

Chapter 15 Taste, Smell and Vision

The special senses are so named because they are associated with specific areas of the cortex. Touch is a general sense, so it's not included with the special senses.

CHEMICAL SENSES alert us to things in our environment. This includes things to avoid and things that are beneficial. The chemical senses are gustation and olfaction!

GUSTATION is one of the chemical senses. The sensory organ of the gustation sense is the TASTEBUD. There are about 10,000 tastebuds on the tongue.

Tastebud location:

- Located on *mucosal papillae* (bumps on the tongue)
- This is located at the top of the *fungiform papillae*, which is mostly on the anterior of the tongue
- Also located on the sides of the *circumvallate papillae*, which is a V-shaped row of 7-12 of them near the back of the tongue.

Tastebud anatomy

- The tastebud consists of about 50-100 epithelial cells. There are three types!
 - RECEPTOR CELL has gustatory hairs at the surface. The NEURONAL DENDRITE coils around several receptor cells.
 - SUPPORTING CELLS are between the receptor cells. They insulate receptor cells from each other so they all don't fire at once.
 - BASAL CELLS are regenerative cells to replace other types that are easily lost.

PHYSIOLOGY OF TASTE

There are five basic taste qualities, and most foods are a complex mixture.

1. **Sweet** (stimulated by carbohydrates-sugar, alcohol, some amino acids, lead salts)
2. **Sour** (acids-lemonade, orange juice)
3. **Salty** (metal ions-inorganic salts)
4. **Bitter** (alkaloids-quinine, nicotine, caffeine & some non-alkaloid aspirin)
5. **Umami** (glutamate, beef flavor, aging cheese, MSG...sometimes "savory")

TASTE PREFERENCES reflect nutrient needs. Taste also triggers digestive reflexes, which begin with salivation and the secretion of gastric enzymes/intestinal juices when you start to think about food!

Classic taste mapping is a bunch of hooey. All tastes are elicited from all areas of the tongue!

MECHANISM OF TASTE

1. Food chemicals bind to hair receptor membrane protein.
2. Neurotransmitter release stimulates action potential in the nerve cell (in some cases by directly opening ion channels)

OLFACTION (SMELL)

The sensory organ of smell is PSEUDOSTRATIFIED OLFACTORY EPITHELIUM.

The cells of the pseudostratified olfactory epithelium:

- OLFACTORY RECEPTOR CELLS
 - Bipolar neurons, they have hairlike extensions into the nuclei called OLFACTORY CILIA. They are non-motile!
 - Axons converge to form filaments of olfactory nerve (CNI)
 - They are able to generate action potentials
 - They are able to regenerate (this is a unique feature!)
- SUPPORTING CELLS
 - Columnar cells that separate receptor cells.
 - They contain pigmented lipofuscin
- BASAL CELLS
 - Short regenerative cells

PHYSIOLOGY OF SMELL (smell is not as quantified as taste)

We can distinguish about 10,000 different odors, and often just a few molecules. Odors stimulate different combinations, about 1,000 different receptor sites. In order to be smelled, the odorant must be volatile (able to go into a gaseous state). It then enters the nasal cavity and dissolves in the nasal mucus!

MECHANISM

1. Odorant binds to receptor
2. Binding stimulates formation of intracellular messenger
3. Messenger opens Na⁺ channels, and generates an action potential (if threshold is reached)

VISION

ANATOMY OF VISION ...THE ACCESSORY STRUCTURES

- EYEBROWS
 - Shade the sunlight
 - Protect from small particles from above
- EYELIDS (palpebrae)
 - The upper and lower lids meet at the **medial and lateral canthi**
 - The MEDIAL CANTHUS is the location of the LACRIMAL CARUNCLE...this secretes sebum and sweat
 - The eyelashes protect the free edge/eye and have nerve endings at the base of the follicle...these stimulate the blink reflex
 - TARSAL GLANDS are modified sebaceous glands that lubricate the eye
- CONJUCTIVA
 - Conjunctiva is a very thin, pleasant membrane that lines the inner portion of the eyelid.
 - PALPEBRAL CONJUCTIVA line the inside of the palpebrae

- Where the palpebral conjunctiva folds back over the anterior surface of the eyeball is the BULBAR CONJUNCTIVA...it covers only the white of the eye, not the cornea.
- Blood vessels show through the conjunctiva
- The major function of the conjunctiva is to produce a lubricating mucus

LACRIMAL APPARATUS

- LACRIMAL GLANDS lie in superolateral orbit and they produce tears (dilute saline lacrimal solution)
- Blinking moves solution over the eye
- Drainage of tears
 - It moves down and medially into lacrimal canals in medial canthus.
 - They empty into lacrimal sac and tapers into lacrimal duct
 - Drains into nasal cavity below inferior nasal concha

EXTRINSIC EYE MUSCLES (move the eyes)

- There are FOUR RECTUS MUSCLES. They rotate the eye in direction of name
 - Superior rectus – CN III
 - Inferior rectus – CN III
 - Lateral rectus – CN VI (abducens nerve...this muscle abducts)
 - Medial rectus – CN III
- TWO OBLIQUE MUSCLES. They attach at an angle and rotate the eye in the opposite direction of the name as well as slightly laterally. This lateral movement counters slight medial pull of opposite rectus muscle.
 - Superior oblique – CN IV (trochlear nerve...this is a pulley!)
 - Inferior oblique – CN III

THE EYEBALL ANATOMY...there are three layers of the eyeball!

1. Outermost = Fibrous Layer (2 regions)
 - a.** The SCLERA is the bulk of the fibrous layer. It is made up of dense avascular connective tissue. It serves as an anchor for eye muscles. It is continuous with the dura mater.
 - b.** The CORNEA is continuous with the sclera. It bulges anteriorly and is clear. It is avascular, but innervated. The external surface is made up of stratified squamous cells, which renew the cornea continually. The internal surface of the cornea is made up of simple squamous cells. A Na⁺ pump continually pumps sodium out, taking water with it. This keeps the cornea clear!
2. Vascular Layer (aka “uvea”)
 - a.** CHOROID is the posterior portion of vascular layer. It is highly vascular and supplies other layers with blood. It contains pigments to absorb stray light from internal reflection.
 - b.** CILIARY BODY is formed from the choroids. The ciliary muscle is a smooth muscle that changes the shape of the lens. The ciliary body has projections, called CILIARY PROCESSES which are capillaries that secrete fluid.

- c. SUSPENSORY LIGAMENTS attach to the lens and are anchored by ciliary processes.
 - d. IRIS is the pigmented portion on the anterior. It acts as a diaphragm, adjusting the size of the pupil. It constricts for near vision and boredom, and it dilates for far vision and interest/excitation. Eye color is related to the amount and location (depth) of brown pigment.
3. Inner Layer (the retina!)
- a. PIGMENTED LAYER is made up of simple, pigmented epithelium. It lies over the entire vascular layer and extends forward to the posterior surface of the iris. This layer absorbs stray light and stores Vitamin A! The pigmented epithelium act as phagocytes to remove dead or damaged photoreceptor cells.
 - b. NEURAL LAYER = multiple layers of neuronal cells
 - i. Extends anteriorly only to ORA SERRATA. This layer contains photoreceptive cells and visual processing cells.
 - ii. The neural layer cells are:
 1. PHOTORECEPTOR CELLS (above the pigmented layer)
 2. BIPOLAR CELLS (middle layer)
 3. GANGLION CELLS (deepest layer...they generate APs)
 4. VISUAL PROCESSING CELLS (between other layers)
 - a. AMACINE CELLS
 - b. HORIZONTAL CELLS
 5. PHOTORECEPTOR CELLS (there are two types)
 - a. RODS respond to all wavelengths of light equally (best to green!). They are very sensitive and have a low stimulatory threshold. They are most active with night vision, but there is poor color discrimination.
 - b. CONES (three types). Each type responds best to either red, green or blue...but there is some overlap. Cones respond best to bright light, so they are most active during the day.
 - c. OPTIC DISC is the region where the nerve exits the eye. There are no photoreceptors at the optic disc...a blind spot!
 - d. Lateral to the optic disc is the MACULA where the innermost layers are pushed aside and it's mainly a bunch of photoreceptor cells. The small pit in the center of the macula is the FOVEA CENTRALIS. It is the point of highest visual acuity! It contains only cones, so used in daylight!

Innermost layer of the retina is made up of ganglion cell axons. The collected nerves from the OPTIC NERVE.

Density of CONES declines with *distance from* the macula

Density of RODS declines with *proximity to* macula.

Rods are the only photoreceptor cells at the periphery (near ora serrata)

SO WHAT IS THE RESULT OF ALL THIS ROD/CONE STUFF?

- Color and bright light discrimination is best at the fovea
- The eye must move constantly to absorb the “big picture”
- Rods discriminate poorly

- Peripheral vision is good at night
- Peripheral and night vision is limited

INTERNAL CHAMBERS OF THE EYE

The **posterior segment** is filled with a clear gel called VITREOUS HUMOR. It provides support (intraocular pressure), holds the lens in place, holds the neural retina firmly against the pigmented layer and transmits light. The vitreous humor forms in embryo and lasts a lifetime.

The **anterior segment** is divided by the iris into anterior and posterior chambers. It is filled with AQUEOUS HUMOR that circulates through the anterior segment and transports nutrients & wastes for the cornea and lens. It is **produced by the ciliary processes** of the ciliary body. It drains through the scleral venous sinus. The aqueous humor forms and drains continually!

THE LENS

The lens is a biconvex, transparent and flexible structure that can change shape to allow precise focusing of light on the retina. It is made up of two tissues:

1. Lens epithelium is made up of cuboidal cells on the anterior surface. They divide continually.
2. Lens fibers (derived from lens epithelium) make up the bulk of the lens. They contain transparent, precision-folded *crystalline proteins*.

The continual lens fiber production causes lens to become less elastic with age.

FOCUSING LIGHT

FAR VISION is used for distances of 20 feet or more. With far vision the ciliary muscles are relaxed and the suspensory ligaments are tensed, so the lens flattens out. So...the parallel light rays are minimally refracted.

NEAR VISION is used for distances up to 20 feet. ACCOMODATION occurs when the ciliary muscles contract and reduce tension on the suspensory ligaments. This causes the lens to bulge. PUPILLARY CONSTRICTION limits the light coming in. It prevents divergent rays at the periphery from entering the eye...it occludes unfocused peripheral rays. CONVERGENCE involves both eyes rotating medially.

THE VISUAL PATHWAY

Each eye sees its own visual field, and there is quite a bit of overlap.

1. OPTIC NERVE carries light information from a single eye
2. Signals from the medial side of the retina cross to the opposite side via the OPTIC CHIASM.
3. The OPTIC TRACT carries signals from the opposite visual field to the thalamus.
4. OPTIC RADIATIONS carry these signals to the VISUAL CORTEX.
5. There, it branches to the SUPERIOR COLLICULI, PRETECTAL NUCLEI (in midbrain) and HYPOTHALAMIC

Superior colliculi
reflex of extrinsic eye muscles

Pretectal nuclei in the midbrain
mediate papillary reflex

Suprachiasmatic nucleus in the hypothalamus
sleep/wake cycle

NUCLIE (suprachiasmatic nucleus, which is involved in the sleep/wake cycle).

DEPTH PERCEPTION requires both eyes. It involves the visual location of objects in space.

DISRUPTION OF THE PATHWAY

- Eye or optic nerve damaged
 - Diminished visual field and loss of depth perception
- Damage to optic tracts, optic radiations or cortex
 - Lose opposite half of the visual field
 - Depth perception is retained in the remaining half of the visual field.

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