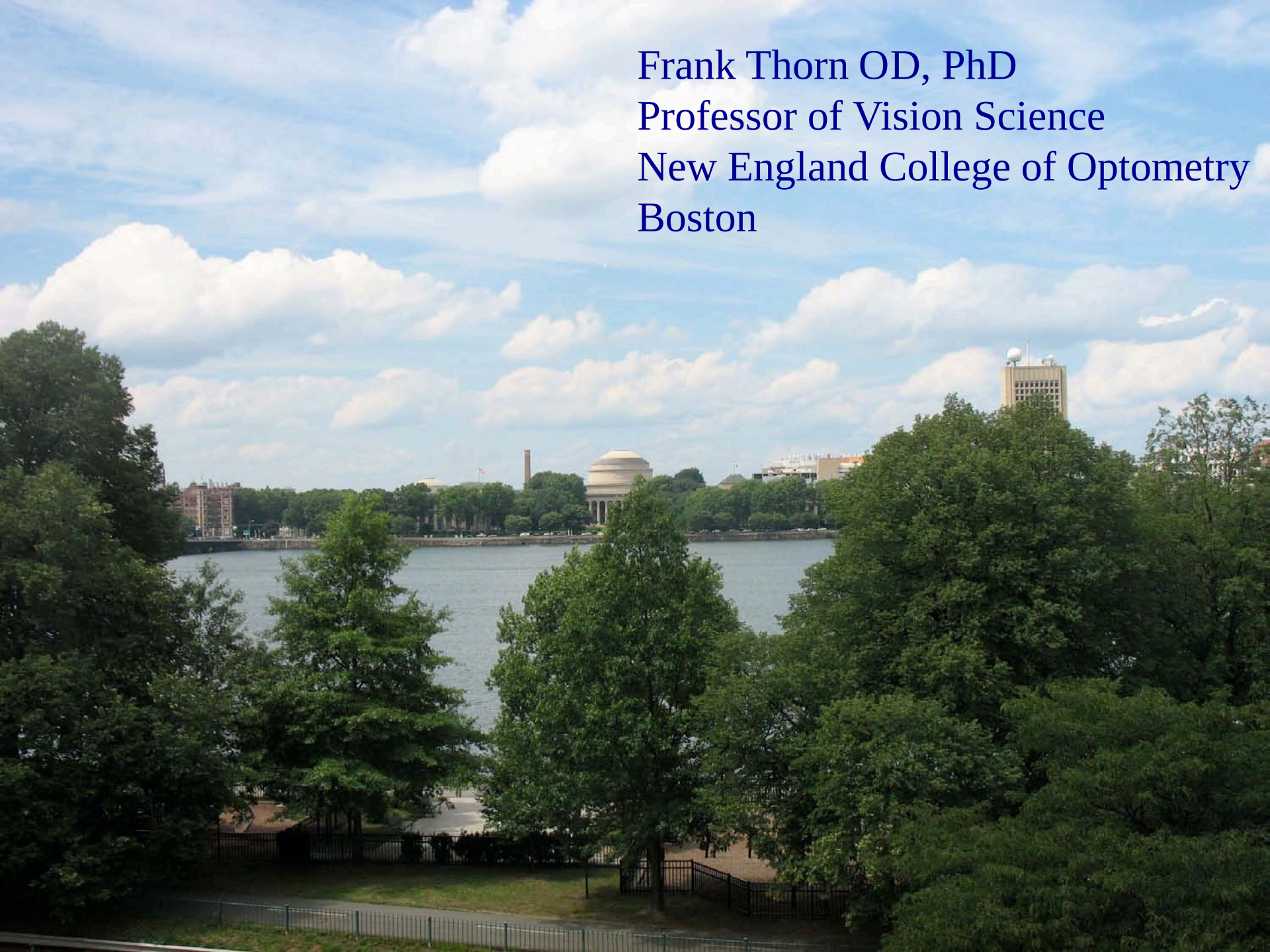
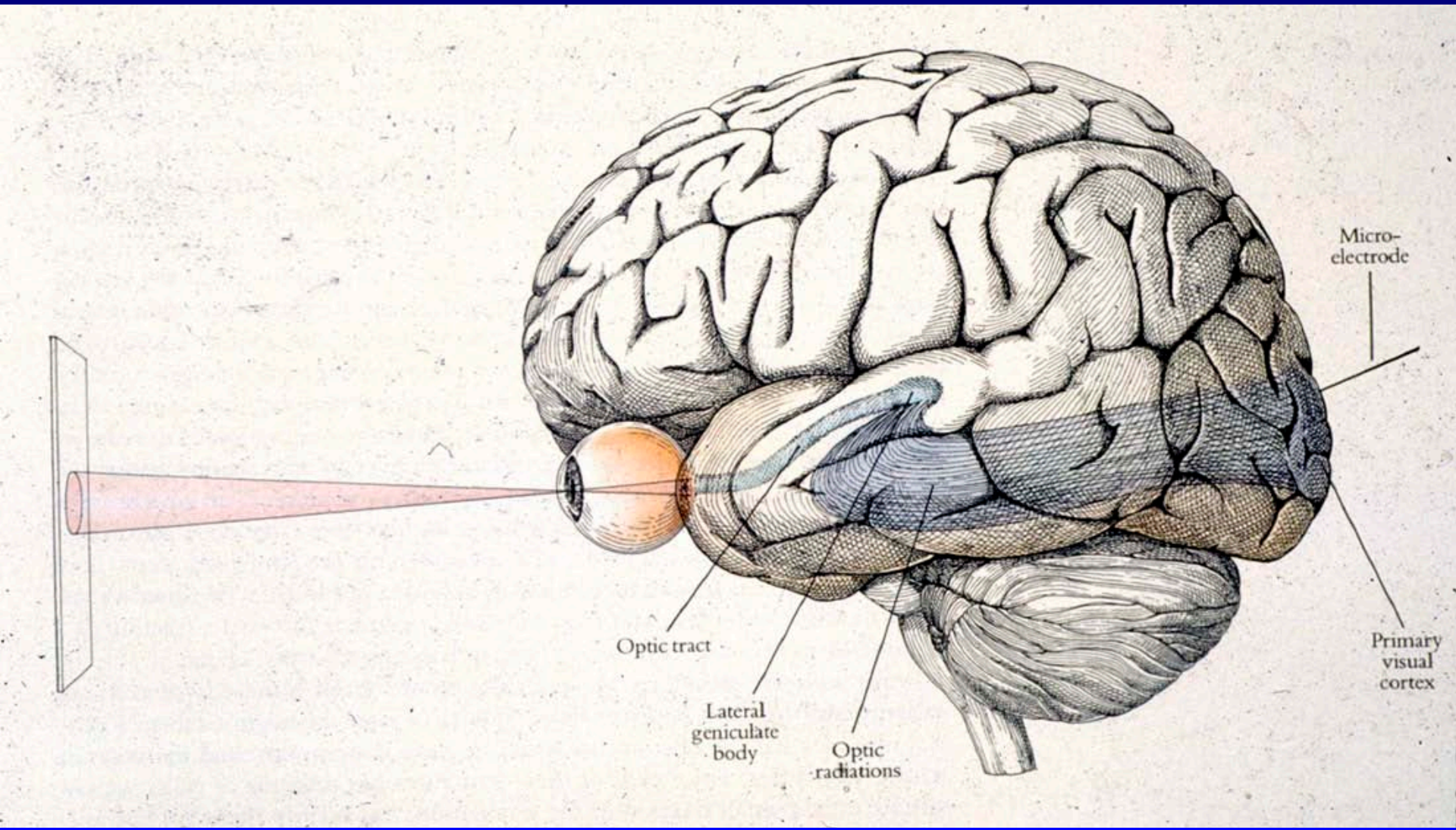


Frank Thorn OD, PhD
Professor of Vision Science
New England College of Optometry
Boston

The Retina in the Human Eye

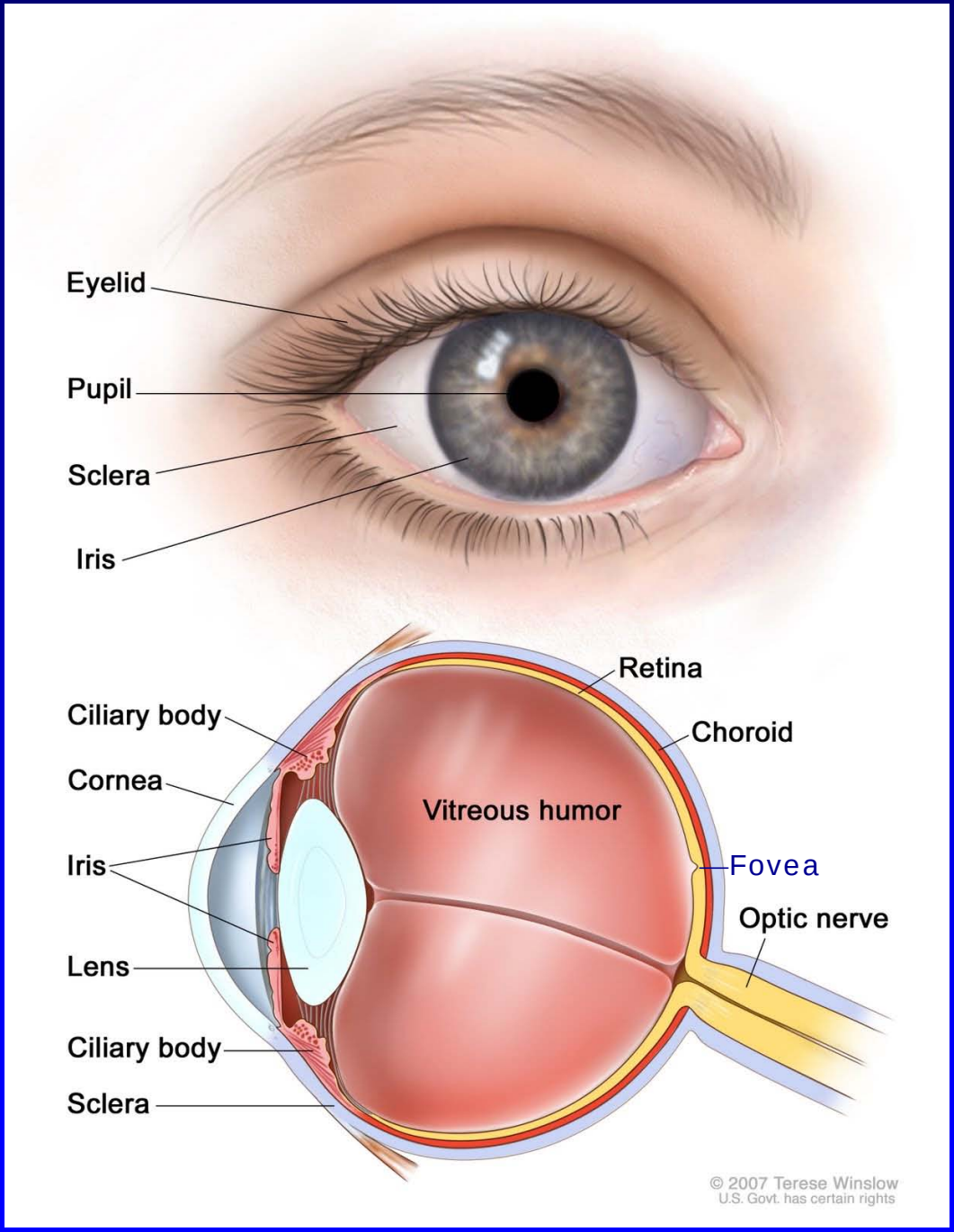
Frank Thorn OD, PhD
Professor of Vision Science
New England College of Optometry
Boston MA

Primary Visual System



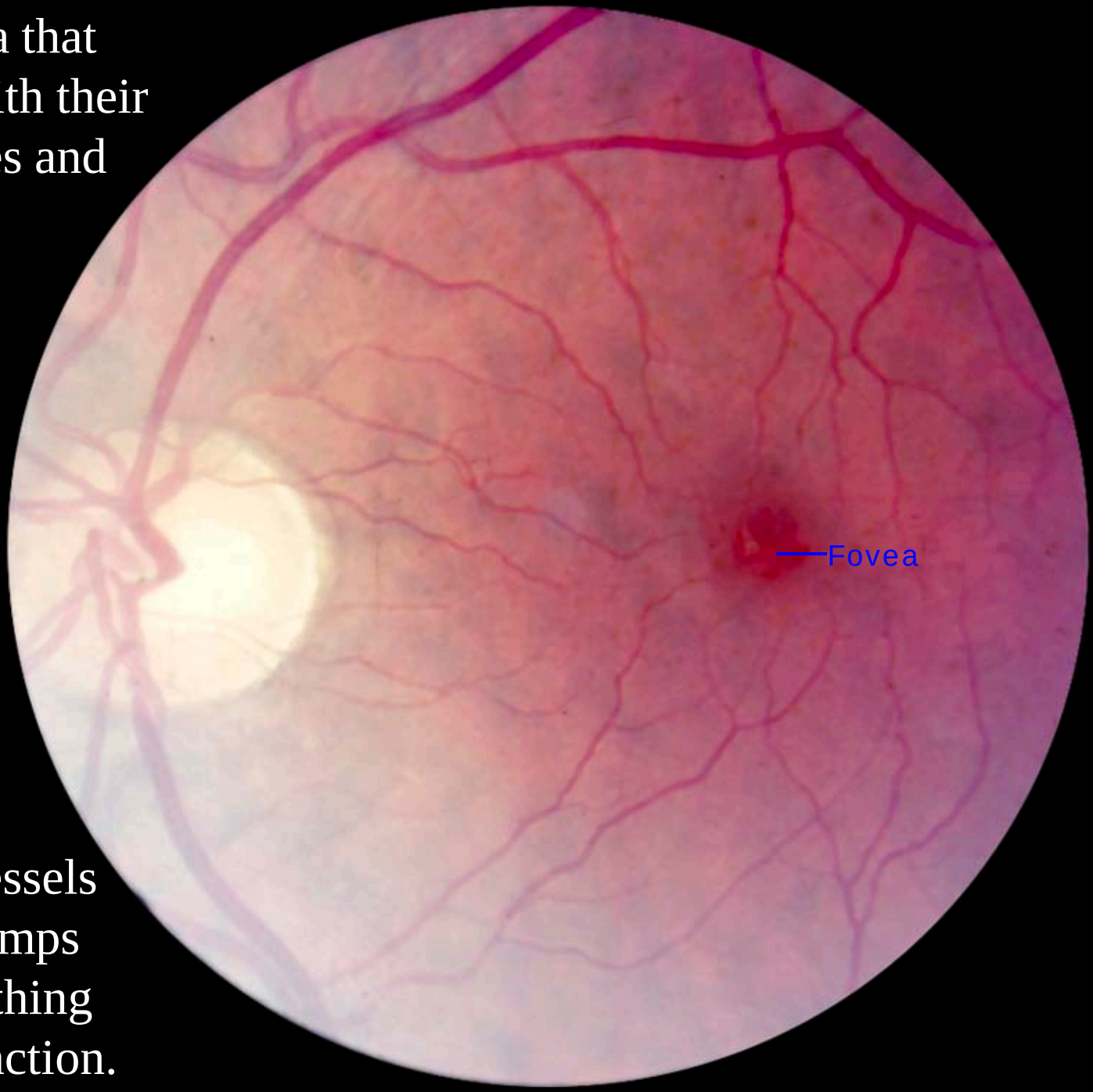
UV & some blue light is absorbed by the ocular media from the cornea through the vitreous. But IR-A is not absorbed much.

Therefore, the retina is poorly protected against most visible and IR-A.



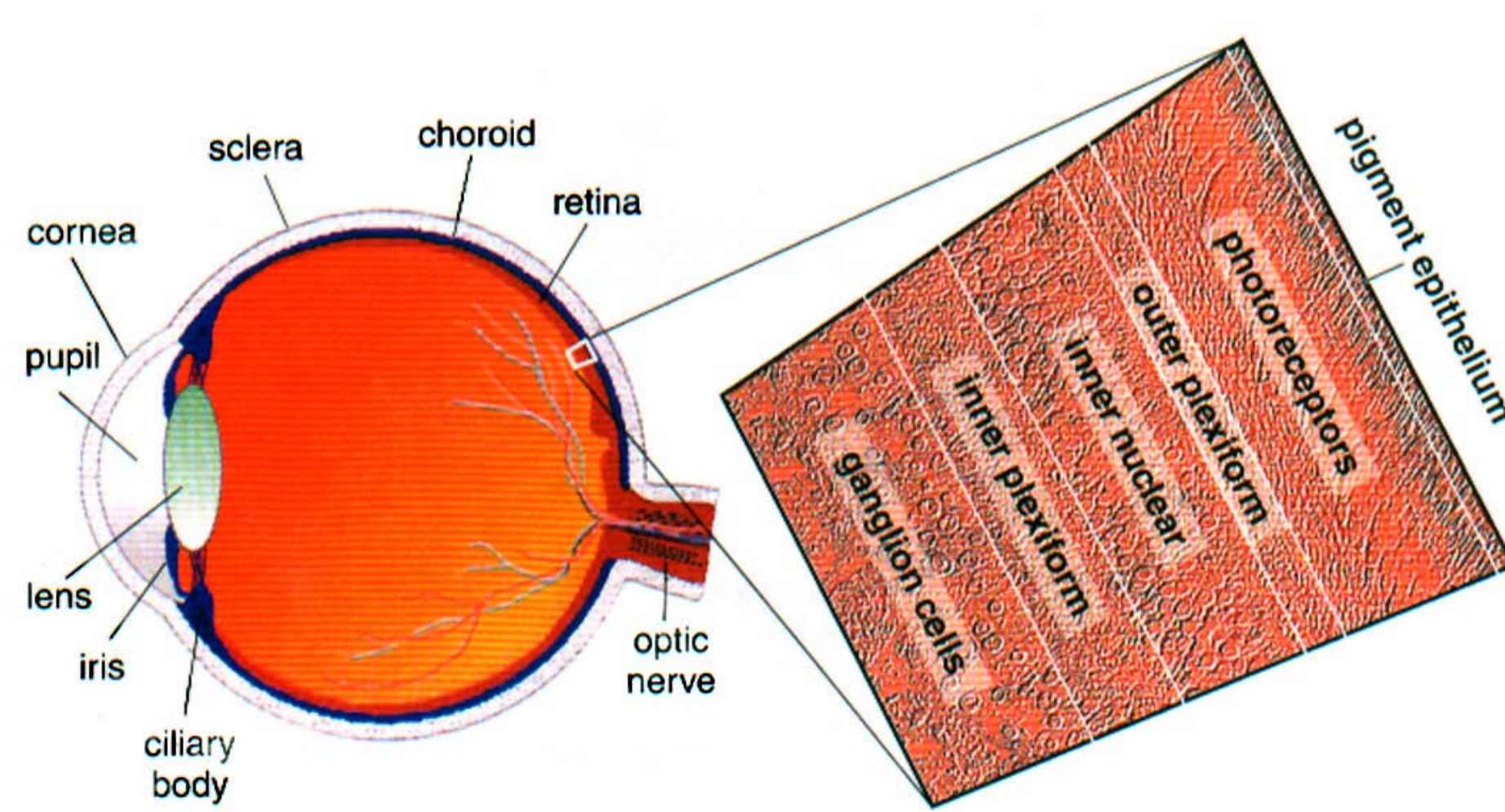
The photoreceptors in the retina absorb 400-700nm & the pigment epithelium behind it absorbs a broad range of wavelengths. This is where light induced damage occurs.

This is the retina that clinicians see with their ophthalmoscopes and fundus cameras. This is where light is focused



We see blood vessels and pigment clumps but can infer nothing about retinal function.

The work of the retina can only be studied in cross section.
It is an incredible machine and I will discuss just 4 aspects of it.

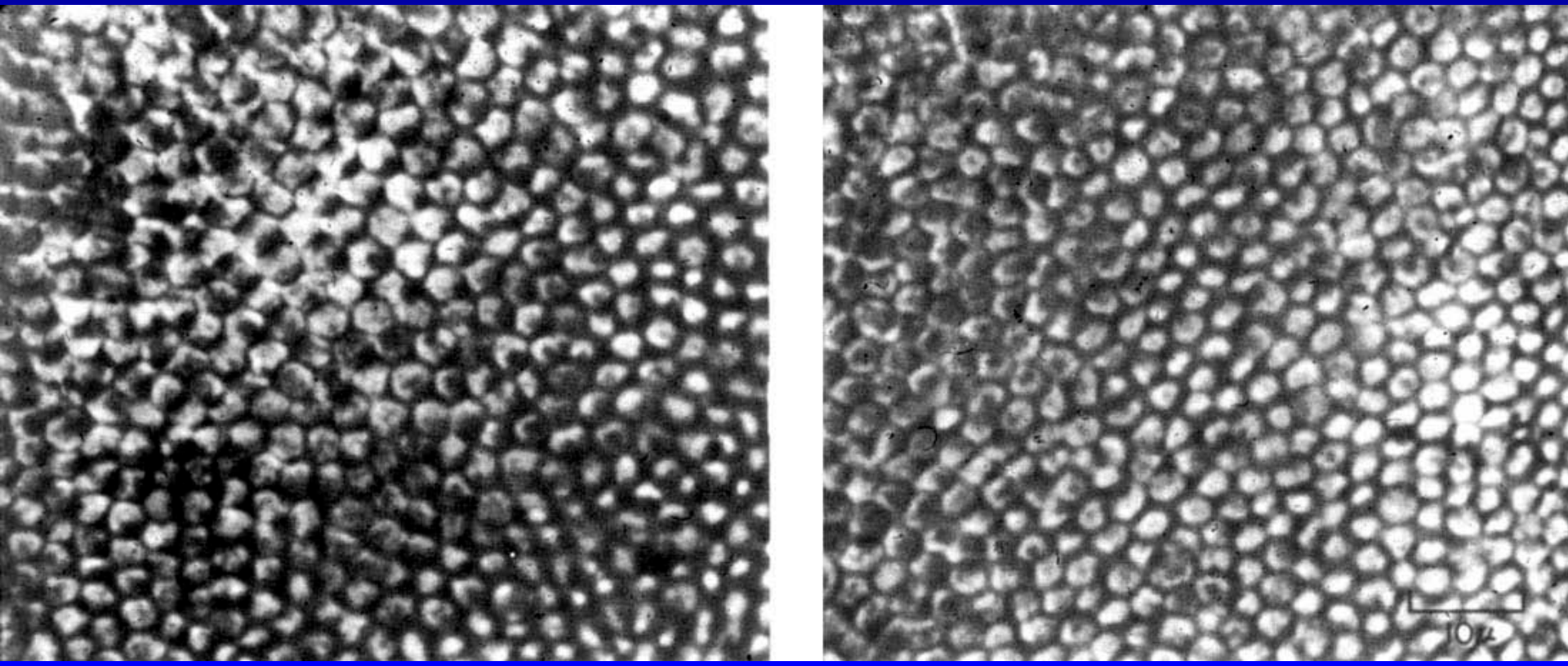


Note that the retina is developmentally an outgrowth of the brain and uses the full range of neural circuits that we see in the brain.

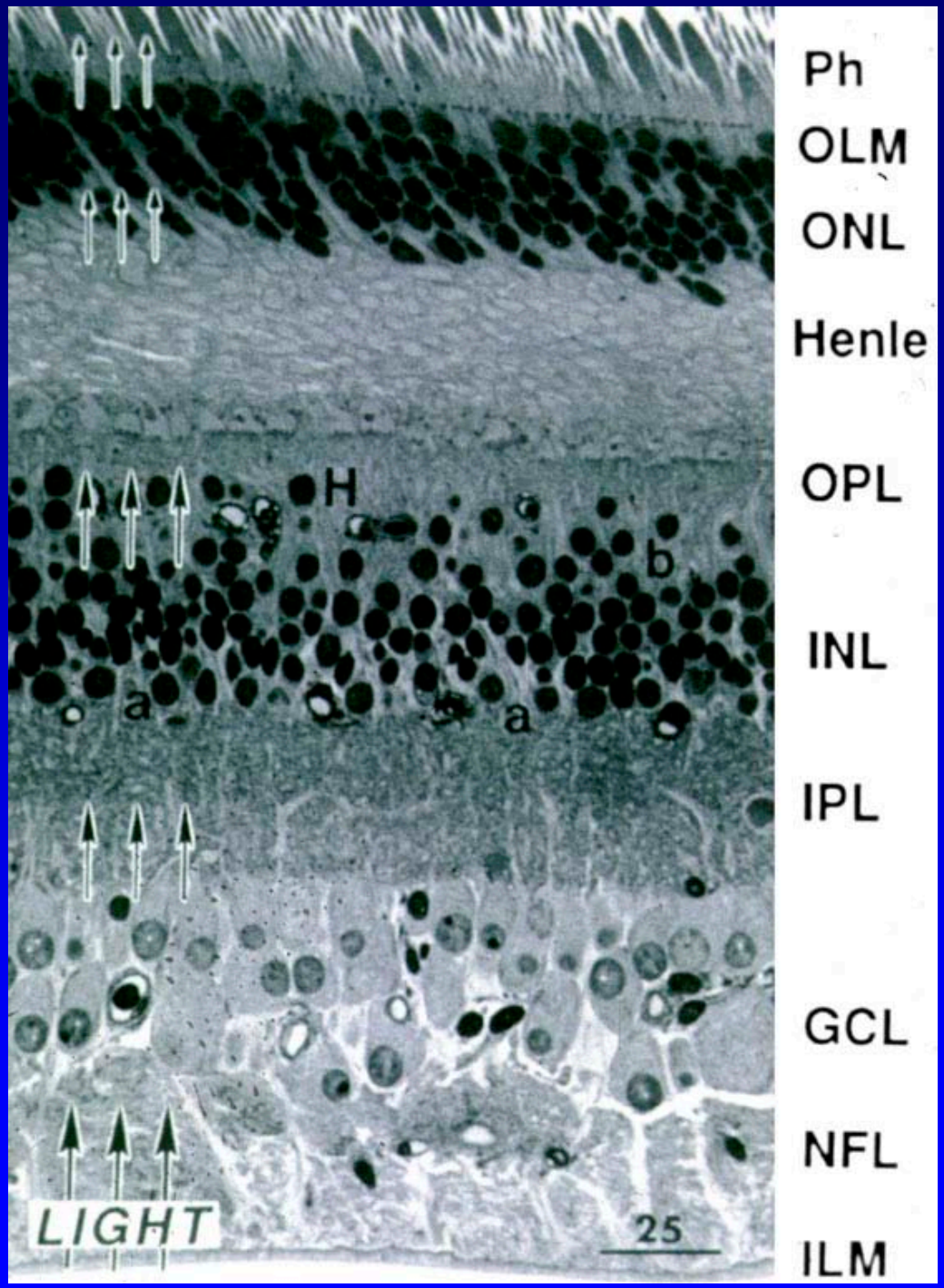
In the past, we used histology to see outer segments of human receptors
Looking down on the outer segments of the receptors

Cones in the fovea
are tightly packed

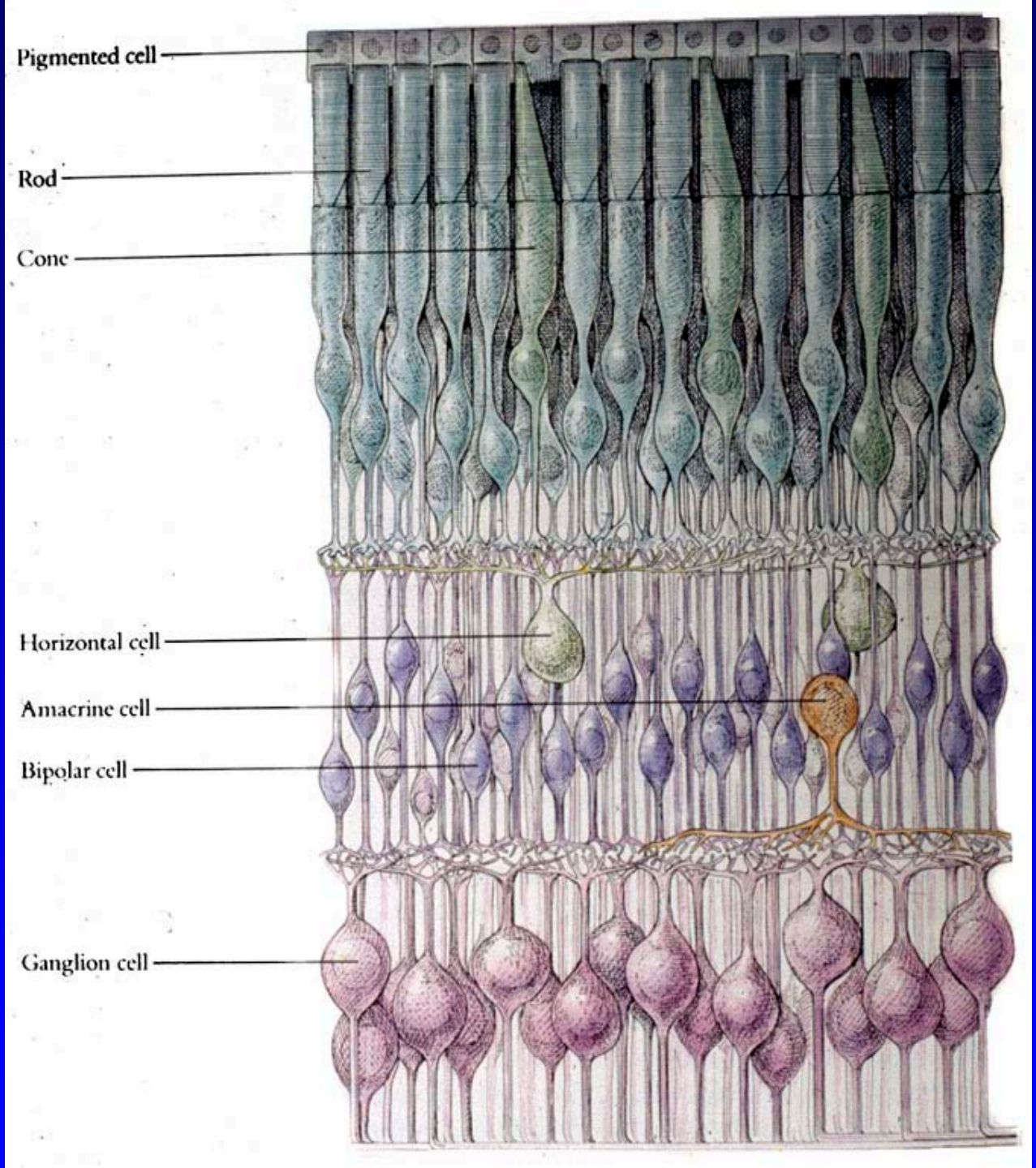
Rods in periphery
are also tightly packed



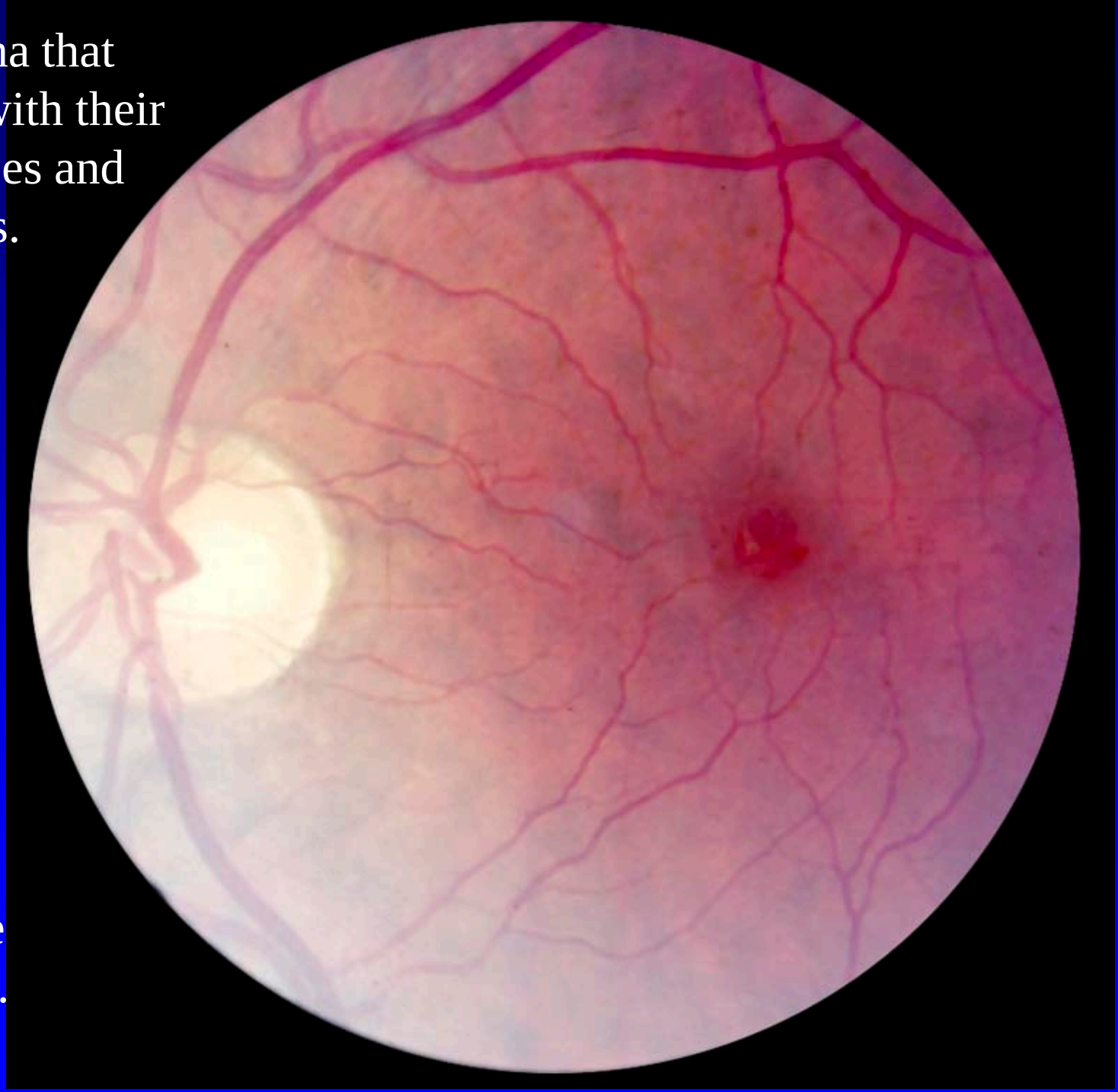
The neurons are in very distinct layers. In this section the outer segments of the receptors & the pigment epithelium are clipped off the top or outer part.



The circuitry can only be pictured in schematics.



This is the retina that clinicians see with their ophthalmoscopes and fundus cameras.

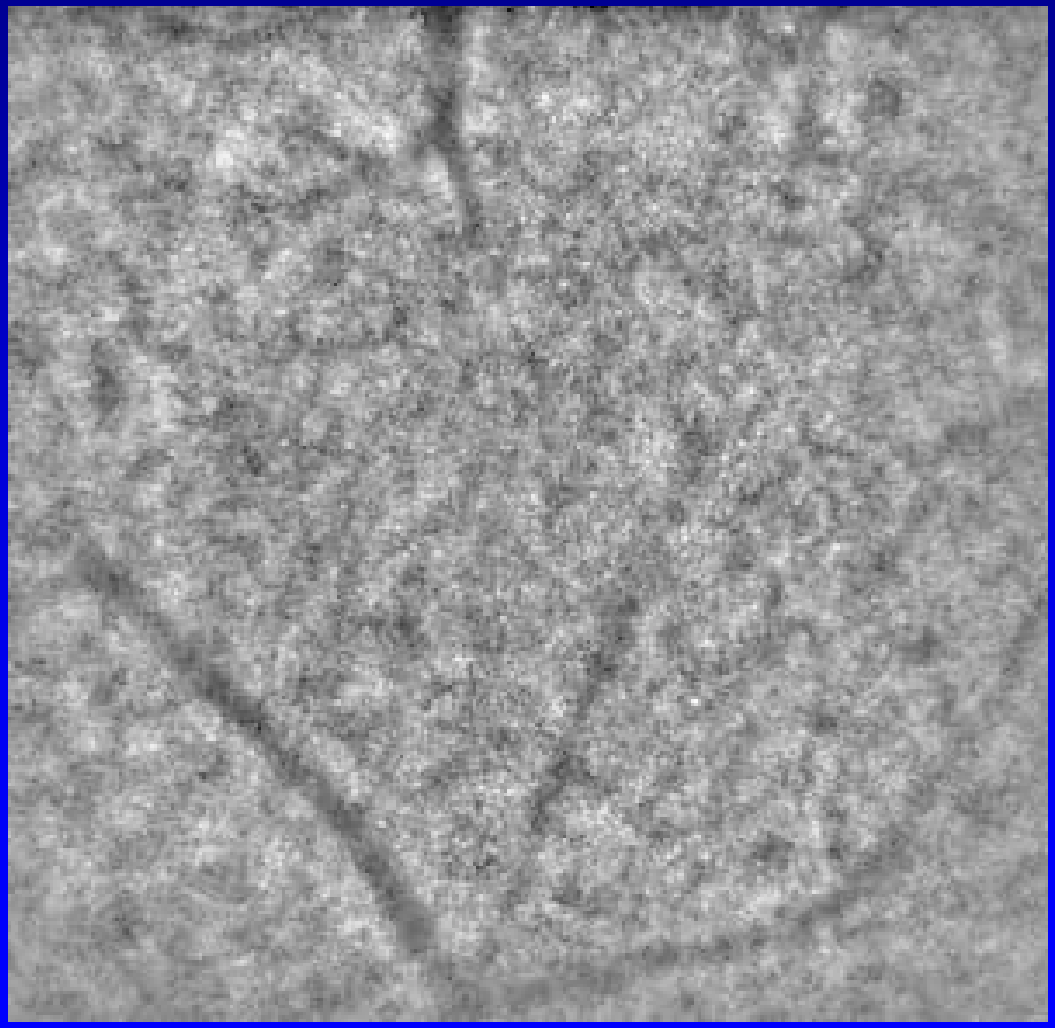


We cannot see individual cone outer segments.

Adaptive Optics-Flood Illumination:

We can now image Cone Photoreceptors

Adaptive Optics are now being used to increase the resolution of the retinal images by >10x to see individual receptors and neurons.

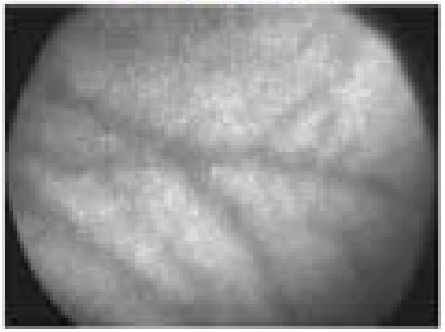


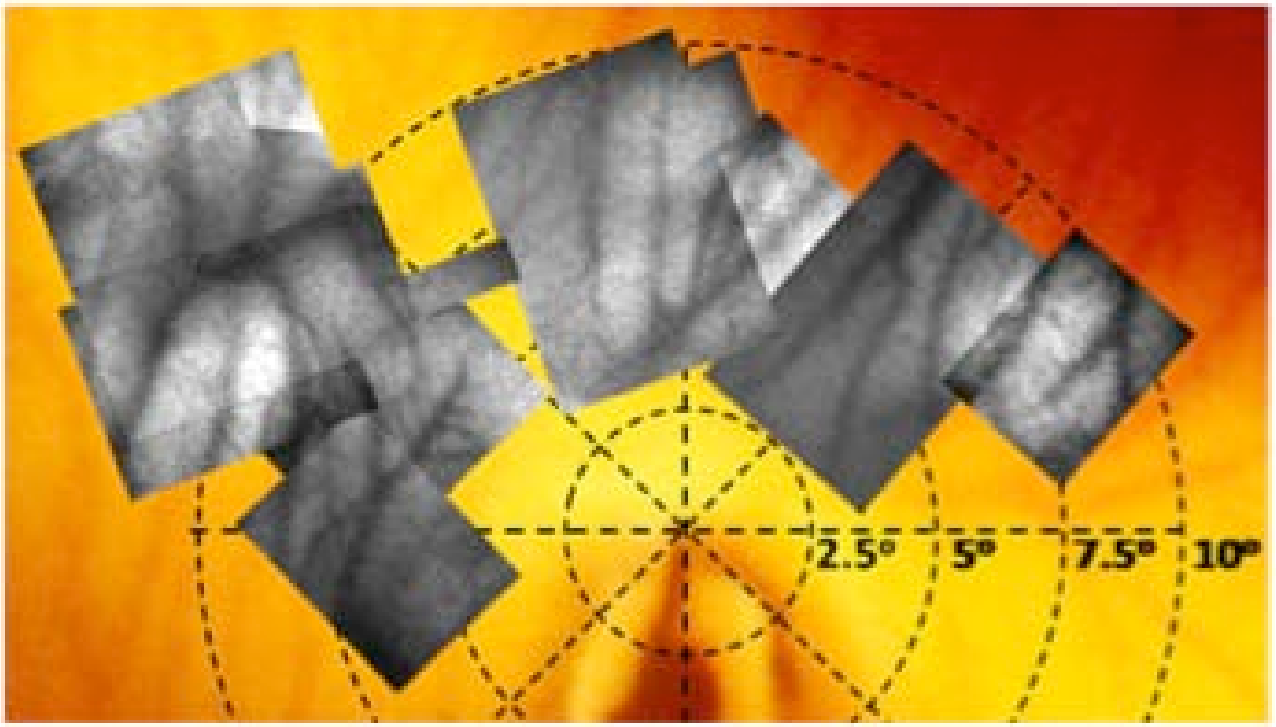
Adaptive Optics-Flood Illumination:

We can now image Cone Photoreceptors

AO sections of the retina are imaged and put back together in a high resolution mosaic of the retina.

2.5° FOV

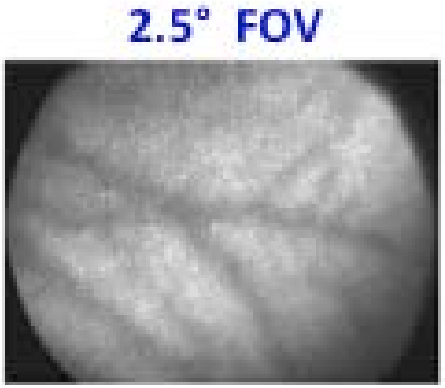


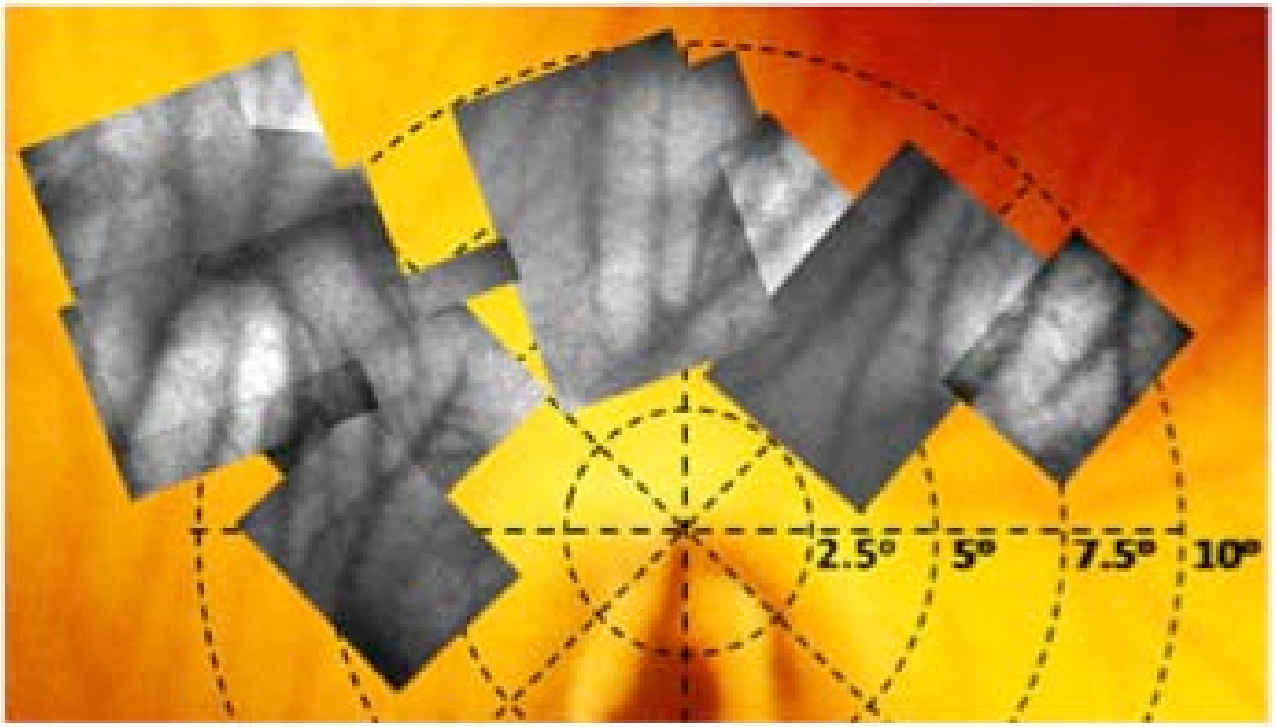


- Cell density : ~ 20,000 - 25,000 cell/mm^2
- Distance between cells: 4.3 - 8.2 µm

From the lab of Nathan Doble & Stacy Choi, NECO

In the future we will use superluminescent diode lasers–680nm±5 to 7nm to achieve even higher resolution. These should be standard clinical instruments within 10 years. The AO-Scanning Laser Ophthalmoscope can image a laser damaged retina to see the exact receptor destruction. However, they use lasers so the instrument's safety is a concern.

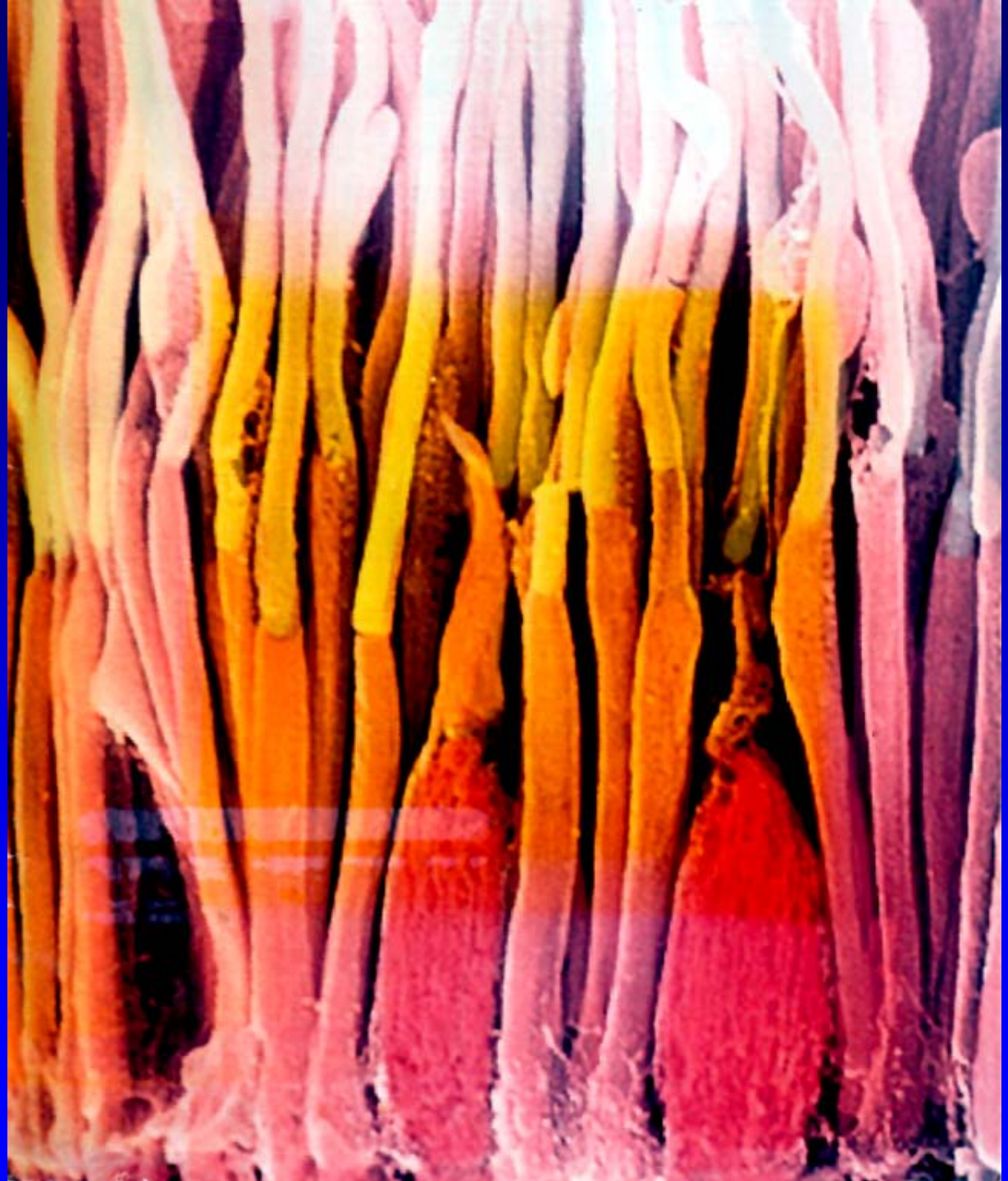


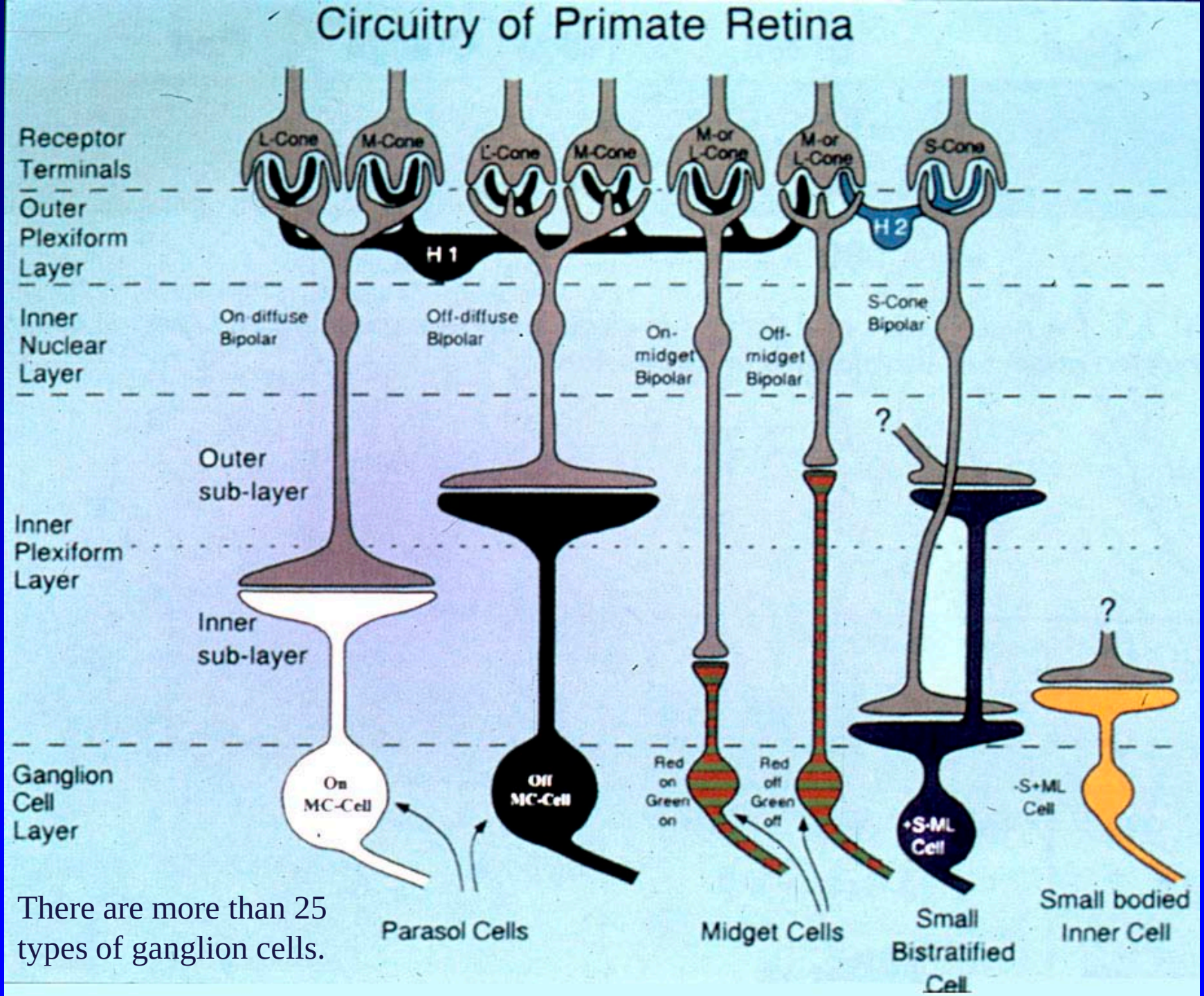


- Cell density : ~ 20,000 - 25,000 cell/mm^2
- Distance between cells: 4.3 - 8.2 µm

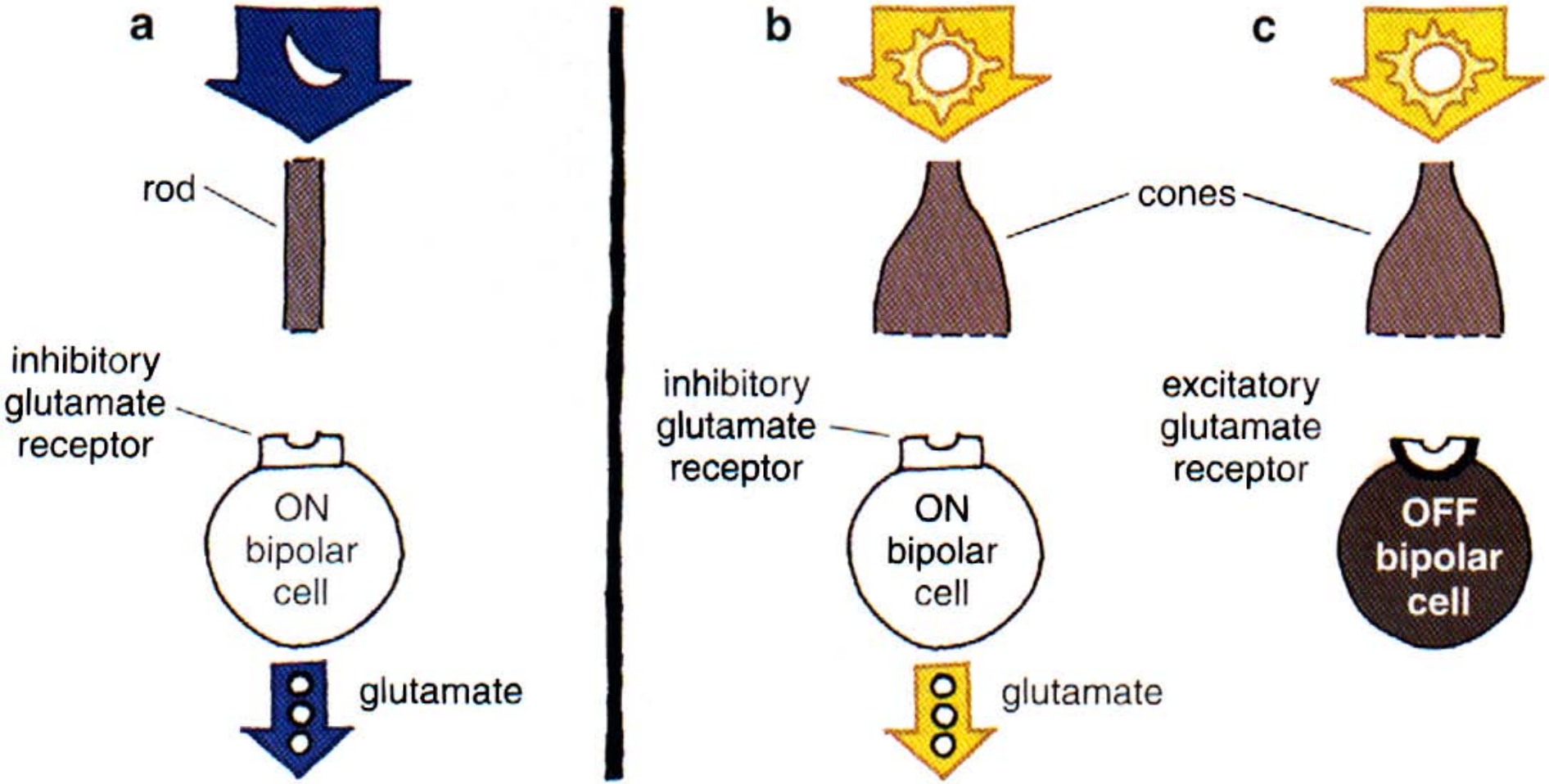
From the lab of Nathan Doble & Stacy Choi NECO

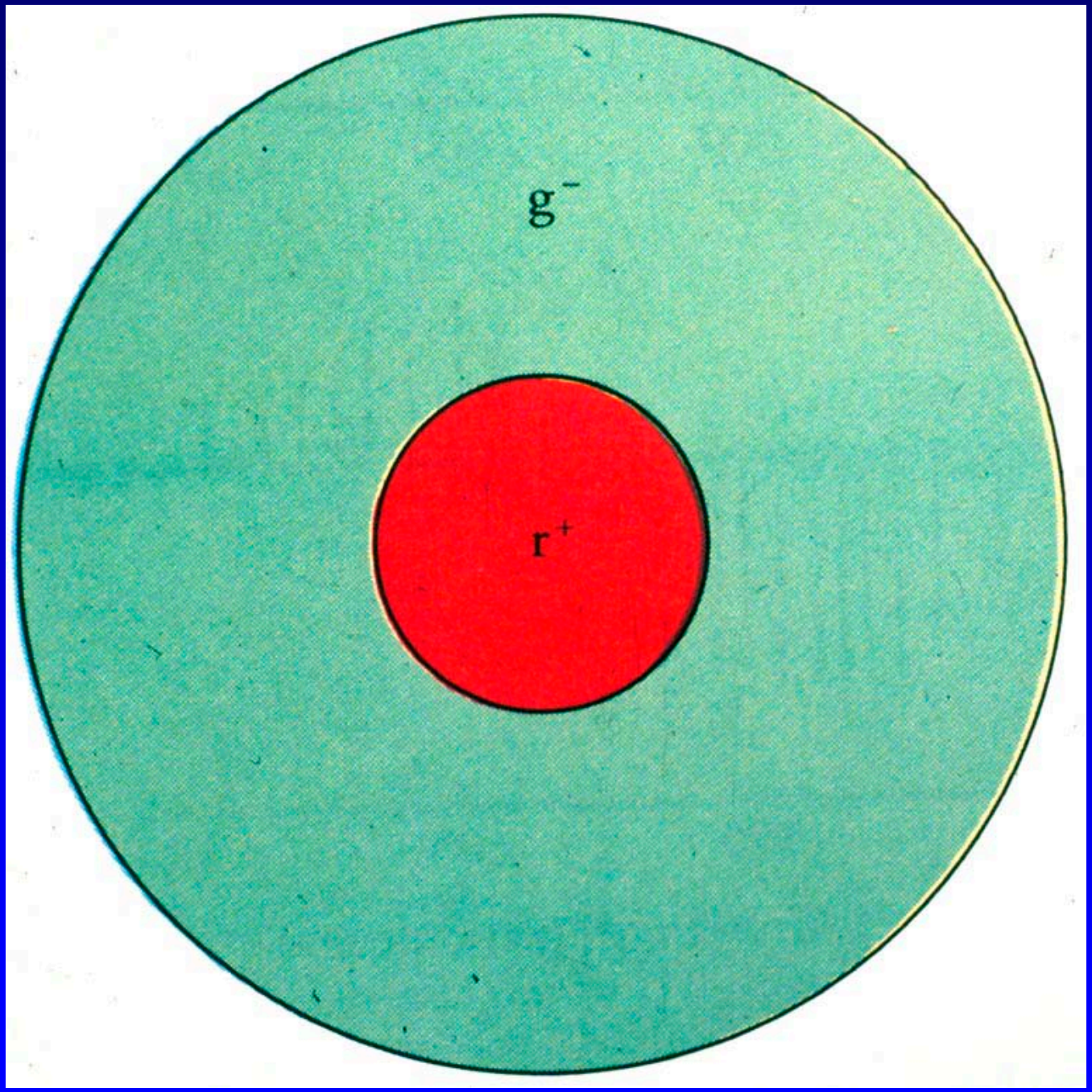
Unexpected Fact:
The rods and cones are hyperpolarized by light. They are actually excited by darkness.
So an “inhibitory signal” in response to light goes to the rest of the retina.





There are more than 25 types of ganglion cells.

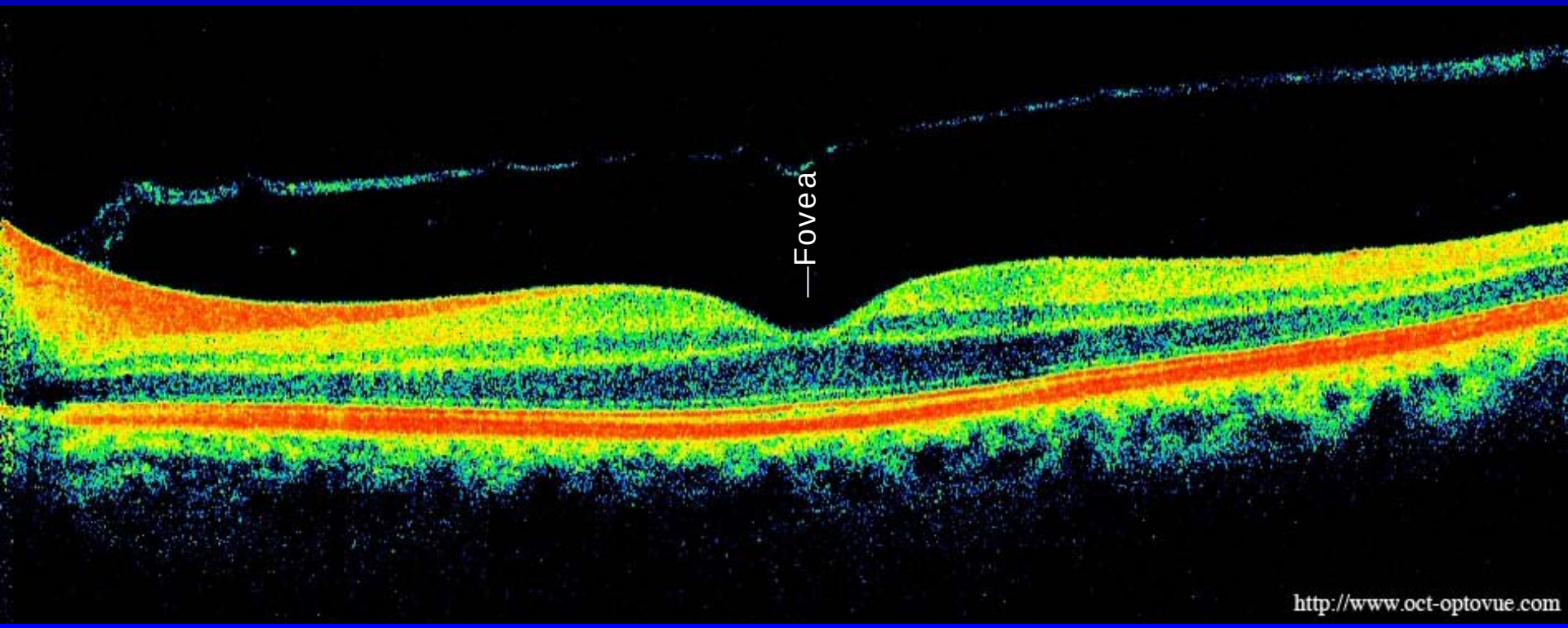

a
rod
inhibitory glutamate receptor
ON bipolar cell
glutamate
b
cones
inhibitory glutamate receptor
ON bipolar cell
glutamate
c
excitatory glutamate receptor
OFF bipolar cell


g⁻
r⁺

Optical Coherence Tomography

- OCT are common clinical instruments that use wide band lasers to take optical cross-section images of the retina.
- OCT has good resolution in retinal depth so we can see the major layers which are usually shown color coded.
- However, the horizontal resolution is very poor.

Regular clinical OCT



Adaptive Optics OCT

- Our AO-OCT is designed to use 860nm±140nm.
- These instruments make retinal cross-sections with resolution to image individual neurons.
- A few labs have software that allows them to rend individual neurons in 3-D and spin them to be seen from all angles.
- These instruments should also be in clinics within 10 years.

Summary: 4 Facts about the Retina

- The retina is organized into layers.
- Adaptive optics fundus cameras allow us to see within layers with almost histological precision. Using laser technology, we can see individual receptor outer segments.
- The circuitry of the retina creates more than 25 different kinds of ganglion cells, each of which sends a different type of message to the brain.
- Adaptive optics OCT allows us to see “histological” sections of the retinas of patients.

Thank you for your Attention