Lecture
Sensation and Perception

PSYC 304

Announcements

RC 1

- Was awesome! There was some amazing discussion, and the presentations sounded great.
- Grades aimed to be released within two weeks.
- Start preparing for RC2

Test 1

- Good job everyone
- We will aim to have grades released within two weeks of the test. We will have a portion of a future class set aside for review (in-person only)
- All question results will be reviewed for fairness (Questions that are too hard/too easy/have an error may be removed)
- All changes will be communicated to the class once grading is complete

Quarter 2 starts today!

- Sensory and Perception
- We will build on the foundation we have built around neuronal communication to understand how we respond to changes in the physical world, and how those changes relate to how we perceive the physical world.

HSP

Study of Hidden Stories
This study aims to investigate the validity of a picture-based questionnaire. Participation involves completing an anonymous online survey about mood, physical activity, and responses to certain settings or situations, as well as reactions to a set of pictures.

Eligibility:

- UBC students who are **16 to 19 years old**
- Fluent in English
- Access to a laptop for study completion

Details:

- **Duration:** 60 minutes
- **Reimbursement:** 1 HSP credit
- **Principal Investigator:** Dr. Joelle LeMoult

Interested students can sign up through HSP by searching **"The Study of Hidden Stories."**

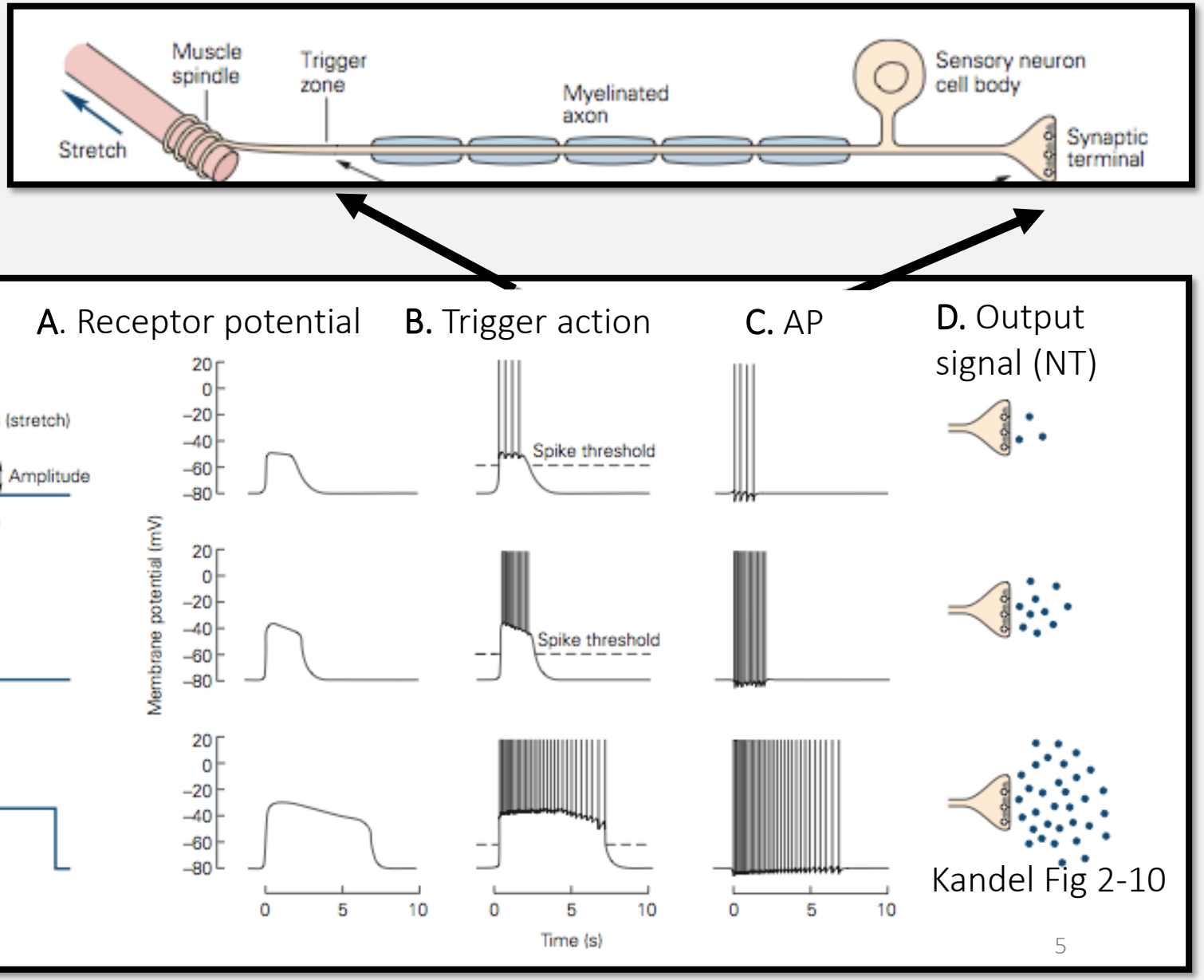
Conceptual review

Relating

Stretch reflex circuit

Information Encoding

- Spindle senses physical changes
- Greater amplitude of stretch
    - Higher frequency of APs
- Longer duration of stretch
    - More APs over time
- 2 signals!



Kandel Fig 2-10

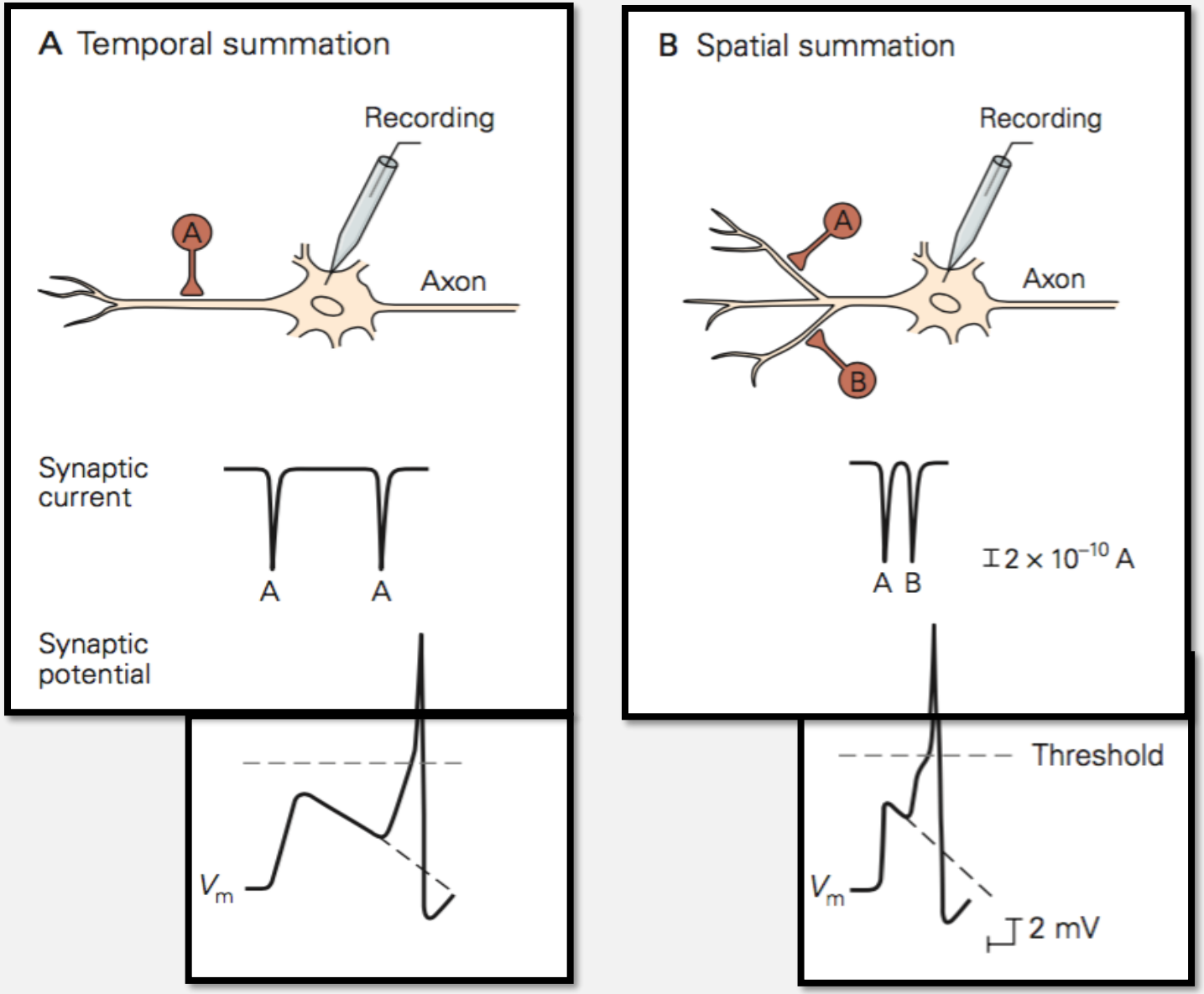
Summation of synaptic potentials

A. Temporal Summation

- Consecutive EPSPs from the same axon can summate to produce an AP

B. Spatial Summation

- Concurrent/consecutive EPSPs from separate cells can also summate to produce an AP

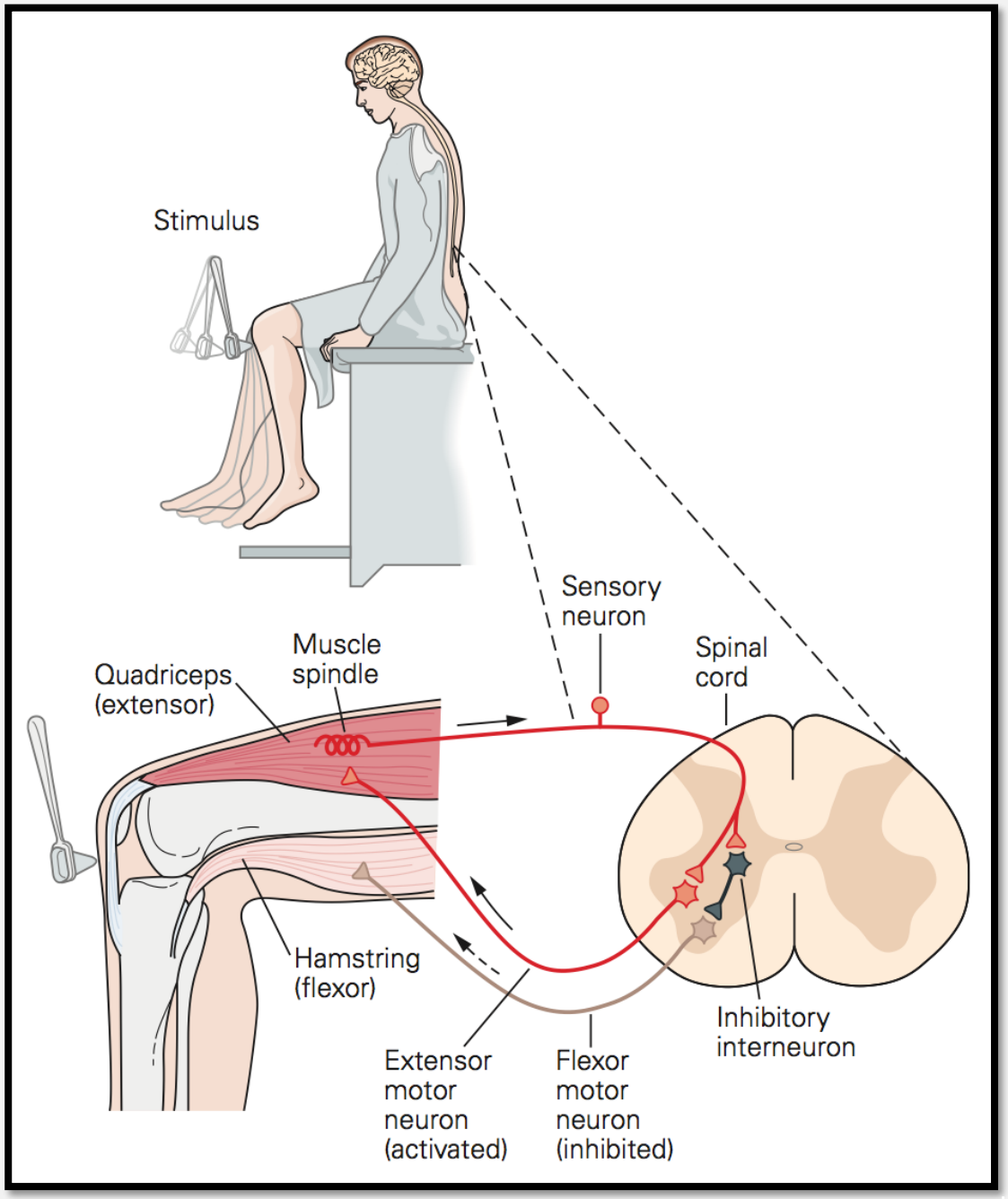


Kandel Fig 10-14

Important concept

Back the reflex circuit

- Sometimes we need a single signal to spread to multiple neurons
- Sometimes we need multiple signals to influence one neuron
- In this example we need the single signal from our sensory neuron to contract our quads and relax our hamstring at the same time.

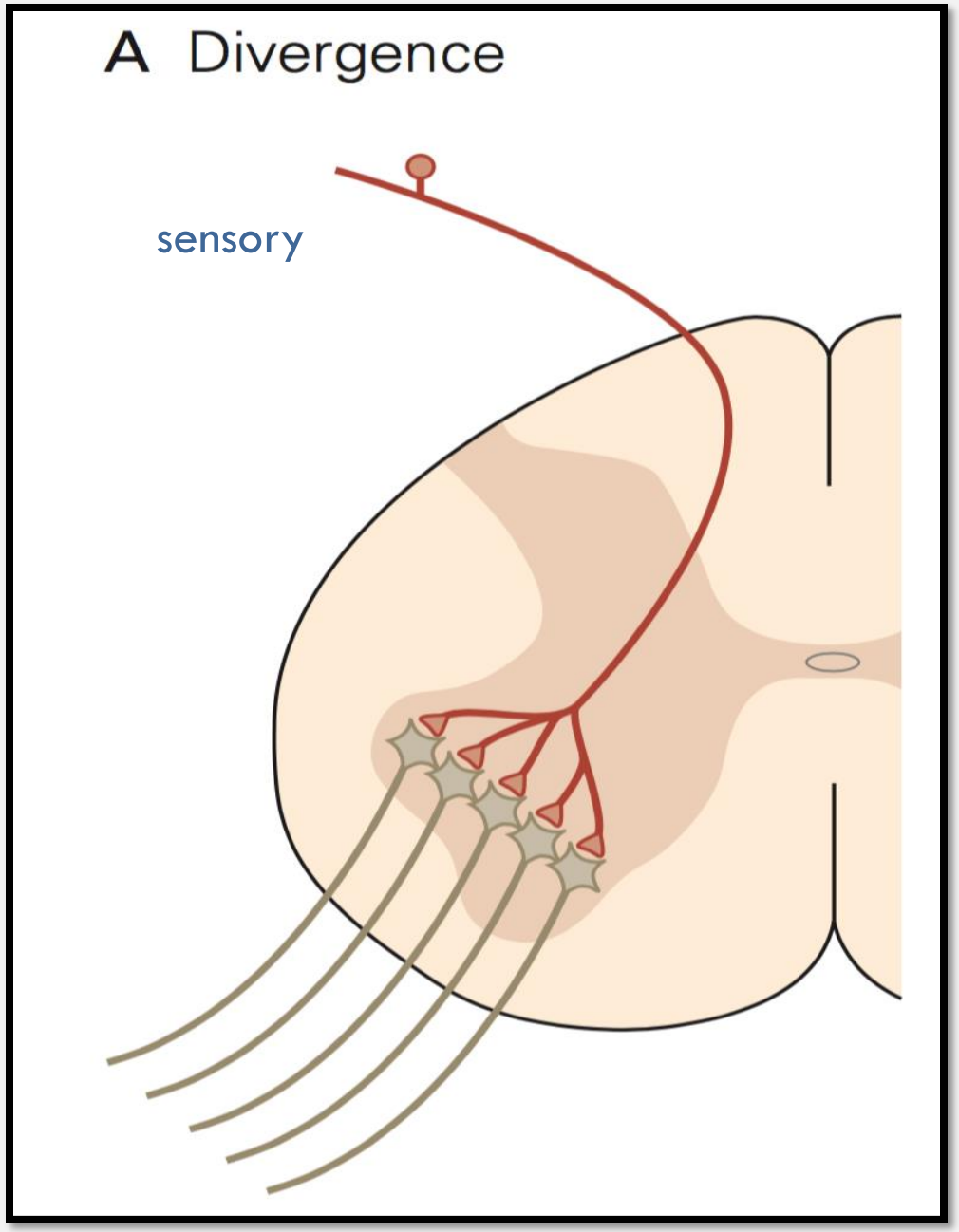


Kandel Fig 2-6

Important concept

Divergence

- One neuron synapses with many neurons
- Information spreads
- Signal can serve different purposes

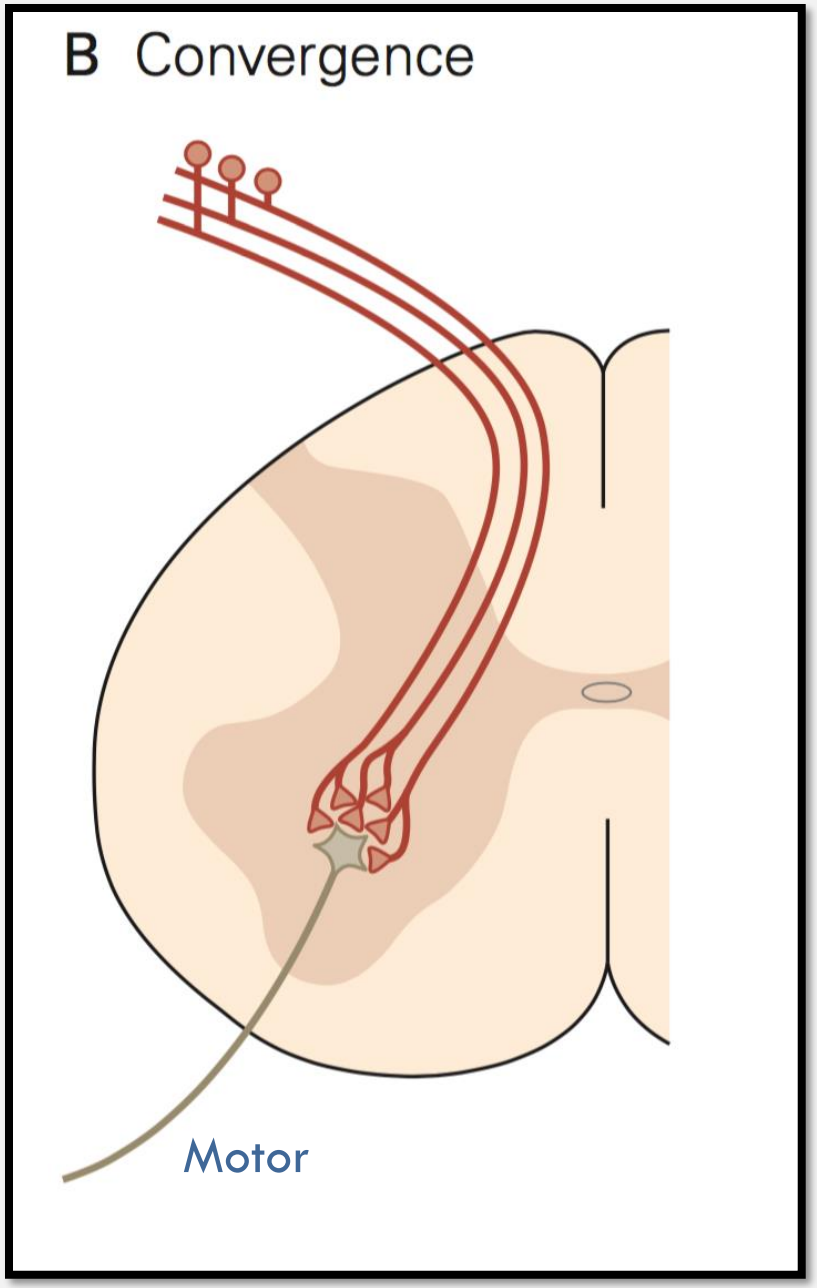


Kandel Fig 2-6

Important concept

Convergence

- Many neurons synapse onto a single neuron
- Integration of different types of information



Kandel Fig 2-6

Sensation and Perception

Sensory Perception

Sensory perception

Sensory Perception

What do you hear?

Learning Objectives

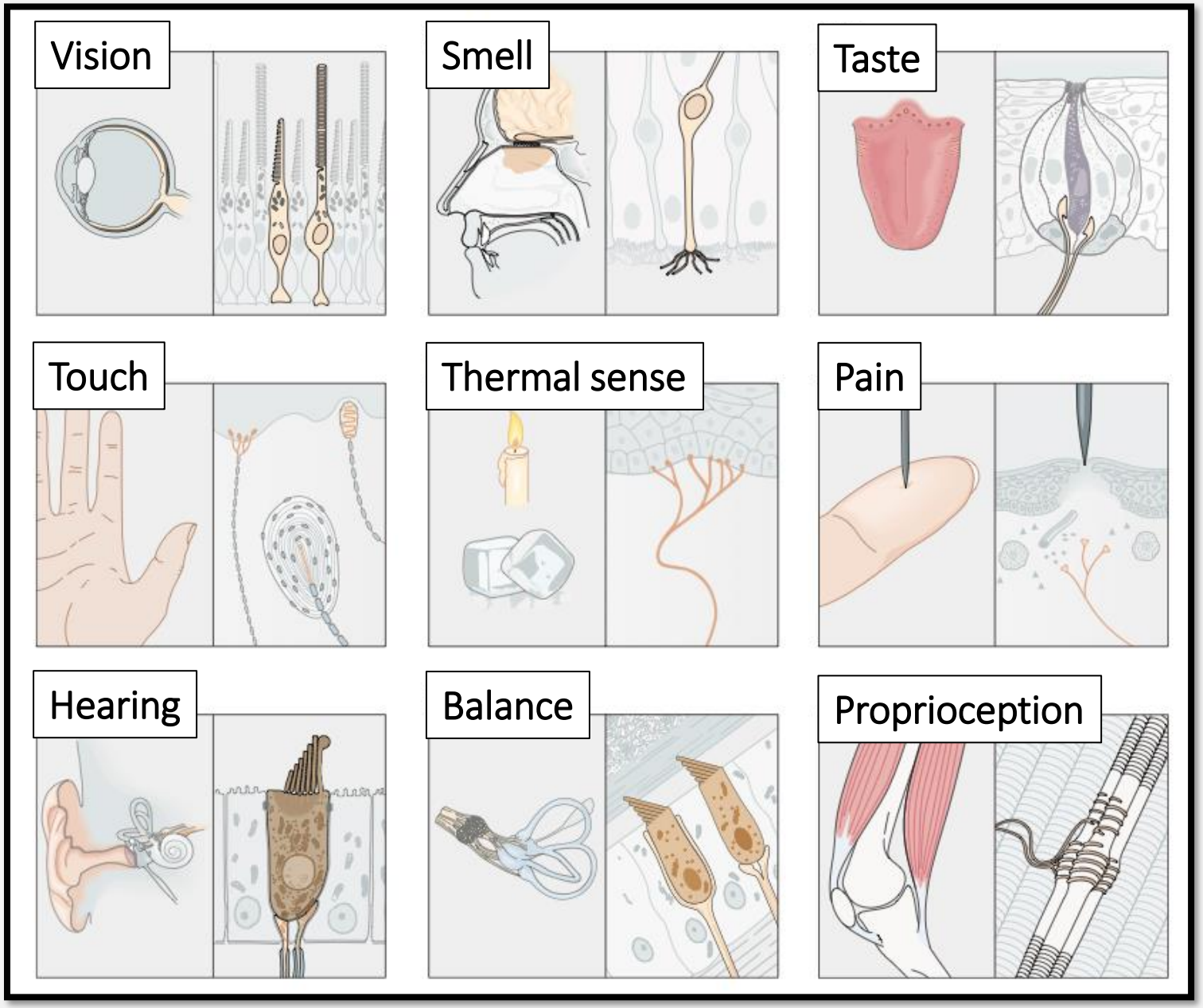
By the end of this lesson, you will…

1. Understand the term transduction as it applies to various sensory modalities
2. Describe the different between a generator potential and an action potential
3. Describe why one might use Psychophysics to study sensory perception.

Sensory Perception

Sensory modalities

- Specially designed receptors
- Convert a particular stimuli from the world into action potentials
- Relative activity of populations of neurons forms a representation (percept) for that sensory stimulus

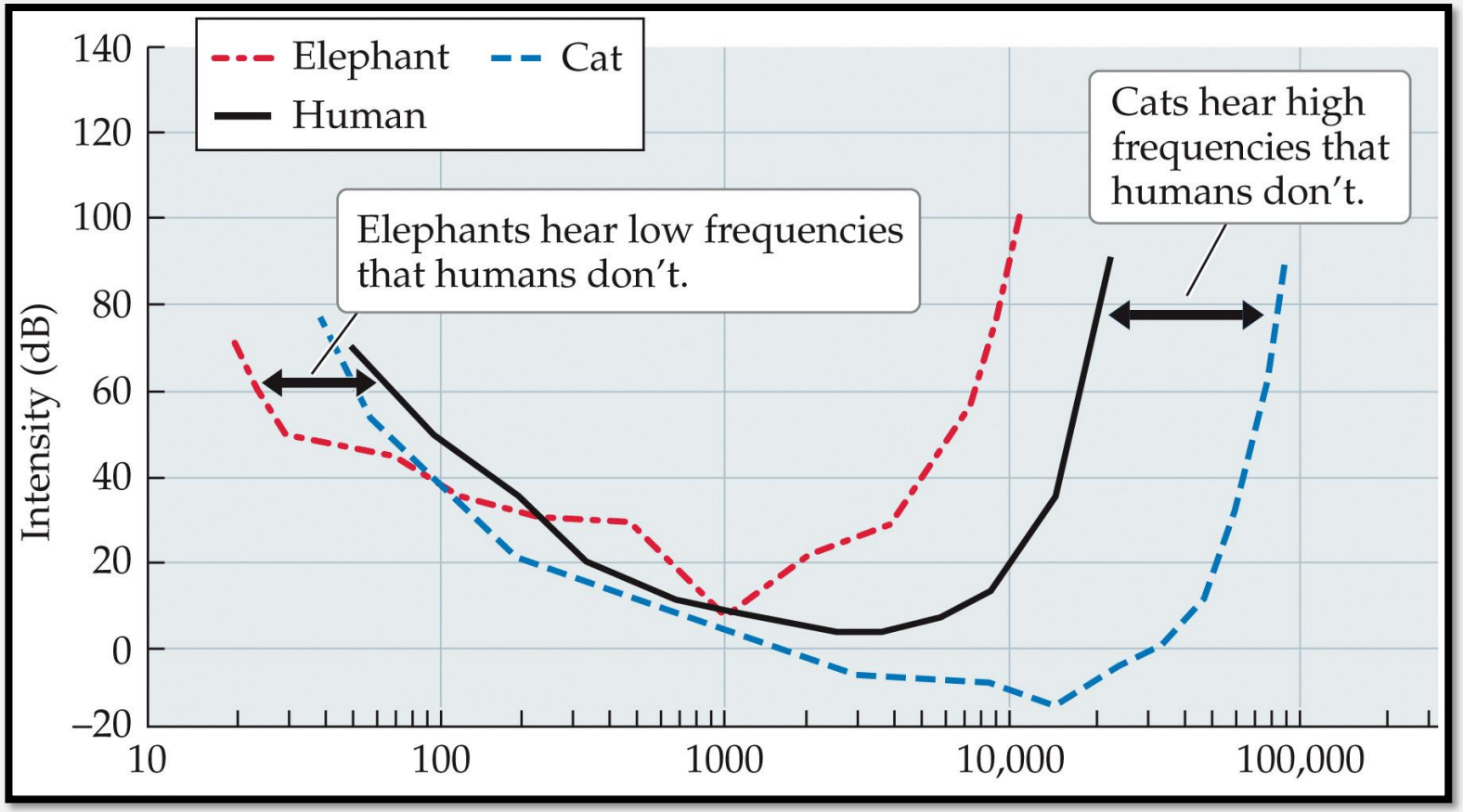


Kandel Fig 21-1

Sensory Reception

Adequate stimulus:

- type of stimulus to which a sensory organ is particularly adapted, e.g., photic (light) energy for the eye.
- Sensory systems have a restricted range of responsiveness.
- Example: the frequency range for hearing, which varies with species.



Sensory Processing - Terminology

Sensory transduction:

- conversion of physical energy from a stimulus into a change in membrane potential in a receptor cell.
- Receptor cells are transducers.

Receptor potentials (generator potentials)

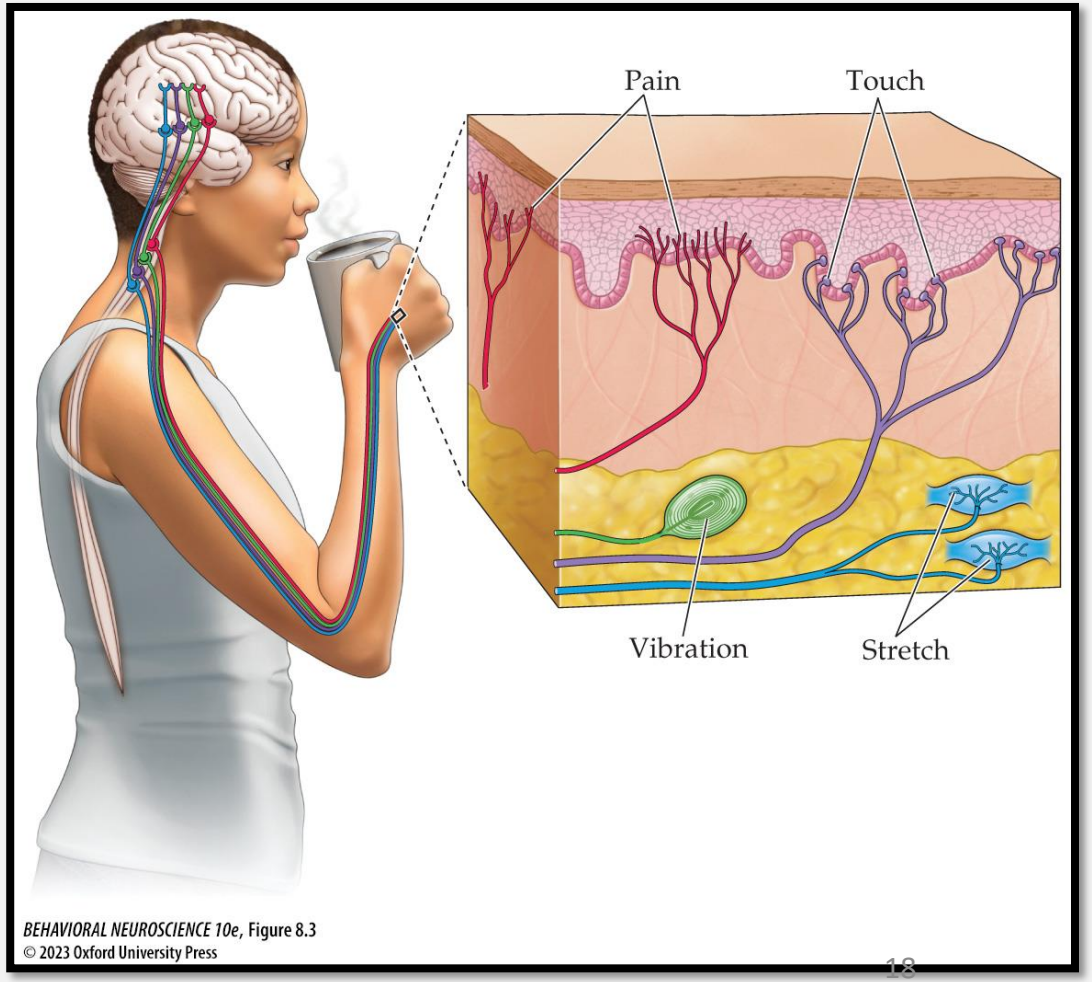
- are local changes in membrane potential.

What Type of Stimulus Was That?

- All the senses use the same type of energy to communicate with the brain: action potentials.

Labeled lines

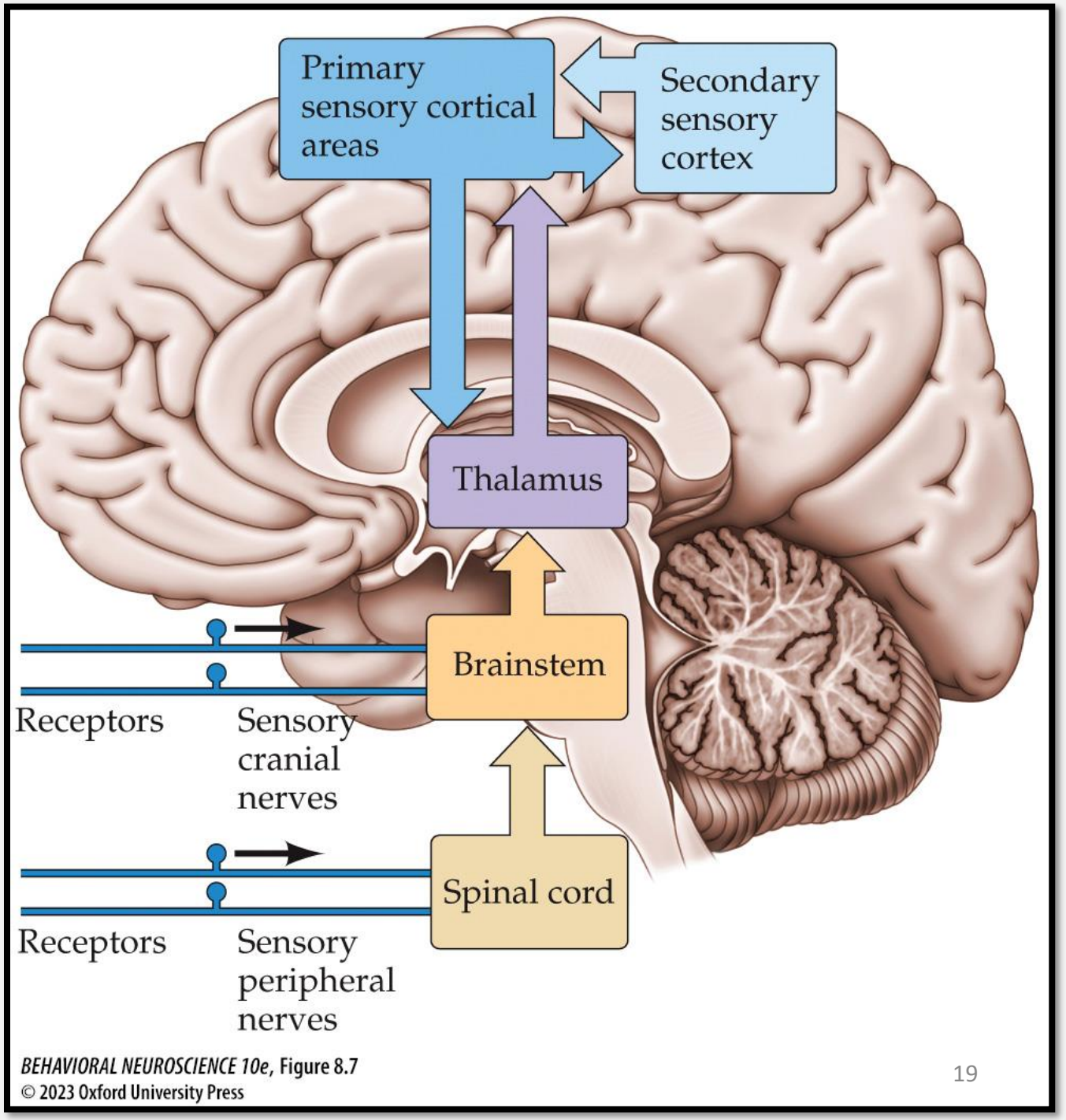
- But the brain recognizes distinct senses because the action potentials travel along separate nerve tracts



Sensory Information Processing

Pathways:

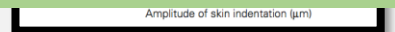
- Each sensory system has a distinct **sensory pathway** in the brain and passes through stations during processing.
- Most sensory pathways pass through regions of the **thalamus.**
- Sensory pathways terminate in the cerebral cortex.



How do you objectively assess someone's subjective perception of the world?

A simple sensory experience

A simple sensory experience



Vision – General principles

Learning Objectives

By the end of this lesson, you will…

1. Describe how visual perception is a constructive process.
2. Understand the difference between bottom-up and top-down processing

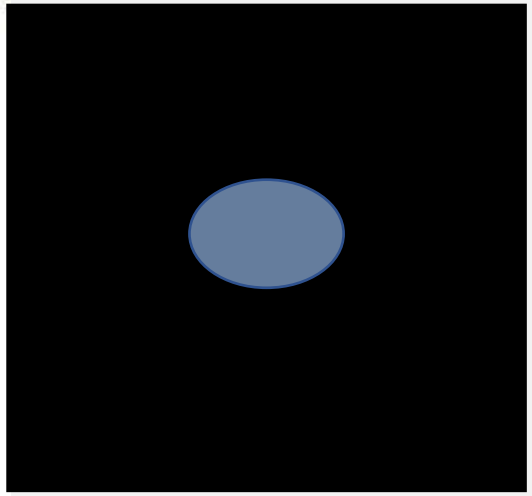
Visual Performance (examples)

Snellen chart

- Visual acuity

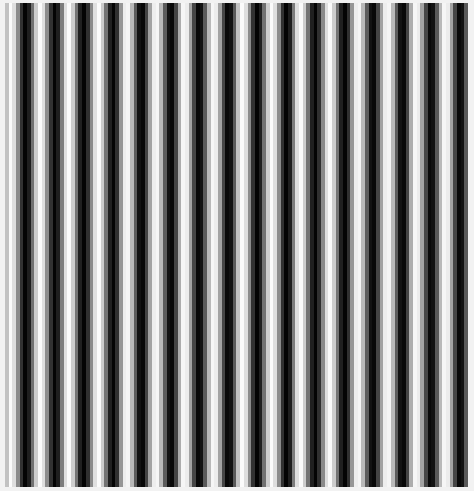
Absolute threshold

- 6-12 photons

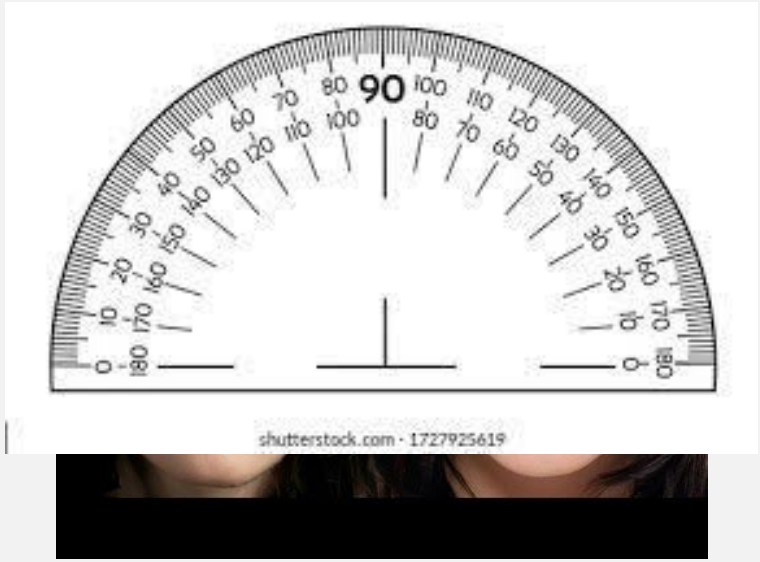


Spatial resolution

- 60 cycles/degree (cpd)

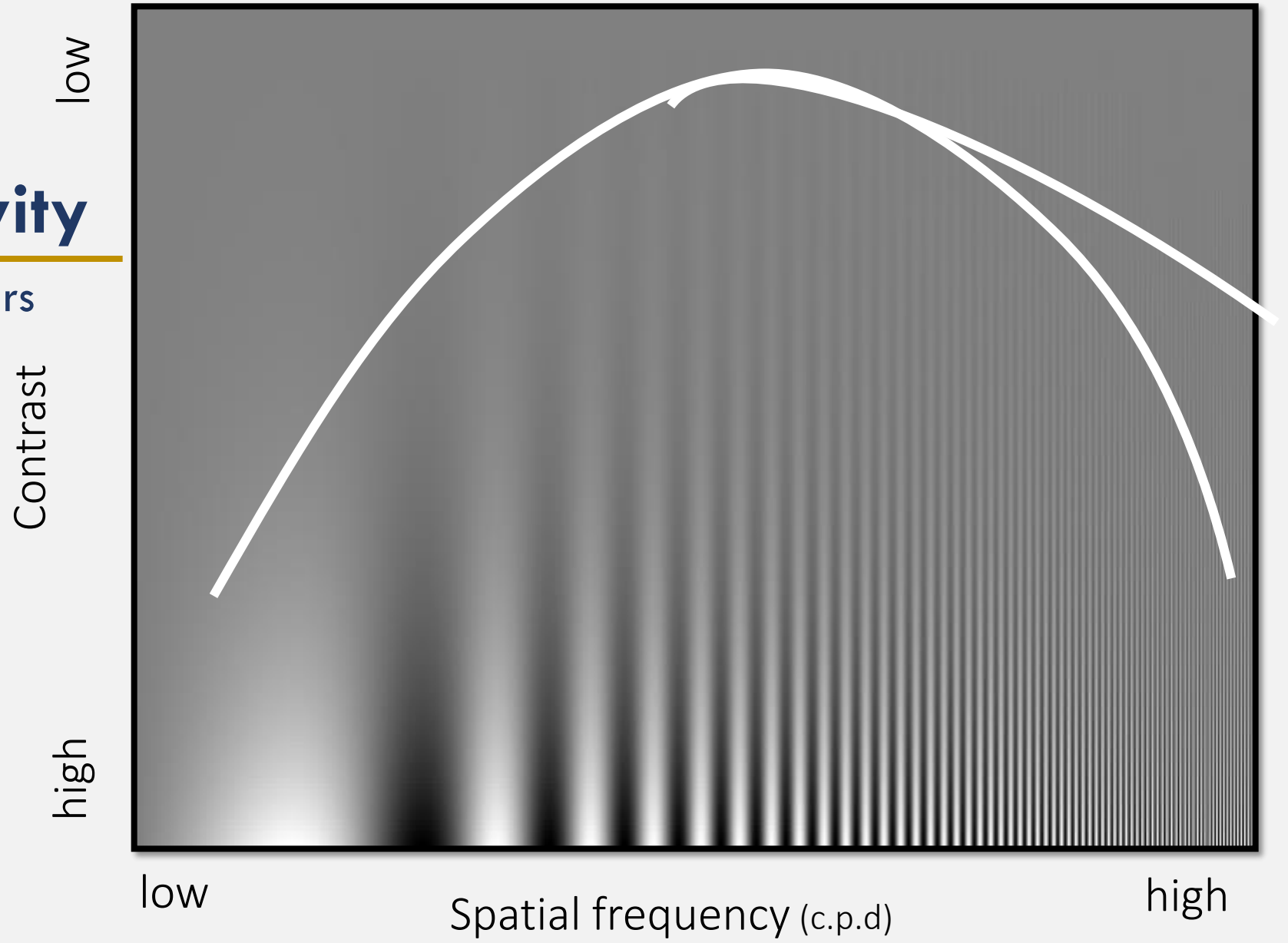


Facial recognition



Contrast sensitivity

Where do the vertical bars disappear?



The constructive nature of visual processing

Low level processing

- Spatial frequency

The constructive nature of visual processing

Low level processing

The constructive nature of visual processing

Low level processing

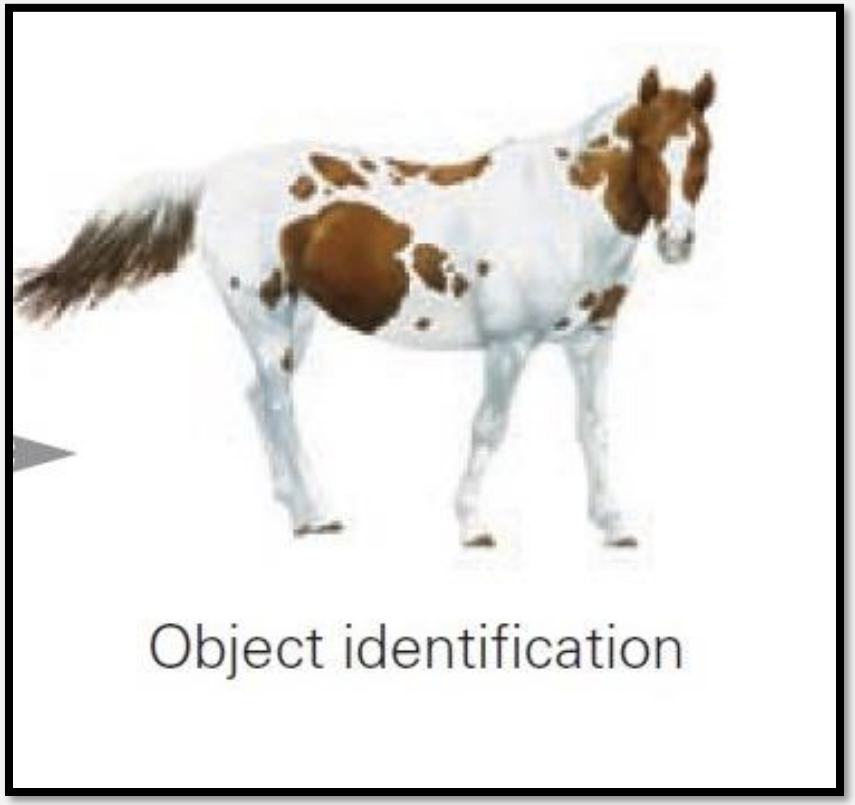
Low intermediate level

The constructive nature of visual processing

Intermediate recognition

Object recognition

Bottom-up processing



Top-down influences

The role of expectation

Kandel Fig 25-3

Let’s prime you for the previous image

Expectations/Priming

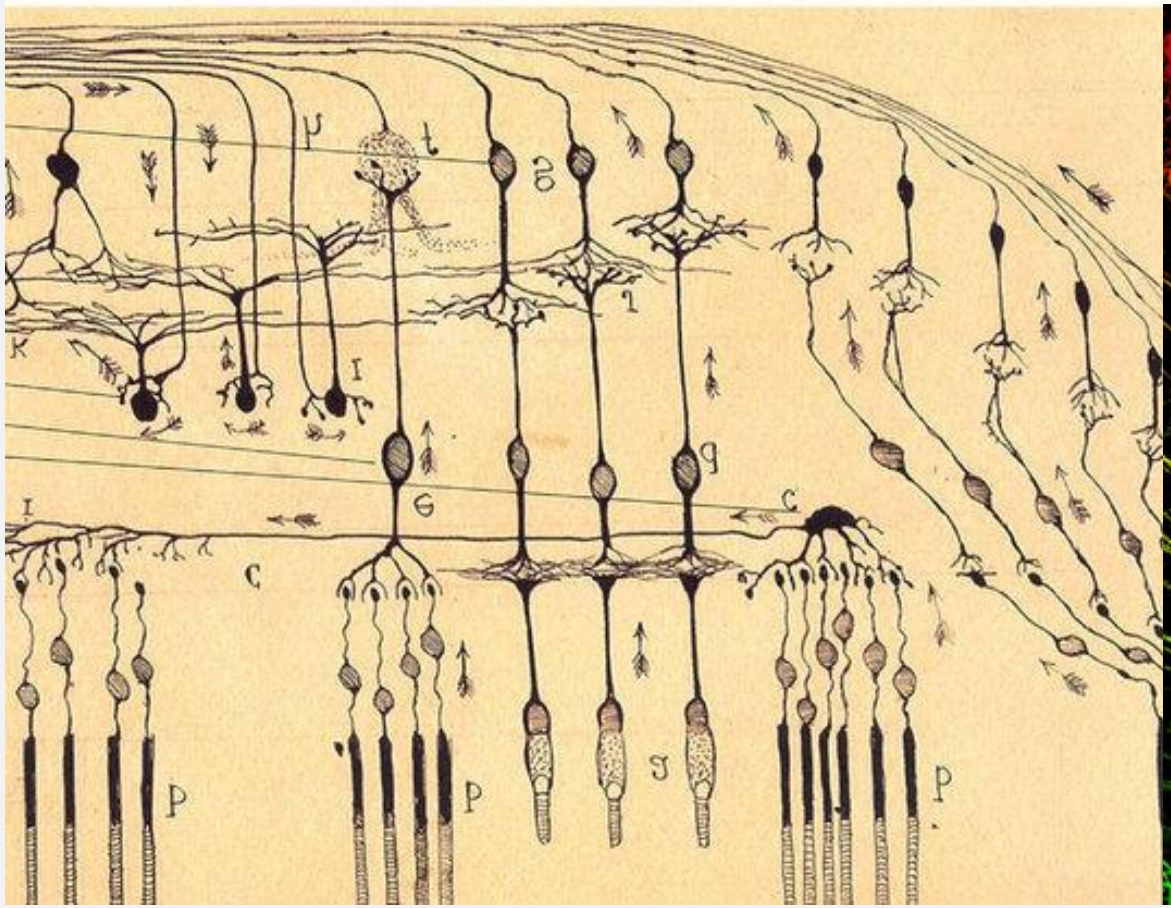
One more!

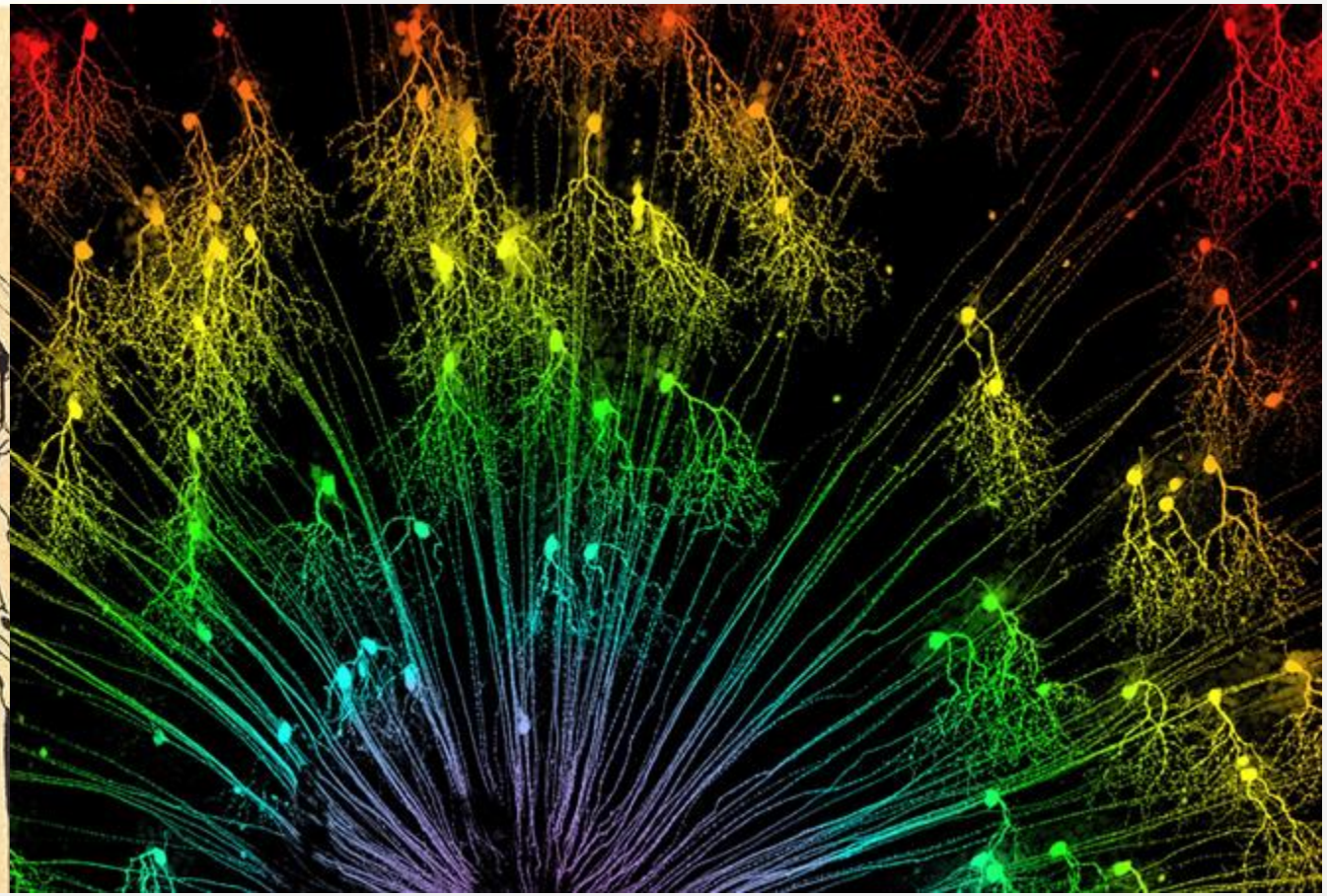
What do you see

One more!

This time we will prime you to a shape

Retina & sensory transduction





What is the purpose of vision?

Instructions

Focus on the fixation cross for 20 seconds, try your best not to move your eyes. What happens if you do?

Learning Objectives

By the end of this lesson, you will…

1. Understand the basic properties of a neuronal receptive field.
2. Appreciate how the structure (anatomy) of the retina relates to its function
3. Be able to use the concept of convergence to distinguish between rod and cone neural circuitry.
4. Distinguish between on-center and off-center receptive fields
5. Describe how different bipolar cells might contribute to each type of receptive field
6. Be able to compare and contrast the morphology, location, and functionality of rods and cones
7. Understand the concept of population coding
8. Be able to describe how lateral inhibition can lead to enhanced contrast perception
9. Appreciate how different retinal ganglion cells can each work in paralell to carry different forms of information for a single spot in the visual field.

Vocabulary

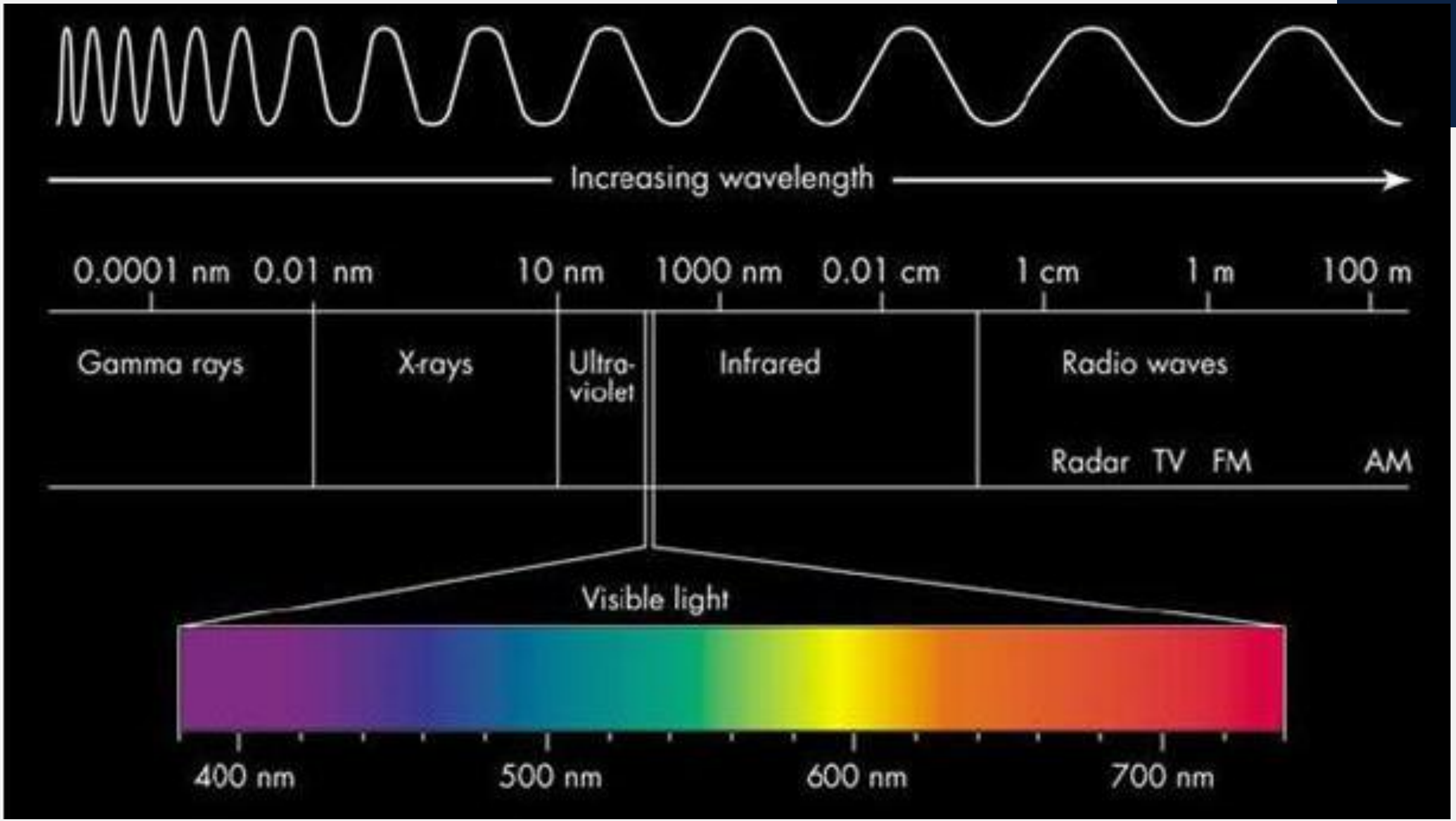
- Light is a band of electromagnetic radiation; comes in packets of energy called *quanta*.

Wavelength

- distance between two adjacent crests of vibratory activity.

Photons

- Human visual system responds only to quanta of wavelengths between 400 – 700 nm; quanta in this range are called Photons


Increasing wavelength
0.0001 nm
0.01 nm
10 nm
1000 nm
0.01 cm
1 cm
1 m
100 m
Gamma rays
X-rays
Ultra-violet
Infrared
Radio waves
Radar
TV
FM
AM
Visible light
400 nm
500 nm
600 nm
700 nm

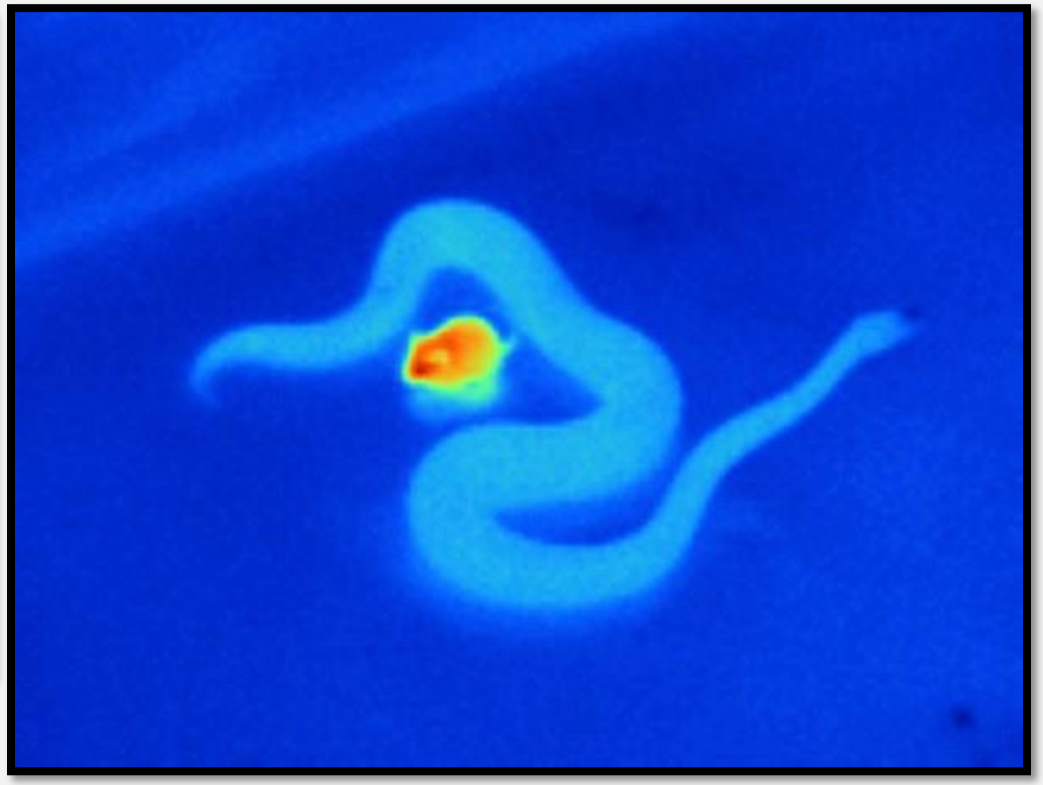
Vision in the animal kingdom

Bee vision

- Ultraviolet

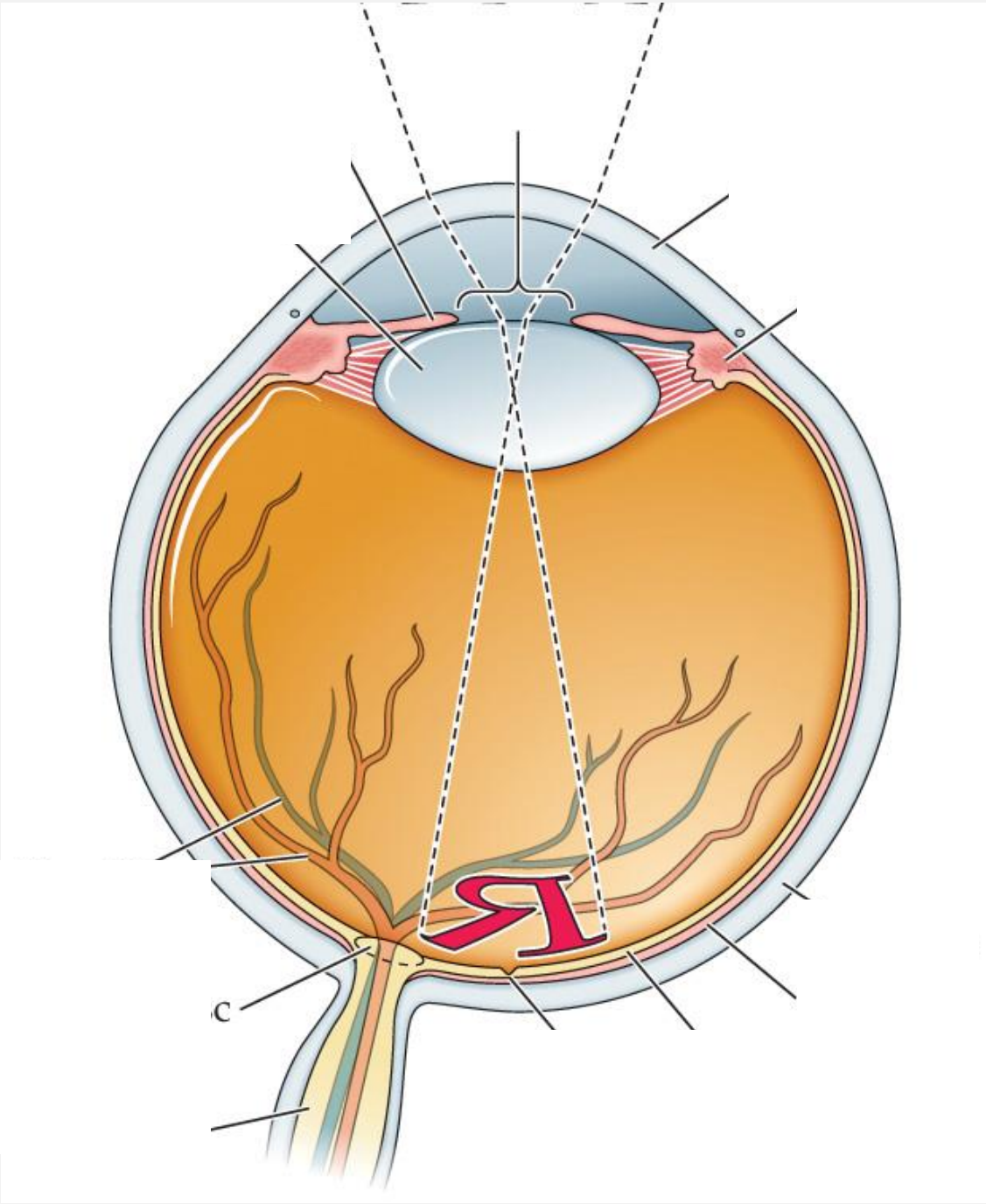
Snake vision

- Infrared



The Eye

What do you remember?



The Eye - Basics

- The eye has camera-like features.

Refraction

- bending of light rays—is done by the **cornea** and **lens** to form the image on the retina.

Accomodation

- **ciliary muscles** in the eye adjust the focus, by changing the shape of the lens.

The Eye - Basics

Pupil

- amount of light entering the eye is control amount light entering the eye by opening/closing in the **iris** (colored disc).

Dilation

- is controlled by the sympathetic nervous system;

Constriction

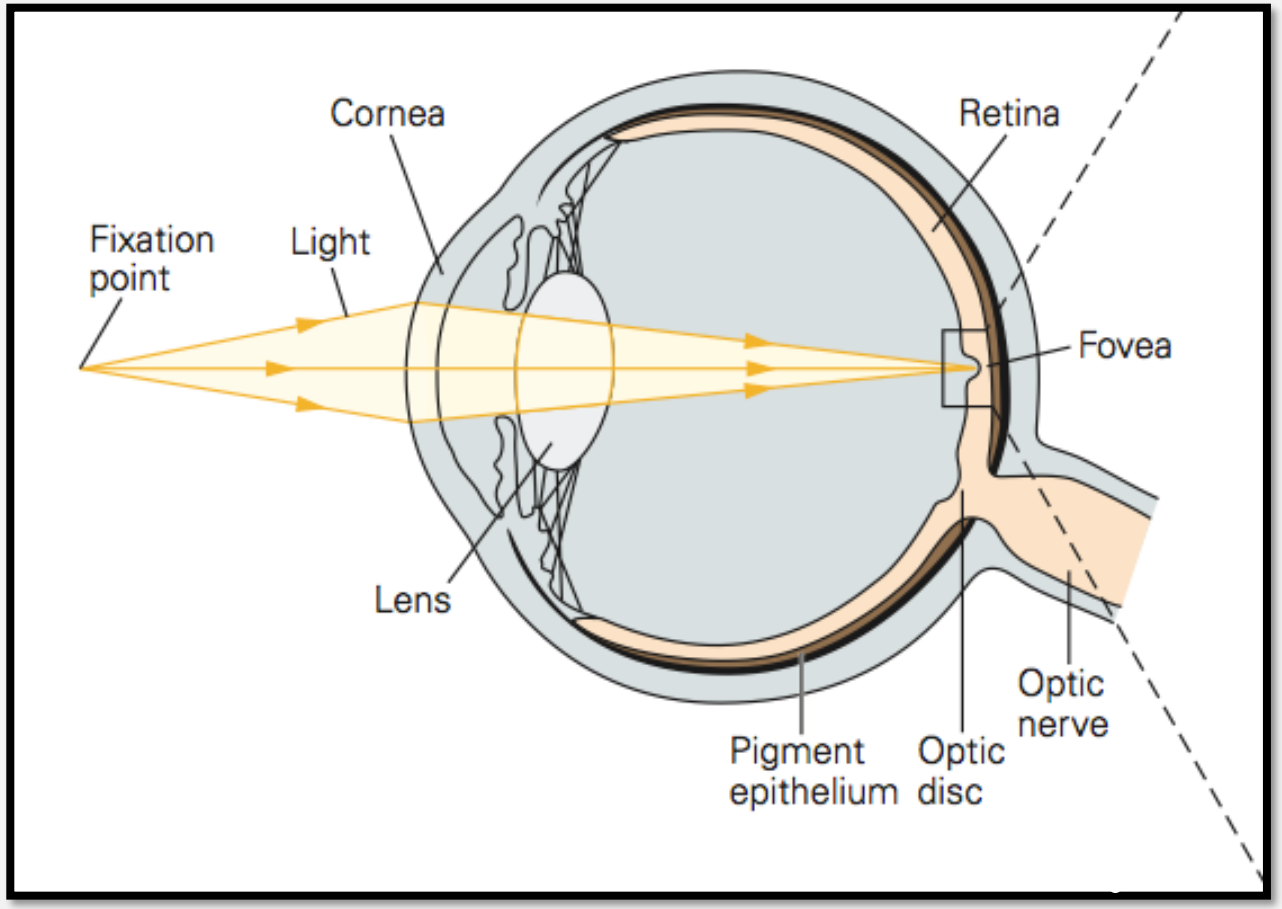
- is controlled by the parasympathetic division.

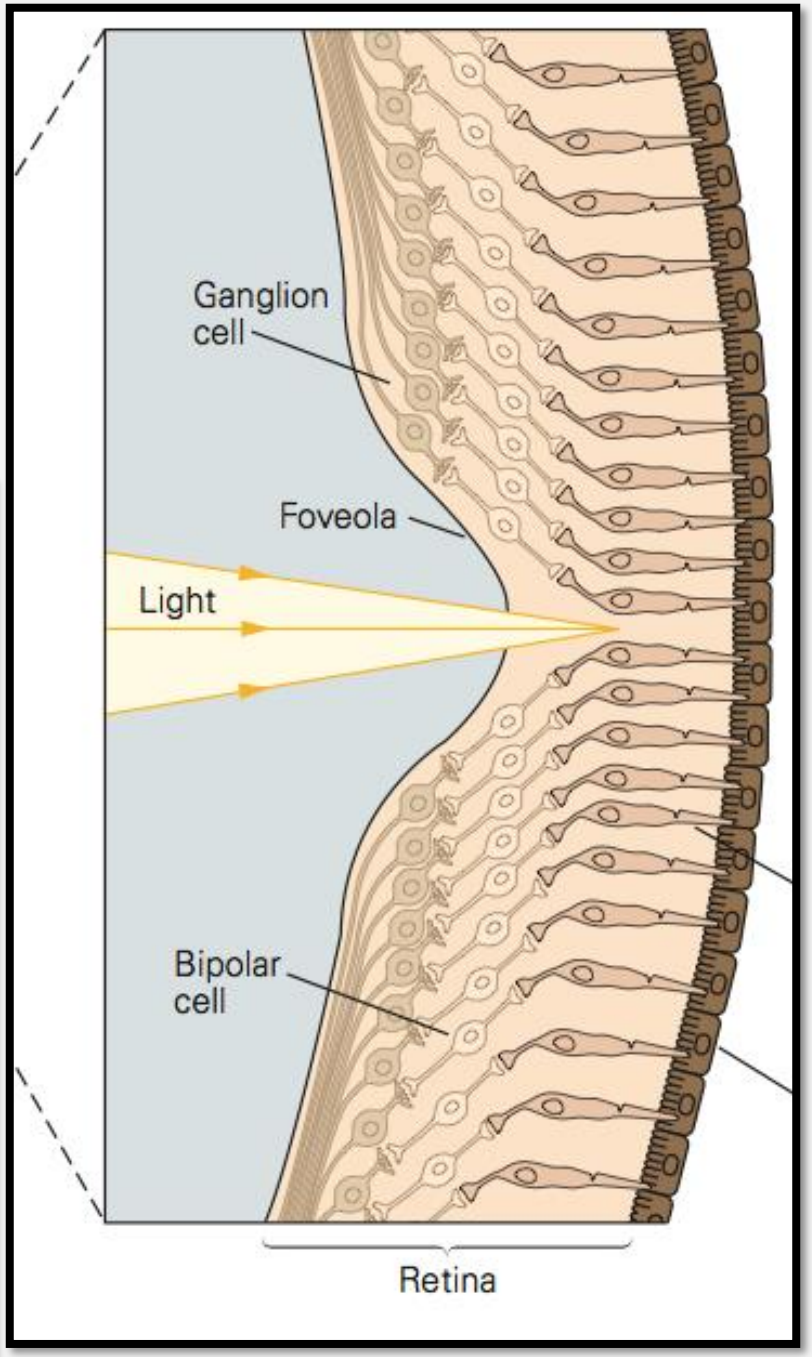
Eye movement

- is controlled by **extraocular muscles.**

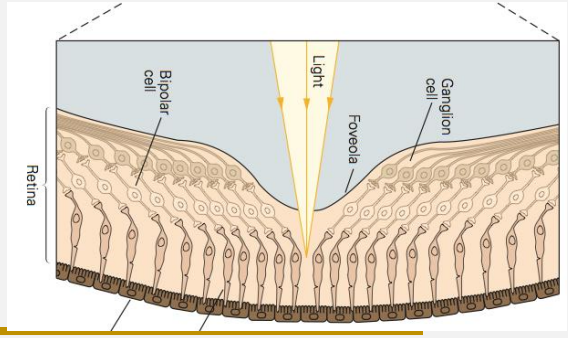
The Eye and Retina

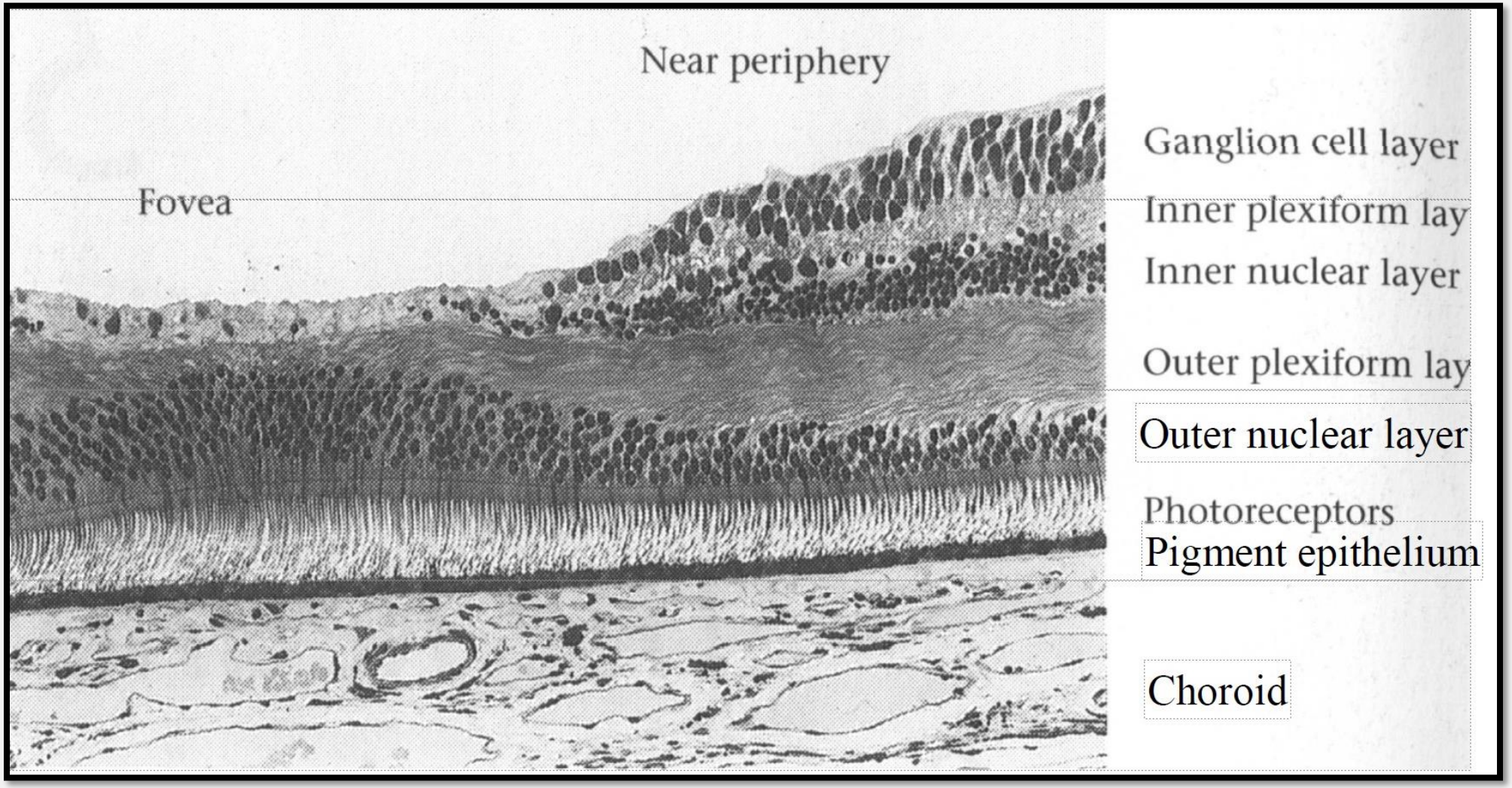
What do you observe?





Histological View of the retina/fovea

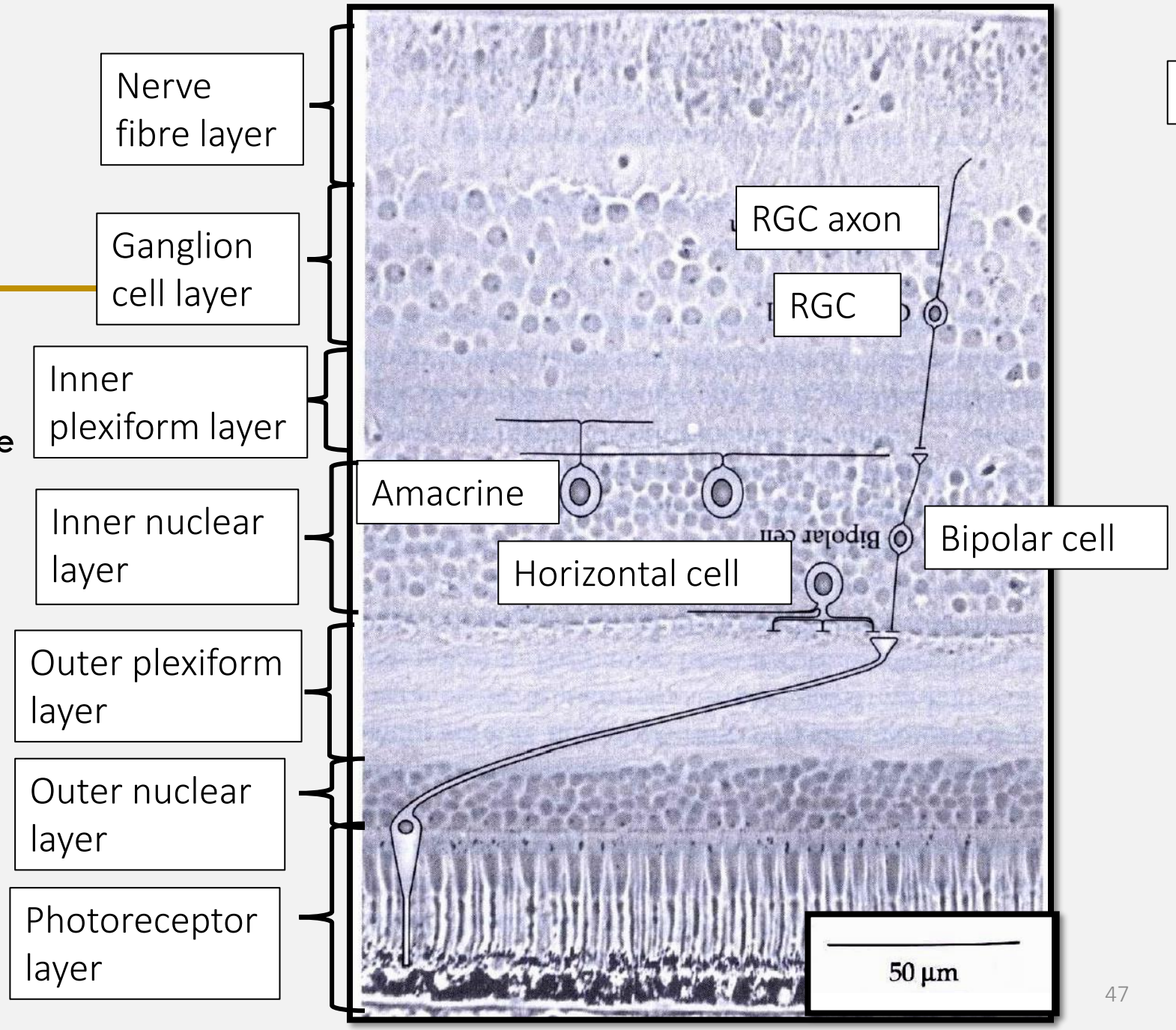




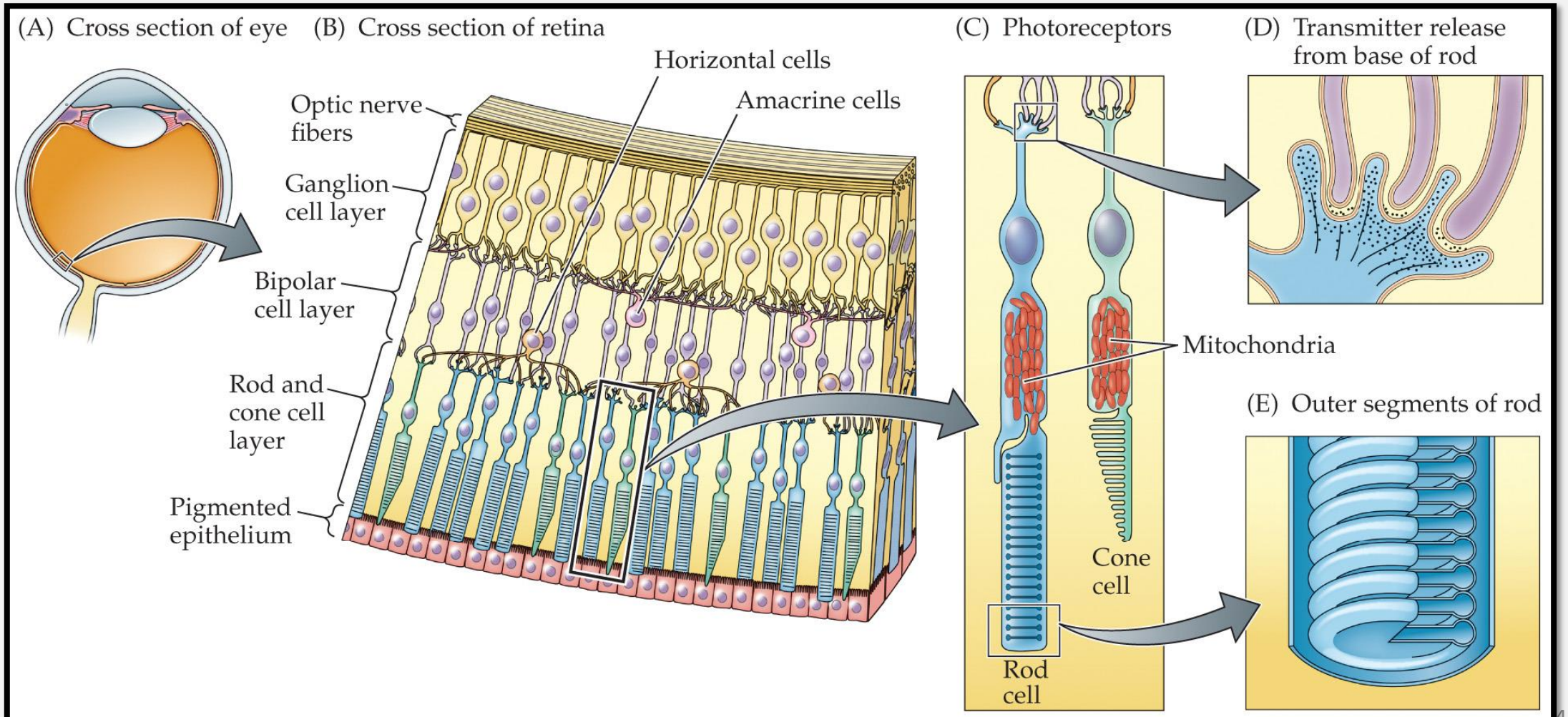
The Retina (periphery)

Cellular organization

- Nuclear layers
  - Where nucleuses are
- Plexiform layers – "plexus" or network
  - Typically axon tracks



Anatomy of the Retina



BEHAVIORAL NEUROSCIENCE 10e, Figure 10.3

Terminology

Visual field

- whole area you can see without moving your head or eyes.

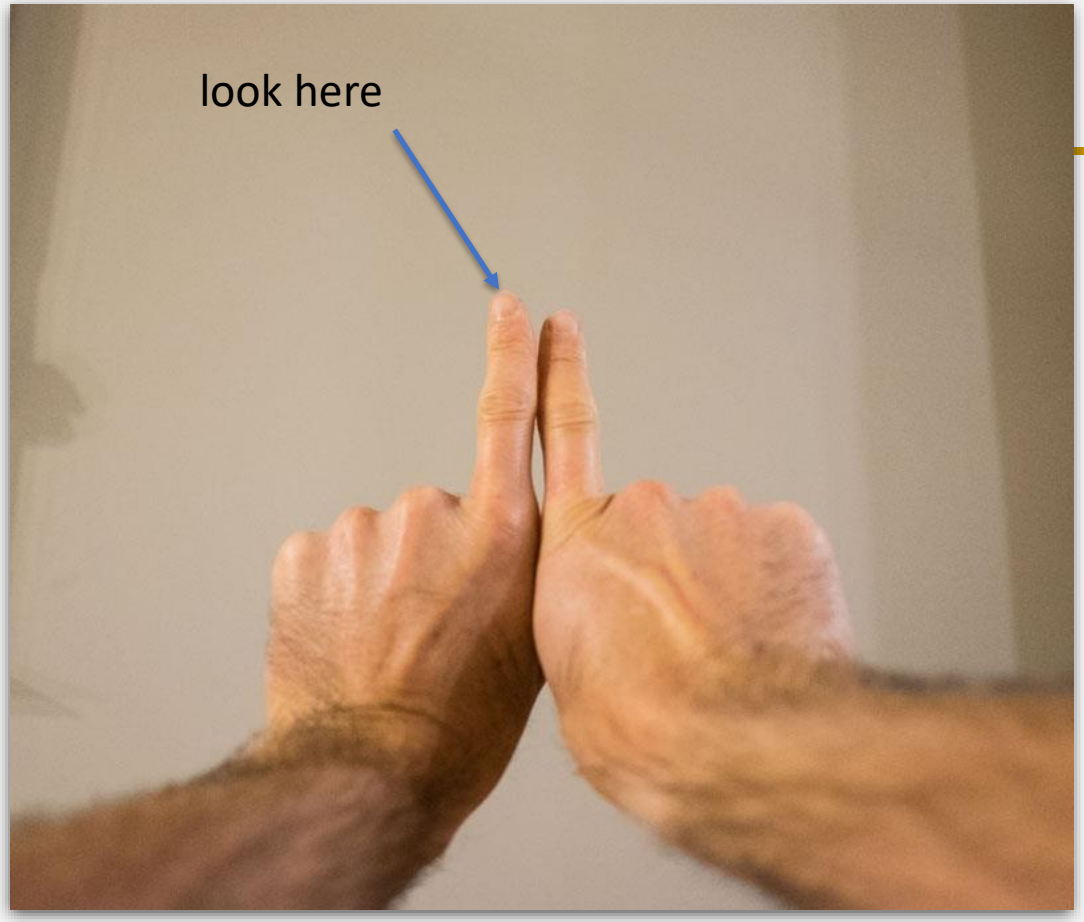
Visual acuity

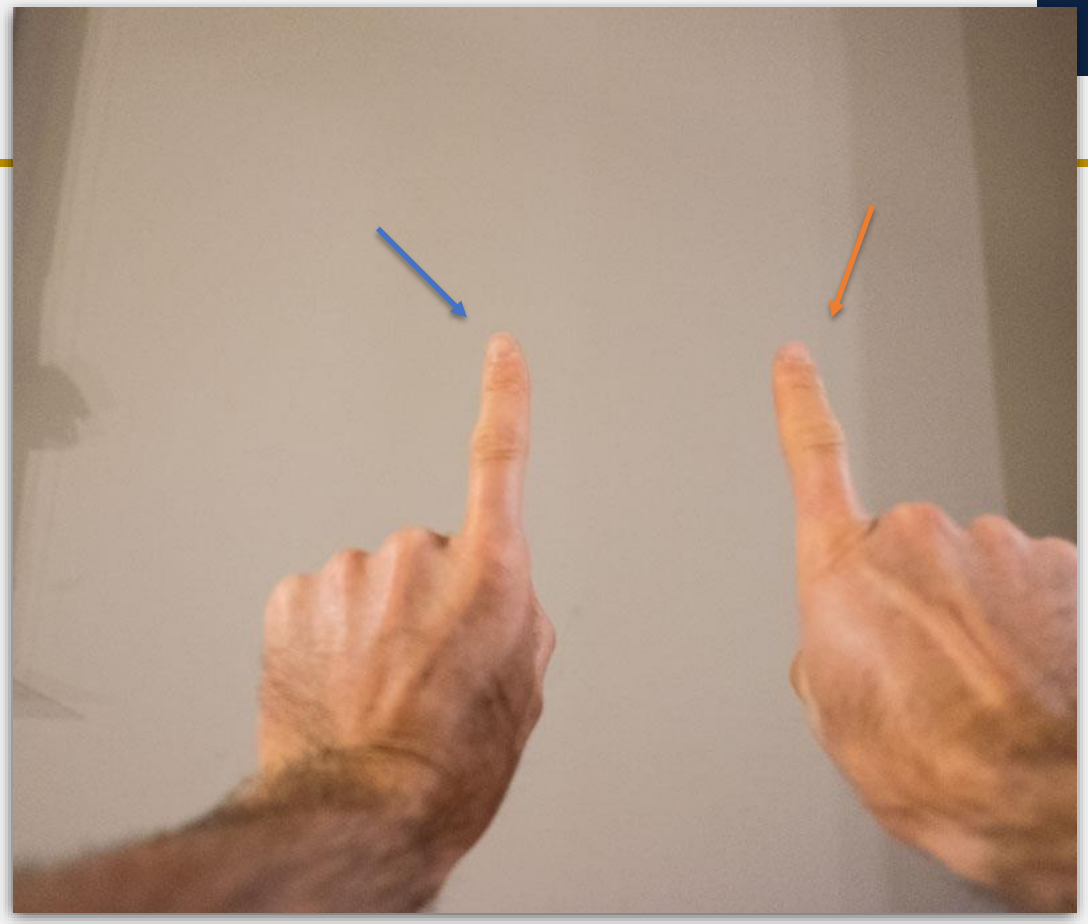
- sharpness of vision; falls off towards the periphery of the visual field.
- Acuity is greatest at the **fovea**, which has a high concentration of cones.

Optic disc

- where blood vessels enter and leave the eye; no photoreceptors here results in a **blind spot**.

Activity: “Seeing” your blind spot





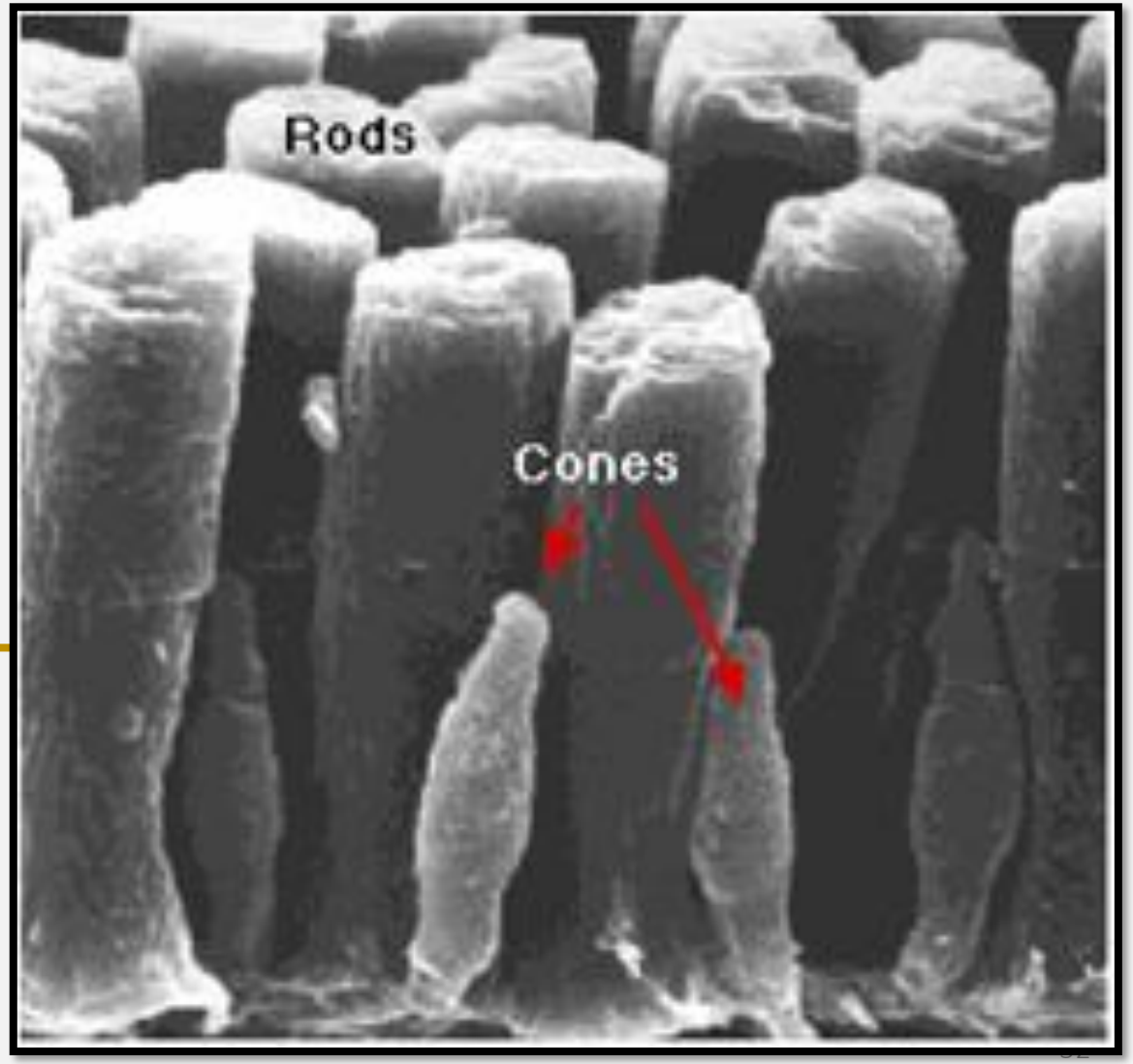
Step 1: with left eye closed and fingers together, focus on left finger

Step 2: with left eye closed, FIXATE ON LEFT FINGER DO NOT MOVE YOUR EYE EVEN ONE BIT, slowly move right finger to the right BUT KEEP FIXATING ON LEFT FINGER IM SERIOUS, notice how right finger disappears NOT LIKE SOME MAGIC SHOW POOF! but subtly like you almost didn’t notice it

Retina Anatomy – Summary

- Photoreceptors (rods and cones) are at the very back of the retina circuitry
- Rods and cones connect to bipolar cells
- Bipolar cells connect to retinal ganglion cells (RGCs)
- RGC axons leave the eyeball at the optic disc forming the optic nerve – creates a blind spot
- Horizontal cells laterally interconnect rods and cones
- Amacrine cells laterally interconnect bipolar and ganglion cells
- Ganglion cell bodies are pushed to the side at the fovea (less light dispersion)

Photoreceptors



Rods and Cones

Morphology

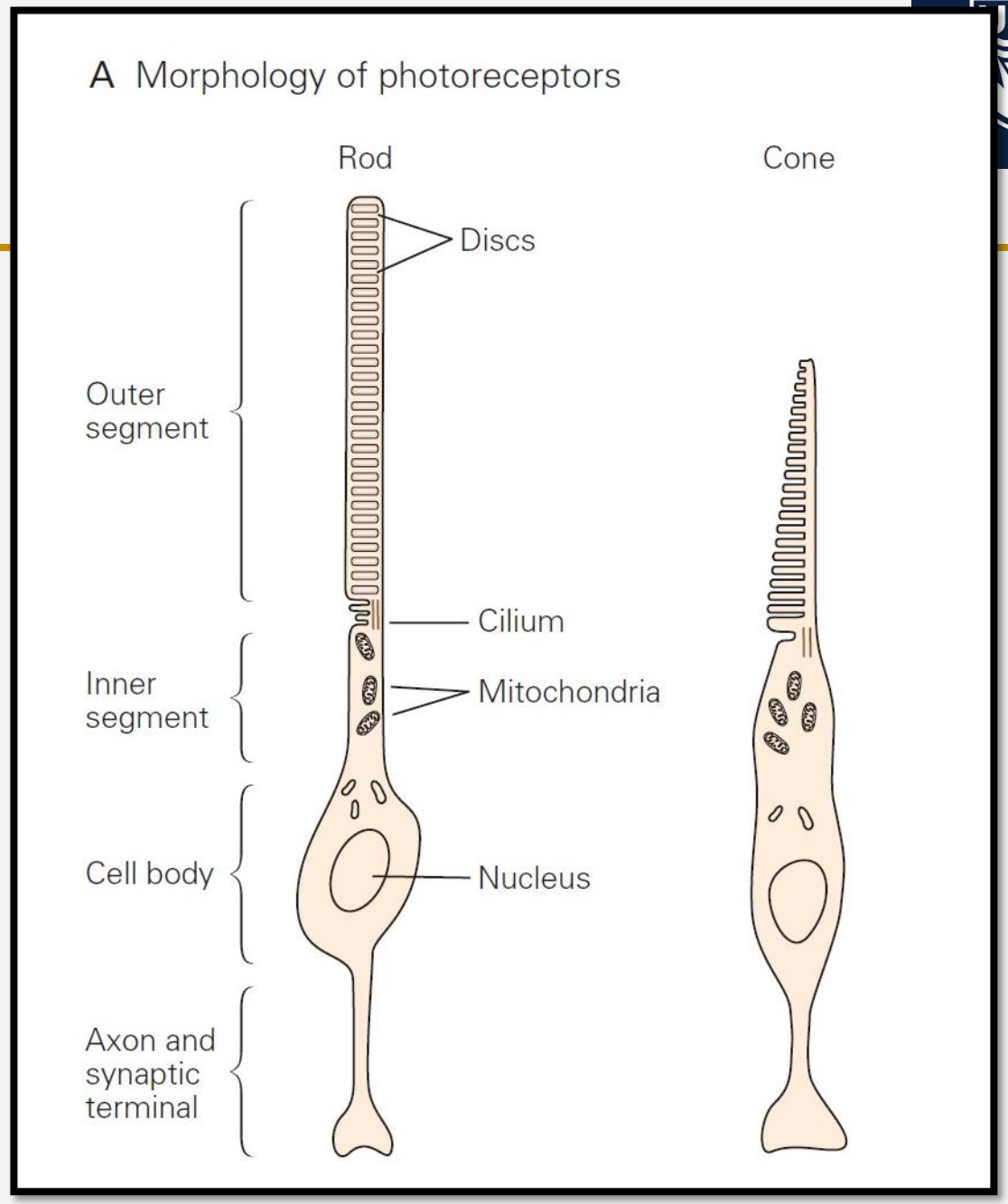
- Outer segment – Stacks of membranous discs – contain ***light absorbing photopigments (Opsins)***
- Inner segment – cell machinery
- Cell body + synaptic terminal
- Both release Glutamate from the axon

Rods

- Contains rhodopsin

Cones

- Contains cone opsin



Kandel Fig 26-5

Rods and Cones

Rods

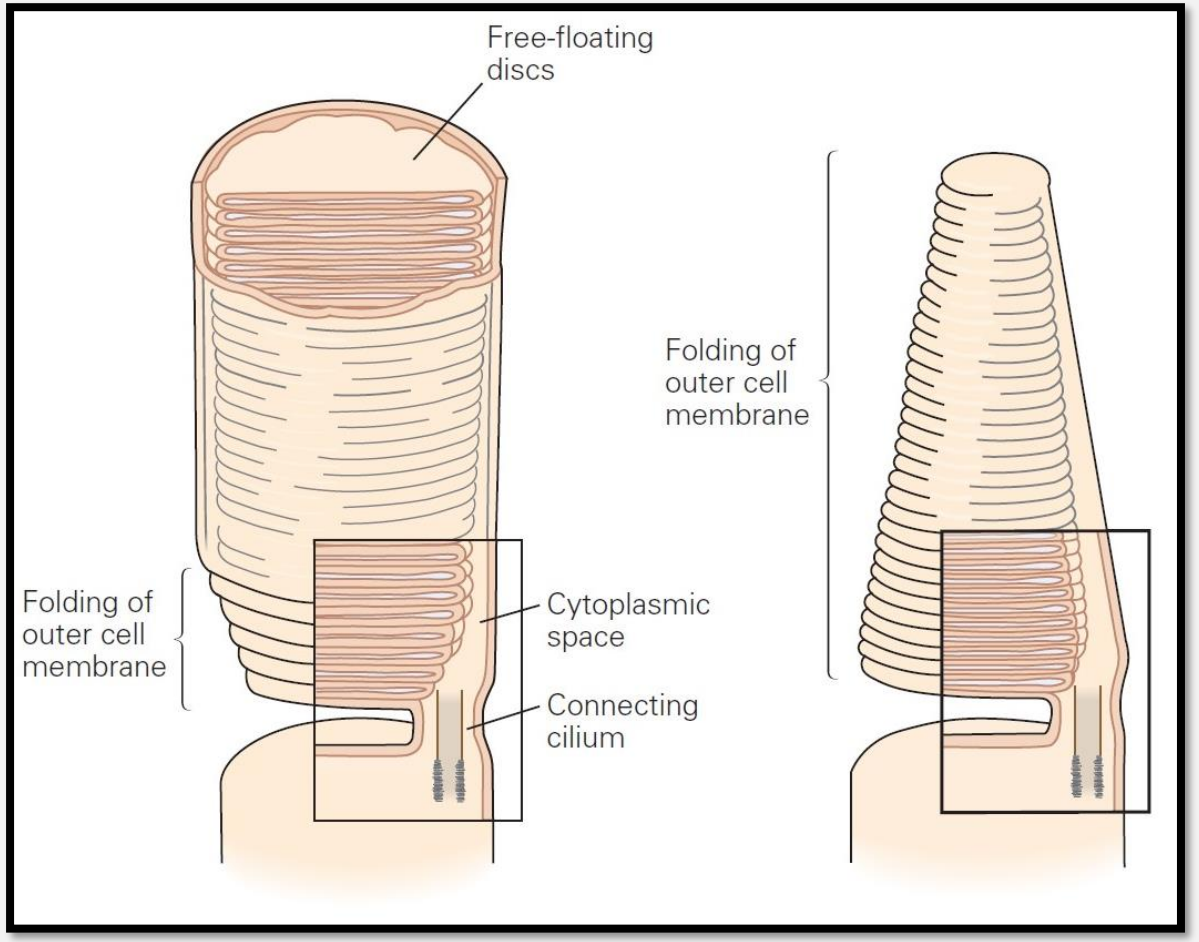
- Free floating discs
- Contains **rhodopsin**

Cones

- Discs continuous with plasma membrane
- Contains **cone opsin**

Opsins

- Light sensitive proteins
- Conformation change in response to absorbance of a photon
- Initiates a signal cascade which alter the conductance of the membrane (causes a hyperpolarization!)



Kandel Fig 26-5

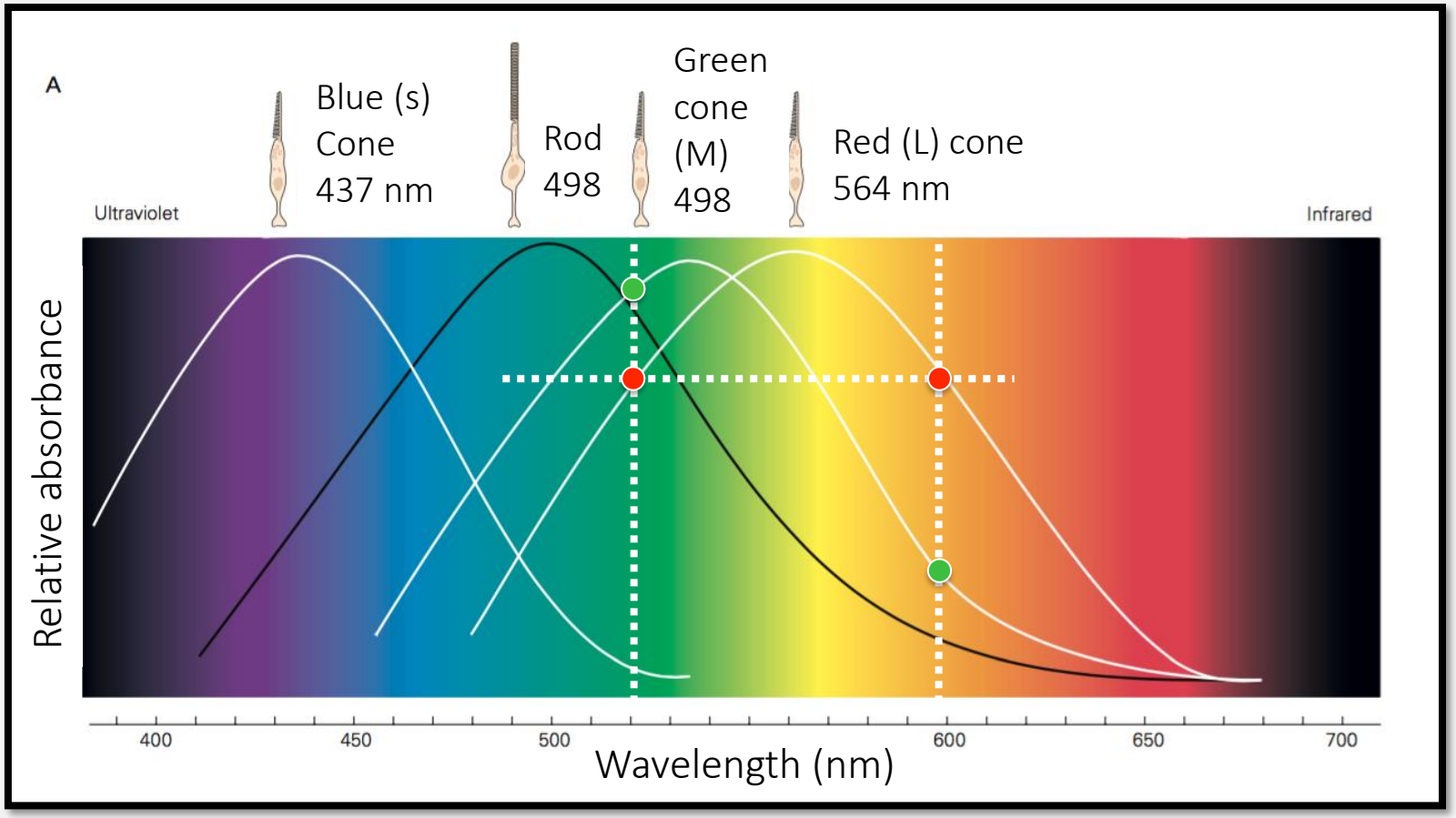
Rod/Cone photosensitivity

Rods

- Stimulation of rods seen as grey
- Highly sensitive
- Low-light vision

Cones

- Simultaneous activity of different cones – basis of colour vision (population coding)
- Less sensitive – Day light vision



Kandel Fig 21-7

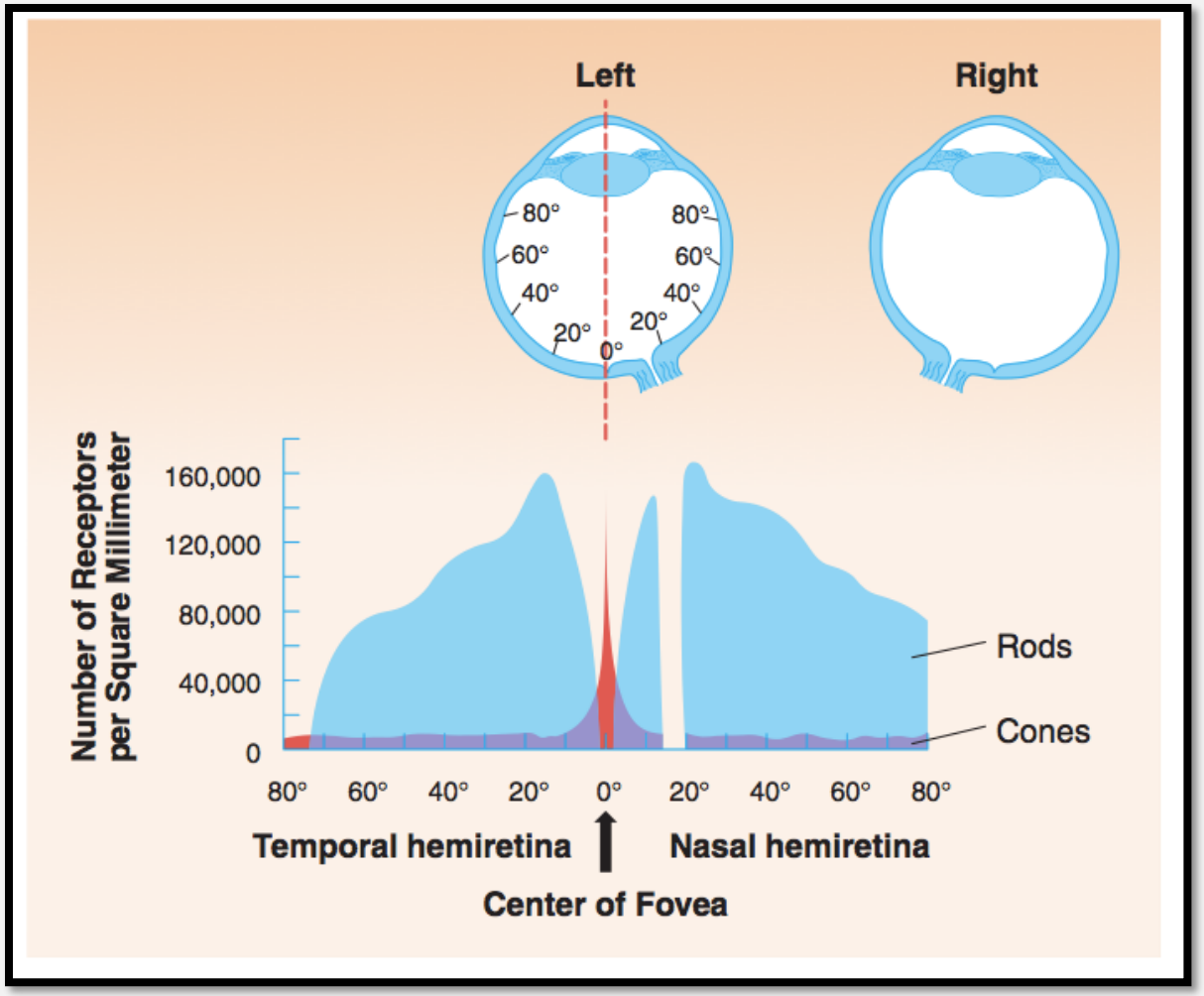
Rod-cone distribution

Rods

- ~100 million
- Predominately located in the periphery
- Periphery for night vision

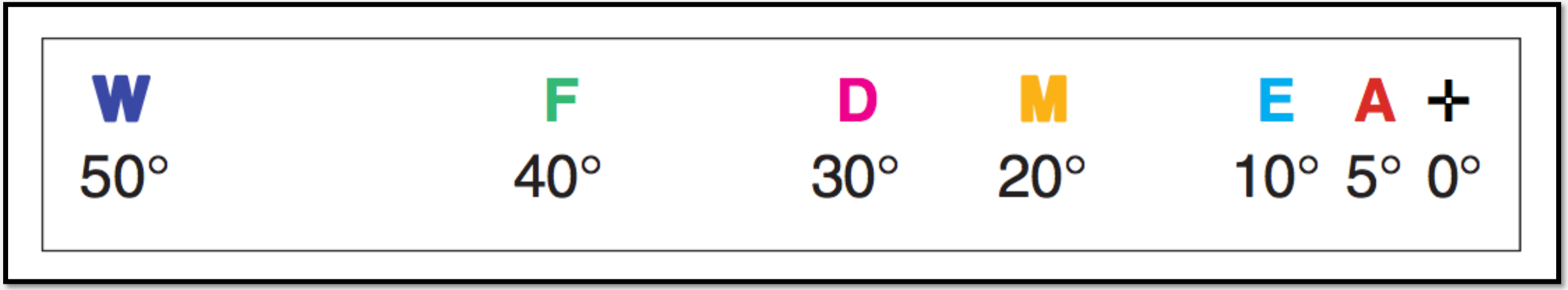
Cones

- ~6 million
- Predominately located at the fovea
- Fovea designed for day vision



Test of peripheral colour-blindness

- Position your face ~10 inches away and fixate on the cross with one eye.
- Notice the loss of color in the peripheral letters



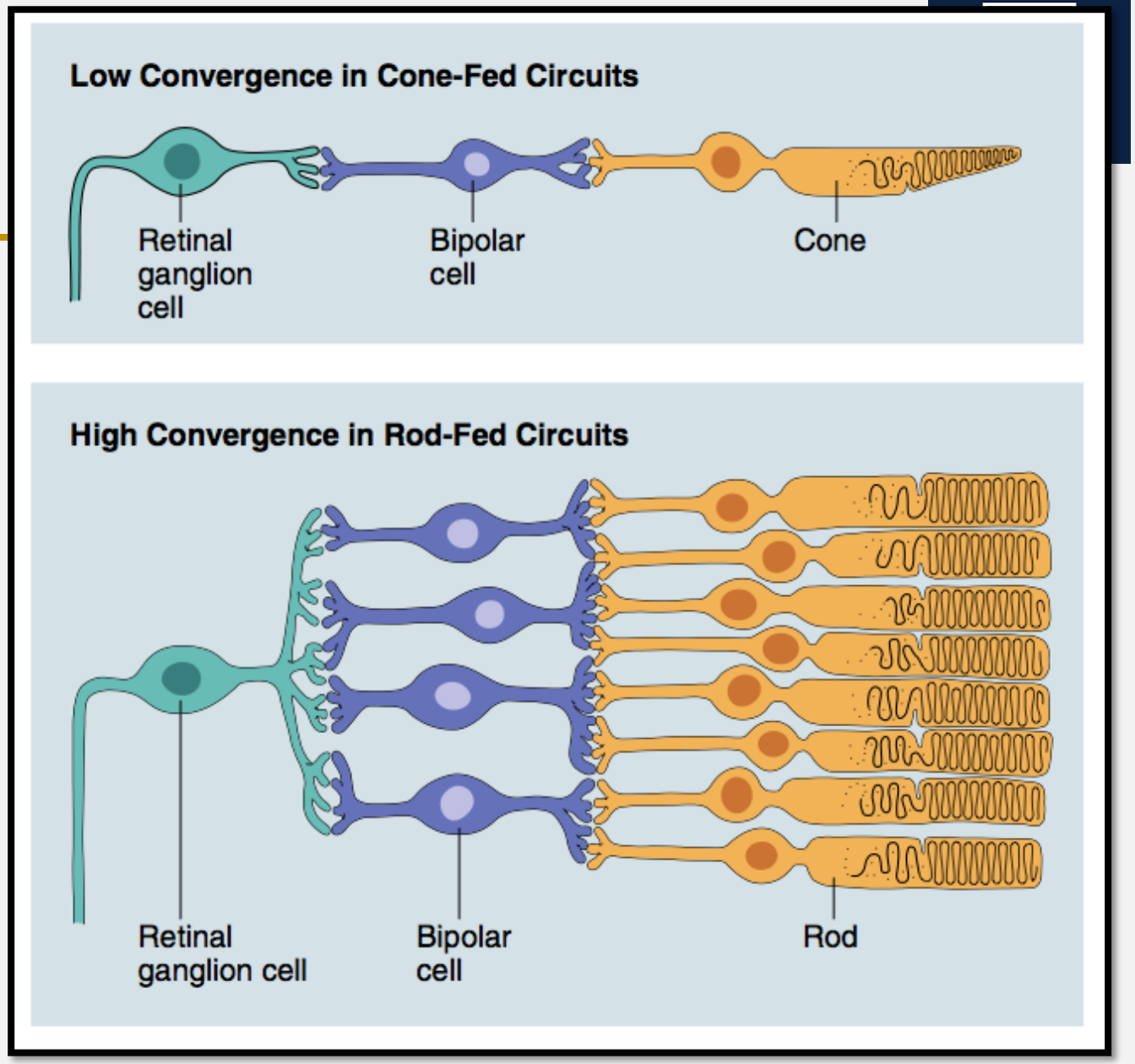
Rod/Cone Circuitry

Cones

- Low Convergence
- What could be the result of this?

Rods

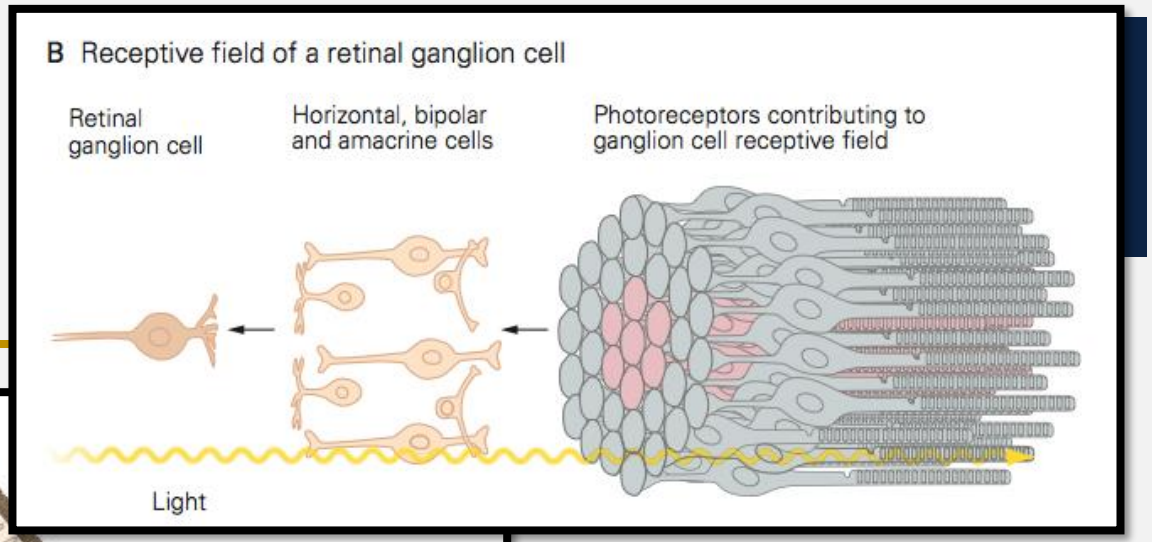
- High convergence
- What could be the result of this?

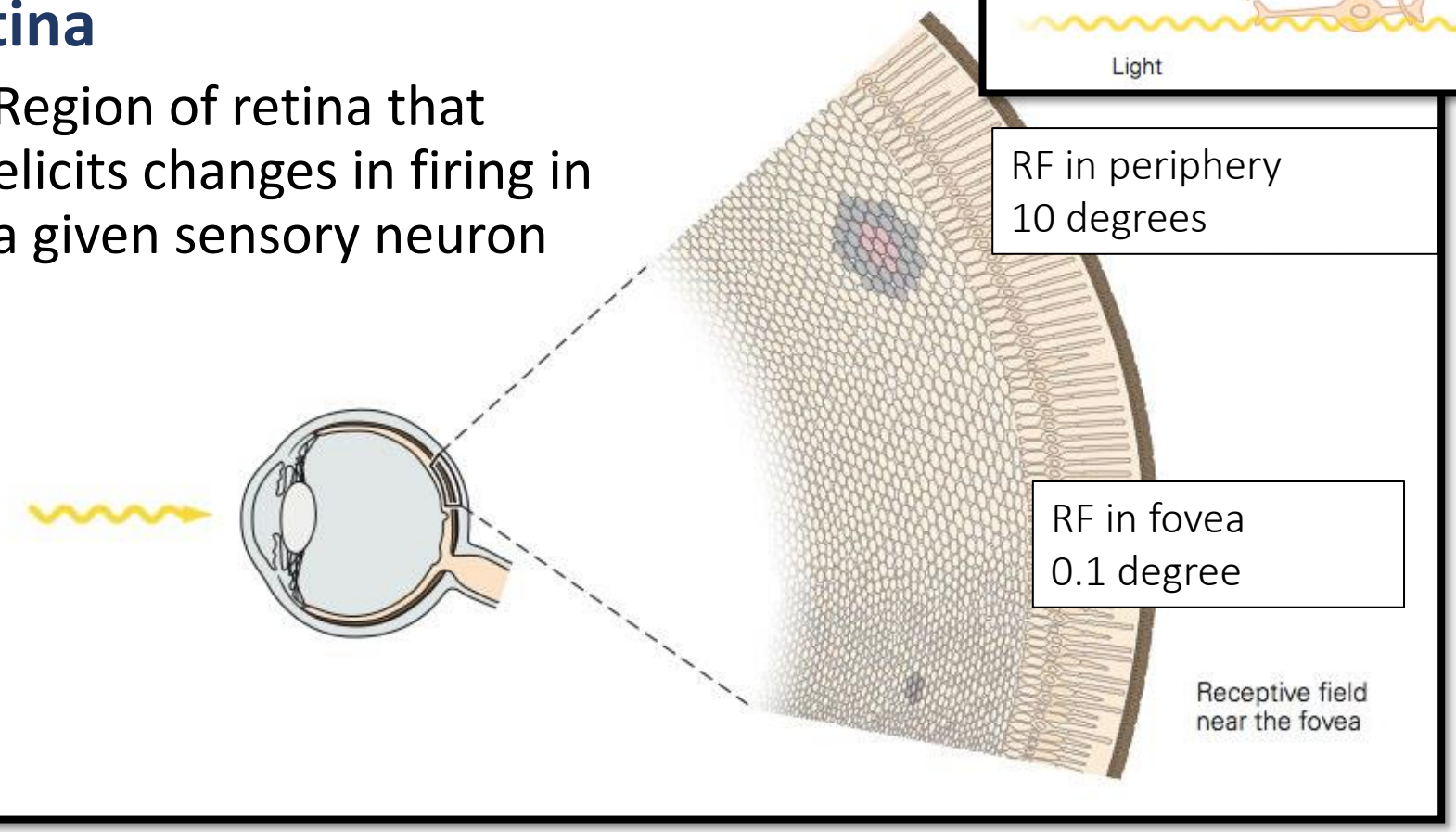


Receptive fields

Retina

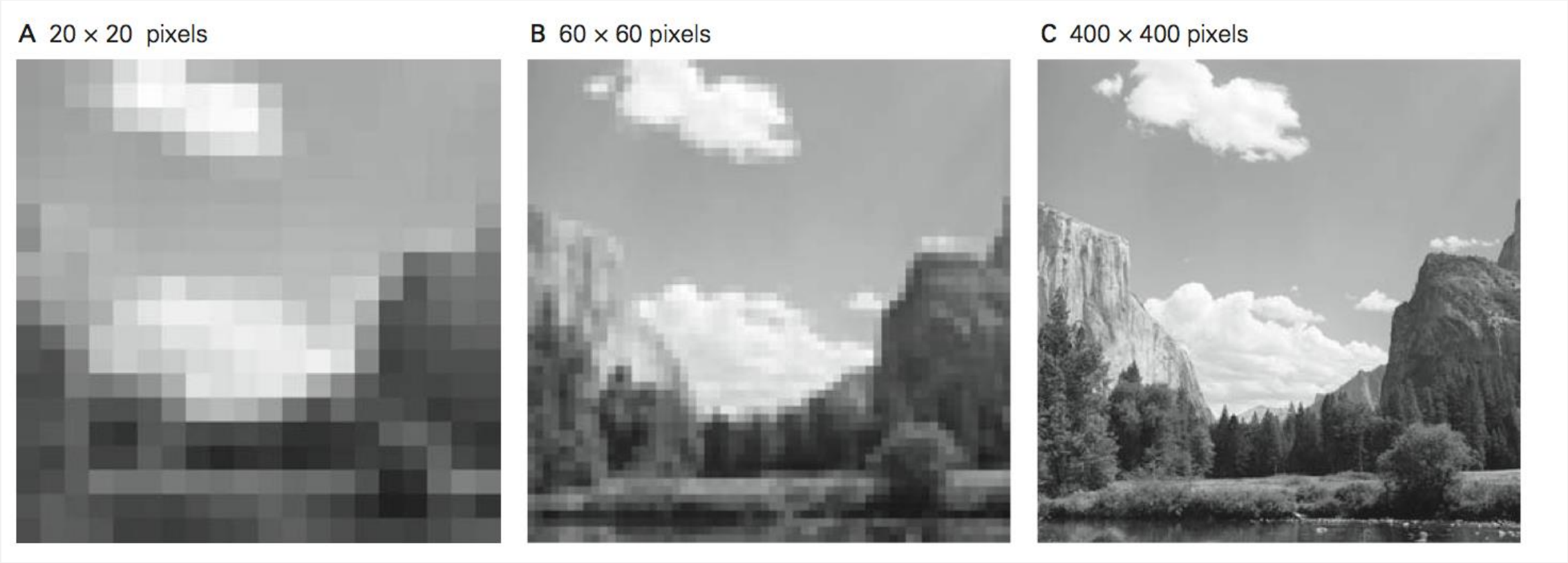
- Region of retina that elicits changes in firing in a given sensory neuron





Kandel Fig 25-8

Receptive Field size – digital analogy



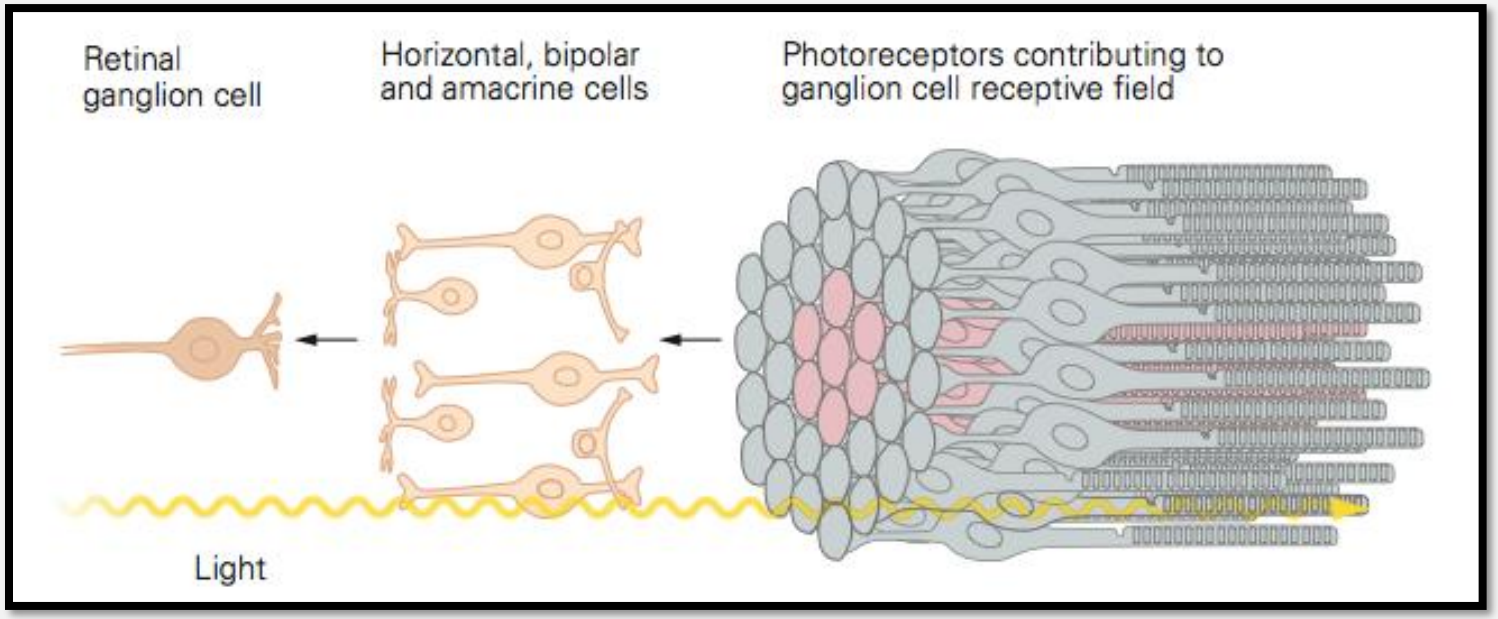
periphery

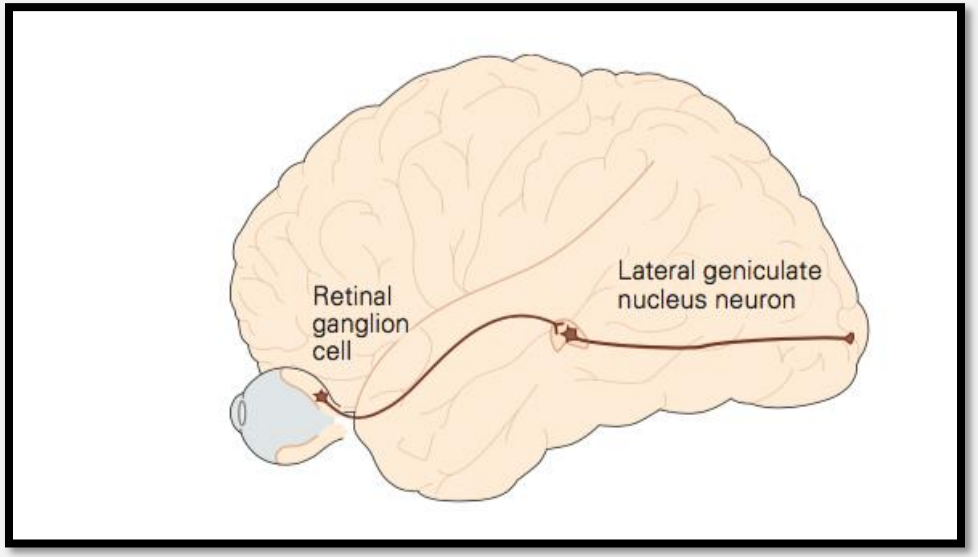
fovea

Kandel Fig 21-10

Ganglion cells – On-center receptive fields

On-center receptive fields

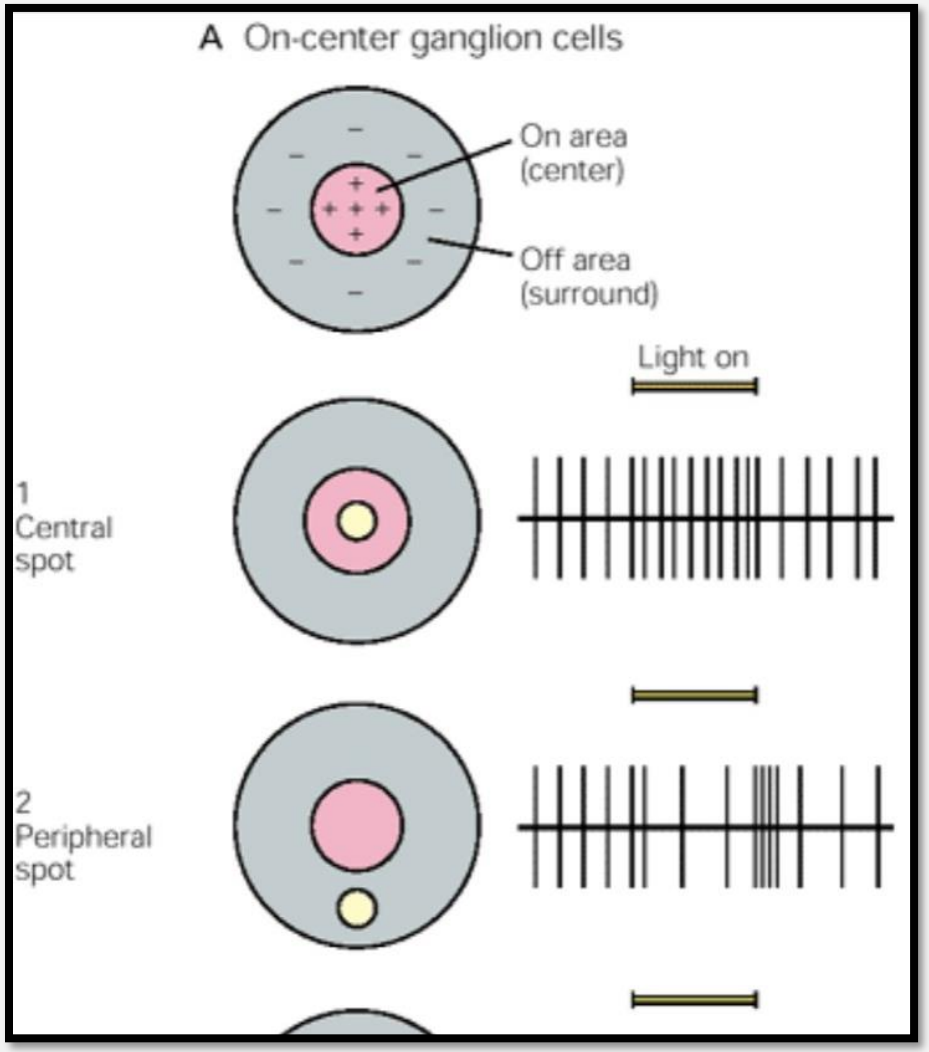


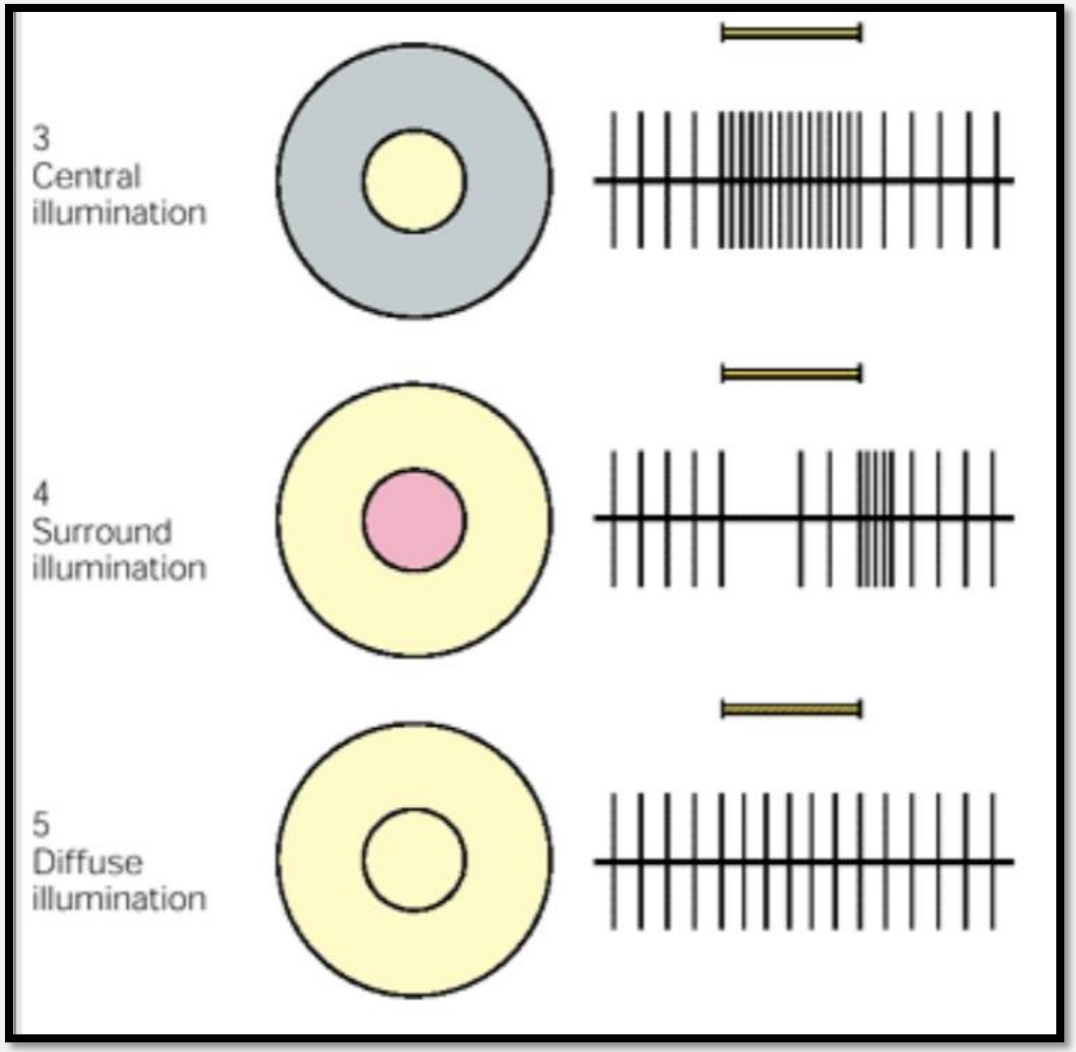


- Receptive fields – circular, smaller for the foveal portion, larger in periphery
- Often have both an excitatory region and inhibitory region

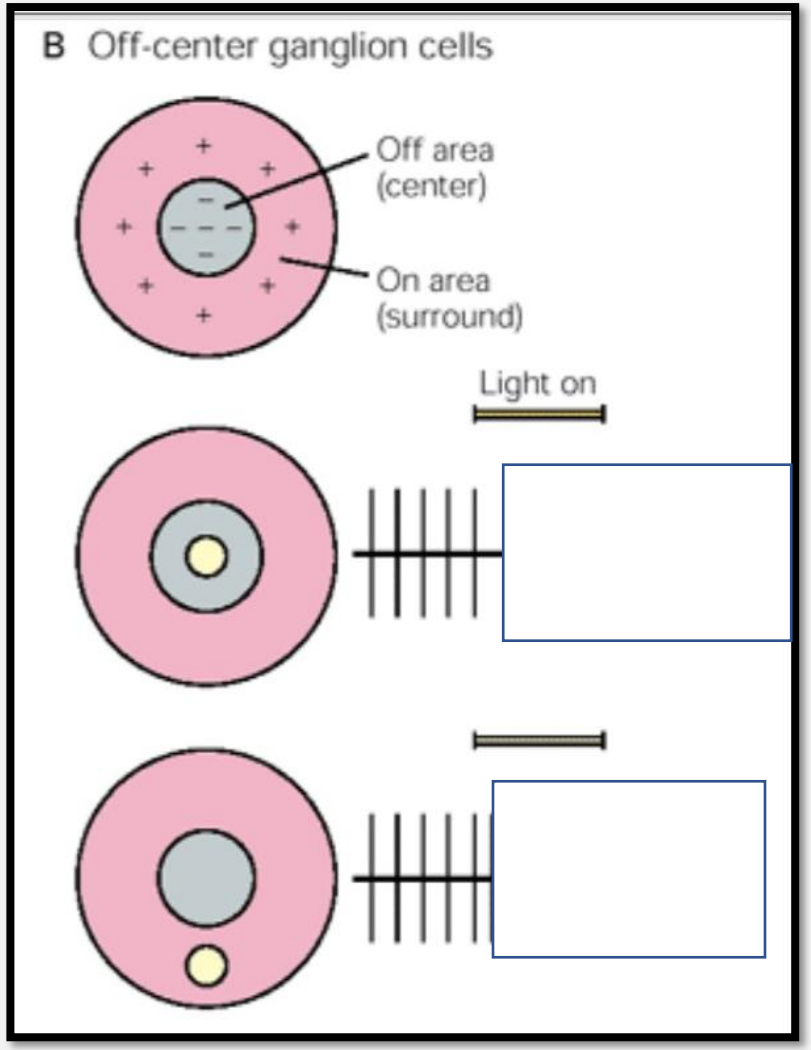
Kandel Fig 25-9

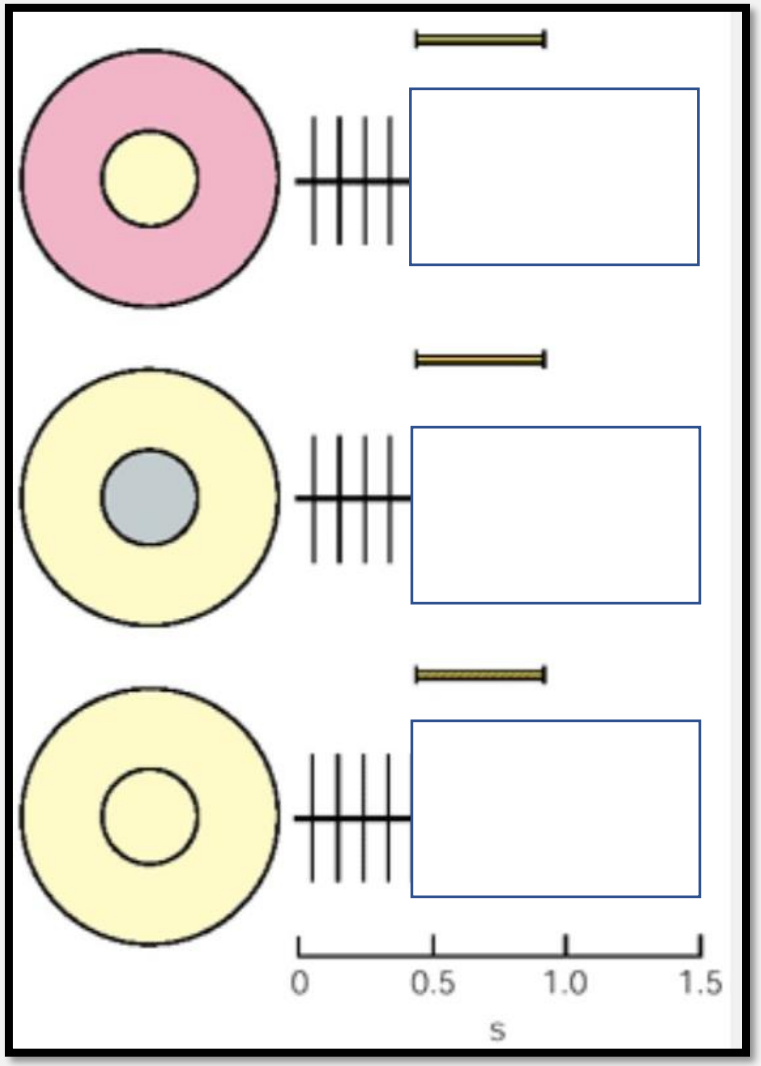
Receptive fields – Retinal Ganglion cells





Receptive fields – Off Center RGCs





Question?

- How can the same light, which causes the same graded response in a photoreceptor, which all release the same neurotransmitter (glutamate), have excitatory and inhibitory effects?

Bipolar Cells

"On" bipolar cells

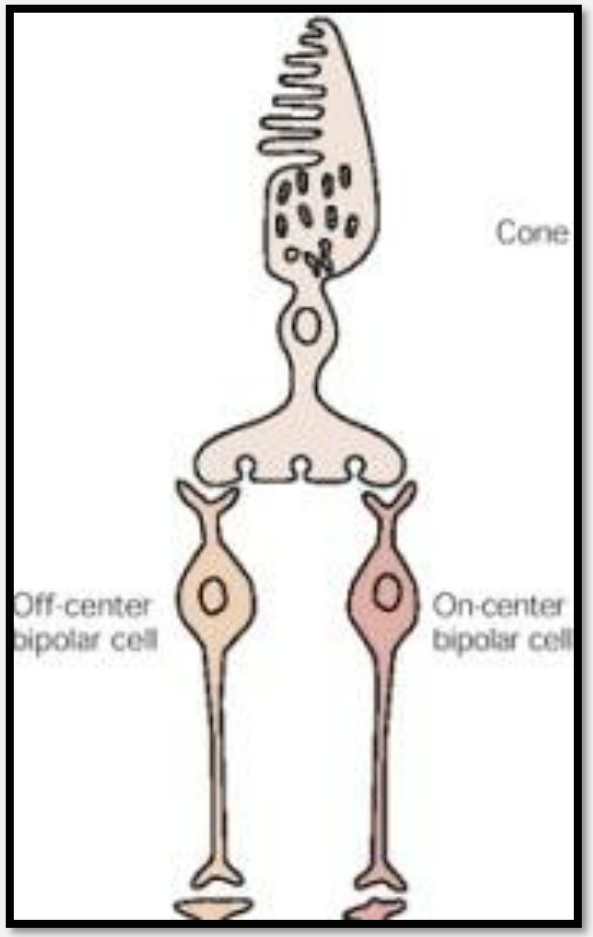
- Metabotropic Glutamate Receptors (mGluR)

In dark

- Continuous Glu release from photoreceptor hyperpolarizes the cell

Add light

- Add light – less Glutamate release from photoreceptors
- Depolarization effect



"Off" bipolar cells

- Ionotropic glutamate receptors

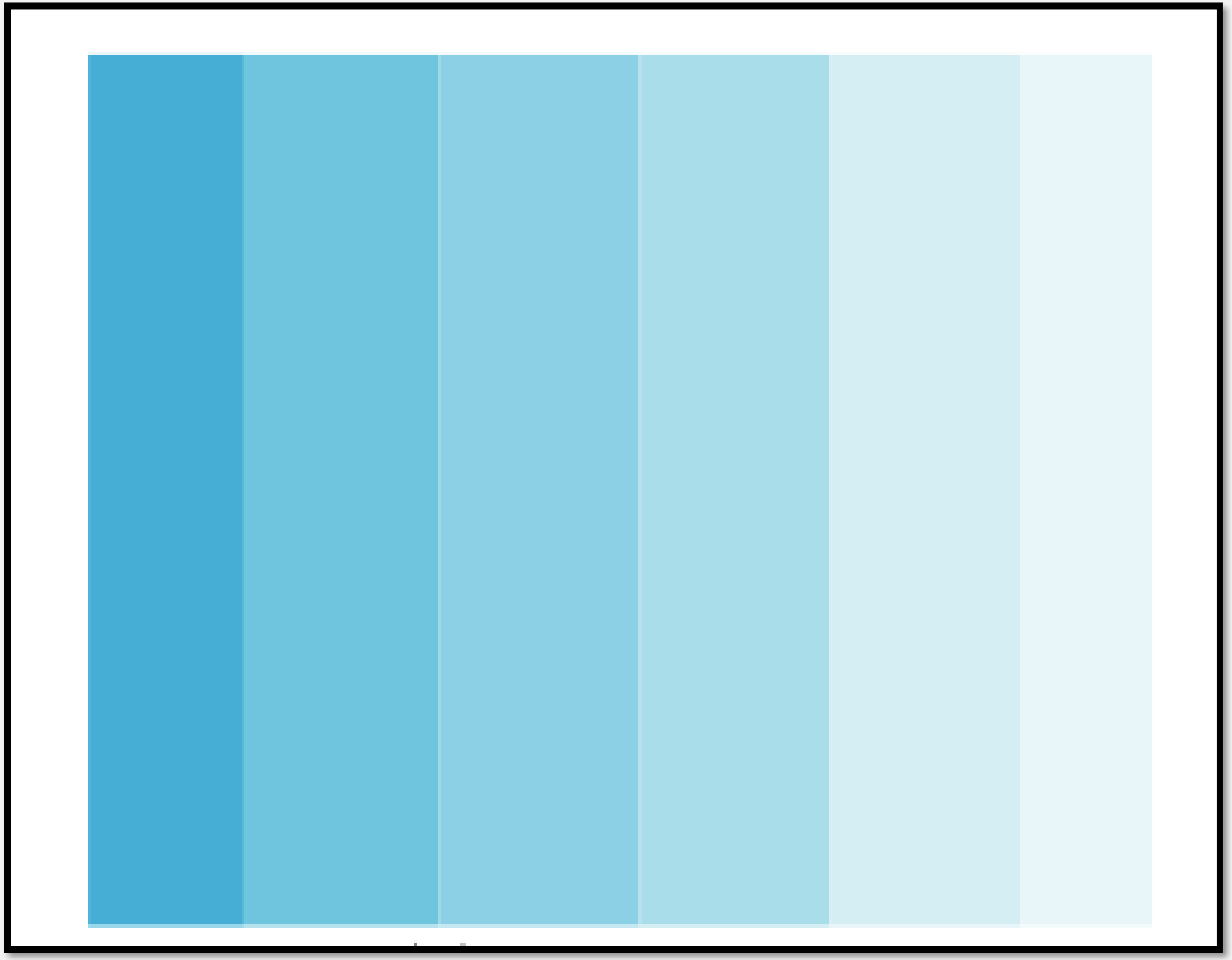
In dark

- Glutamate binds – opens cation channels – depolarizes the cell

Add light

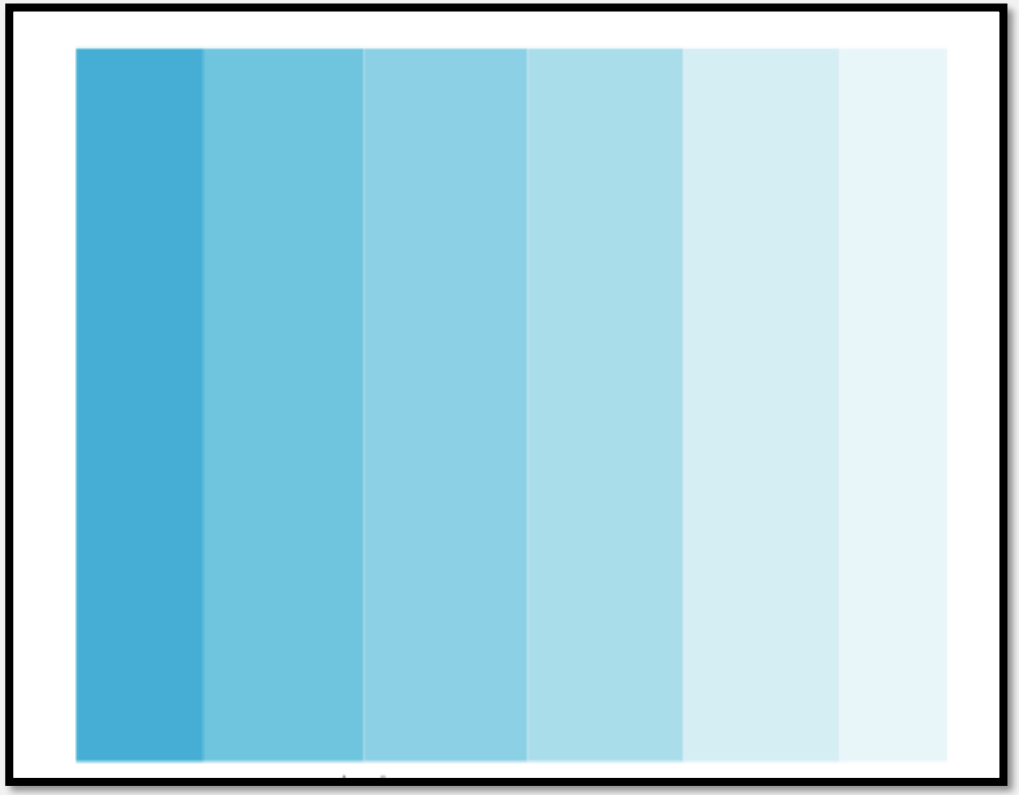
- Less glutamate release from photoreceptors – less bound ionotropic receptors, cell becomes more hyperpolarized

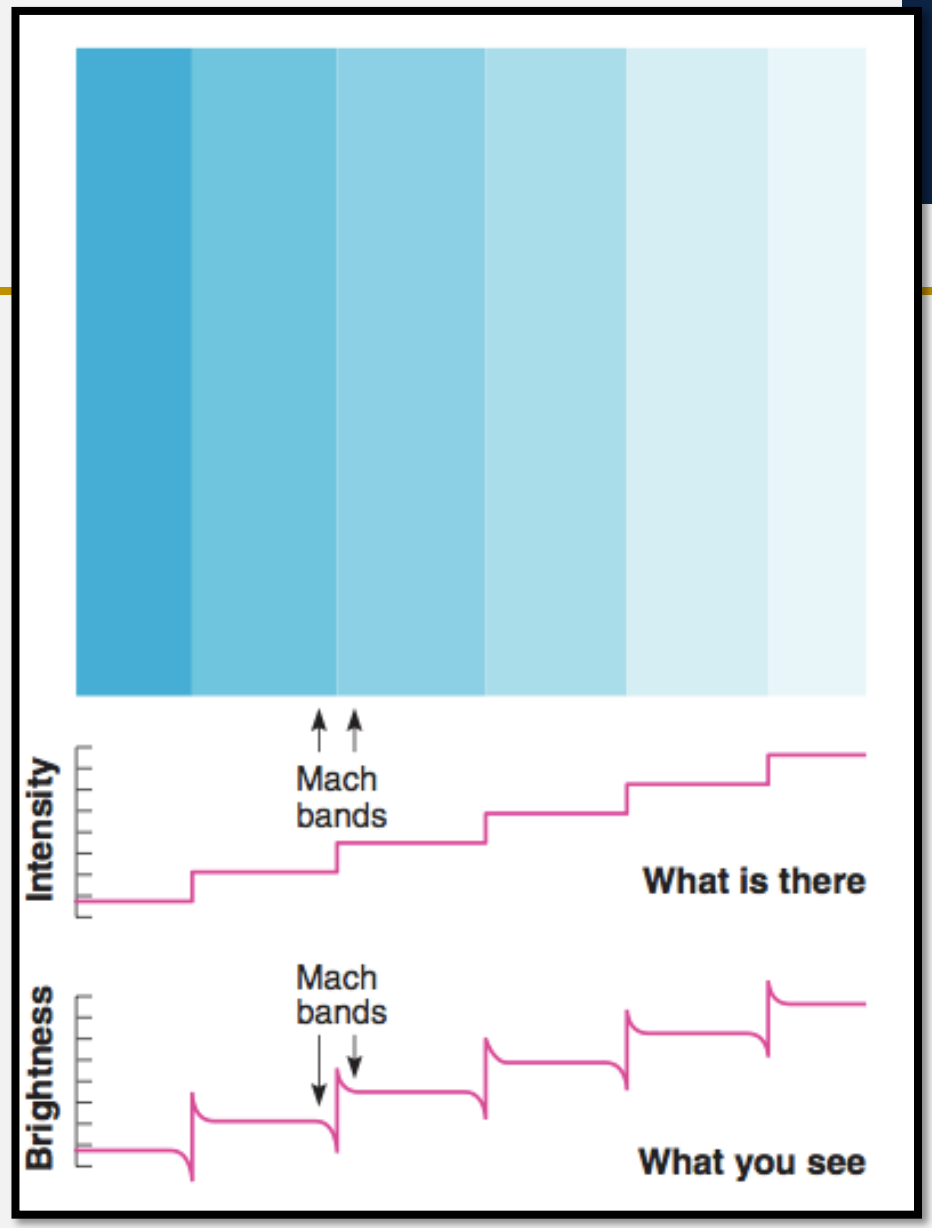
What do you see?



Lateral inhibition

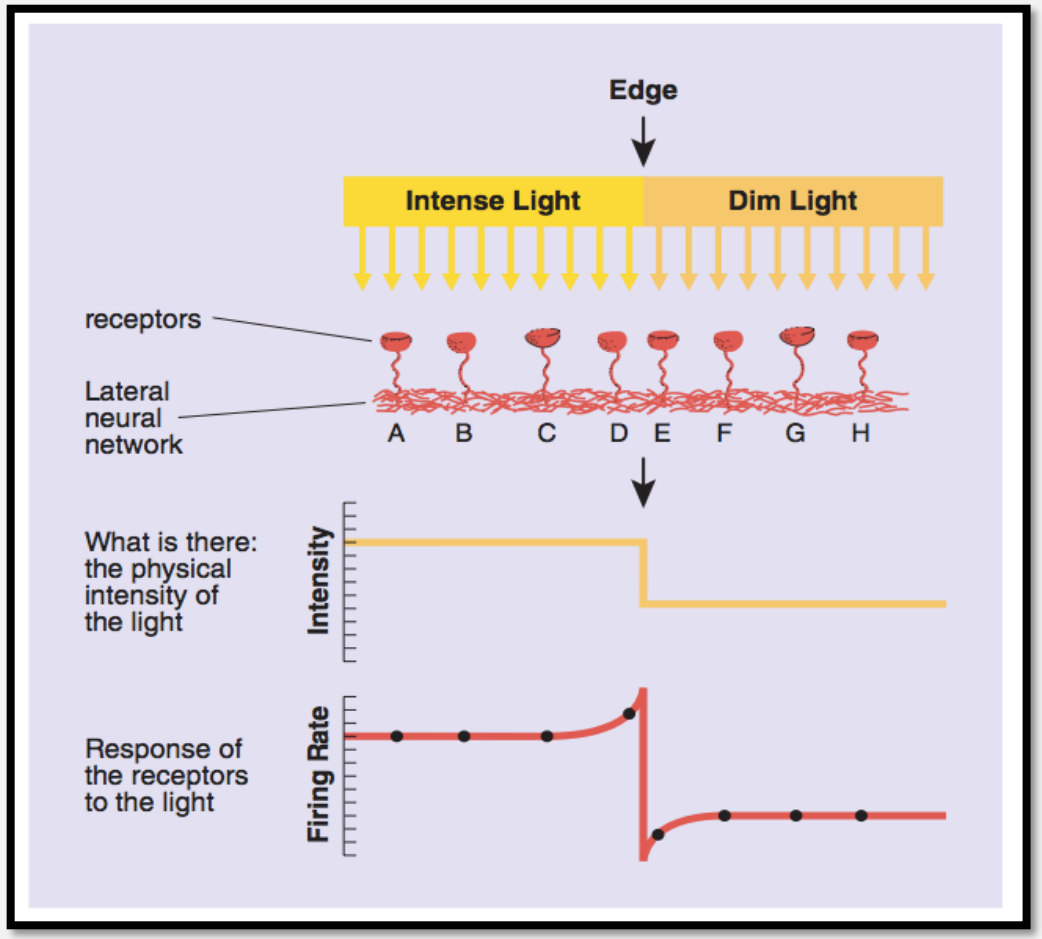
Contrast enhancement

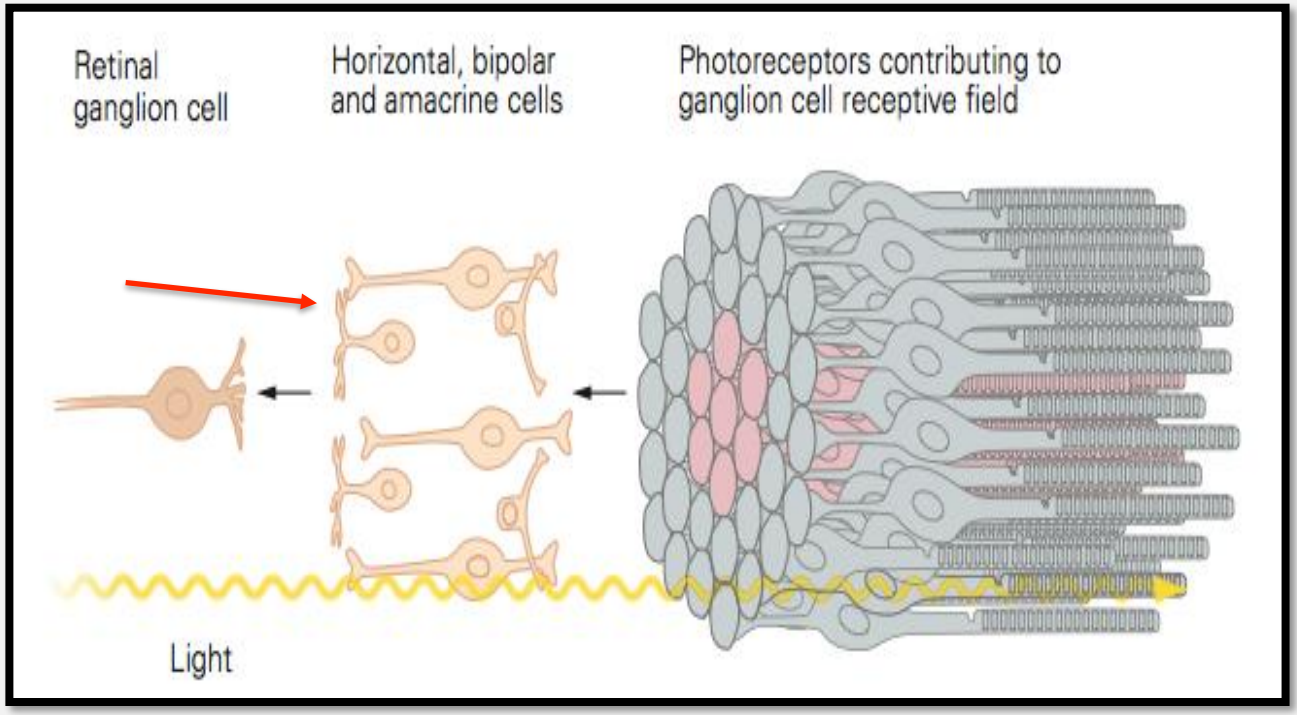




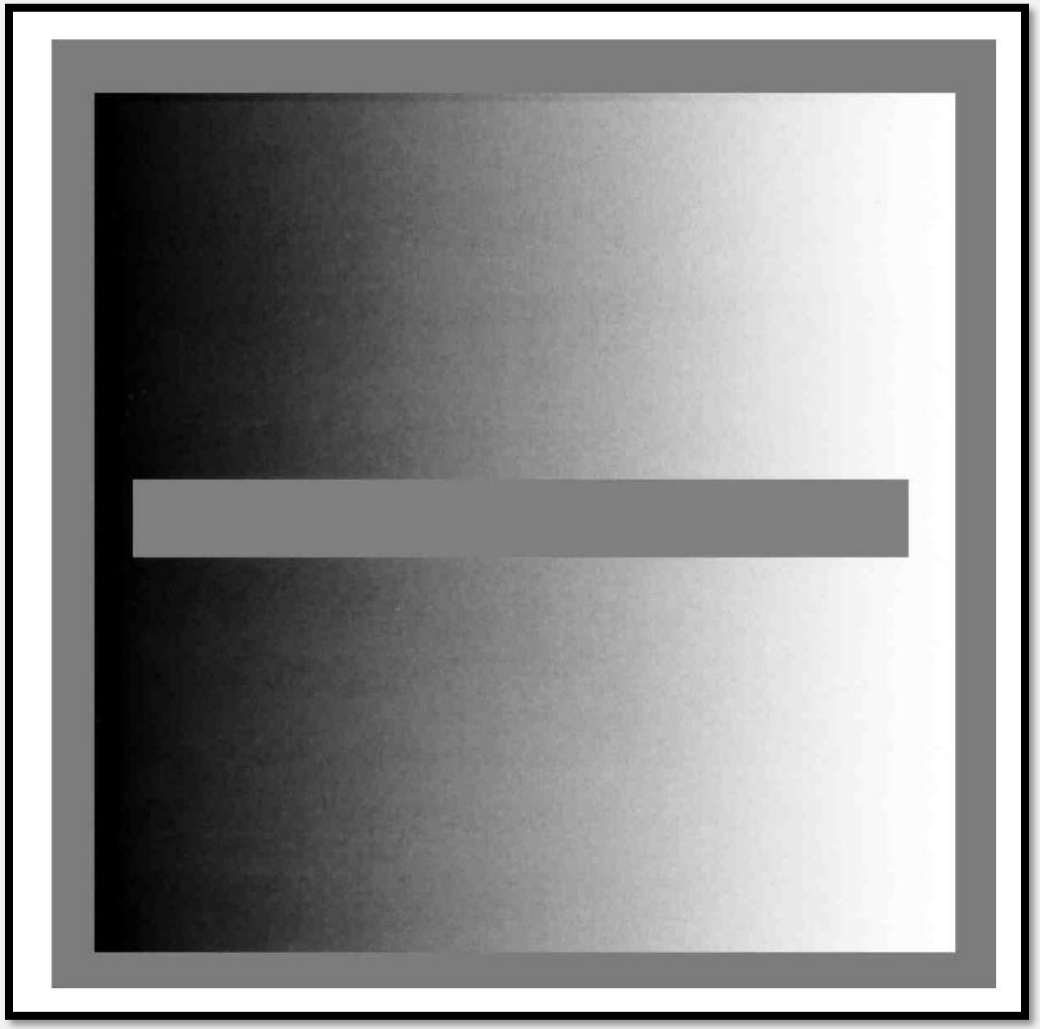
Lateral Inhibition

Contrast enhancement

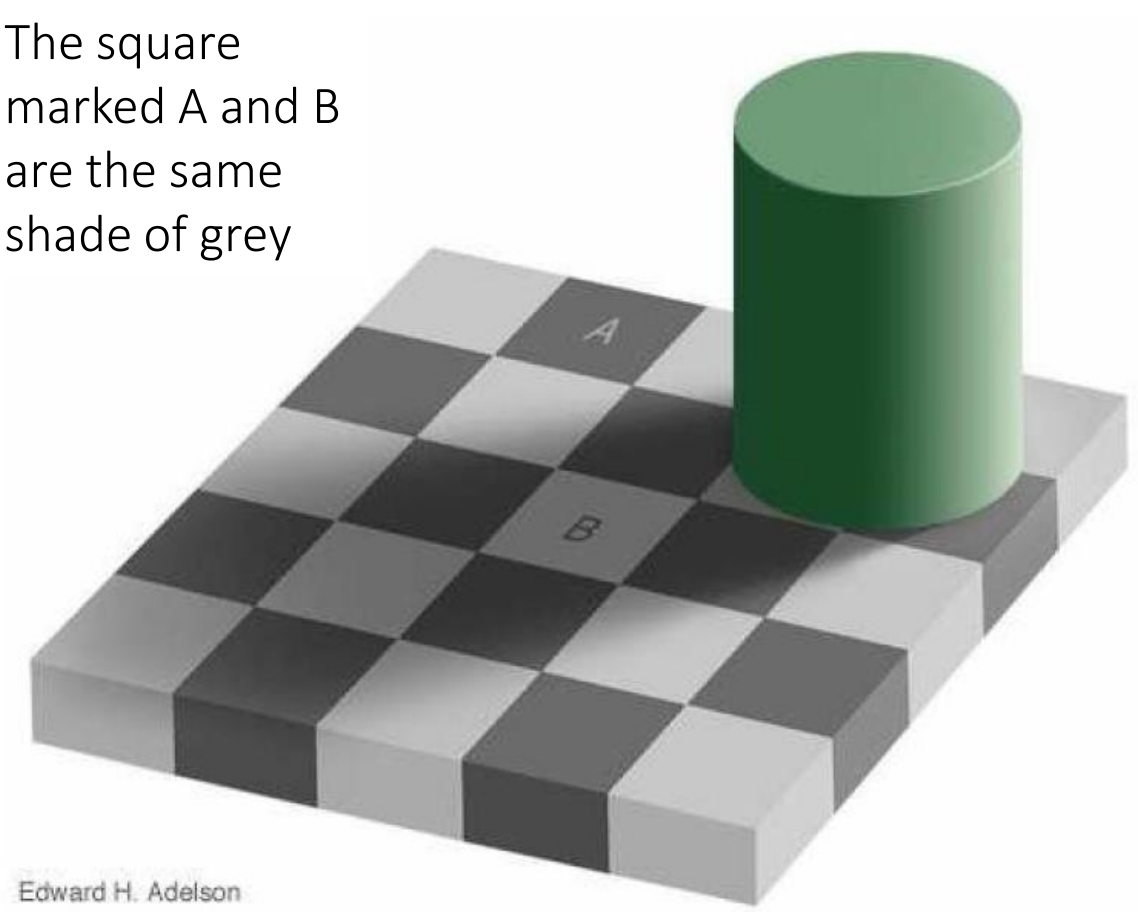




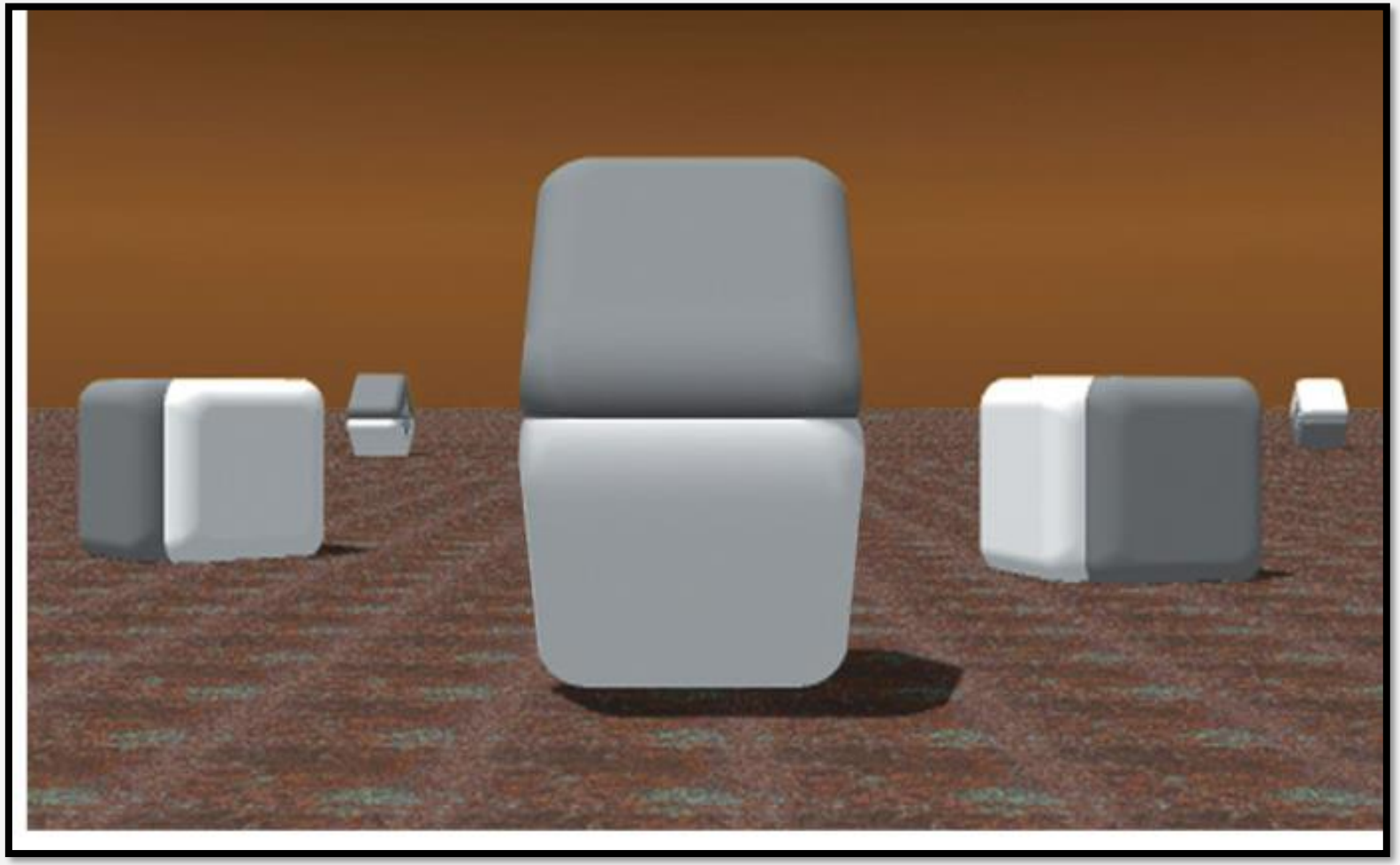
Simultaneous contrast illusion

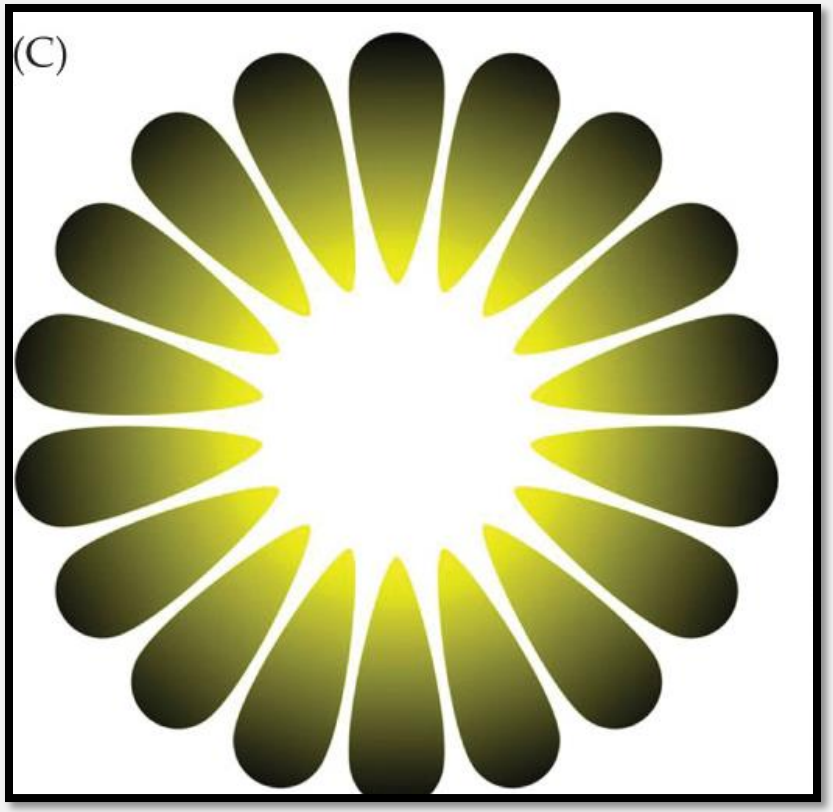


The square marked A and B are the same shade of grey



Context on brightness perception

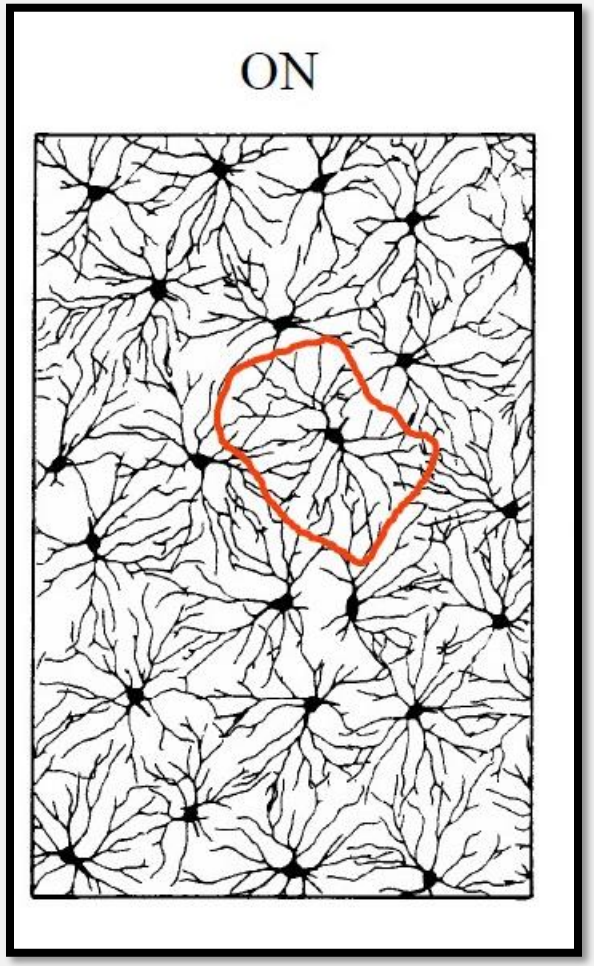




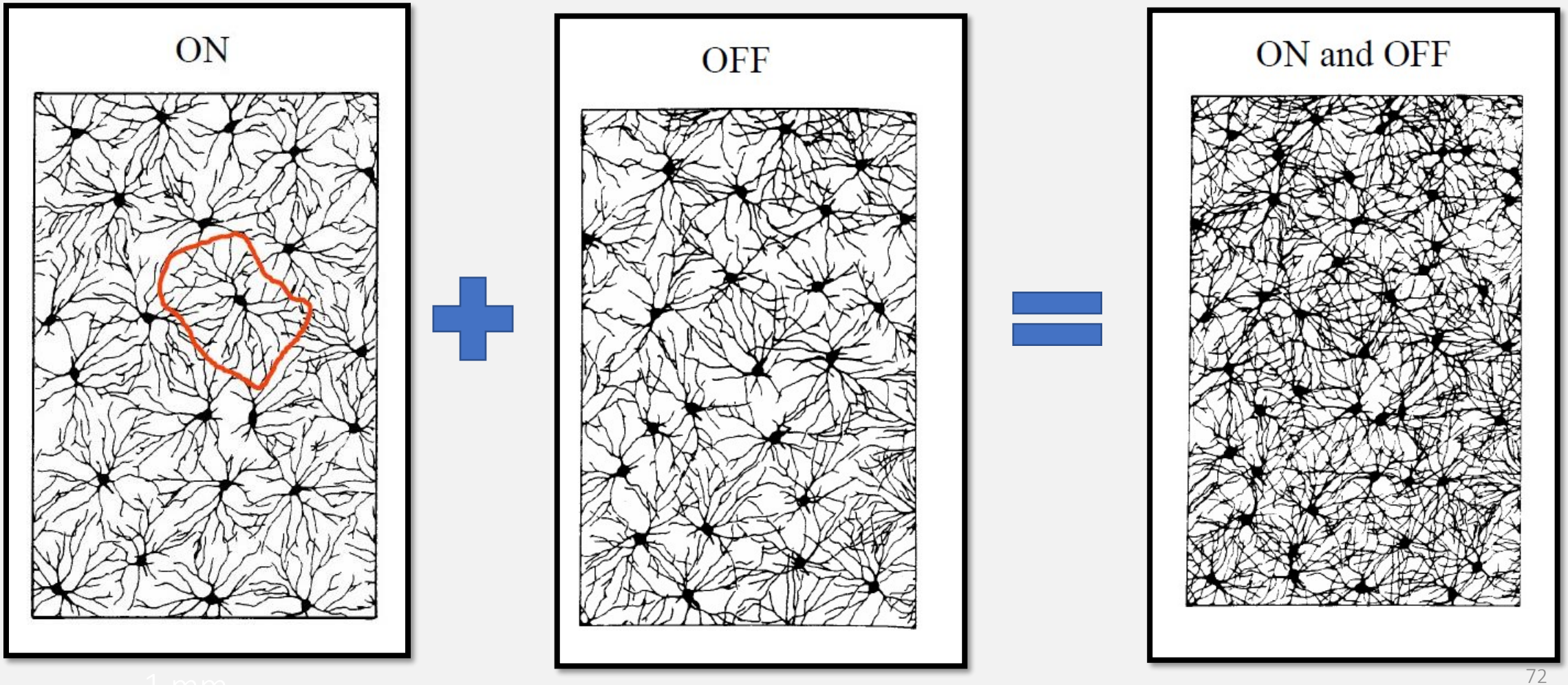
Retinal ganglion cells

Organization

- 20 types described
- Cover retina in tiled fashion
- Each send a unique representation of a certain area of the visual field
- Each point of the visual field hits *at least 1* retinal ganglion cell
- Optic nerve contains ~20 representations of the world (for a single spot in the visual field)
  - Polarity (on vs off)
  - Spatial resolution
  - Temporal responsiveness
  - Spectral filtering
  - Motion



Retinal ganglion cells in the cat retina



Summary

Photoreceptors

- Communicate with grade potentials to bipolar cells
- Light → hyperpolarization → less glutamate release to bipolar cells
- Magnitude of the hyperpolarization determines the reduction in neurotransmitter release.
- Remember that the visual system responds to *changes* in light.

Bipolar cells

- Broadly can be “on” or “off” center bipolar cells
- On cells become depolarized with light
- Off cells become hyperpolarized with light

Retinal ganglion cells

- RFs can vary in size based on eccentricity (distance from fovea)
- RFs tend to be circular and either have on center (with inhibitory surround) or off center (with excitatory surround)

Summary

Horizontal cells

- make contacts photoreceptors and bipolar cells.

Amacrine cells

- contact bipolar and ganglion cells.

All cell types *except* ganglion cells generate only graded local potentials; ganglion cells fire action potentials.

“In total about *20 ganglion-cell types* have been described. Each type covers the retina in a tiled fashion, such that any point on the retina lies within the receptive field center of at least one ganglion cell. One can envision each separate population as sending a distinct neural representation of the visual field to the brain, where the firing of an individual ganglion cell represents one pixel in the representation. In this view the optic nerve conveys about 20 neural representations of the world that differ in polarity (ON or OFF), spatial resolution (fine or coarse), temporal responsiveness (sustained or transient), spectral filtering (broadband or dominated by red, green, or blue), and selectivity for other image features such as motion.”

Kandel p 592