

Introduction to Course 9.04, Vision and Audition

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Audition: Chris Brown

Reading assignments

Research report

Exams

Introductions

What aspects of visual processing are we trying to understand?

Color vision

Movement processing

Depth perception

Object recognition

Generation of visually guided eye movements

Tools of the trade:

Psychophysics

Anatomy

Physiology

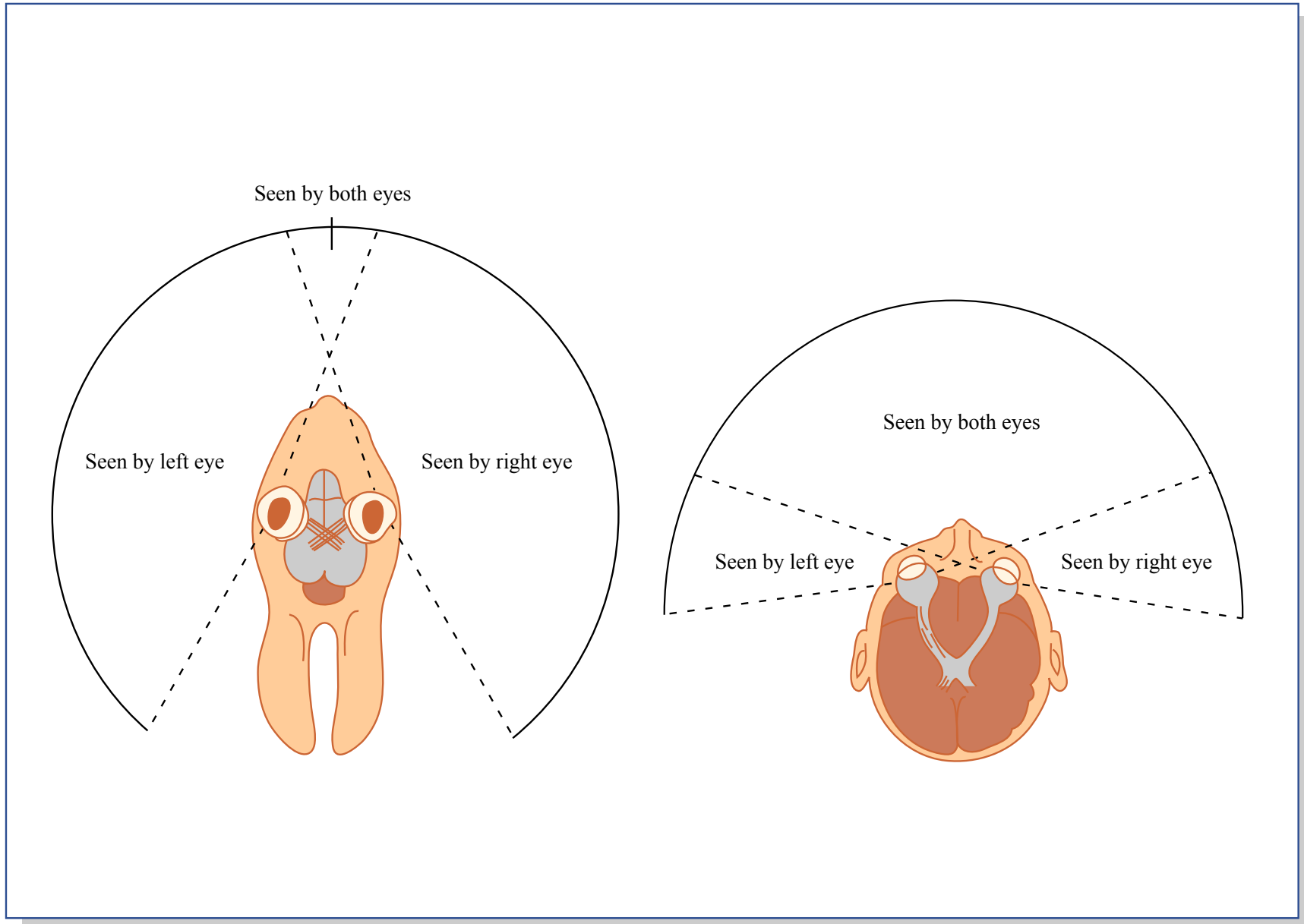
Pharmacology

Brain lesions

Imaging

Basic Wiring of the Visual System

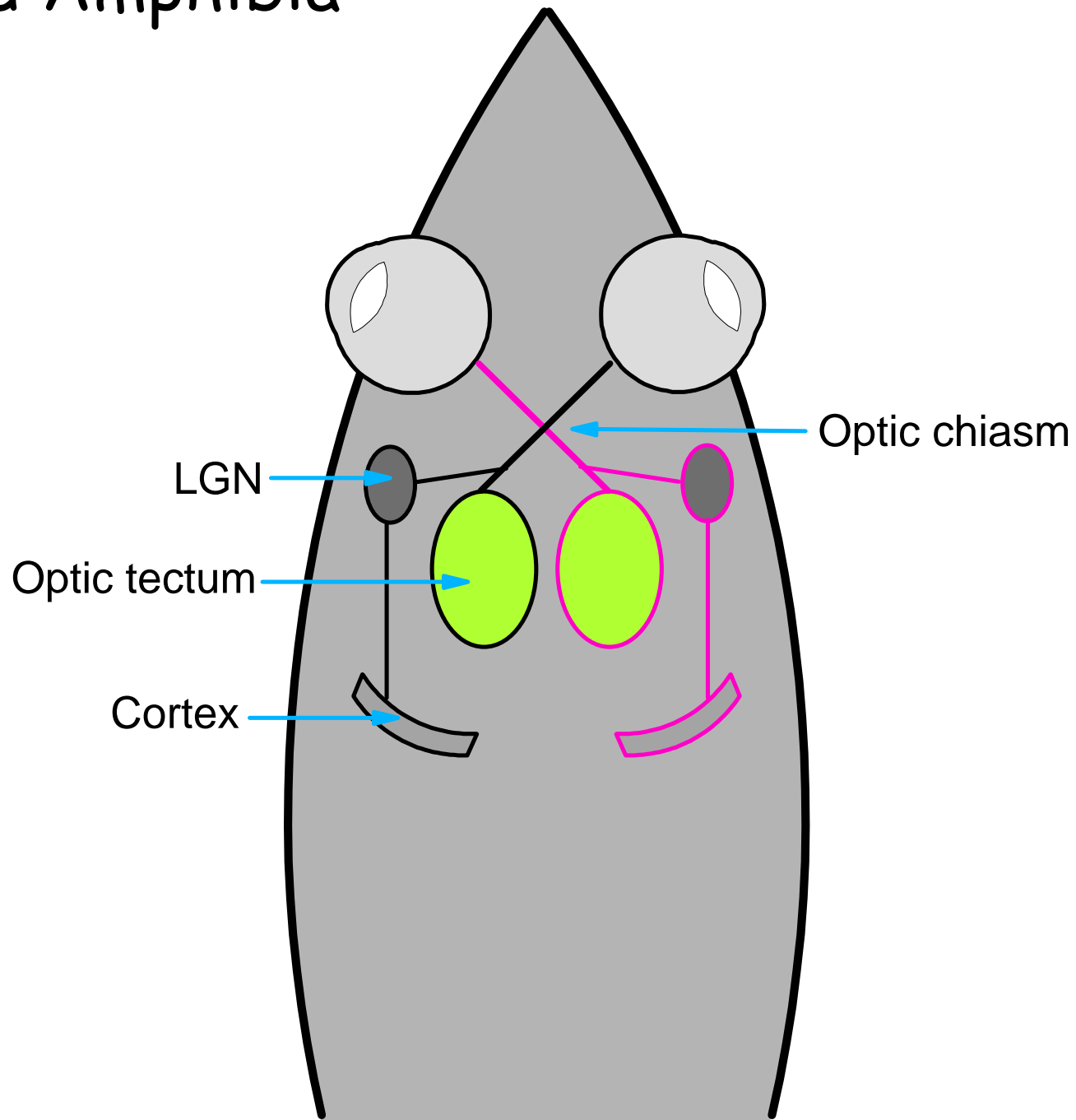
The world seen by the two eyes



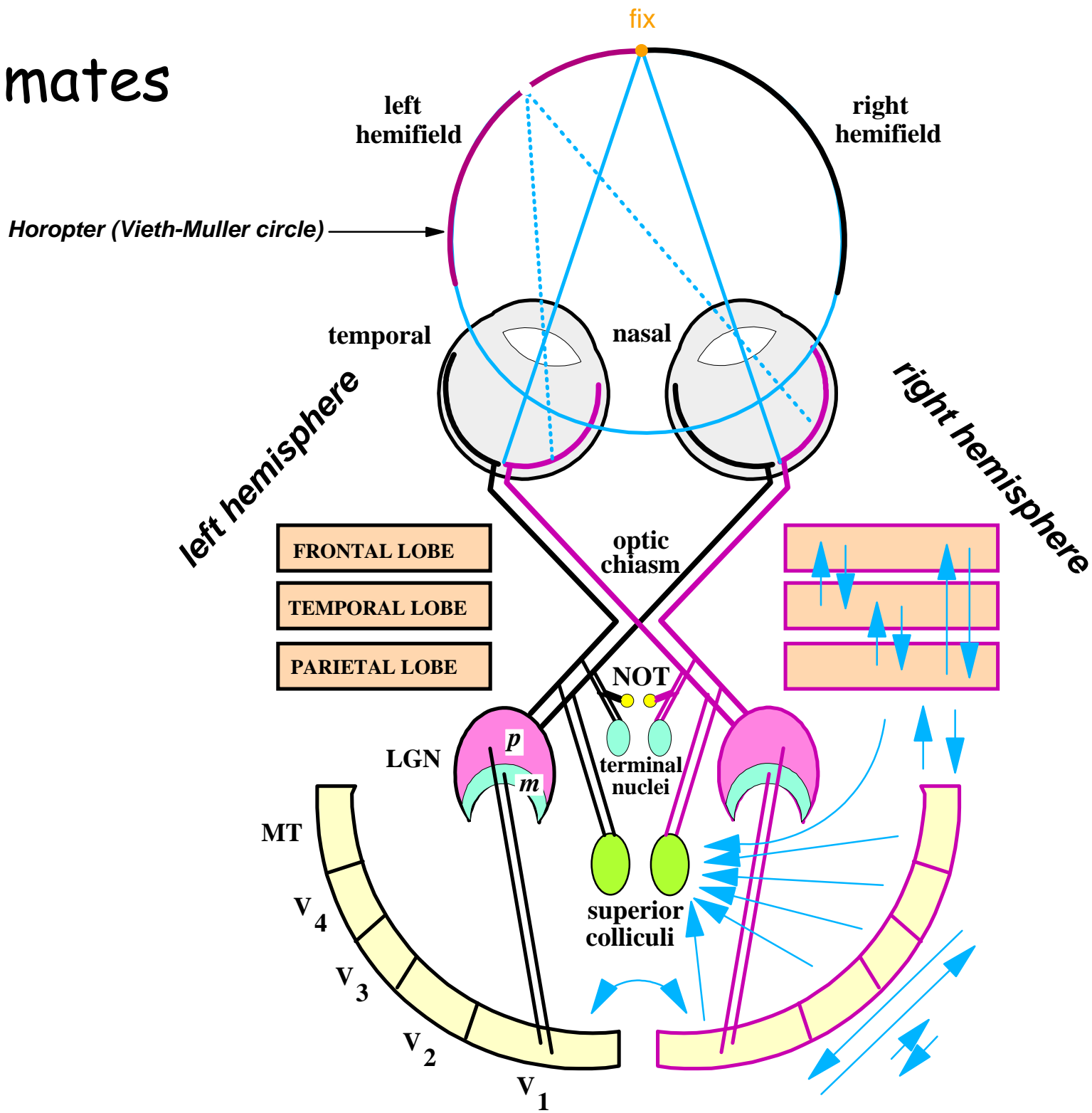
rabbit

human

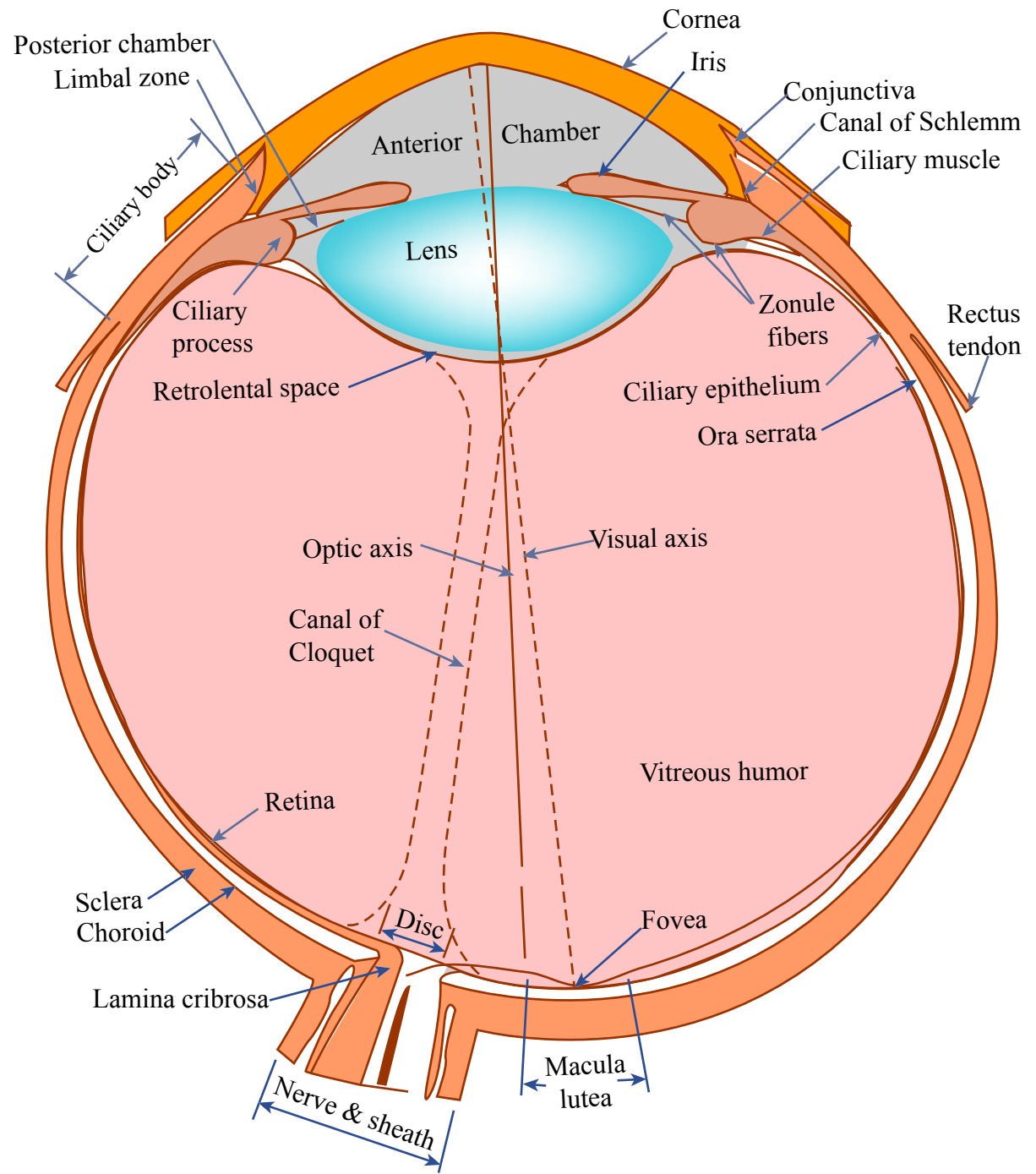
Fish and Amphibia



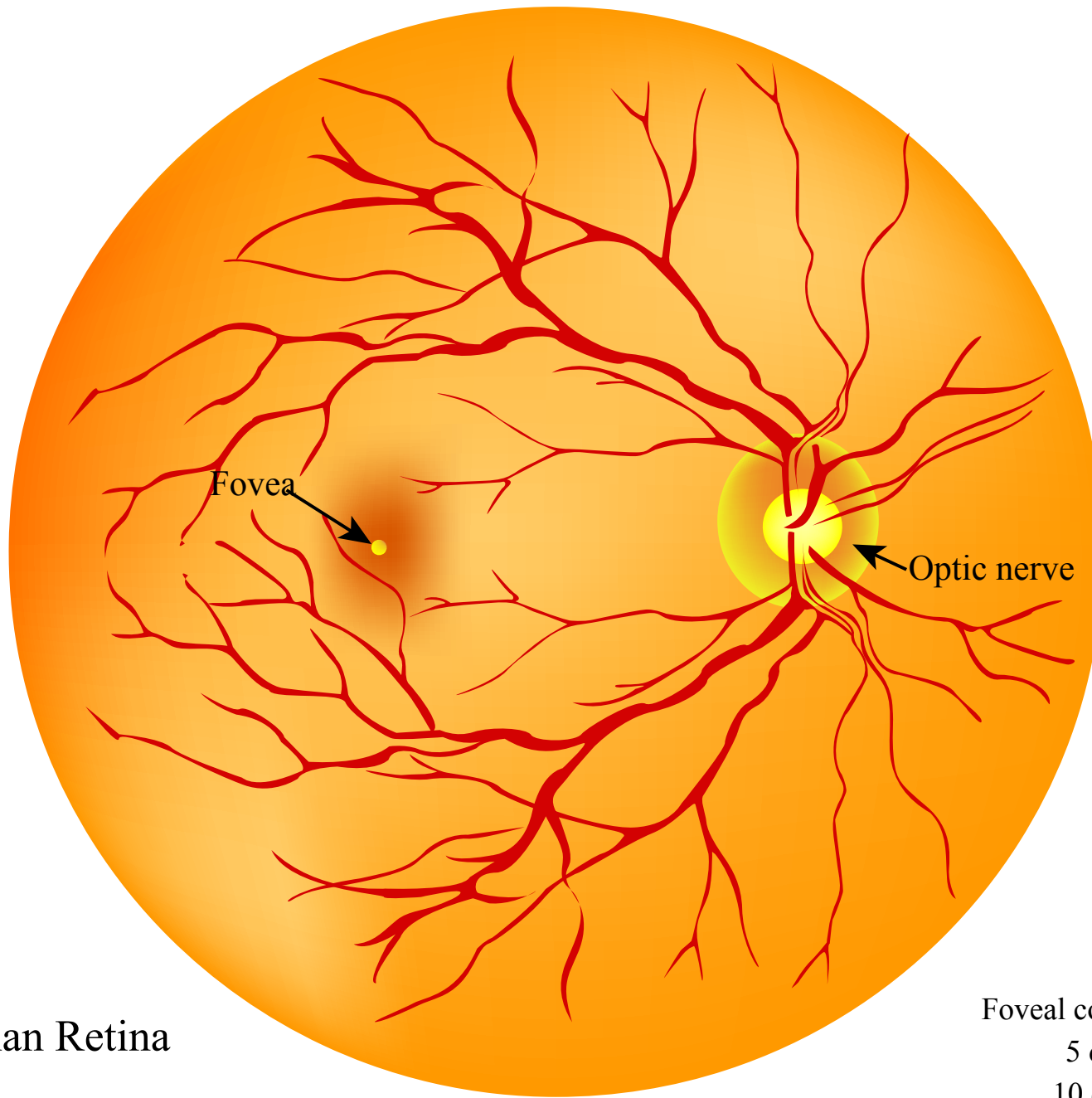
Primates



Basics of Retinal Connections and Retinal Ganglion Cells



Horizontal section of the right human eye.



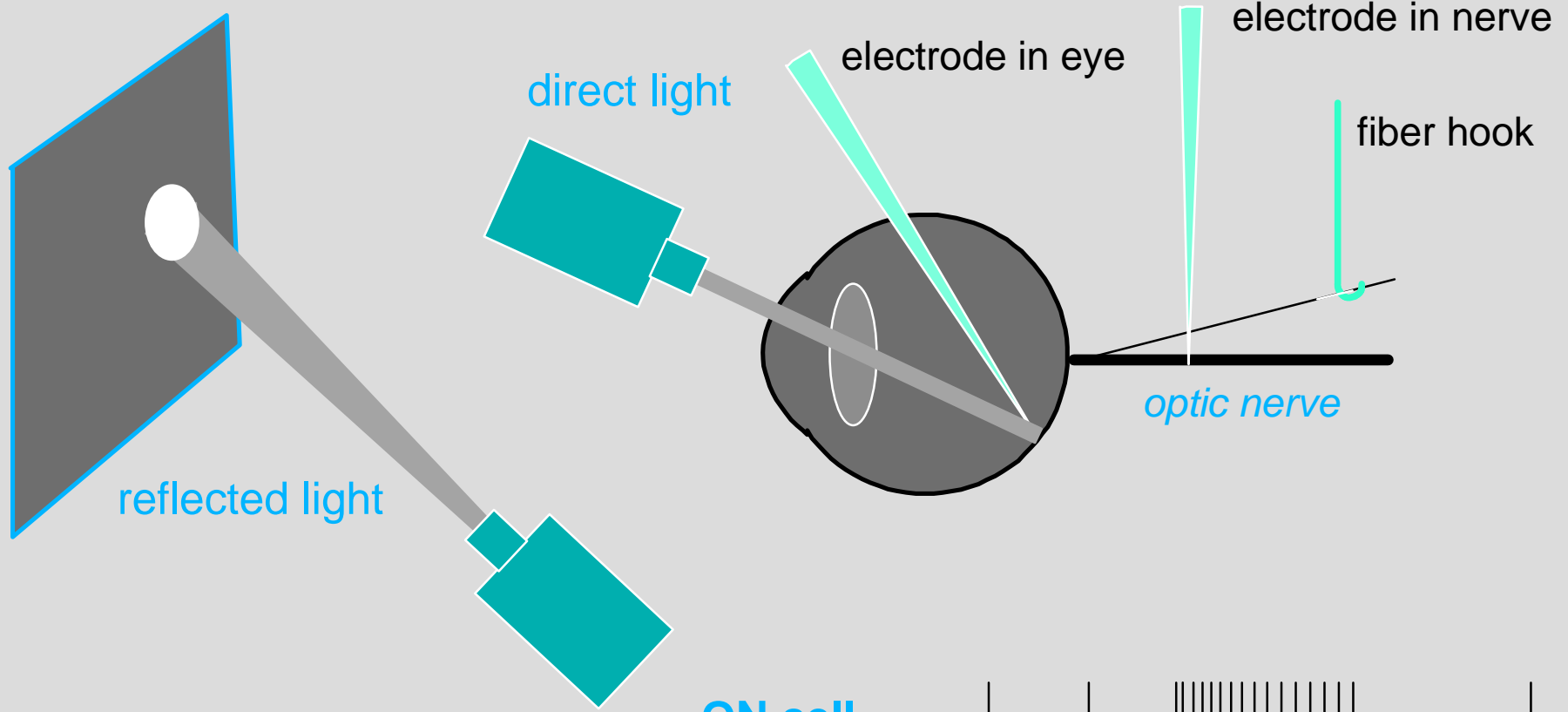
Human Retina

Foveal cone density: 200,000/sqmm
5 degrees out: 20,000/sqmm
10 degrees out: 10,000/sqmm

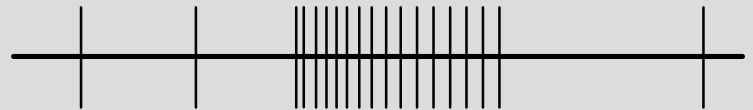
Physiology of retinal ganglion cells

Recording Methods:

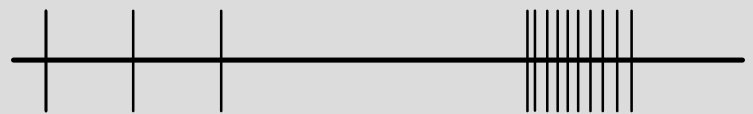
Stimulation Methods:



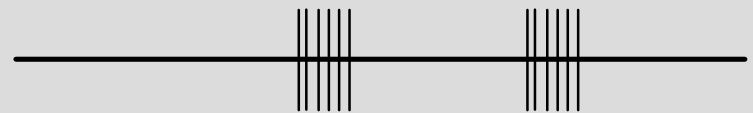
ON cell



OFF cell



ON/OFF cell



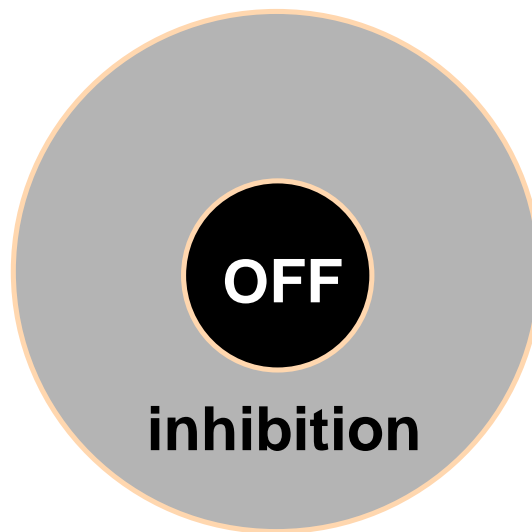
on



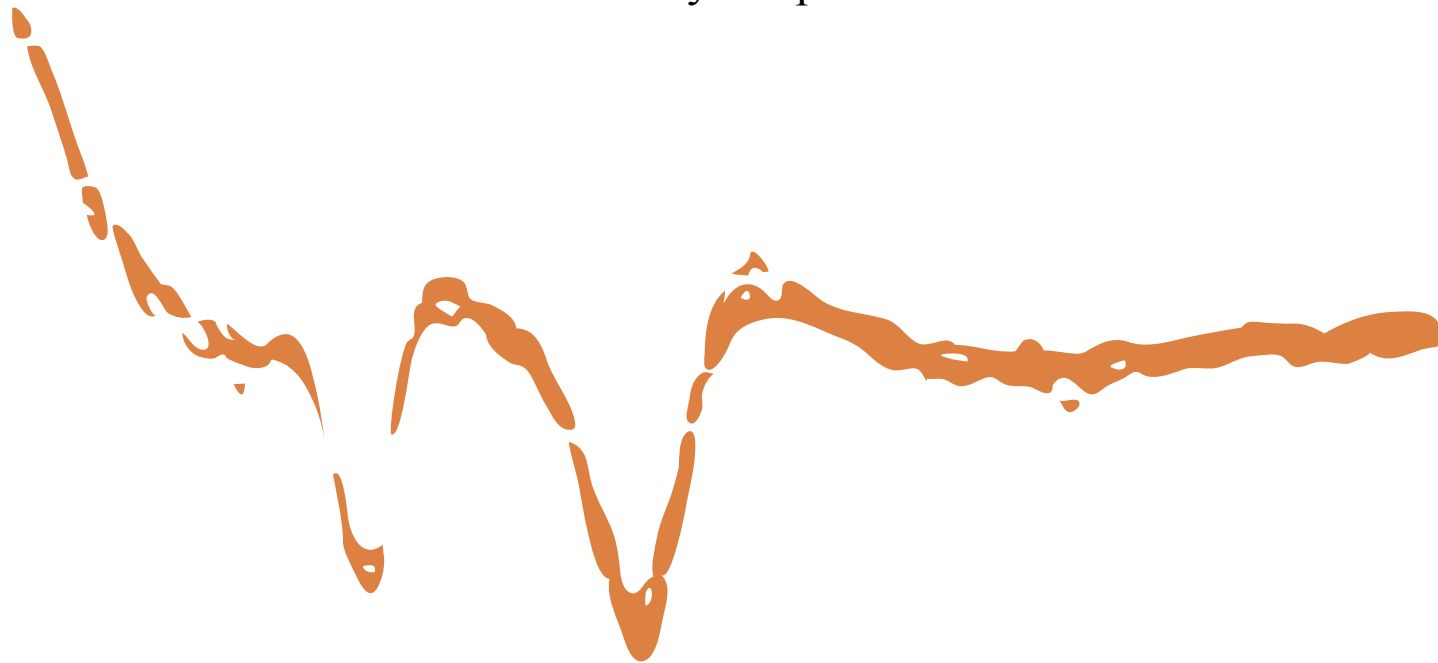
time



The receptive fields of three major classes of retinal ganglion cells



Conduction velocity in optic nerve fibers



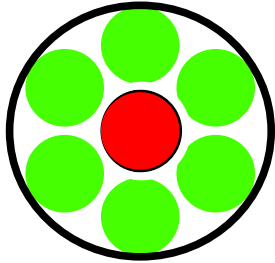
Rapid

Slower

Very slow

Three populations of fibers

MIDGET SYSTEM

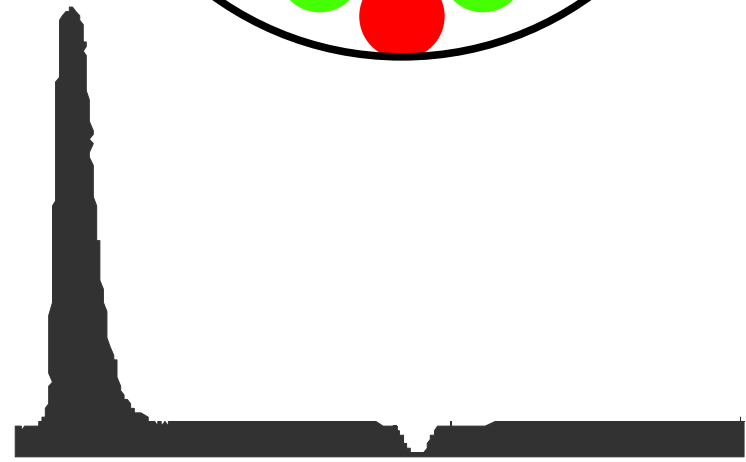
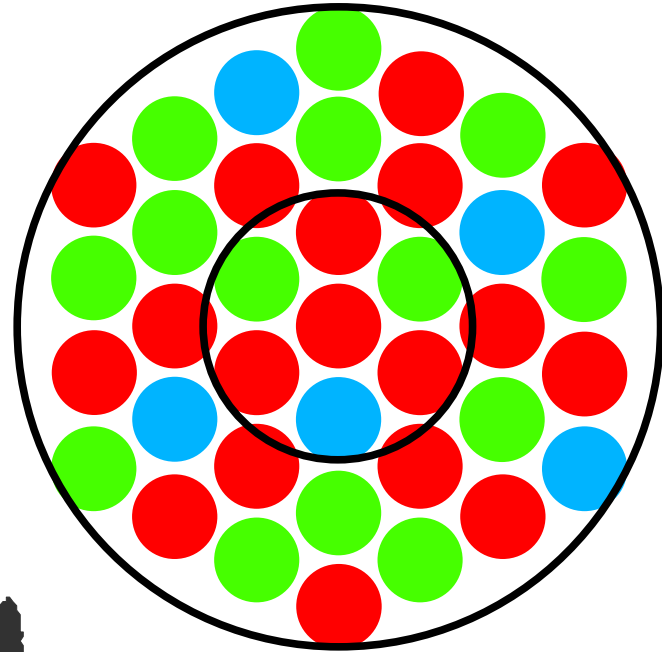


neuronal response profile



time →

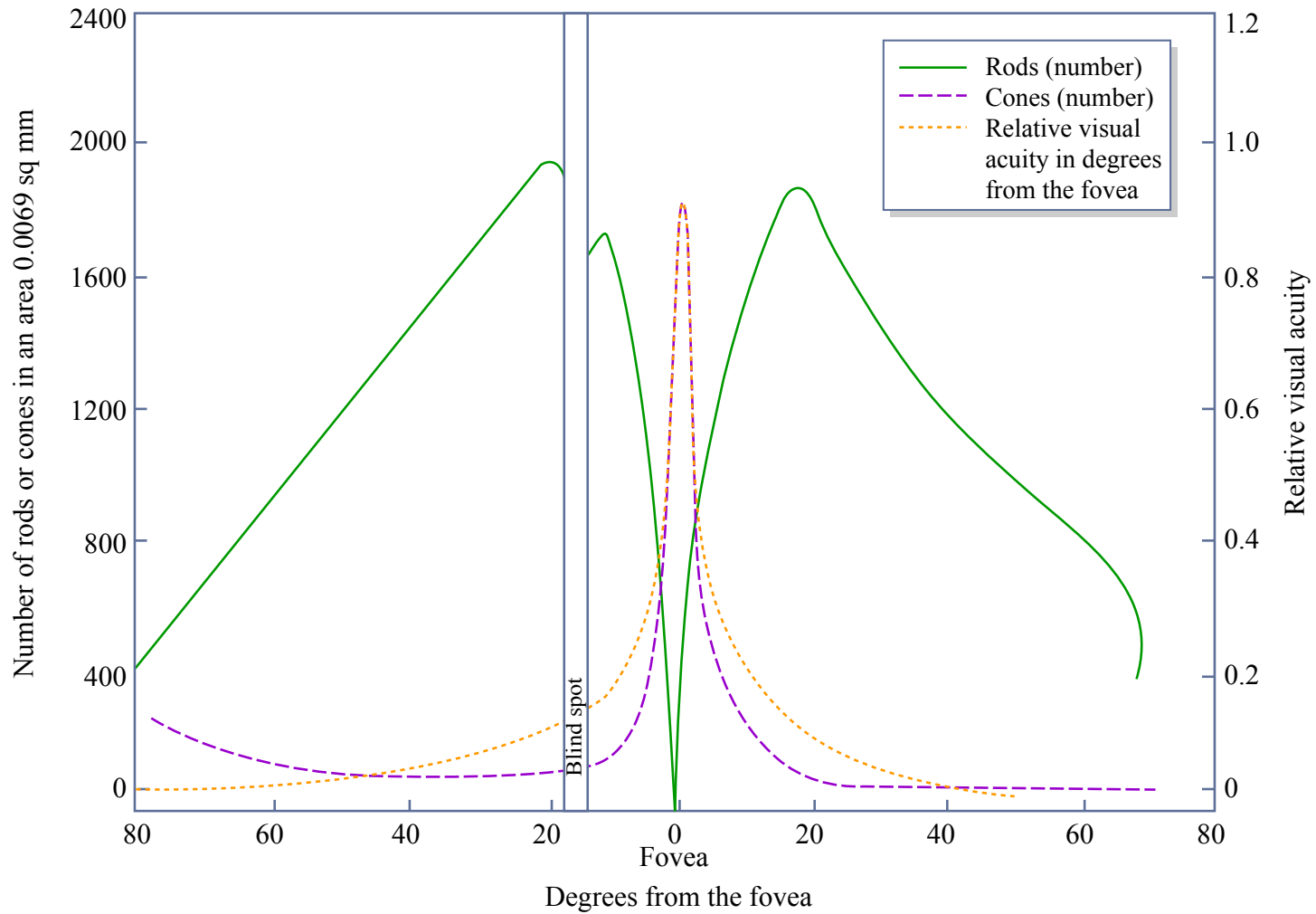
PARASOL SYSTEM



time

Photoreceptors

Distribution of rods and cones on the retina



Distribution of rods and cones along a horizontal meridian. Parallel vertical lines represent the blind spot. Visual acuity for a high luminance as a function of retinal location is included for comparison.

Some basic facts about the receptor array:

1 degree = 200u on retina

Intercone distance in fovea = 2.4u (0.7 min)

200,000 cones per sq.mm. in fovea

20,000 cones per sq.mm. 5 degrees out

Thumbnail at arm's length = 1 degree

The 12 font letter "I" activates about 80 cones at 23 cm

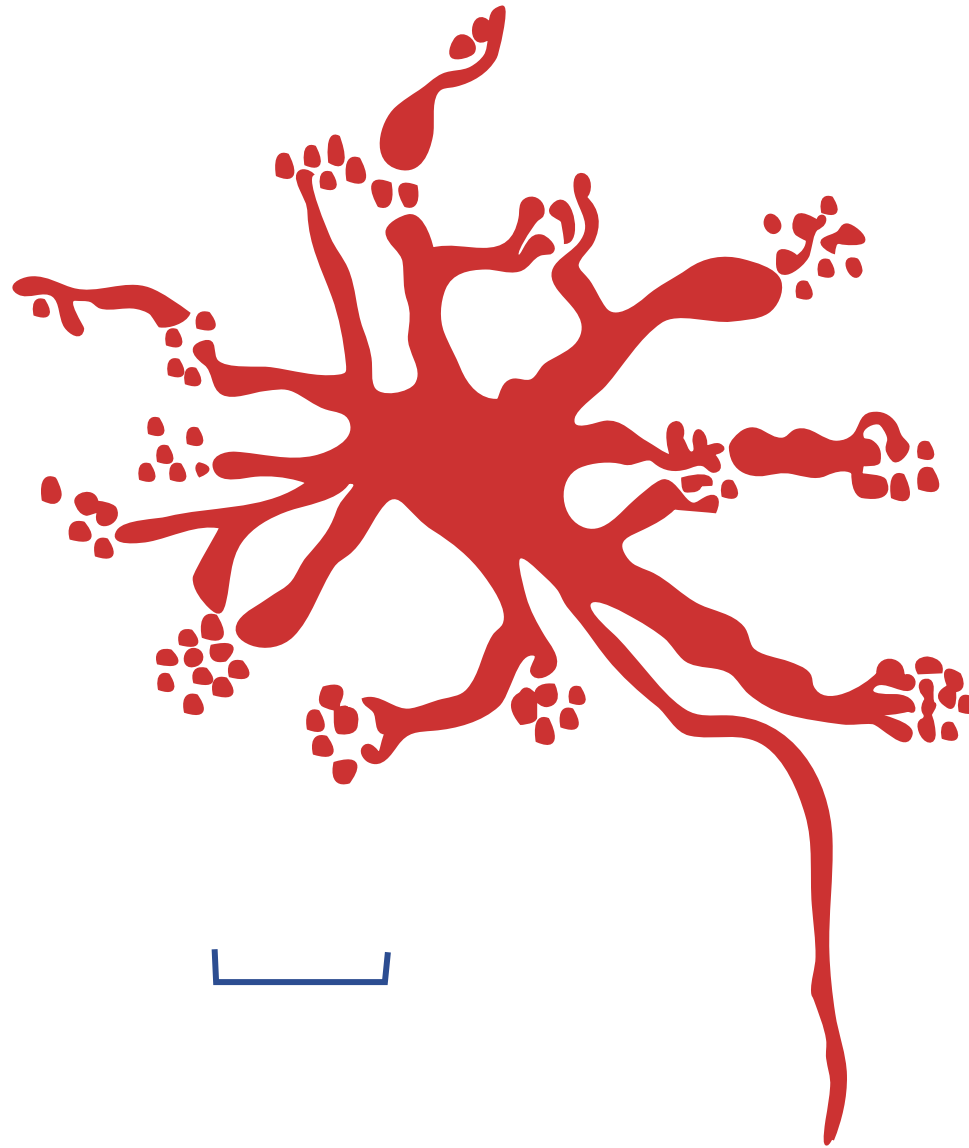
Each rod has 1,000 disks, each with 10,000 molecules

Only 1 of 8 cones is blue. Red and green are equal.

Photoreceptor basics:

1. All photoreceptors hyperpolarize to light.
2. Depolarization of the photoreceptor releases glutamate.
3. Photon absorption by the photopigment results in isomerization of the chromophore from 11-cis to all-trans. This causes hyperpolarization thereby reducing neurotransmitter release.
4. Two classes of bipolars are the ON and the OFF. The synaptic junction of OFF bipolars is sign conserving; that of the ON bipolar is sign inverting.
5. The ON bipolar receptor is mGluR6. Its activation leads to closing of channels causing hyperpolarization.

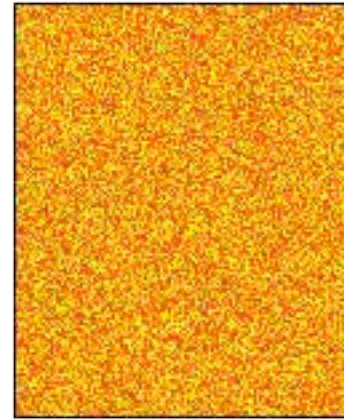
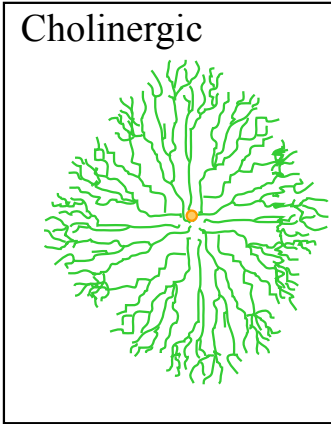
Horizontal cells



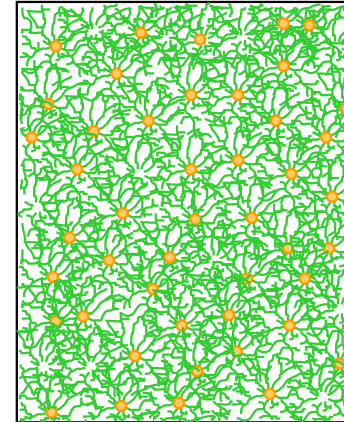
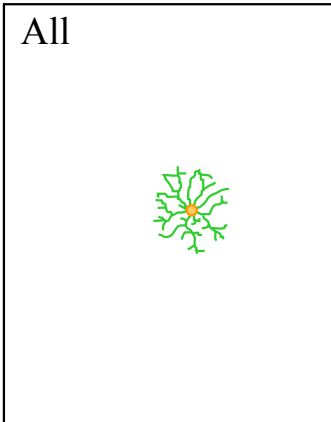
A Horizontal cell with regularly arranged dendrites that is connected to 15 cones in a cone density region of 20.

Amacrine cells

cholinergic cell



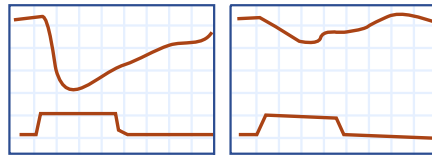
All cell



dopaminergic cell

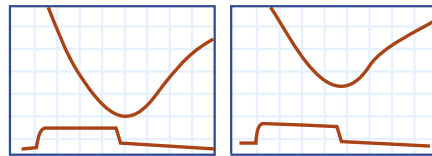


Electrical responses in the retina



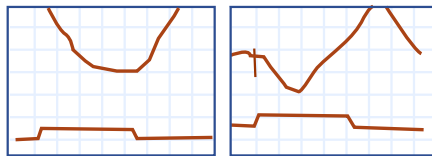
Receptor

all hyperpolarize to light



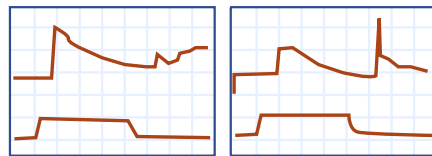
Horizontal Cell

all hyperpolarize to light



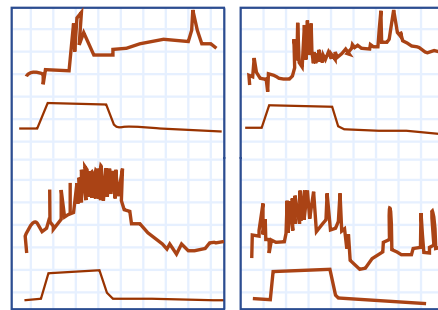
Bipolar Cell

some hyperpolarize and some depolarize



Amacrine Cell

some give action potentials



Ganglion Cells

all give action potentials

Overview of retinal connections:

Photoceptors all hyperpolarize to light. They produce only graded potentials. Glutamate is the neurotransmitter.

Horizontal cells all hyperpolarize to light and produce only graded potentials.

Some bipolar cells depolarize (ON) and some hyperpolarize (OFF) to light. Bipolars produce only graded potentials.

Some amacrine cells produce action potentials. There are many classes including ON and OFF.

Ganglion cells produce action potentials. There are many classes including midget and parasol that come either as ON or OFF.

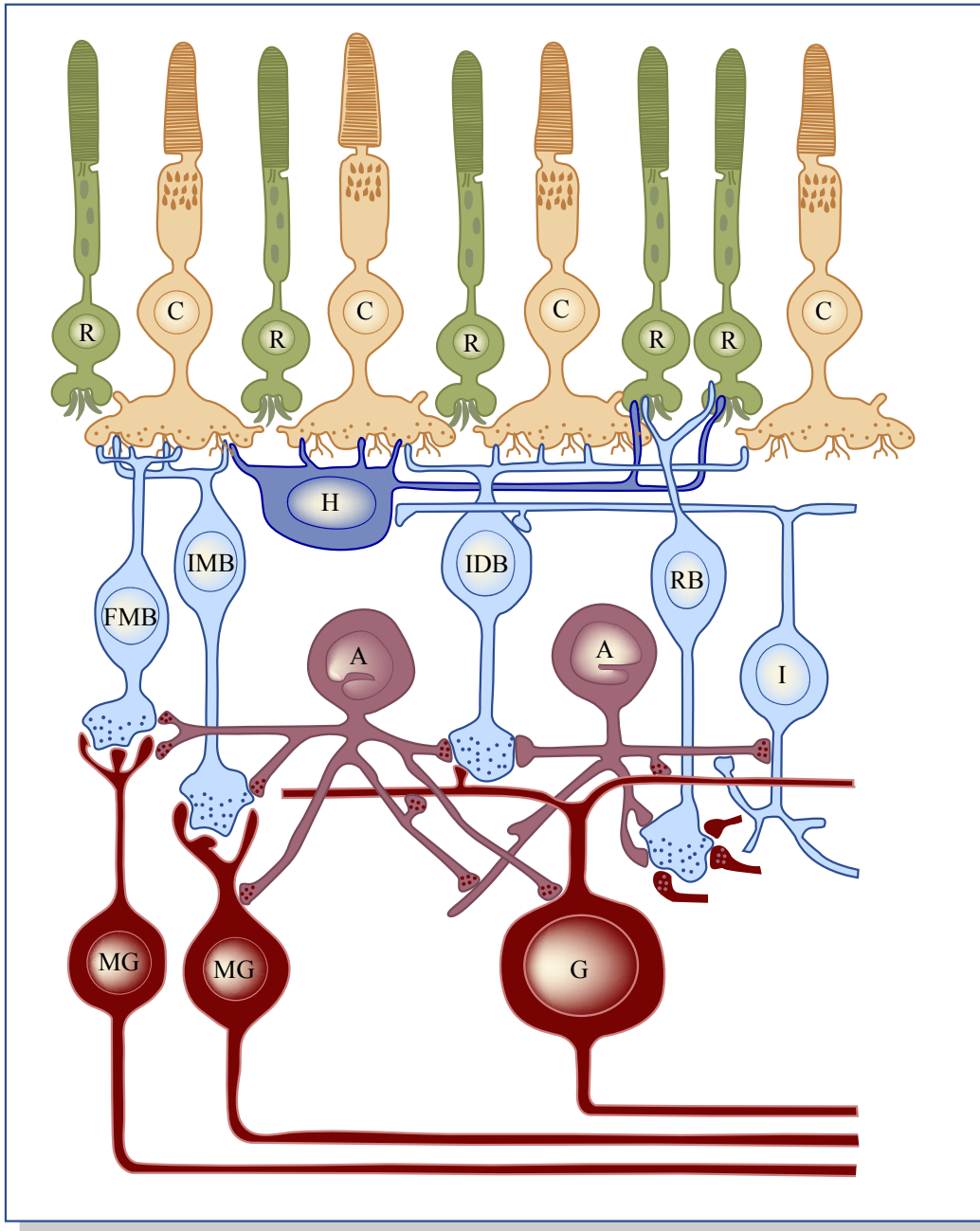


Figure by MIT OCW.

Summary:

1. In primates the right brain receives input from the left visual hemifield and the left brain from the right hemifield.
2. There are five major classes of retinal cells: photoreceptors (rods and cones), horizontal cells, bipolar cells, amacrine cells, and retinal ganglion cells (RGC).
3. The receptive fields of RGCs have antagonistic center/surround organization.
4. There are several classes of RGCs, two of which are (a) the ON and OFF and (b) the Midget and Parasol.
5. All photoreceptors and horizontal cells hyperpolarize to light.
6. There are both hyperpolarizing and depolarizing bipolar cells.
7. Action potentials in the retina are generated only by amacrine and RGC cells.
8. The lateral geniculate nucleus of the thalamus is a laminated structure. What is segregated in the laminae varies with species.
9. The parvocellular layers receive input from the midget cells and the magnocellular layers from the parasol cells. Inputs from the left and right eyes are segregated in the laminae.
10. The receptive field properties of LGN cells are similar to those of the retinal ganglion cells.