Neuroscience

- Cellular and molecular neuroscience
- Neuroanatomy
- Systems neuroscience

The astonishing hypothesis

- Perception
- Thought
- Emotion
- Memory
- Consciousness

- Material processes in vast networks of neurons
- “You’re nothing but a pack of neurons.”
Perception

- Where physics meets psychology
- Vision
- Hearing
- Touch
- Etc.

Light

- Photon energy = Planck’s constant x frequency
- Wavelength x frequency = speed of light

Figure by MIT OCW.
Electromagnetic spectrum

- White = superposition of all frequencies.

Why is “visible” where it is?

- Notch in water absorption spectrum
- “Visible” light is what is available in the ocean.
- Evolution has exploited this fact.
Reflection and absorption

• Lightness
  – Dark objects absorb more than light ones

• Color
  – Frequency-dependent absorption

Refraction

Figure by MIT OCW.
Functions of the eye

- Forming a stable image on the retina
- Emphasizing spatial and temporal differences in images

Gross anatomy of the eye

Figure by MIT OCW. After figure 9.4 in:
Opthalmoscopic view


Blind spot demo


Further reading:
V.S. Ramachandran and S. Blakeslee, *Phantoms in the Brain*
Filling in

Moral: perception is an active process.
"Seeing is believing."
"Believing is seeing."

Cross-sectional anatomy

Refraction by the cornea

Formula:

\[
\text{Refractive Power (Diopters)} = \frac{1}{\text{Focal Distance (m)}}
\]


Accommodation

Visual field

Retinal images are inverted.


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Visual angle

- Distance on the retina corresponds to visual angle.
- 20/20 vision = resolution of 1/12 degree

Retinal circuitry


Laminar organization

Rods and cones

Scotopic/night vision 1000 x more light sensitive
 Photopic/day vision
 Color vision

Cell bodies
Inner segments
Photoreceptors

Synaptic terminals
Membranous disks containing photopigment

Spatial organization

- Photoreceptors less dense in periphery
- Ratio of photoreceptors to ganglion cells higher in the periphery
- Acuity is lower, sensitivity higher in the periphery
Fovea in cross section

Lateral displacement of ganglion cells at fovea improves acuity


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Neurotransmission and phototransduction

**Response to light**

- Dark current due to open sodium channels
- Light depletes cGMP, closing sodium channels


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**Rhodopsin photoactivation**

Opsin has seven transmembrane alpha helices, like other GPCRs

Signaling cascade


Chemical amplification

- Each rhodopsin activates many G-proteins
- Each PDE converts many cGMPs
- Detection of a single photon is possible!

Further reading: