid (inner ear contains fluid)

Ossicles: transfer vibrations from tympanic membrane to oval window (3 bones: malleus, incus, stapes)

Eustachian tube: connects middle ear to airways to equalize pressure

Acoustic reflex:

Tectorial membrane:

Basilar membrane:

Oval window: membrane between middle and inner ear, vibrates to send sounds to inner ear

Round window: membrane at the end of cochlea; pressure release for fluid in the ear

Scala vesitubli:

Scala tympani:

*basilar membrane widens from basal end to apical end

Dampening: outer hair cells provide defensive mechanism for loud sounds

Component	Structure	Deflected by	Kind of movement
Utricle	Macula	Mvt of Otoliths on gel matrix	Horizontal accel.
Saccule	Macula	As above	Vertical accel.
Ampulla of semicircular canals	Crista	Mvt of cupula filled with gel	Angular accel. in 3 different planes

Lecture 14 – Photoreception

Photopigment: molecules that detect photons. Has a chromophore which absorbs light

Chromophore: molecule that absorbs light

Rhabdomeric photoreceptor: microvillar projections on apical surface (invertebrates)

Ciliary Photoreceptors: cilium projection forms disks with photopigments (vertebrates)

Rod vs Cone: rods are longer, but the photoreceptor area is smaller than the cone

Table 6.1 Mammalian rods and cones.

Feature	Rods	Cones
Class of photoreceptor	Ciliary	Ciliary
Shape	Outer segment rod shaped	Outer segment cone shaped
Sensitivity	Sensitive to very dim light	Sensitive to brighter light
Type of photopigment	One type	Up to three types in mammals

Inactive photopigment state: chromophore in cis-conformation

Active photopigment state: chromophore is in trans-conformation when light is absorbed.

Bleaching: trans-chromophores are released from opsin

Opsin: a type of G-protein involved in visual transduction

Transduction pathway: pretty much the cis-chromophores are changed into trans-chromophore, which then are released/dissociated from opsin, ultimately resulting in depolarization (invertebrates) or hyperpolarization (vertebrates)

Flat sheet eyes	-Layer of photoreceptors for the primitive retina -little sense of light direction and contrast -pigment epithelium
Cup shaped eyes	-retinal sheet is folded forming a narrow opening/aperture -better sense of light direction and contrast -trades resolution for better light intensity (i.e. nautilus cephalopods)
Vesicular eyes	-lens in aperture -lens creates better resolution by refracting light onto one single point on retina
Convex eyes	-photoreceptors radiate like a fan -resolution not as good as vesicular/vertebrate eyes -but can capture image from any direction

Ommatidium: functional unit of the compound eye and has retinular cells

Retinular cells: are found in ommatidia and are arranged in a circle with microvilli in the centre. The microvilli have photoreceptors in them.

Sclera: the white part of the eye

Cornea: transparent layer that refracts the light onto the retina

Iris: controls amount of light entering the pupil through dilation or constriction.

Lens: refracts light to help focus images

Ciliary body: cilia muscles

Retina: lined on the back surface of the eye. Has photoreceptor cells

Choroid: pigment layer with lots of blood for the retina, and absorbs excess light in the back of eye

Fovea: are of high visual acuity

Accommodation: when an eye changes its focal length. Pretty much allows focusing on objects from different distances.

Invertebrates/Polychaetes: change fluid volume in eyes, thus moving lens forward/backward, altering the focal length.

Vertebrates: change their lens shape to alter focal length, rather than moving the lens like the inverts.

Chapter 15: visual processing, thermoreception, magnetoreception

Processing of visual info starts at the retina; like a small brain outside the real brain

-photoreceptors absorb light then interneurons emit graded potential

Blue, green, & red cones: colors cause activity in all three cones, creating the proper colored imaged

Visual field: region detected by both retinas

Binocular zone: region where visual fields of both eyes overlap

Optic nerves: axons of retinal ganglion cells

Optic chiasm: the axon intersection

Optic tracts: comes after the optic chiasm

Lateral geniculate nucleus: thalamic nucleus that receives and processes the visual info

Visual cortex: integrates the visual information

Thermoreception: responds to changes in temperature

--HYPOTHALAMUS

--warm sensors, cold sensors, and pain sensors

Pit organ: highly sensitive thermoreceptive organ in snakes. Rapid heat dissipation to detect small temperature changes

Magnetoreception: response to magnet fields; can be used for navigation

-magnetite has influence on the navigation

-hypothetically: magnetite + sensors, respond to magnetic field