Summary: The Senses

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Contents

1 The function of sensory receptors in processing environmental data

In order to respond to a particular stimulus, the body must first be capable of capturing, interpreting, and applying data. The first of these three properties, the capturing of data, is addressed through the utilization of **sensory receptors**, which detect stimuli and, eventually, open or close an ion channel in a neuron.

The process of **sensory transduction** describes the aforementioned technique whereby sensory data is converted to a negative or positive change in the charge of a neuron. For example, take the process whereby food is digested:

1. Sugar molecules bind to receptors in a taste receptor cell
2. A signal transduction pathway is triggered, generating a **receptor potential** through a modification to the existent ion gradient
3. The aformentioned ion gradient change, or signal, is propagated throughout the nervous system
4. The signal reaches the brain, where it is processed, and conveyed as "perception."

As is the case with certain "links" between neurons (i.e., neuroplasticity), this process is dulled through repeated activation, or **sensory adaptation**.

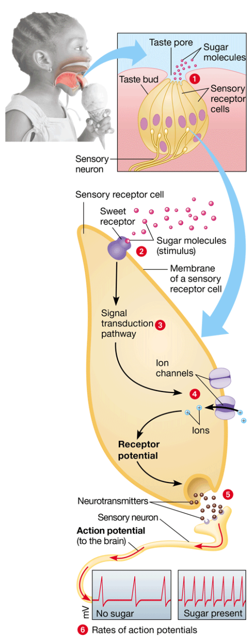

Figure 1: Sensory transduction at a taste bud

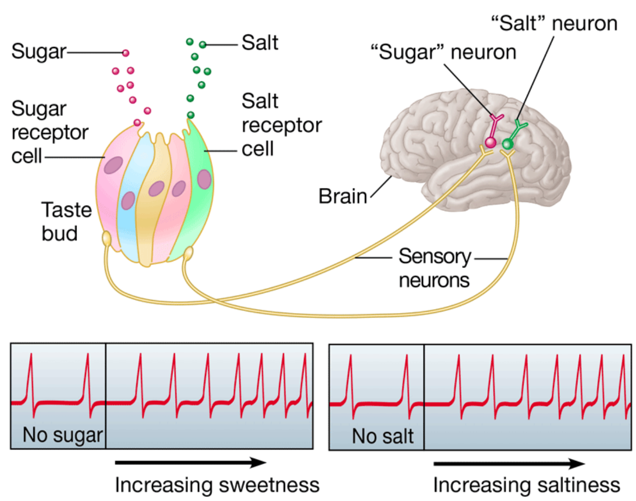

Figure 2: Action potentials transmitting taste sensations

1.1 The various types of sensory receptors

In animals, sensory cells are modeled to fit a specific class of stimuli. Accordingly, sensory receptors are described with respect to the stimuli that they "match:"

1. **Thermoreceptors**: detect heat or cold—exist in the skin, and deep in the body such that the receptors are capable of monitoring bloodstream temperature. Data received from these receptors are sent to the hypothalamus, which keeps the temperature of the body within a tolerable range.

2. **Mechanoreceptors**: detect changes in environmental factors including pressure, touch, stretch, motion, or sound through manual stimulation by the environment (i.e., bending or stretching by environmental actors causes the plasma membrane to let more sodium or potassium in). Examples of mechanoreceptors in animals are:
   - **Stretch receptors**: monitor the position of body parts
   - **Hair cells**: detect sound waves and movement in fluid
3. **Pain receptors**: detect pain and minimize damage caused by intense presesure or temperature
4. **Chemoreceptors**: detect chemical changes in the body or in the environment
5. **Electromagnetic receptors**: detect electromagnetic energy (e.g., electricity, magnetism, light). A common example of an electromagnetic receptor found in animals is the **photoreceptor** —a receptor containing light-absorbing pigment

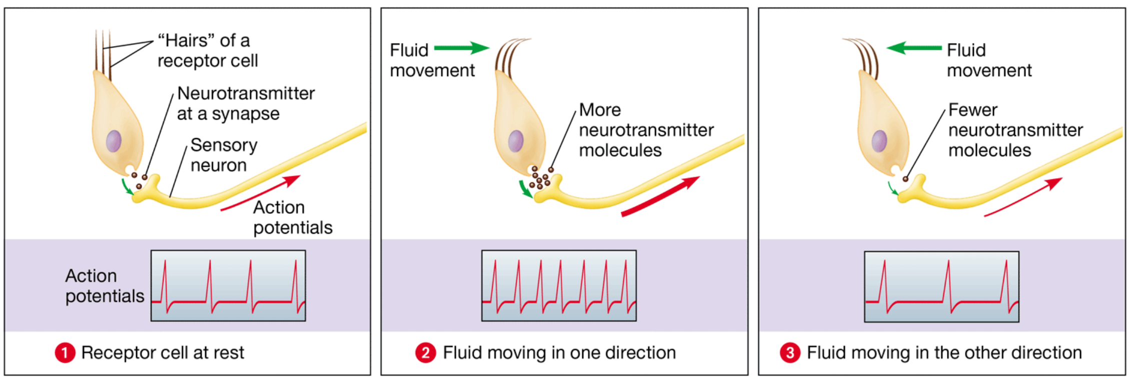

Figure 3: Mechanoreception by a hair cell

2 Hearing and balance

2.1 The structure of the ear

In humans, the ear is instrumental to our innate sense of balance, and is divided into three regions, each consisting of various components:

- The **outer ear**, which is comprised by the:
  - **Pinna**: the external part of the ear visible in daily life
  - **Auditory canal**
- The **middle ear**, which is separated from the outer ear by a sheet of tissue termed the **eardrum**, and is comprised by the:
  - **Hammer** (malleus), **anvil** (incus), and **stirrup** (stapes), to which vibrations derived from sound pressure received by the eardrum are passed
  - **Oval window**—vibrations conveyed through the stirrup, to which this structure is attached, pass through this hole in the skull bone, and into the inner ear
  - **Eustachian tube**—through the connective capability provided by this structure, air pressure parity is maintained between the inner ear and the pharynx
- The **inner ear**, which is comprised by the following fluid- filled chambres:

- **Cochlea**: consists of the
  * **Organ of Corti**—the human hearing organ composed of various **basilar membrane**-embedded hair cells

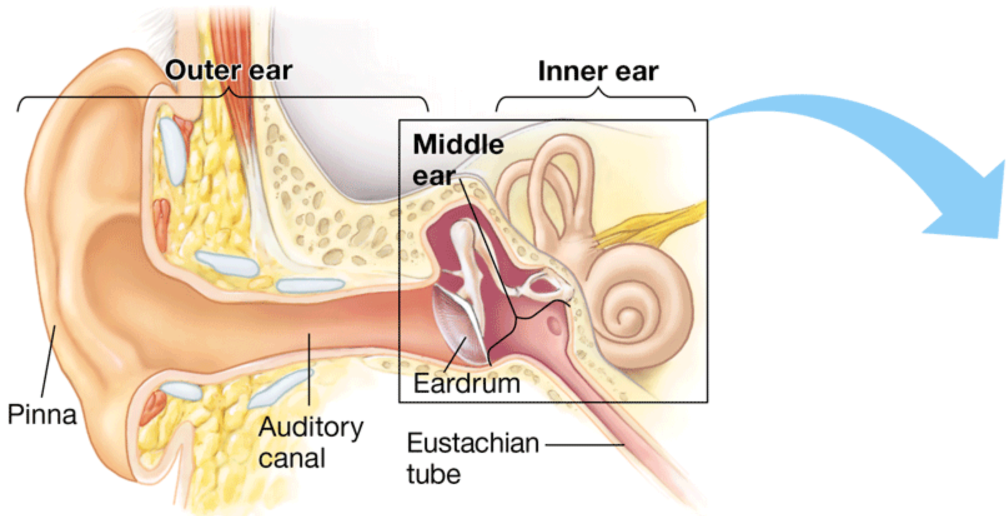

Figure 4: The structure of the human ear

2.2 The ear as an organ of balance

In addition to each of the aforementioned functions, the ear aids in the perception of position, movement, and balance, through the utilization of several structures located adjacent to the cochlea named the **semicircular canals**, which deal specifically with detecting changes in angular movement and rate of rotation. Each of these canals operate on the basis of the movement of a **capula**, or a thick, sticky fluid against which hairs in the canal are placed. Higher rates of movement result in faster movement of the capula, resulting in a greater frequency of released action potential signals from this organ.

3 Vision

In invertebrates, **compound eyes** are the image-forming sensory organs of the body. These functional groupings of components contain thousands of light-detecting **ommatidia**, which capture a "field of view" of light. Each of these parallel stream of information contributes to a larger picture, which is splied together by the brain of the animal.

In all vertebrates, **single-lens eyes** are the image-forming sensory organs of the body. Though it is more structurally complicated than the compoudn eye, the single-lens eye can be broken down into various functional groups. For example, as is often useful in studying the ear, the eye can be divided into a front and rear chamber—both of which are filled with fluid. These fluids—the aqueous and more viscous vitreous humors, respectively—aid in the circulation of necessary minerals and nutrients, and dispose of waste. With a more practical focus towards the functionality of the single-lens eye, one might turn to the following structures:

- The **cornea**: helps let light into and focus the eye
- The **choroid**: composed of the
  - **Iris**: allows more or less light into the eye by modifying its diameter
  - **Pupil**: receives and transfers light to a lens

- A **lens**: conveys light in a focused manner[1]onto the **retina**, and its constituent photoreceptors[2]—of which there are the most of towards the **fovea** or center of the eye

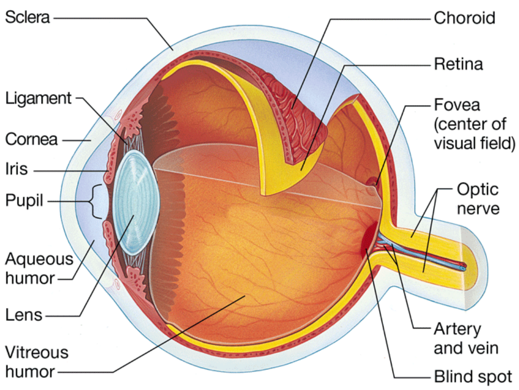

Figure 5: The single-lens eye of a vertebrate

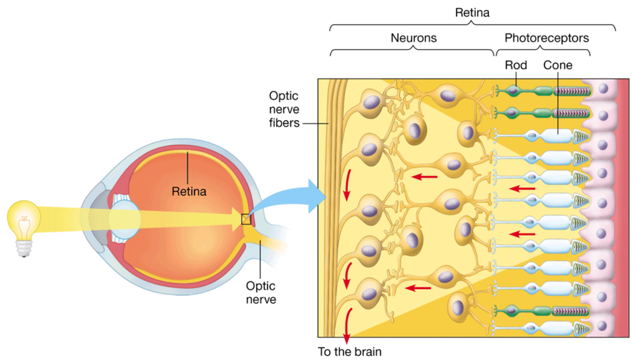

Figure 6: The transfer of light data through the eye

4 Taste and Smell

In the nasal cavity, **olfactory** receptors are responsible for informing the portion of the brain responsible for the sensation of smell (i.e., the olfactory bulb) of incoming stimulus data. This is achieved through the binding of an odorous sustance to receptor proteins in nasal cilia.

In the mouth, responsibilities for certain tastes are deleagted to specific taste buds on the tongue. Namely, umami, swwet, sour, salty, and bitter are each detected by only one kind of taste receptor.

[1]generally, an eye is focused through a process of accomodation, wherein ciliary muscles are contracted or relaxed and ligaments are loosened or tightened.

[2]in humans, there are two types of photoreceptors: **rods**, which are more sensitive to light, and **cones** which are more suited for color. These types of photoreceptors each contain their respective pigments which account for their abilities to discern different types of incoming light (i.e., **rhodopsin** in rods and **photopsins** in cones).