

THE VISUAL SYSTEM: THE EYEBALL, RETINA & BASIC ANATOMY

1. The Eyeball

Sclera

Cornea

Anterior and Posterior chambers (Aqueous & Vitreous humors)

Iris muscles, Pupil, Lens

Retina, retinal blood supply (blood vessels anterior to retina & Choroid Layer)

“Blind Spot” = Optic Head = Optic Disc (start of optic nerve, C.N. II)

2. The Retina

Sensory receptors: “rods” and “cones” (and more?)

Bipolar cells (neurons)

Ganglion cells (neurons)

Amacrine cells (neurons)

Horizontal cells (neurons)

Macula, Fovea (high acuity vision, Macular Degeneration)

“backwards” layout of retina (with receptors away from light)...why?

Detached Retina (secondary to concussion, uncontrolled diabetes)
& possible repair

3. Photopigments & Duplicity Theory of Vision

Rods – use Rhodopsin (Scotopic vision)

In low light levels, very sensitive to even dim light (much summation of signals onto one neuron), very poor acuity, monochromatic

Located in periphery of retina

Nocturnal species (e.g. rats, cats, dogs)

Cones – use one of 3 Opsins (Photopic vision)

Require higher light levels (little to no summation), high acuity, color

Located in fovea, macula

Diurnal species (e.g. goldfish, eagles, humans)

4. **“Electrically Backwards” Retina**

Visual receptors (rods & cones) are active in complete darkness!

The unstimulated (by light) receptors open Na^+ ion channels, which lets in Na^+ and keeps the receptor depolarized (receptor potential)

The depolarized receptor releases glutamate (an excitatory NT), which in turn stimulates the bipolar cell (generator potential)

The bipolar cell fires, and releases its NT which is GABA (an inhibitory NT) onto the next neuron, a ganglion cell

The ganglion cell is hyperpolarized by the GABA, is inhibited, and does not fire --- no signal goes into the optic nerve

When visual receptors are stimulated by light, their Na^+ ion channels then close, the receptors become hyperpolarized, and they then release no/less glutamate

--- the bipolar cells are no longer stimulated, and they then release no/less GABA

--- the ganglion cells are no longer inhibited, and they then begin to fire --- a signal goes up the optic nerve into the brain...weird!

(see Pinel, Fig. 6.12)

5. **Accommodation**

Lens assumes natural shape to focus on near objects (ciliary muscles contract --- less pull on ligaments that encircle the lens --- lens

Assumes its natural round shape)

When need to focus on distant objects (ciliary muscles relax --- more pull against the ligaments that encircle the lens --- lens flattens out)

Changes with increasing age (less able to contract ciliary muscles) ---

Poor accommodation to focus on near objects (“far-sighted”)

6. **Convergence**

Ability of both eyes to look at the same point in the visual world

Essential for good depth perception (stereoscopic, 3-D vision)

May need to improve responses of external eyeball muscles

7. **Pupil Size**

Pupil dilates under conditions of high SNS arousal

Increases field of vision at expense of acuity & depth of focus

Pupil constricts under conditions of low SNS arousal

Increases acuity & depth of focus at expense of field of vision

C.N. III (Oculomotor)

Affected by various drugs/medicines

ACh antagonist --- pupillary dilation (e.g. atropine, Donatol)

CNS stimulants (e.g. amphetamines, cocaine)

Heroin --- pupillary constriction (“pin-point pupils”)

8. **CNS Pathway into the Brain**

optic nerve --- optic chiasm --- optic tract --- thalamus (lateral geniculate nucleus) --- occipital lobe

“retinal-thalamic-cortical” pathway...there are other pathways...

in occipital lobe: primary visual cortex (V1) or striate cortex (layer IV)

prestriate cortex (V2), posterior parietal cortex (dorsal pathway),

inferotemporal cortex (ventral pathway)

(see Pinel, Fig.6.13, 7.8, 7.9)

is a **retinotopic** pathway (part of “labeled lines” neural coding)

Note: 25% of cortical neurons receive input from fovea

9. **Magnocellular and Parvocellular Pathways**

Magnocellular pathway:

More primitive, evolved earlier, found in all mammals

Bottom two layers of LGN

Have large somas (neurons in LGN), hence “magno”

Responsive to movement, gross detail, & depth

Input is mostly from rods

9. **Magnocellular and Parvocellular Pathways** (cont.)

Parvocellular pathway:

More recently evolved, found only in primates (apes, monkeys, man)

Top 4 layers of LGN

Have smaller somas (neurons in LGN)

Responsive to color, fine detail, to stationary or very slowly moving Stimuli

Input is mostly from cones

Note: Most of magnocellular input ends up in **dorsal** pathway after it leaves V1; most of parvocellular input ends up in **ventral** pathway after it leaves V1

10. **Optic Chiasm**

Species with laterally placed eyes have 100% cross-over at optic chiasm
all of R eye axons end up in L V1; all of L eye axons end up in R V1
e.g. rabbit, chickens, mice, goldfish

Species with frontally placed eyes have < 100% cross-over at chiasm
e.g. cats – about 40% remain ipsilateral, 60% cross over
e.g. humans – about 50%-50% (half of axons from R eye go to L V1
and the other half of axons from R eye go to R V1)

11. **Right and Left Visual Fields (within both eyes) in Humans**

Input from the right visual fields of both eyes send axons to L V1

Input from the left visual fields of both eyes send axons to R V1

There they terminate on binocular cells (neurons that receive input from both the R & L eyes, but from the same point of the R or L visual field)