1. Special senses include vision – eyes; chemical senses – smell (nose) and taste (tongue); hearing and balance – ears.

2. **The Eye and Vision**: The eye is formed of eyeball and placed in bony socket – Orbit and is padded with fat. 6 extrinsic muscles rotate eyeball and lacrimal gland is also present in orbit.

3. **The lacrimal apparatus**: lacrimal glands secrete tears that protect and provide nourishment to eye. Lacrimal canaliculi drain excess fluid to lacrimal sac $\rightarrow$ nasolacrimal duct $\rightarrow$ inferior nasal cavity

4. **6 eyeball muscles’ nerve supply**: lateral rectus = 4th; medial rectus, superior rectus, inferior rectus and inferior oblique = 3rd; superior oblique = 6th cranial nerve Fig 9.9

5. **Eyebrows** – shade and protection of eye

6. **Eyelids** – protection and lubrication of eye by reflex blinking. 2 muscles orbicular oculi and levator palpebrae lie in the eyelids. Modified skin glands – sebaceous and sweat, are also present.

7. **Conjunctiva** – is the internal lining of eyelids and covers the anterior side of eyeball. It secretes mucous to aid in lubrication.

8. **Structure – the eyeball** is formed of 3 layers = tunics; fibrous – Sclera, vascular – Choroid or uvea and sensory – Retina. Fig 9.12

9. **Outer layer** = 2 parts.

10. Sclera – white and opaque, protective, maintains shape and muscle attachments.

11. **Cornea** – transparent anterior part, allows light to enter and participates in image focusing.

12. **Middle layer** = 3 parts choroid, ciliary body and iris.

13. Choroid – dark brown, vascular – provides nutrients to all 3 layers, eliminates scattering of light.

14. Ciliary body – ring like, has muscles to change lens shape and secretes aquous humor. Fig 9.10

15. Iris – the colored part of eye seen from eye, has Pupil – an opening at the center, has muscles to regulate pupil size. These days used to positively identify humans. Fig 9.11

16. **Innermost layer** = Retina = 2 parts. Fig 9.12

17. **Pigment layer** = outer layer and absorbs light.

18. **Neural layer** = inner layer – formed of 3 layers of neurons – in front ganglion cells, their nerve fibers form optic nerve; middle layer of Bipolar neurons; and outer layer of photoreceptors – the cone cells and rod cells. Fig 9.19

<table>
<thead>
<tr>
<th>Cone Cells</th>
<th>Rod Cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Stimulated by bright light</td>
<td>1. Stimulated by dim light</td>
</tr>
<tr>
<td>2. Located at the center of retina</td>
<td>2. Located at the periphery of retina</td>
</tr>
<tr>
<td>3. Give colored vision</td>
<td>3. Give black and white vision</td>
</tr>
</tbody>
</table>
19. I made a flow chart below and light comes from the front side of retina – bottom in chart

**Diagram:**

- **Sclera** – white opaque, protection, shape
- **Fibrous** – allows light to enter
- **Cornea** – transparent
- **Vascular**
- **Choroid** – dark brown, provides nutrient
- **Ciliary body** – has muscles to change lens thin = far, thick = close
- **Iris** – has muscles to change pupil
- **Pigment layer** – absorbs light
- **Retina**
- **Photoreceptors**
  - Cone cells – central, colored vision in bright light
  - Rod cells – peripheral, B/W vision, in dim light
- **Neuronal layer**
- **Bipolar neurons**
- **Amacrine cells**
- **Ganglion cells** – fibers form optic nerve

**Focusing for distant and close vision:**

20. **Far objects** – Ciliary muscles relaxed → suspensory ligaments tense → lens thin

21. **Near objects** – Ciliary muscles tense → suspensory ligaments relaxed → lens rounded

22. **Myopia** – near object seen clearly; can’t see far objects; corrected with a Concave lens glasses. Fig 9.17

23. **Hyperopia** – far objects seen clearly; can’t see near objects; corrected with a Convex lens glasses.

24. **Suspensory ligament** holds the lens in position in the eye. Ciliary muscles in ciliary body can stretch or relax the suspensory ligament which in turn makes the lens thin or thick. By default eyes are focused on far objects.

25. **Vitreous humor** a thick jelly like material fills the posterior cavity behind lens – suspensory ligament – ciliary body. It helps to maintain retina pressed against the choroid. Some impurities called floaters are present in vitreous humor.

26. **Aqueous humor** fills the anterior cavity in front of lens – suspensory ligament – ciliary body. Ciliary body secretes it and then it passes through pupil to anterior chamber. It is drained by Canal of Schlem. If not drained, the eye pressure can increase dramatically and make a person blind within hours – **homeostatic imbalance is Glaucoma.**
27. Chemical Senses – Smell = Olfaction: Olfactory epithelium = sensory epithelium for detecting smell lies in roof of nasal cavity. Nerve fibers of these sensory cells pass through pores in Cribriform plate of ethmoid bone and synapse with neurons of olfactory bulbs below cerebral hemispheres. Olfactory tracts carry information to in temporal lobe. Some fibers of olfactory tract carry the sensory input also to limbic system for emotional interpretation.

28. Chemical Senses – Taste = gustatory sensation: fig 15.23 Tongue is the main organ of Taste. Smelling vapors of food is 80% taste. Temperature, texture and touch etc. completes the experience. About 10,000 taste buds are present on tongue. Each taste bud has sensory and basal cells in it. Sensory Cells of taste buds get burnt with hot foods and are replaced every 7-10 days. Vapors of food dissolve in water or mucous and stimulate specific sensory cells by binding to specific receptor proteins.

29. H+ = stimulate sour tasting sensory cells.
30. Metal ions = stimulate salt tasting sensory cells.
31. Sweet = sugars and other organic compounds
32. Bitter = alkaloids and some others like aspirin
33. Umami = recently discovered by Japanese scientists = beef, taste of steak, tang of aging cheese, yummy taste of some foods = by amino acids asparate and glutamate.
34. Water receptors are present in pharynx.
35. Taste maps of tongue are not true.
36. The EAR – Hearing and Balance: Ear is formed of 3 main parts as shown in the flow chart below. Fig 15.25
37. External ear = auricle or pinna, collects sound waves + external acoustic meatus, carries sound waves to tympanum. The meatus has ear wax glands – cerumen glands to protect against fungal and bacterial growth.
38. Middle ear = tympanum + 3 ear ossicles + middle ear cavity with pharyngotympanic tube + oval and round windows to internal ear.
39. Middle ear cavity is a narrow high cavity inside temporal bone. On lateral side it has tympanum. On medial side it has Oval and round windows that open into bony labyrinth.
40. Tympanum vibrates with sound waves and passes vibrations to malleus joined at medial side of tympanum. Tensor tympanic muscle is joined to malleus and regulates the tension of tympanum.
41. 3 Ear Ossicles: Malleus passes the vibrations to incus and incus in turn to stapes (the smallest bone in human body). Stapedius muscle is the smallest muscle in human body. Ear ossicles amplify the sound signal.
42. Internal Acoustic Meatus or auditory tube joins middle cavity to nasopharynx and helps to maintain similar pressure on both sides of tympanum.
43. Internal ear = bony labyrinth + membranous labyrinth
44. Bony labyrinth has 2 membrane covered openings oval and round windows that open into middle ear cavity. Bony labyrinth has Vestibular duct and Tympanic duct parts that lie superior and inferior to Cochlear duct. Bony labyrinth is filled with a fluid perilymph.
45. **Membranous labyrinth** – named so due to complex structure: is filled with a fluid Endolymph. Its parts and their functions are listed in the following chart.

46. Vestibule = detects movements of head and passes information to cerebellum to control body position. **Angular = Acceleration in rotational motion** is discovered by **cristae** present in ampullae of semicircular canals. **Pull of gravity and Straight motion** are detected by **maculae** of utricle and saccule.

47. **Hearing** is detected by **spiral organ of Corti** present in basilar membrane of scala media of Cochlea. Each cell of Organ of Corti gets depolarized by a narrow range of sound frequency. High frequency sounds stimulate cells closer to oval window. Low frequency sounds stimulate sensory cells closer to end of cochlear duct.

48. Vestibular nerve collect information about balance from vestibule and Cochlear nerve collect information about hearing from Cochlea and make VESTIBULOCOCHLEAR (8\(^{th}\)) cranial nerve.