

## THE VISUAL SYSTEM

### PERIPHERAL MECHANISMS

- 1) Light enters retina
  - a. Lens adjusted by ciliary muscles – can relax/contract to flatten/slacken lens to focus far/near objects
- 2) Light detected in retina
  - a. **Rods** – in the periphery, very sensitive to light (can absorb single photon), no color; good for night vision
  - b. **Cones** – in fovea, low sensitivity (require 100s of photons), sensitive to color; operate in daylight
  - c. Outer segment consists of stacked membranous discs (rods)/sacs (cones) → increase surface area of membrane
  - d. **Rhodopsin** – light-absorbing pigment in membrane = **opsin** and **11-cis retinal**
- 3) Light converted to signal
  - a. Opsin absorbs light → retinal converts from 11-cis to all trans → detaches from opsin
  - b. Opsin now active → activates **transducin** → activates **PDE** → hydrolyzes **cGMP** → channels close → hyperpolarization → less Glu released
    - \*in darkness: constant Glu release → cell depolarized = dark current; light closes channels → hyperpolarization (counterintuitive)
  - c. **Adaptation**: photoreceptors change biochemistry to adjust sensitivity to light:
    - i. Bright light → Ca feedback mechanism → reduced light sensitivity
    - ii. Darkness → recovers sensitivity
- 4) Pre-processing and transmission of information
  - a. **Bipolar cells**
    - i. D-bipolar: light detector cells – depolarize when photoreceptors are stimulated
    - ii. H-bipolar: darkness detector cells – hyperpolarize when photorec are stimulated
  - b. **Ganglion cells**
    - i. On-center: D-bipolar synapse with them, activate action potential
    - ii. Off-center: H-bipolar synapses, inhibits AP
    - iii. Axons of ganglion cells form optic nerve
  - c. Other cells
    - i. **Horizontal cells** (lateral inhibition network)– inhibit neighboring synapses when stimulated → light detection produces opposite response in cells in surrounded area = **center-surround** organization → best stimulus is light surrounded by dark/dark surrounded by light – enhances contrast: light and dark dots
    - ii. **Amacrine cells** – detect motion
- 5) Color vision
  - a. Cones have 3 different forms of pigment – sens to blue, green, red light (s-,m-,l-opsin)
  - b. Compare output of 3 types to extract color information

### CENTRAL ORGANIZATION

- 1) Pathway to thalamus

- a. Temporal and nasal division of retina – rec info about contra/ipsilateral visual fields
  - b. **Optic nerve** – contains information from one eye, but both visual fields
  - c. **Optic chiasm**: nasal fibers decussate →
  - d. **Optic tract** contains info about contralateral visual field only, but from two eyes
  - e. Before LGN, collaterals to: SC of thal (modulates circadian rhythms), Edinger-Westphal nucleus (ocular reflexes), superior colliculus (orient head and eyes to visual stimulus) = unconscious responses
- 2) Relay of input in LGN
- a. Magnocellular layers (1-2): large cell, large receptive field; high temporal resolution
  - b. Parvocellular layers: (3-6): small cell and field; high spatial resolution and color
  - c. Each layer has complete, retinotopic map of visual field
- 3) Striate (primary visual) Cortex
- a. **Optic radiations** – info from LGN to primary visual cortex
  - b. Information goes to layer 4 of cx (monocular input), begins to mix as it projects to other layers (binocular input)
  - c. Properties of receptive field change: from spot detector to bar/edge detector (then corner detector, finally complex cells that rebuild image)
  - d. Each column has preference for bar of light in certain rotation, 10 deg difference between each column (18 total for 360 degree spectrum)
  - e. **Ocular dominance columns** – cells with preference for one eye also grouped together

#### EXTRASTRIATE CORTICES

- 1) Receptive field properties
- a. Striate cortex: spatially discrete analysis of visual stimuli
  - b. Visual association cortex (temporal lobe): cell here responds to entire image
  - c. Each extrastriate area – analysis of one or more visual attributes
- 2) Streams of visual processing
- a. Ventral stream: V1 → V2 → V4 temporal lobe: high resolution and color = WHAT
  - b. Dorsal stream: V1 → V2 → MT → parietal lobe: space and motion = WHERE
  - c. Diff lesions disturb diff aspects of visual processing – also fusiform face area, inferotemporal cortex = emotional significance of visual stimuli, object recognition

#### CLINICAL LECTURE

- 1) Optic nerve lesion → loss of vision in one eye
- 2) Optic chiasm lesion → bitemporal or hemianopsia (tunnel vision) binasal much rarer
- 3) LGN lesion → homonymous hemianopsia (see contra visual field)
- 4) Optic radiation lesions:
  - lower retina → temporal lobe (Meyer's loop) – stroke can damage → upper quadrantanopsia
  - upper half of retina → parietal lobe – lower quadrantanopsia (rarer)
- 5) Occipital cortex lesions: contralateral homonymous hemianopsia
- 6) Macular sparing: top of occipital cortex represents bilaterally – if stroke in one lobe, macular vision spared