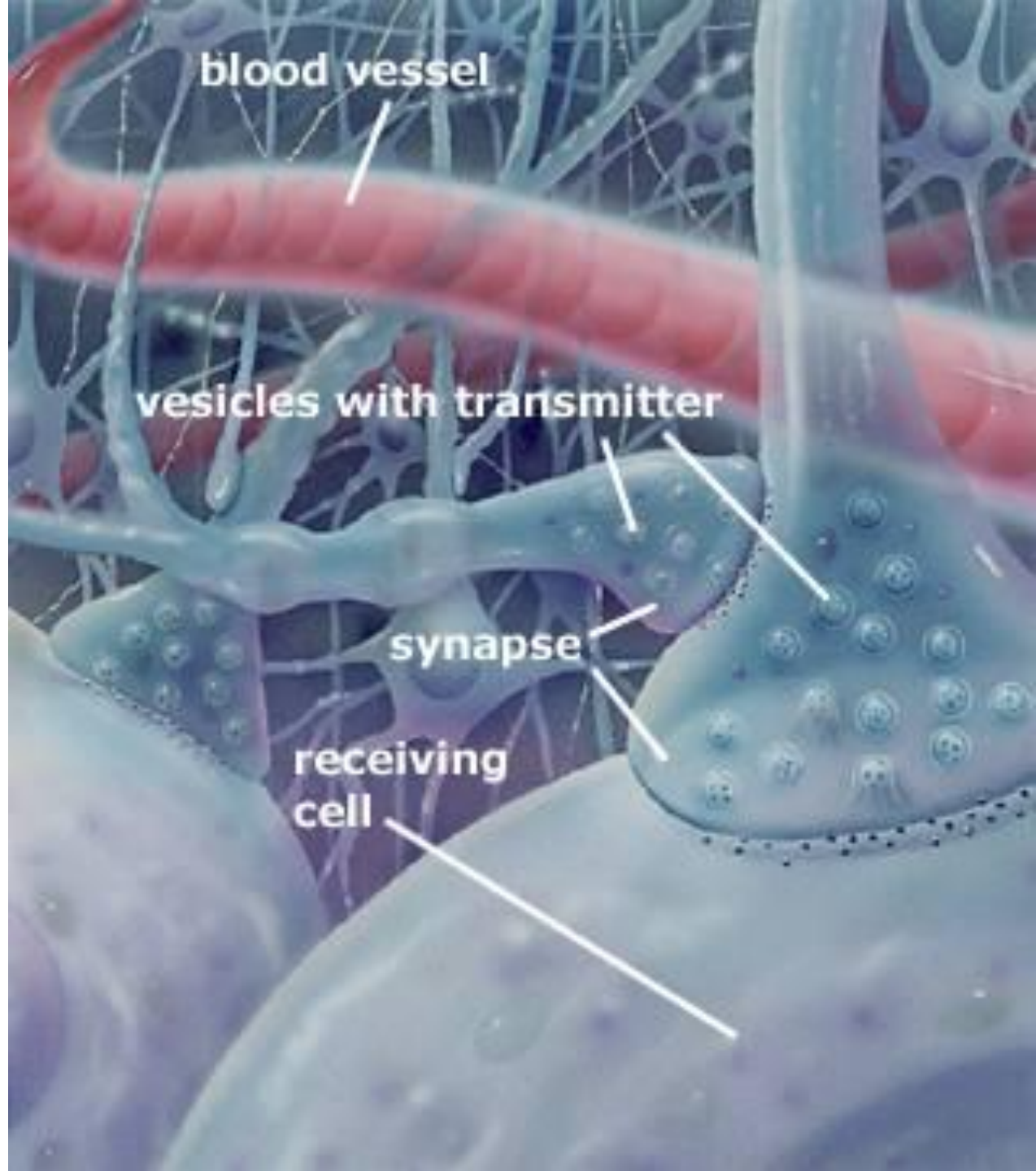


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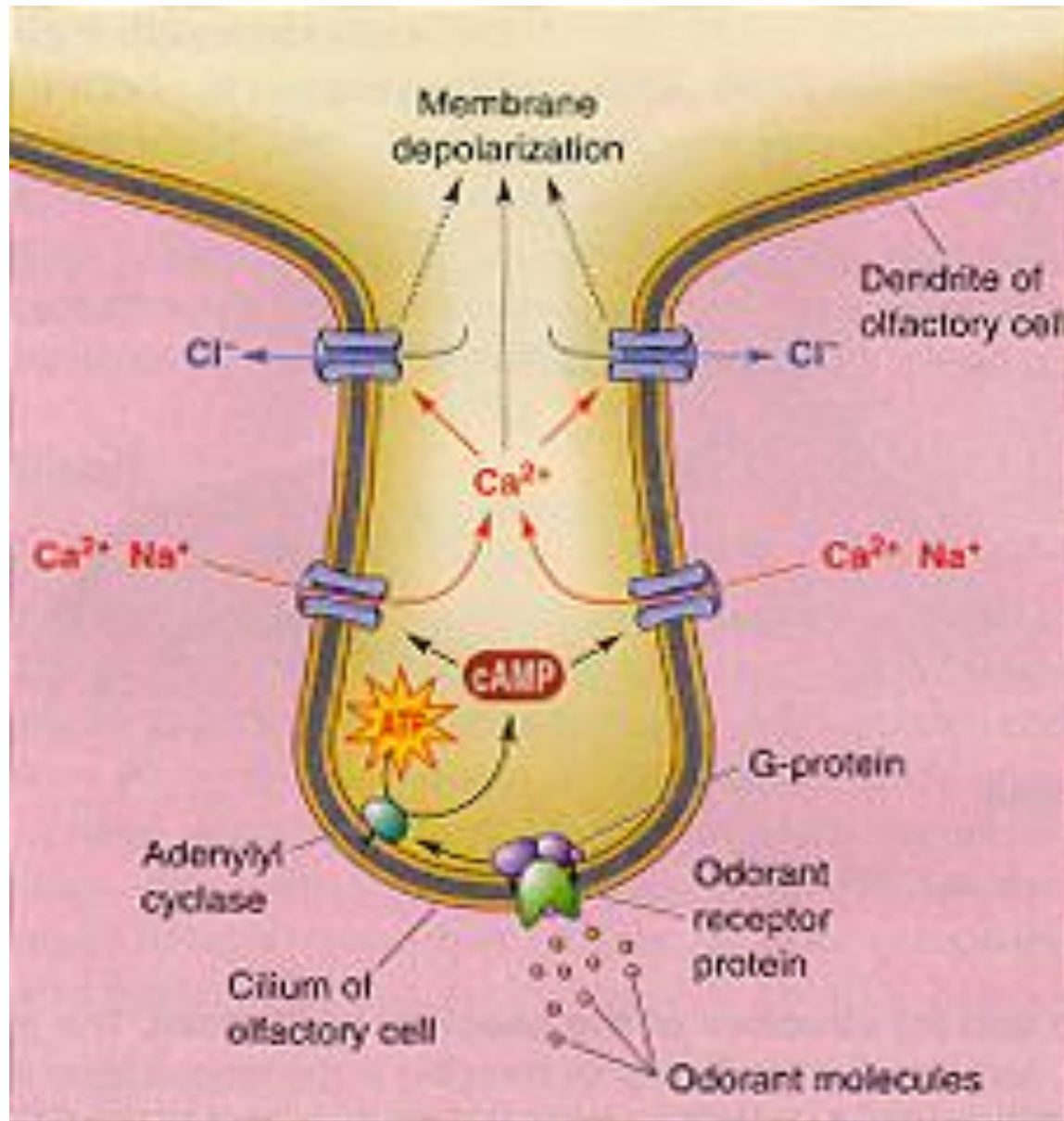
Neurobiology of the Synapse

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Lecture 20
Sensory Systems
Chpt 19, 2, 20



Transduction in Olfactory Cilia





Chemical Amplification

- Olfaction depends upon chemical amplification in order to yield sensitivity
- Chemical amplification - second messenger pathways in which enzymatic cascades produce large #s of intermediate products, thereby increasing by 1000x the effect of one activated receptor molecule



Odorant Specificity

- Humans can discriminate odors due to thousands of different olfactory receptors
- Each olfactory receptor recognizes a spectrum of odors rather than being highly selective
- Each particular odorant receptor is found in a restricted area of the epithelium; different families of R genes are expressed in zones extending along the length of the epithelium

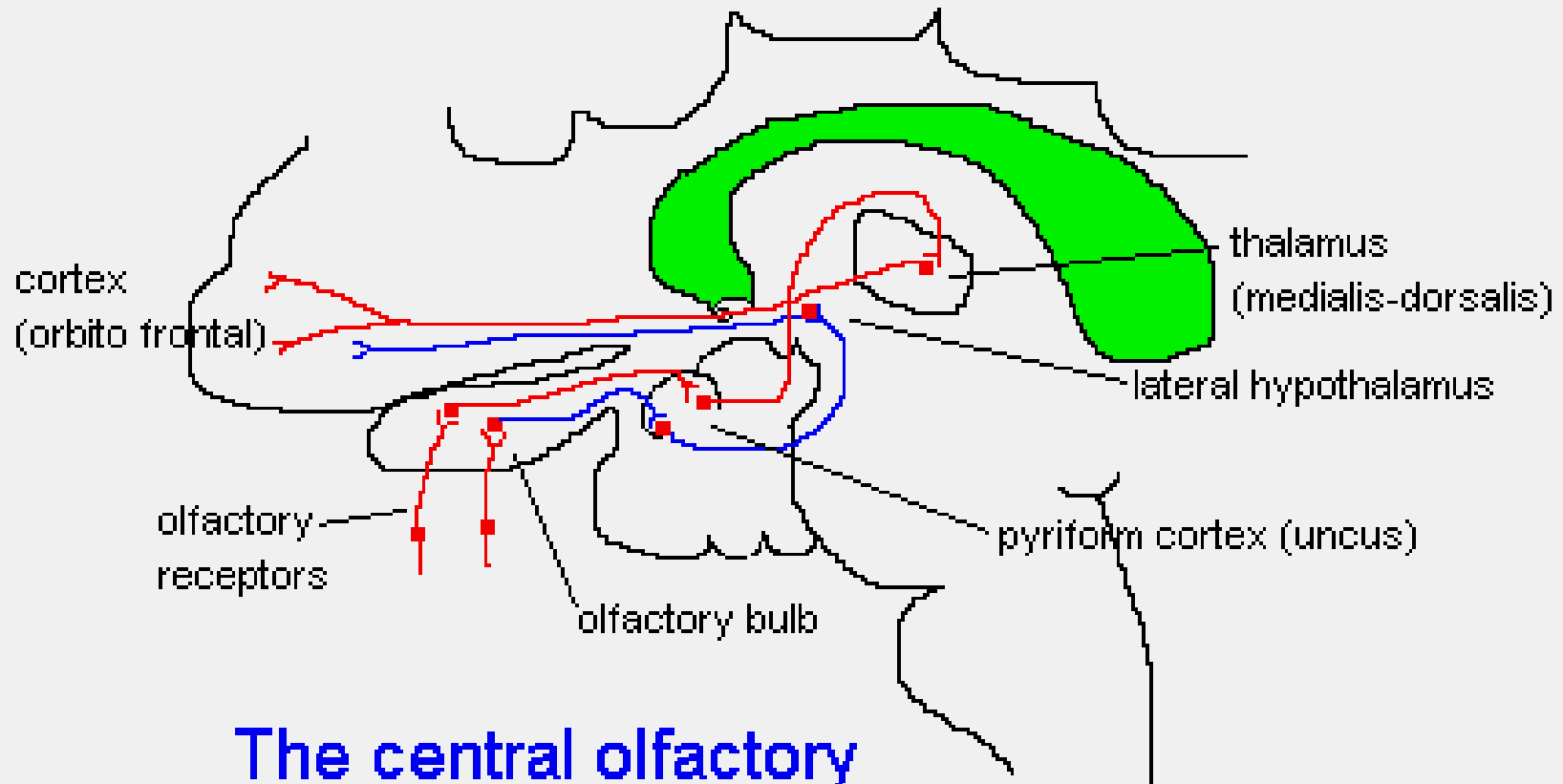


Central olfactory pathways

- Neurons from the lateral olfactory tract project to;
- (1) the limbic system (amygdala, the entorhinal cortex, hippocampus and the subiculum.
Remember that the limbic system is an ancient region of the brain concerned with motivation, emotion and certain kinds of memory.
- (2) Projections are also sent to the thalamus and then to the frontal cortex for recognition.



Central olfactory pathways



**The central olfactory
projections**

Olfaction & Gender



- Olfactory sensitivity can be induced in humans e.g. humans who were initially unable to smell the volatile steroid androstenone developed the ability after repeated brief exposure
- In addition, humans can show enhanced sensitivity to odors they could previously detect; but this form of increased sensitivity which averages an increase of five-fold was only observed in females of reproductive age
- This suggests that the greater olfactory sensitivities among females may be associated with female reproductive behaviors such as pair bonding and kin recognition
- *Nature Neuroscience 2002 Volume 5 p. 200*



Anosmia

- A condition where the sense of smell is reduced or lost entirely
- Caused either by traumatic head injury or a virus (temporary)
- Some people are born without a sense of smell - congenital anosmia, and some develop it as a consequence of another disorder, e.g. Alzheimer's disease.
- Some anosmics suffer from depression and their quality of life is severely affected - at the moment there is little that can be done to help them.



TASTE (GUSTATION)

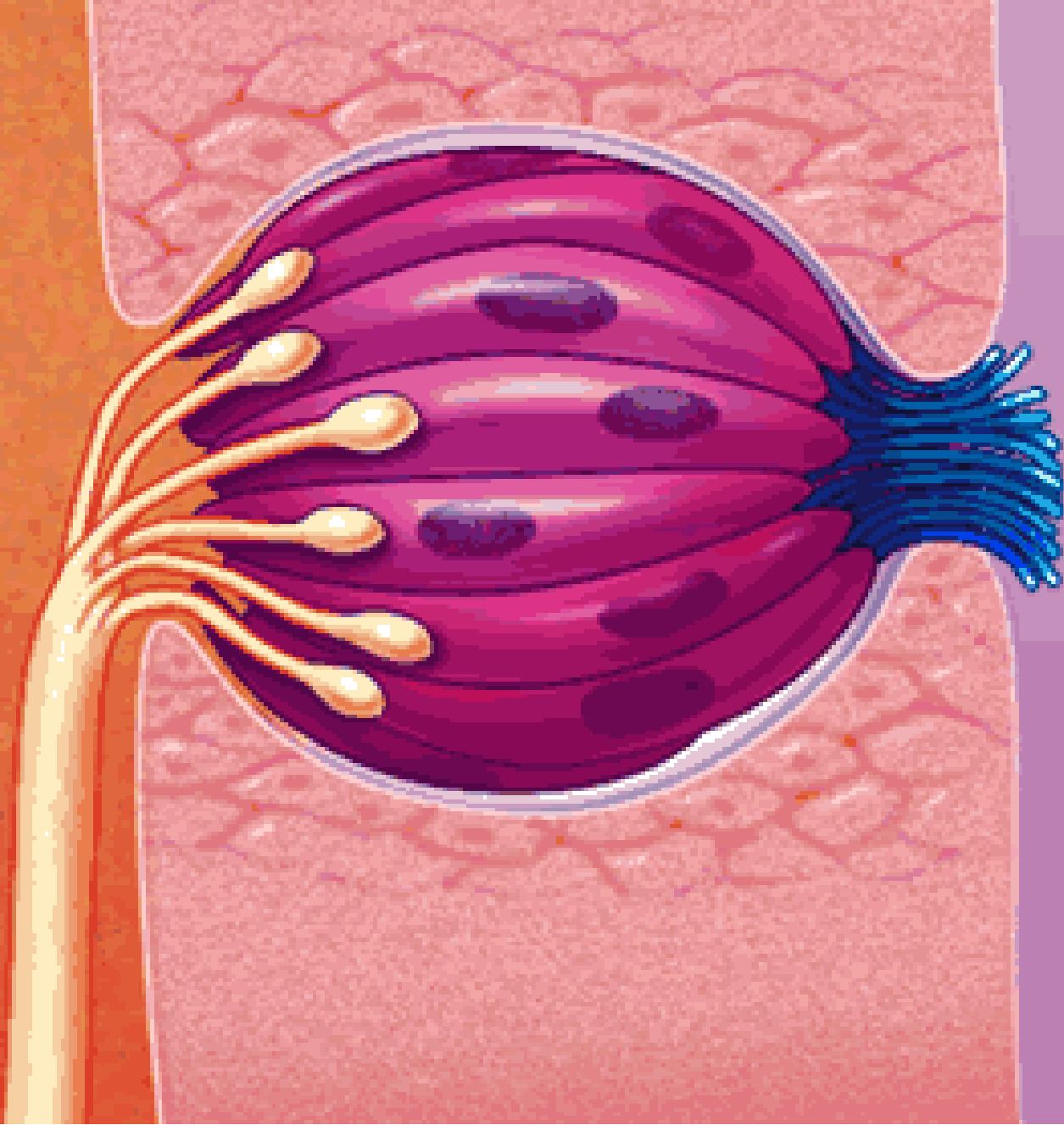
- Taste and Smell are often associated; one reason is that both senses are activated by external chemical stimuli
- In addition, some taste stimuli (tastants) also act on G protein coupled receptors similar to odorants
- Other tastants, however, act directly on membrane conductances



Taste Receptor Cells



- Taste Rs are ciliated neuroepithelia cells found in taste buds
- Taste cells are also regenerated throughout life
- Taste cells don't have axons, they form chemical synapses with afferent neurites in the taste bud; microvilli project from the taste cell into the taste bud where they are bound by tastants (which have been dissolved in saliva)





Taste Receptor Cells

- Tastants are divided into :
 1. Salt
 2. Sour
 3. Bitter
 4. Sweet
 5. Umami
(MSG – amino acid taste)



Taste Receptor Cells

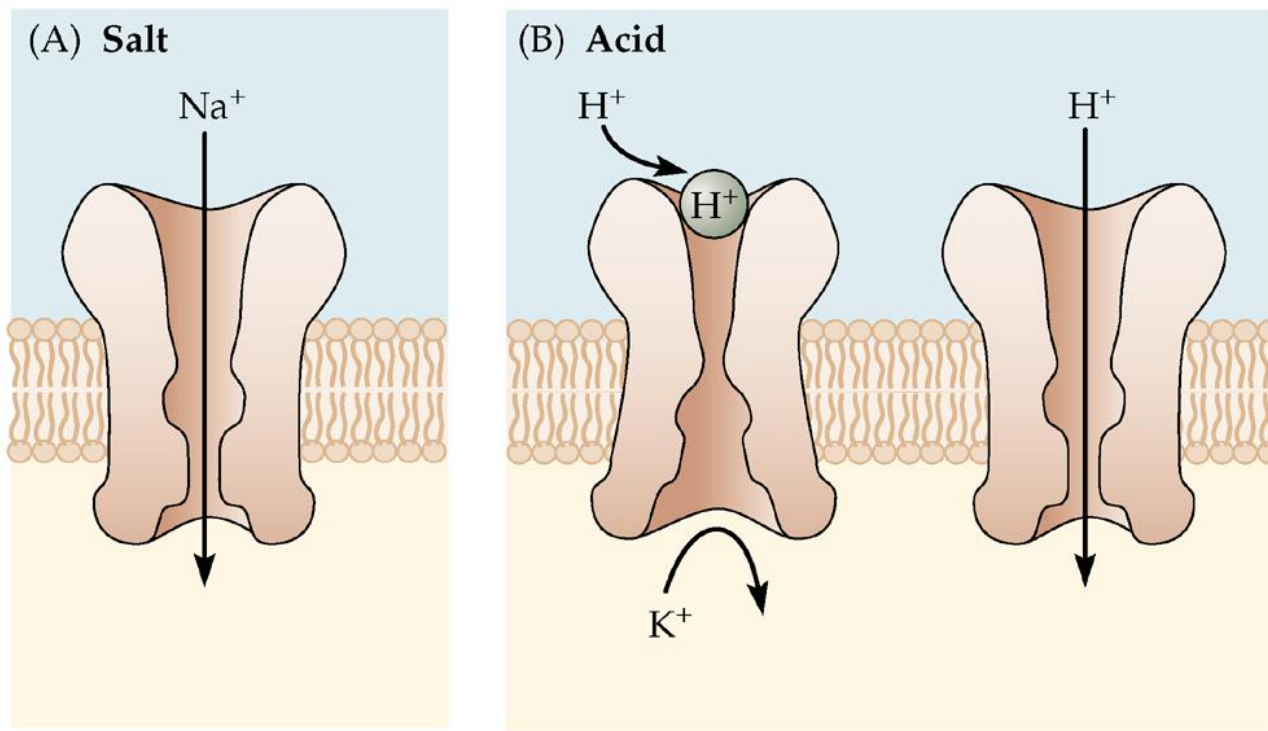


- There are 2 broad categories of transduction mechanisms for these 5 tastants:
 1. Direct action on ion channels
 2. Second messenger activation



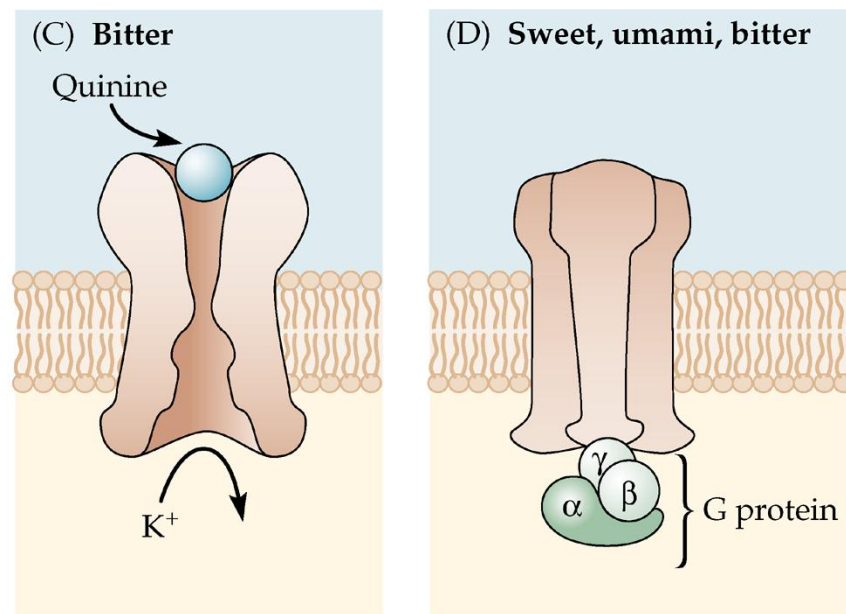
Salt & Sour

- The taste of salt results from direct flux of Na^+ through channels in the apical membrane of the taste cell
- Salty foods contain a high $[\text{Na}^+]$; it diffuses down its concentration gradient into taste cells
- The salt induced depolarization produces transmitter release from the taste cell onto afferent neurons



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- Salts and acids can permeate ion channels in the sensitive ending or block normally open K^+ channels
- Sour taste results from the high [proton] in acidic foods
- In some cases protons block K^+ channels, also leading to depolarization



- Sweet and bitter substances tend to be large molecules bound by macromolecular receptors with high specificity
- Sweet and bitter tastants activate second messenger pathways through interaction with G protein-coupled receptors

Molecular Receptors for Chili

- Hot chilis are not sensed by taste cells, but by pain fibers in the tongue that are activated by capsaicin
- The capsaicin R is a calcium-sensitive cation channel





Transduction of Nociceptive and Thermal Stimuli


- There are 2 kinds of skin temperature receptors: warmth & cold
- Test it for yourself: press a pencil against various points on the back of your hand; sometimes you will feel cold other times you will just feel touch
- These types of temperature sensitive Rs do not sense extreme temperatures

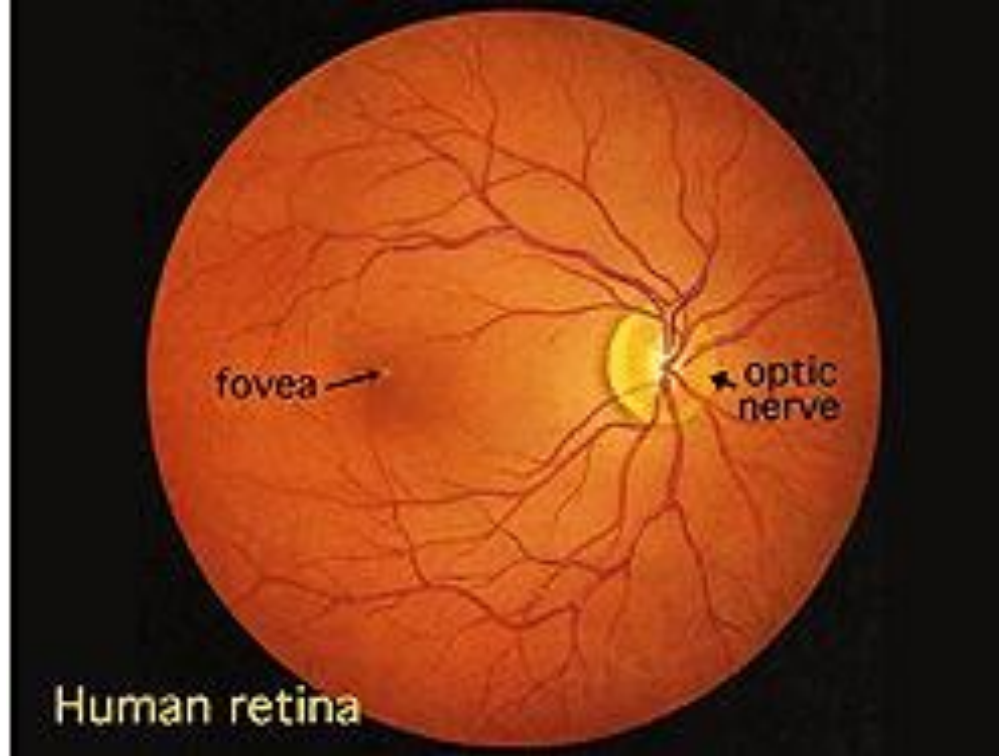
Activation and Sensitization of Nociceptors

- Nociception: the perception of noxious or damaging stimuli
- e.g. painful heat causes nonspecific cation channels to open and subsequent signaling to the CNS
- In addition to the direct action of these stimuli, damaged cells release chemicals (e.g. ATP); a subunit of ATP R (P2X)

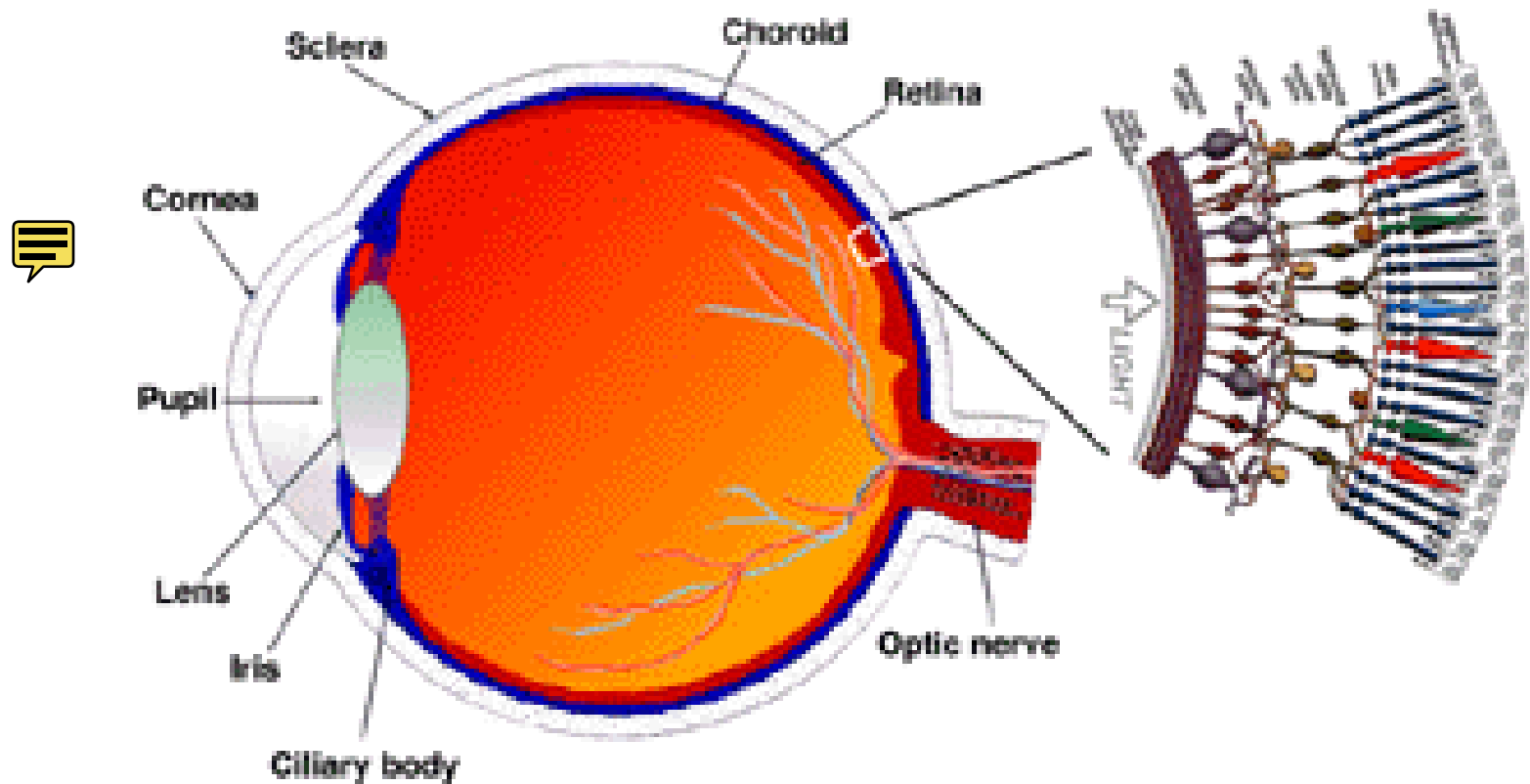


Visual System

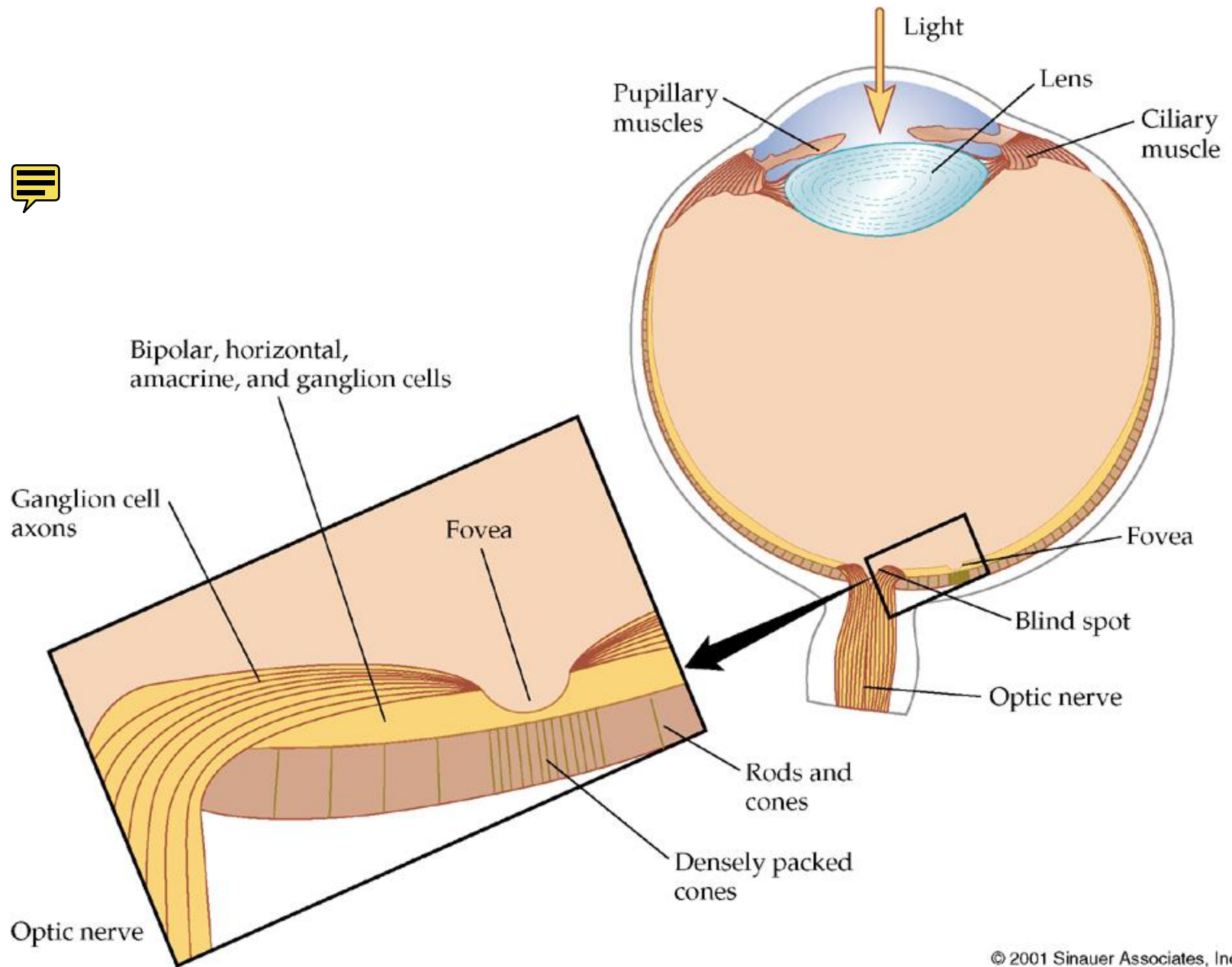
 The visual system, whose activity involves roughly a quarter of the cells in the human cerebral cortex, has attracted more research than all the other sensory systems combined.

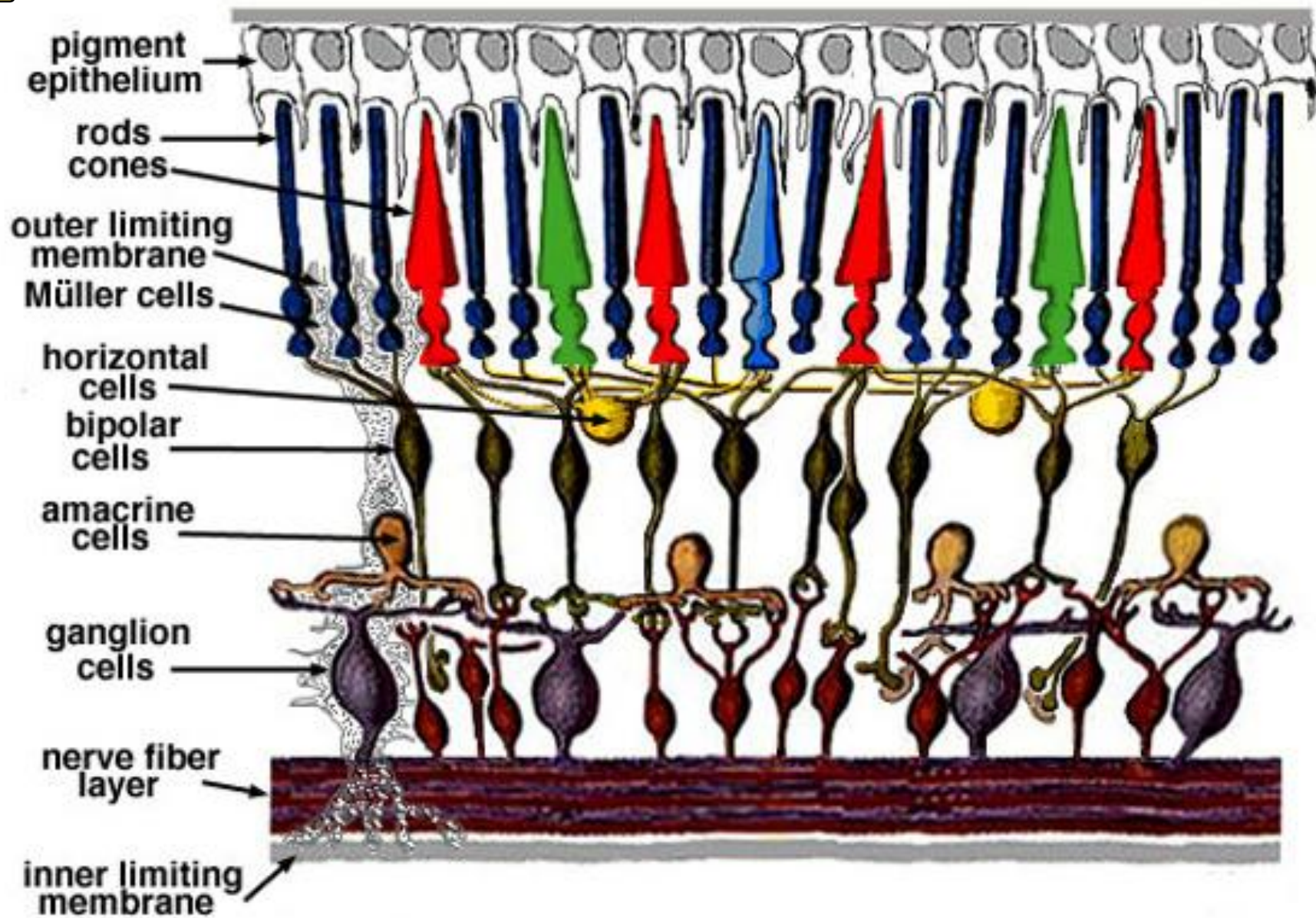


- The human retina viewed with an ophthalmoscope
- The optic nerve is in the center of the retina
- The optic nerve contains the ganglion cells which are the output neurons of the retina running to the brain
- The major blood vessels of the retina radiate from the center of the optic nerve



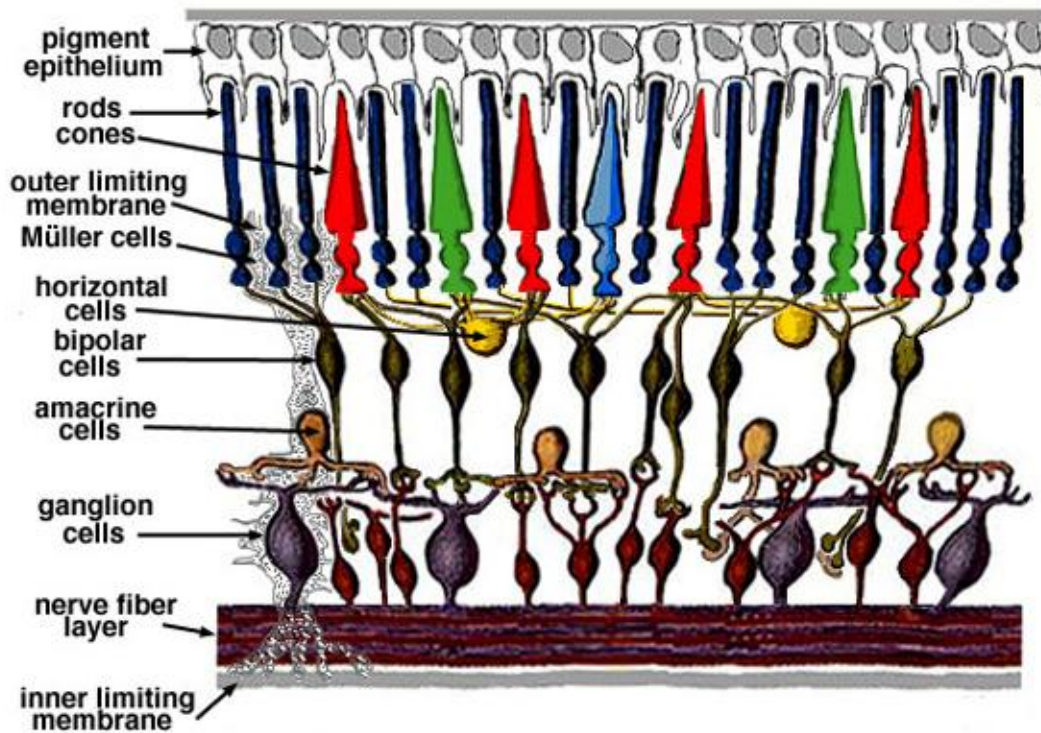
- The retina lines the back of the eye
- The ganglion cells lie innermost in the retina closest to the lens and the photoreceptors lie outermost
- Therefore light must travel through the thickness of the retina before reaching the rods and cones
- The absorption of photons by the visual pigment of the rods and cones is translated into a biochemical message and then electrically communicated to other neurons in the retina





The Retina

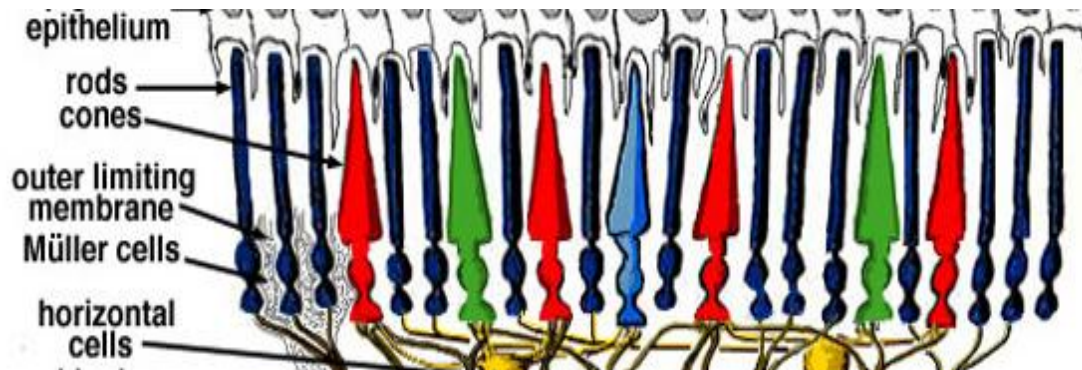
- Neatly layered; 5 main classes of cell types: photoreceptors, amacrine cells, bipolar cells, horizontal cells and ganglion cells
- The photoreceptors are the rods and cones
- Rods (dark vision) and cones (light vision) are connected to bipolar cells, which are connected to ganglion cells
- Numerous lateral connections are made with horizontal and amacrine cells
- Only the amacrine and ganglion cells can generate APs



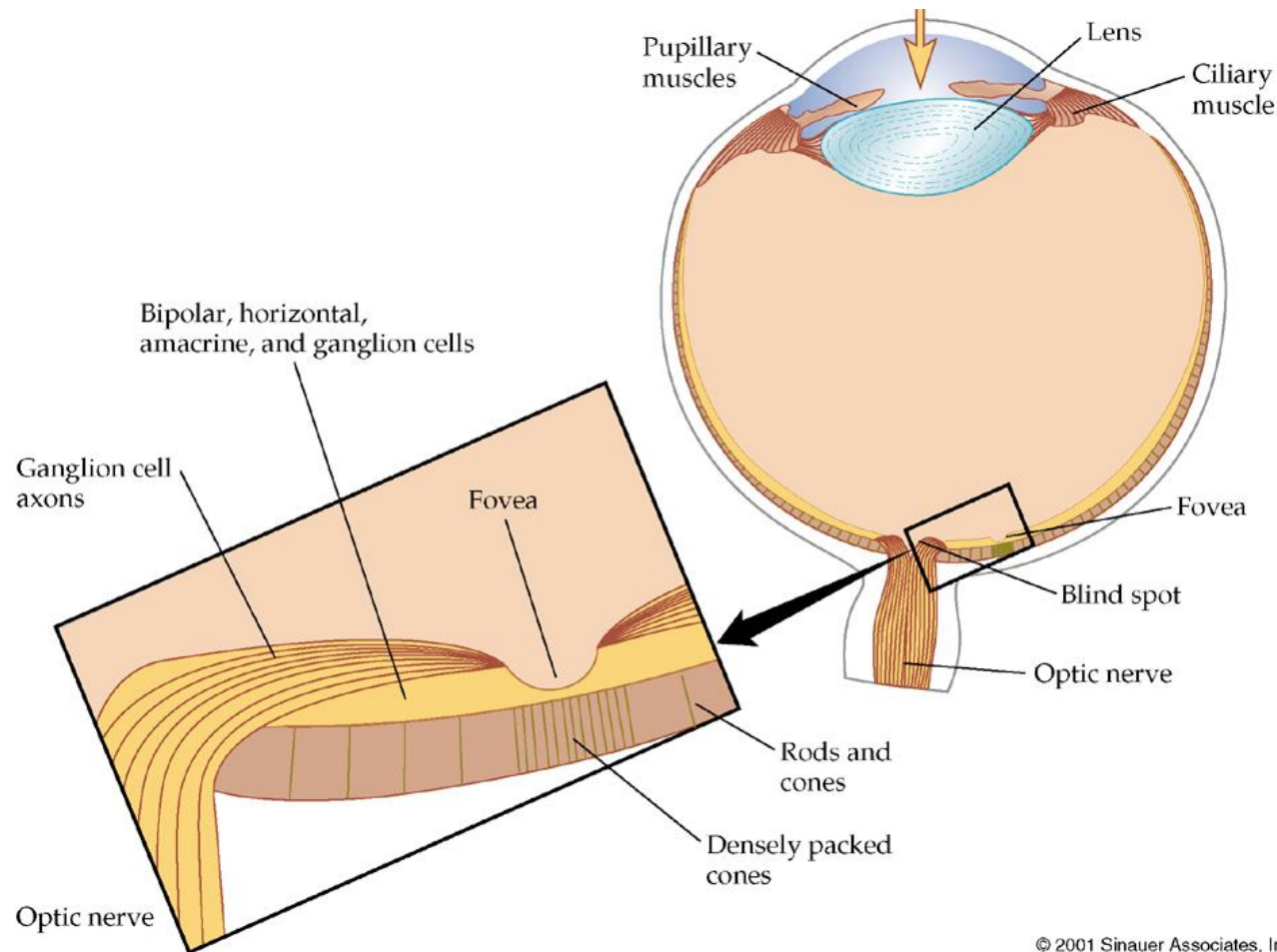
- There are many interneurons packed into the retina intervening between the photoreceptors and the ganglion cells
- The retina is composed of 3 layers of nerve cell bodies and 2 layers of synapses; the outer layer contains the rods and cones, the inner layer contains bipolar, horizontal and amacrine cells, and the ganglion cell layer contains ganglion cells

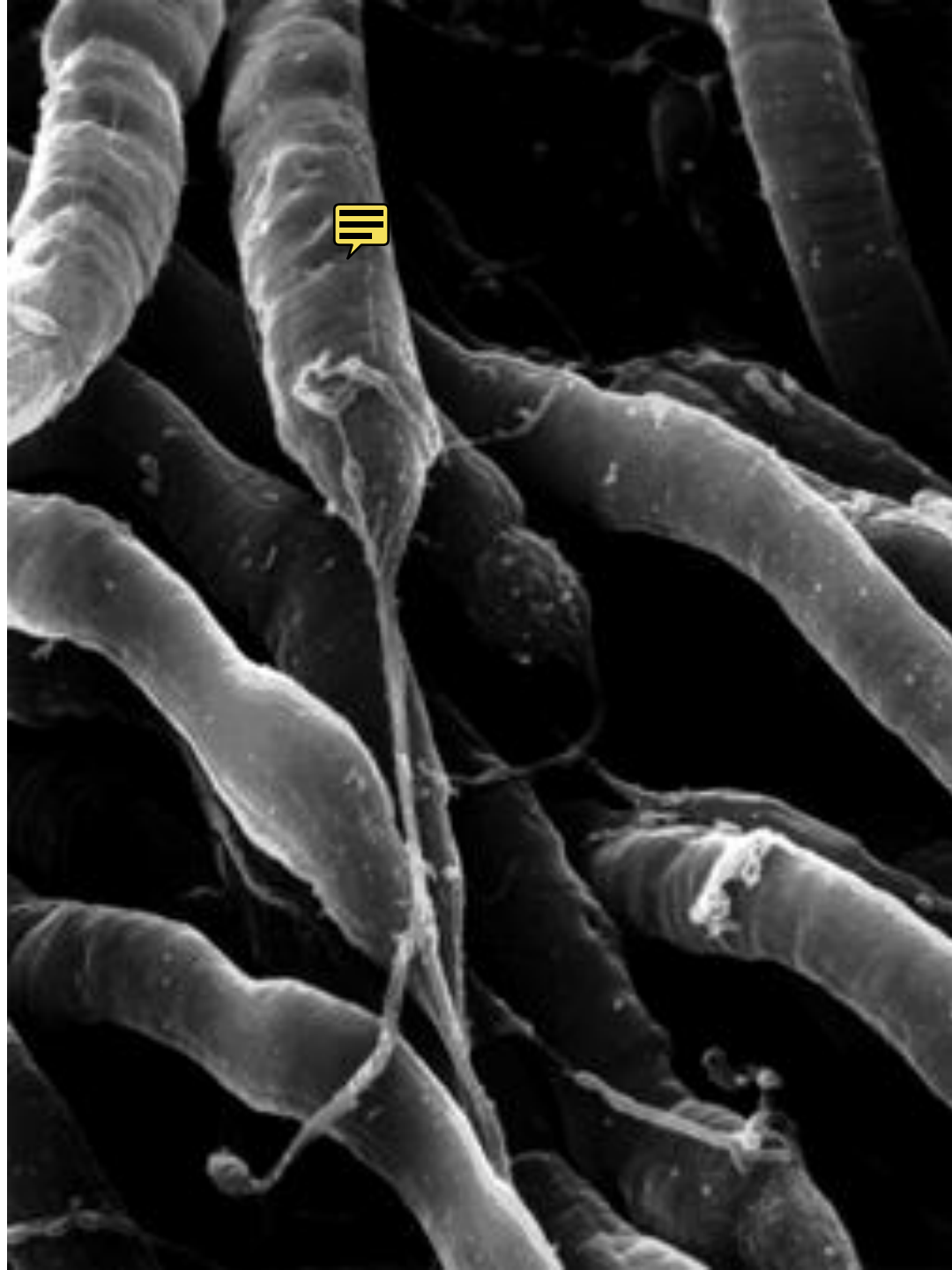
Transduction and Signaling in the Retina

- The response to light begins with receptors termed rods and cones
- Rods are most sensitive; can be activated by a single quanta of light
- Cones are responsible for colour and daylight vision



- These photoreceptors define the limits of vision e.g. snakes can detect infrared radiation humans can not
- Rods and cones are densely packed (furthest from light); Except for the fovea, light must cross layers of tissue before reaching the photoreceptors
- The fovea is a specialized area containing densely packed cones used for fine discrimination
- The point where the optic nerve exits the eye has no photoreceptors – the blind spot





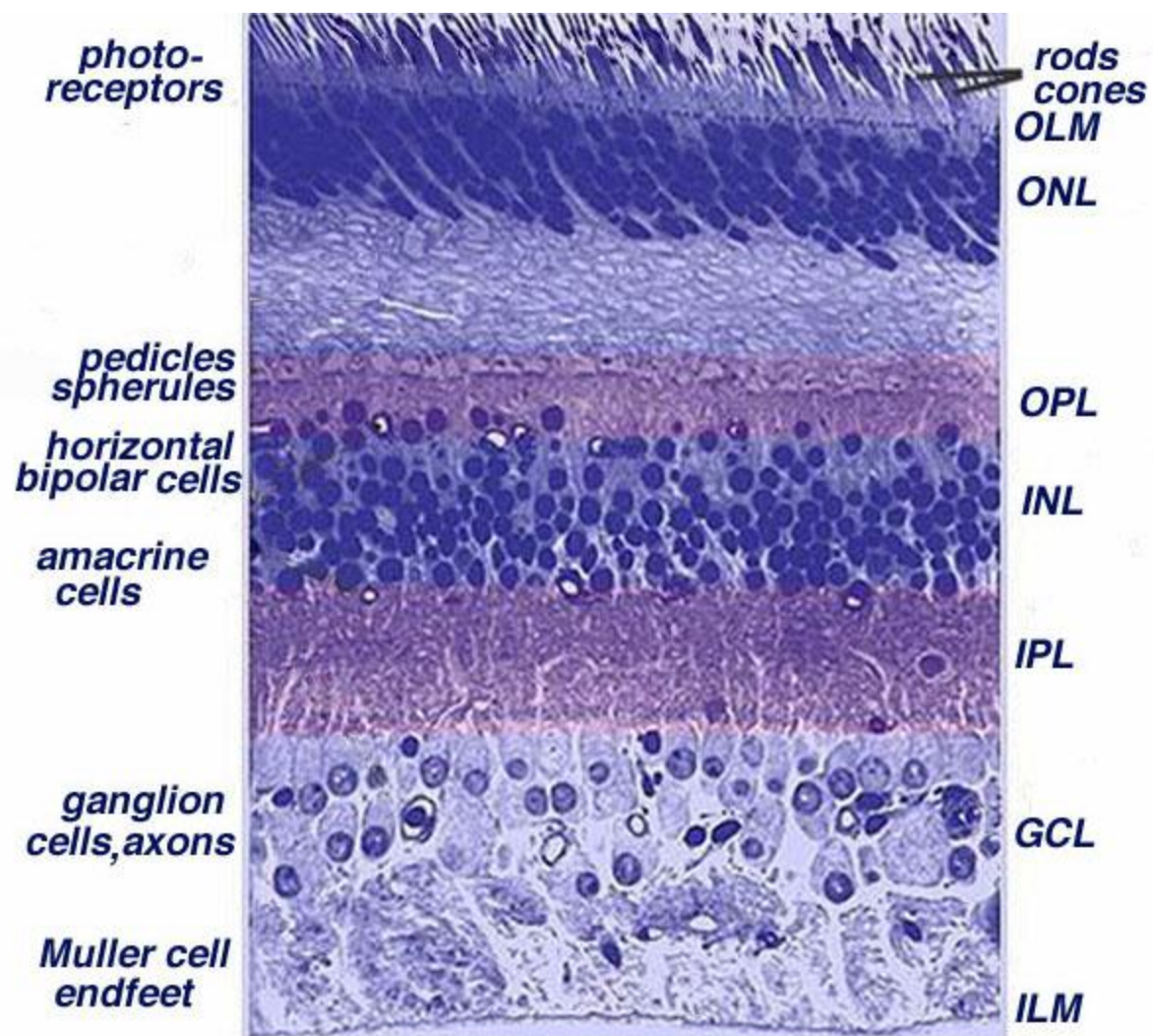


Fig. 3. Light micrograph of a vertical section through central human retina.