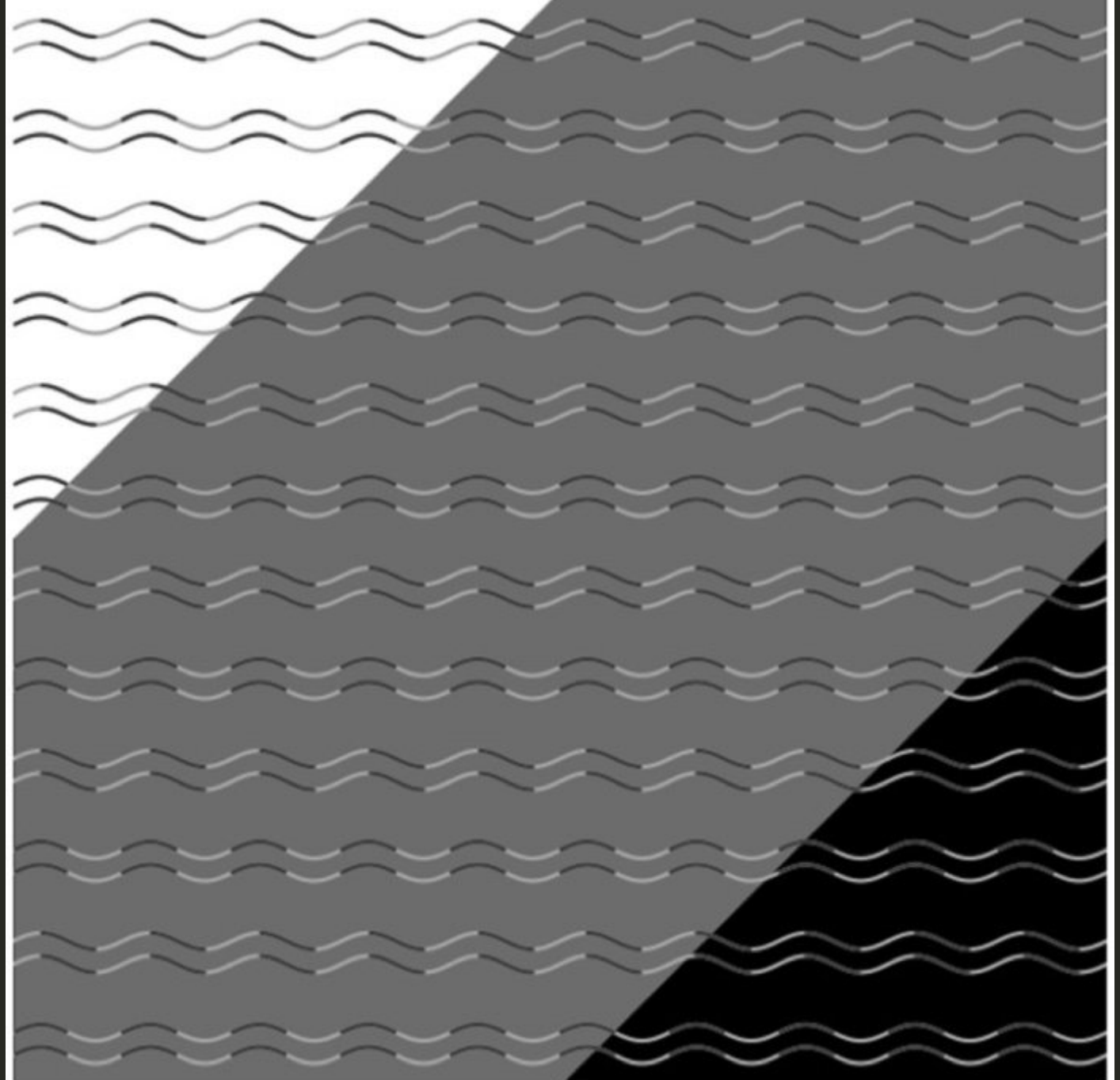
2017-01-08 Course Introduction

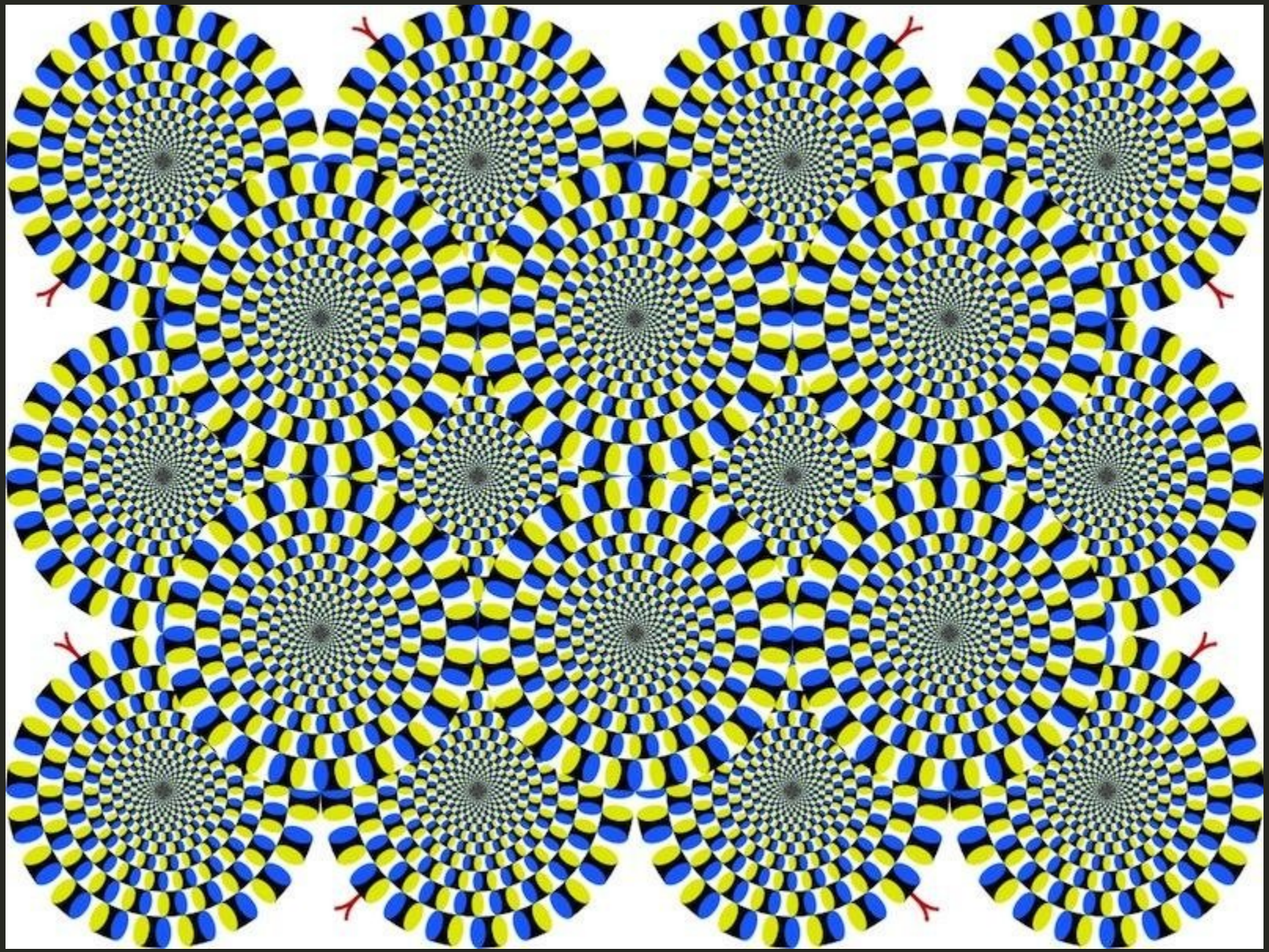
PSY 525.001 • Vision Science • 2018 Spring

Rick Gilmore

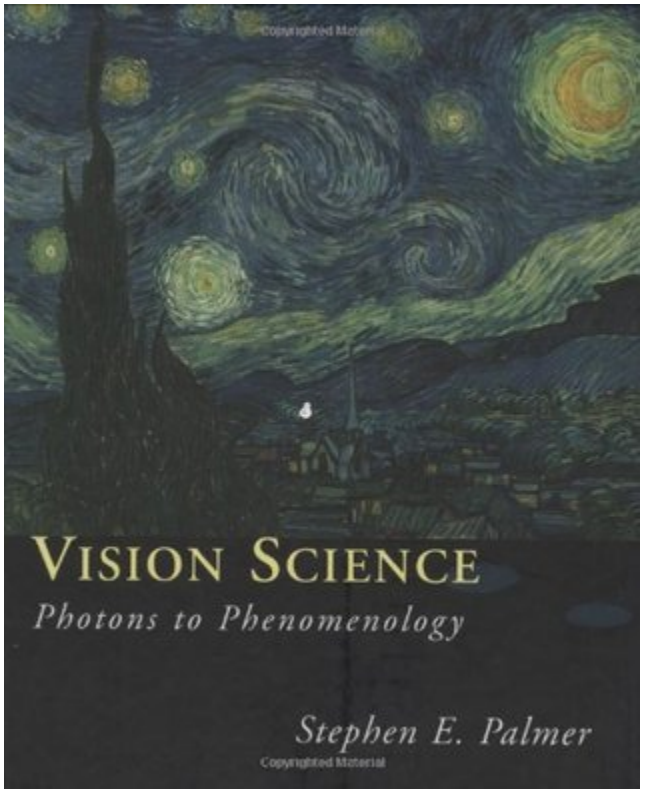
2018-01-08 10:55:53

Amazing T-Rex Illusion!





PSY 525 Vision Science



Today's topics

Today's topics

Introduction to the course

Today's topics

Introduction to the course

An introduction to vision science

Today's topics

Introduction to the course

An introduction to vision science

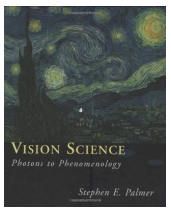
Discussion of Barlow

Introduction to the course

Resources

Text

Palmer, S. E. (1999). *Vision Science: Photons to Phenomenology*. MIT Press. Retrieved from https://books.google.com/books?id=mNrxCwAAQBAJ.



Website

http://psu-psychology.github.io/psy-525-vision-2018/

Semester schedule

http://psu-psychology.github.io/psy-525-vision-2018/schedule.html

Typical class

1st 75 min: lecture/tutorial

Break

2nd 75 min: discussion

Evaluation

Component	Points	% of Grade
Class participation	5 pts/class * 14 weeks = 60	60
Term project	40 pts	40
TOTAL	**100**	**100**

Examples

- Build a Raspberry Pi computer for vision science and demo it.
  - e.g., using Google's AIY hardware.
- Write computer code to demonstrate a core idea or phenomenon in vision science.
- Write research proposal for a project in vision science.
- Evaluate a machine learning algorithm applied to some defined class of images or videos.
- Write a critical review of some selection of papers from the vision science literature.
- Write a persuasive piece on the topic "What X scientists should know about vision" where X is some subdiscipline you feel would benefit from knowledge about vision science.
- Carry out and report on a small-scale pilot study on some topic in vision science.
- Plan and carry out a replication study of some paper in vision science.
- Demonstrate and explain a set of compelling visual illusions.

Questions?

An introduction to vision science

What is perception?

Properties of light

Hardware

What is perception?

Perception asks...

What's out there?

Perception asks...

What's out there?

Shape/form, color, size, identity

Perception asks...

What's out there?

Shape/form, color, size, identity

Where is it now?

Perception asks...

What's out there?

Shape/form, color, size, identity

Where is it now?

Where is it moving?

Perception asks...

What's out there?

Shape/form, color, size, identity

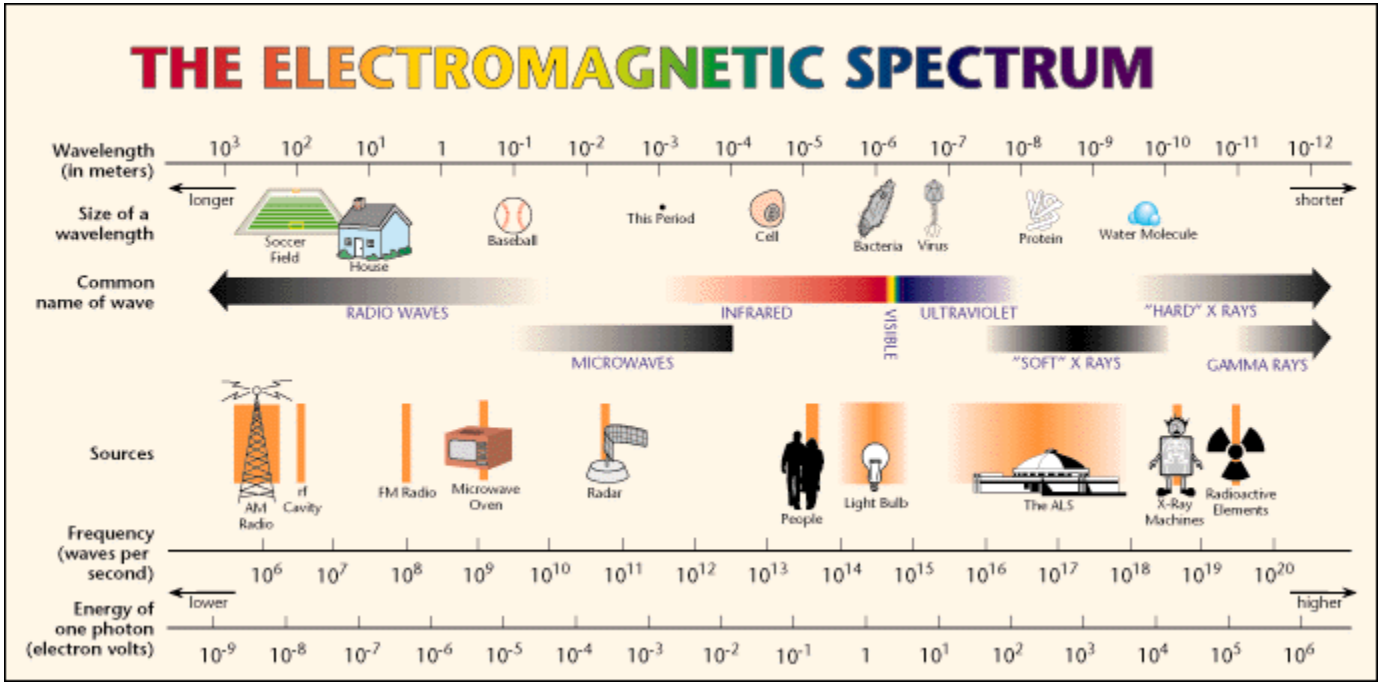
Where is it now?

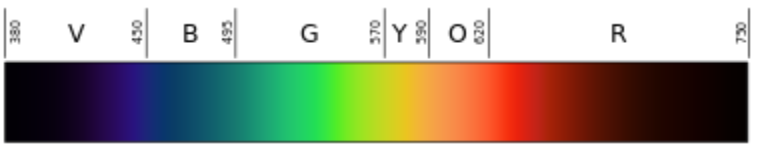
Where is it moving?

What time of {day, year} is it?

Properties of light

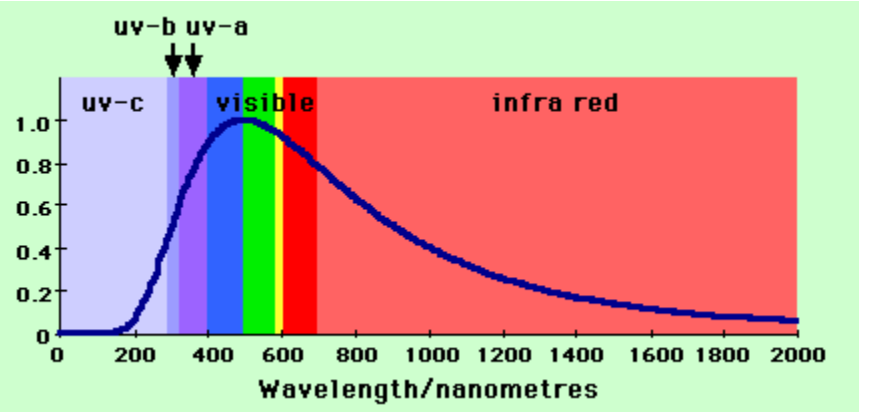
Light is electromagnetic radiation



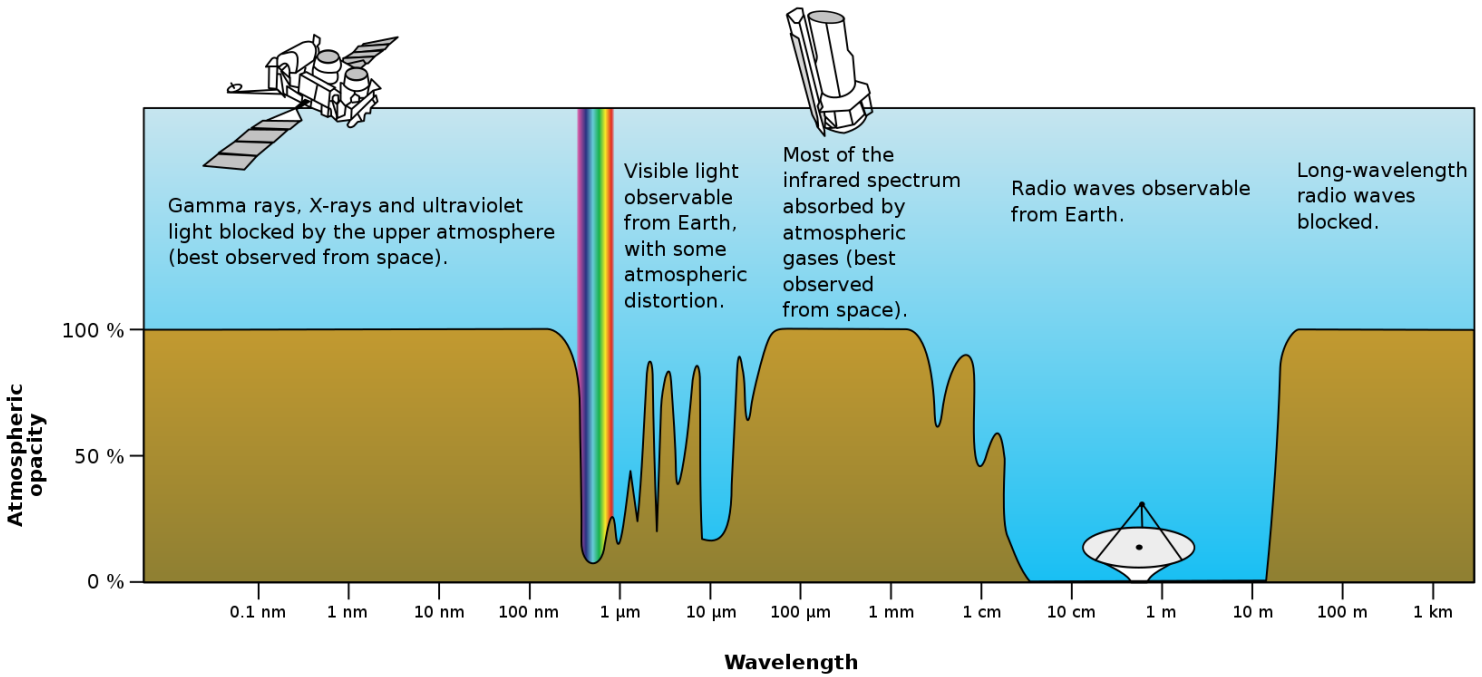


Human eye responds to ~ 390-700 nm (770 - 430 THz)

The Sun's emission spectra peaks in the visible portion of the EM band.

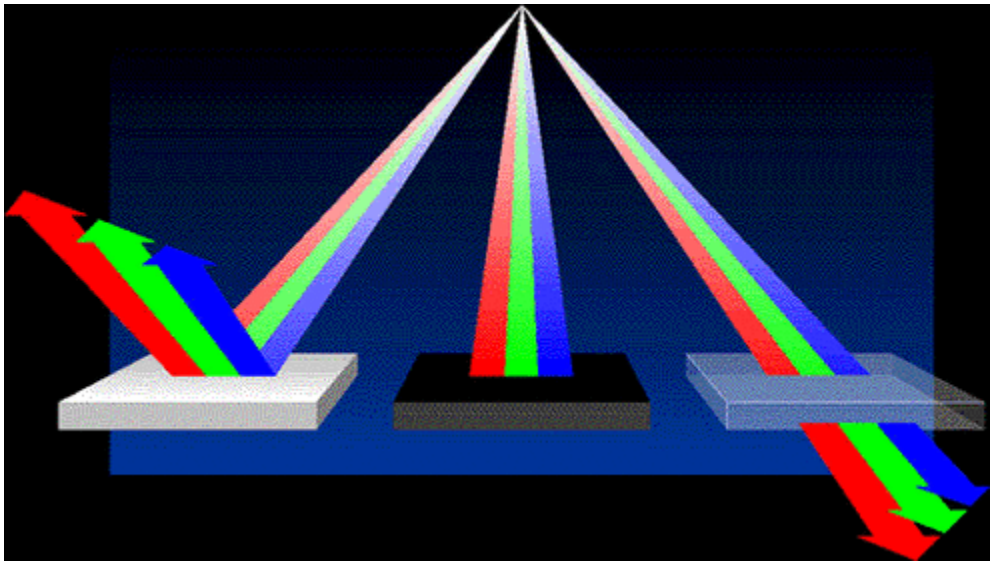


Earth's atmosphere largely transparent to visible EM



Light illuminates surfaces (point source vs. diffuse/spatially extended)

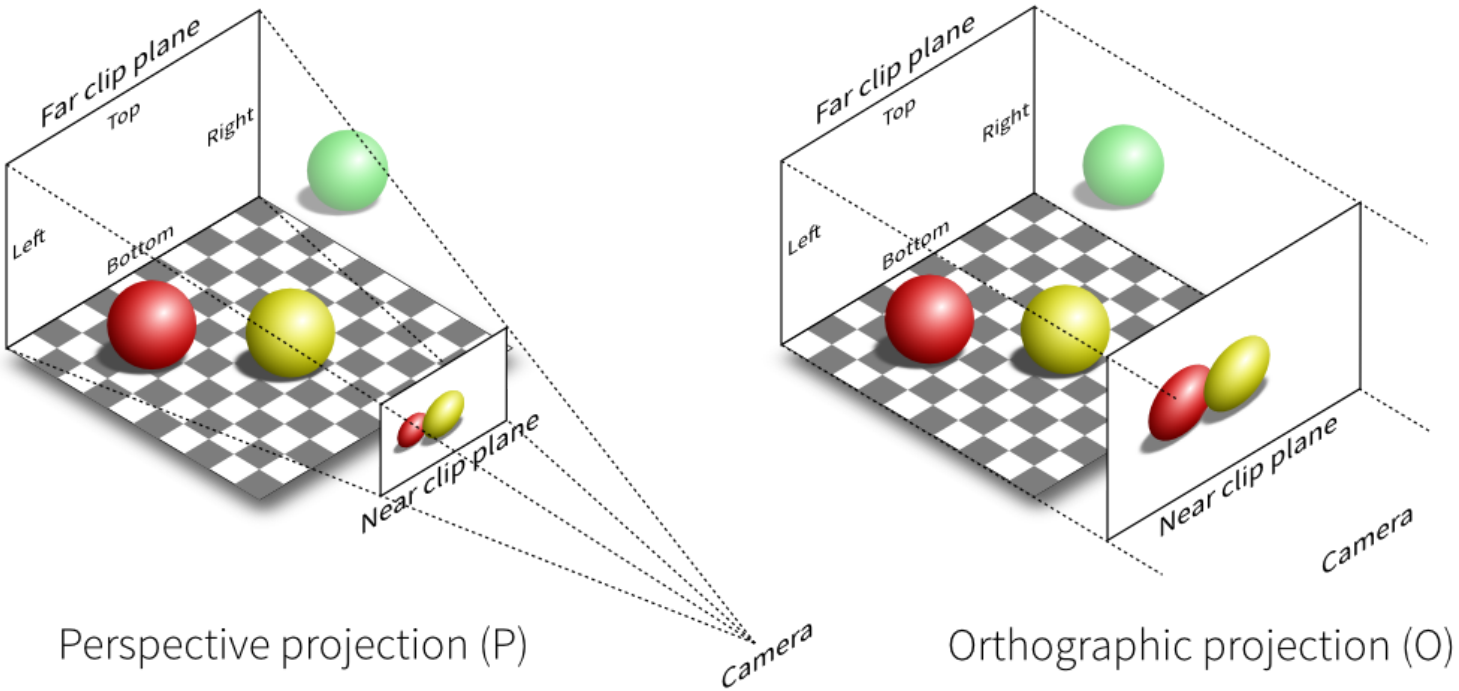
Light is transmitted, absorbed, or reflected from surfaces



Surface properties (geometry, materials) affect.

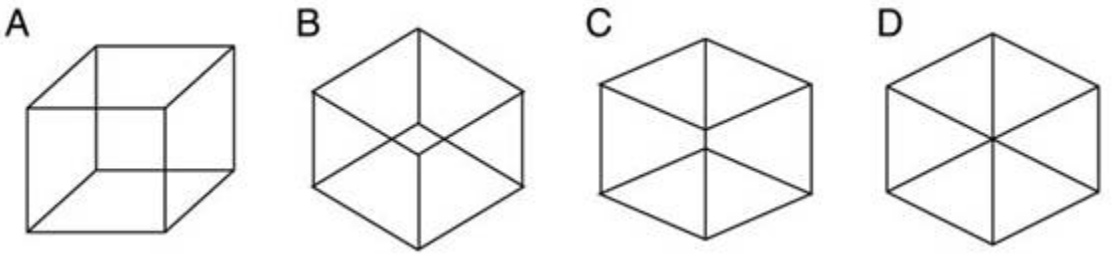
Monochromatic (white, gray, black) surfaces reflect/absorb all visible wavelengths equally.

Distal 3D patterns of light form proximal (projective) 2D images

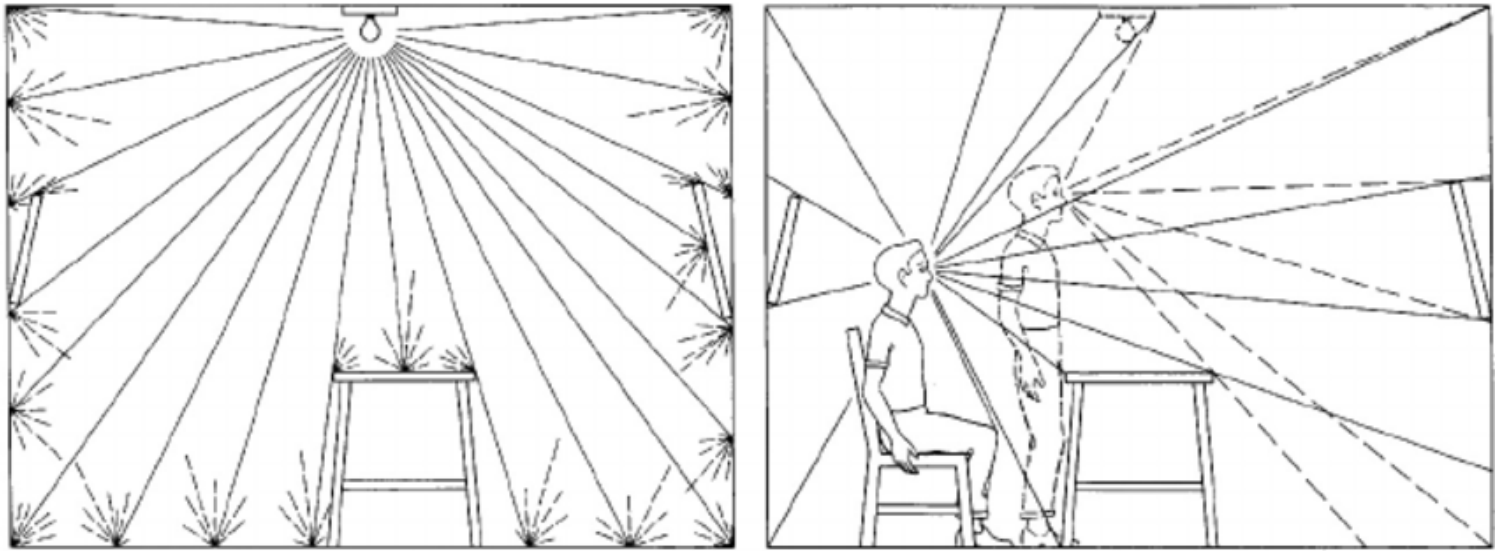


Perspective (size scales ~ $1/d$) vs. *orthographic* projection

Same 3D shape can yield different 2D projections



Is vision an ill-specified "inverse" problem (2D -> 3D)?



Gibson says no, ambient optic array uniquely specifies geometry and observer position & motion.

The plenoptic function

$$P(x, y, z, \theta, \phi, \lambda, t)$$

From every point in space, (x, y, z), at each time t, looking in every direction (θ, ϕ), there is a set of wavelengths λ...

How does a {biological, artificial} visual system detect this and convert it into information about objects, positions, and motions?

Adelson, E. H., & Bergen, J. R. (1991). The plenoptic function and the elements of early vision. Vision and Modeling Group, Media Laboratory, Massachusetts Institute of Technology. Retrieved from http://faculty.cs.tamu.edu/jchai/CPSC641/elements91.pdf

Lenses realign light rays through larger apertures

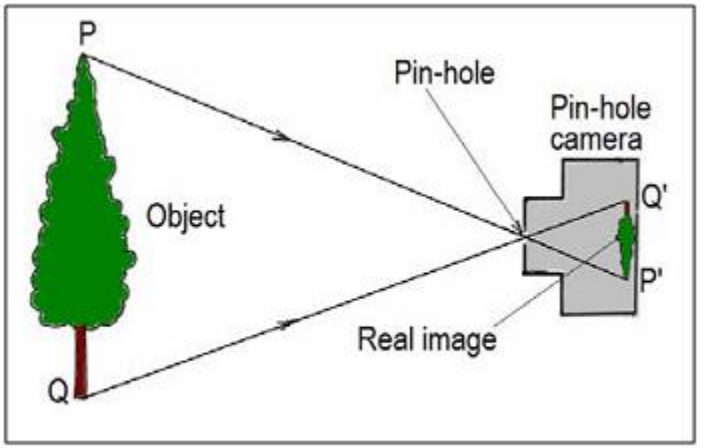


Fig.5(a) Real image by a pin-hole camera

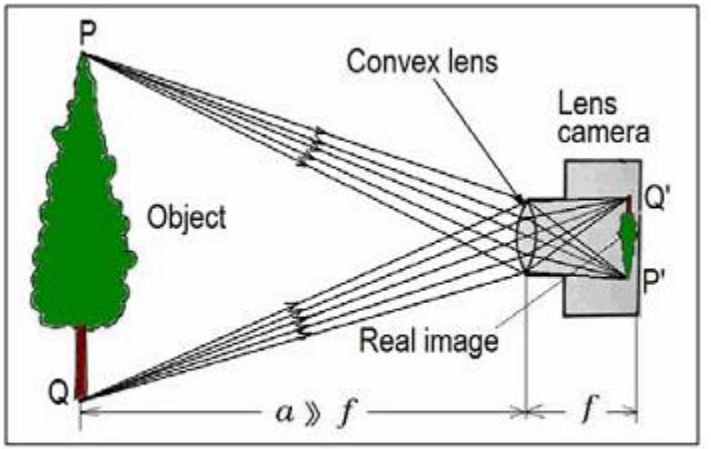
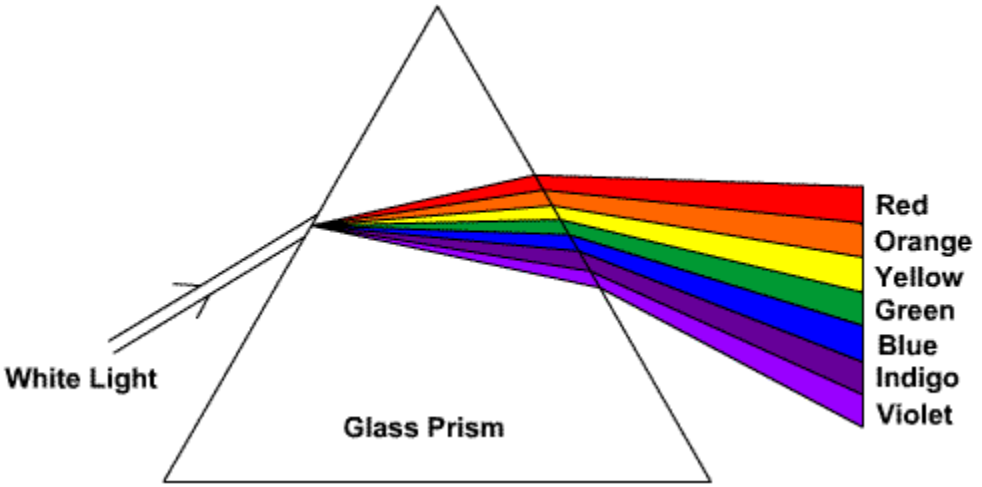
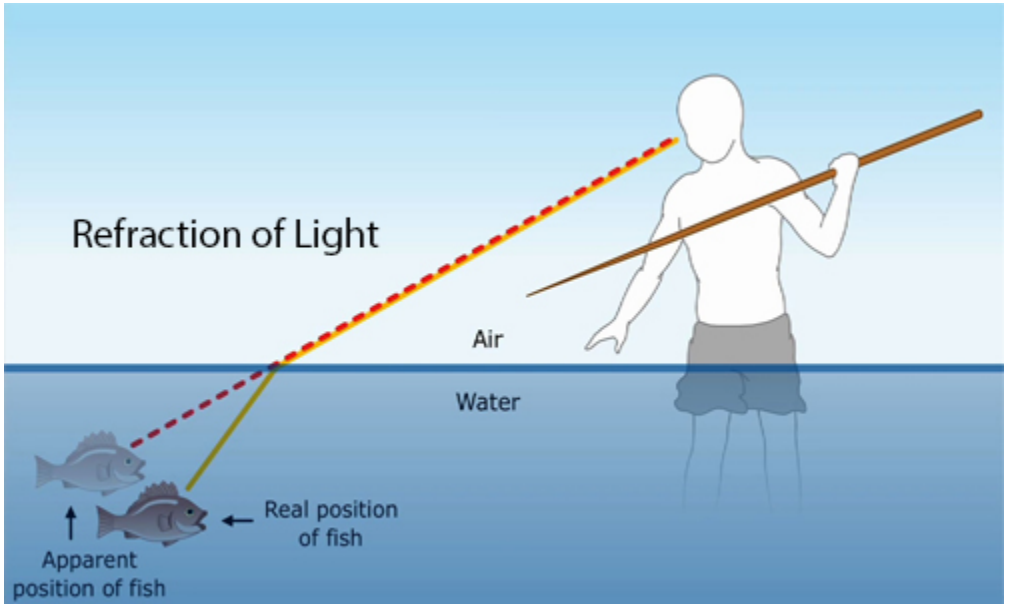


Fig.5(b) Real image by a lens camera

Light can be refracted in transmission



Why? Light doesn't always go 186K miles (300 km)/s. Speed a function of wavelength and the propagating material.


Refraction of Light
Air
Water
Real position
of fish
Apparent
position of fish

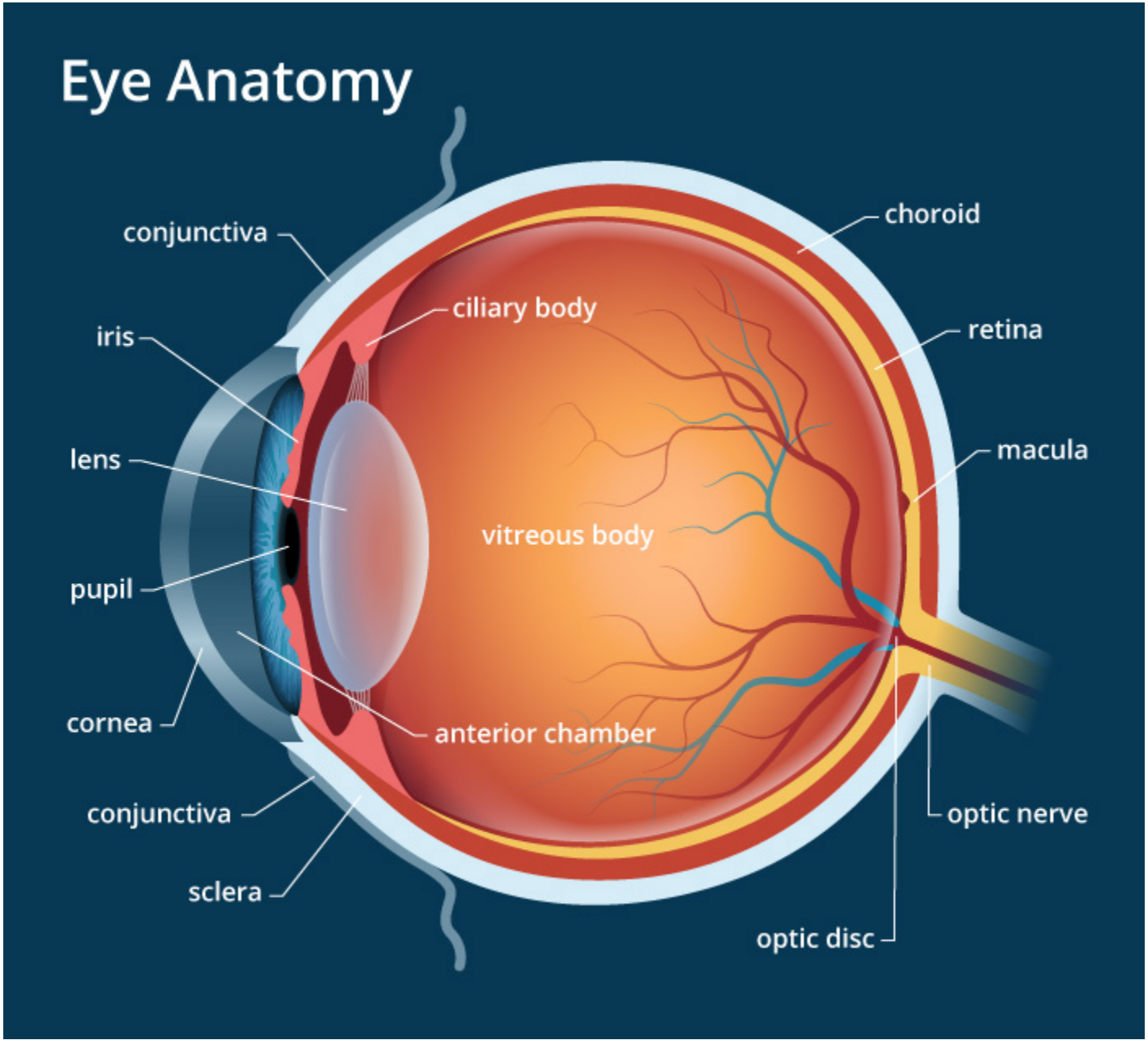
The virtues of light-based sensation

Fast (relative to sound/vibration or chemical diffusion)

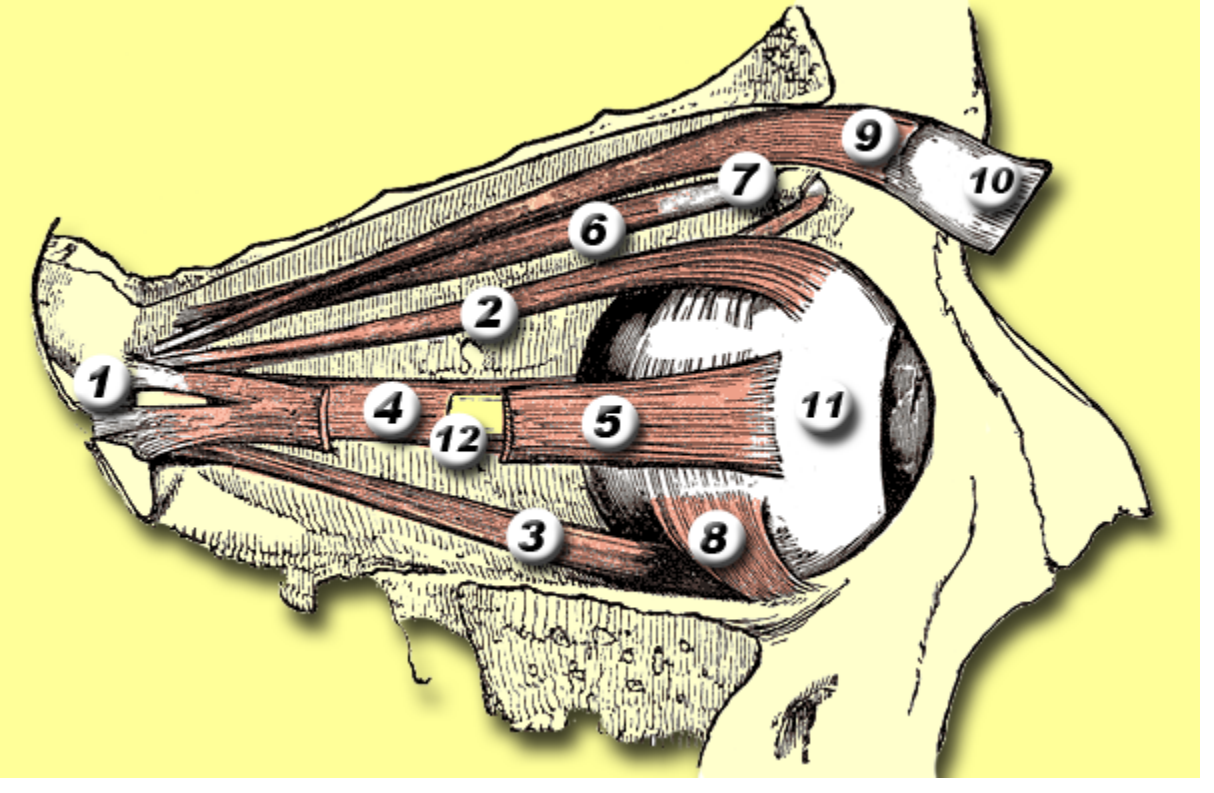
Provides information about surface geometry, composition

Biological materials can detect, emit, alter

The hardware of vision

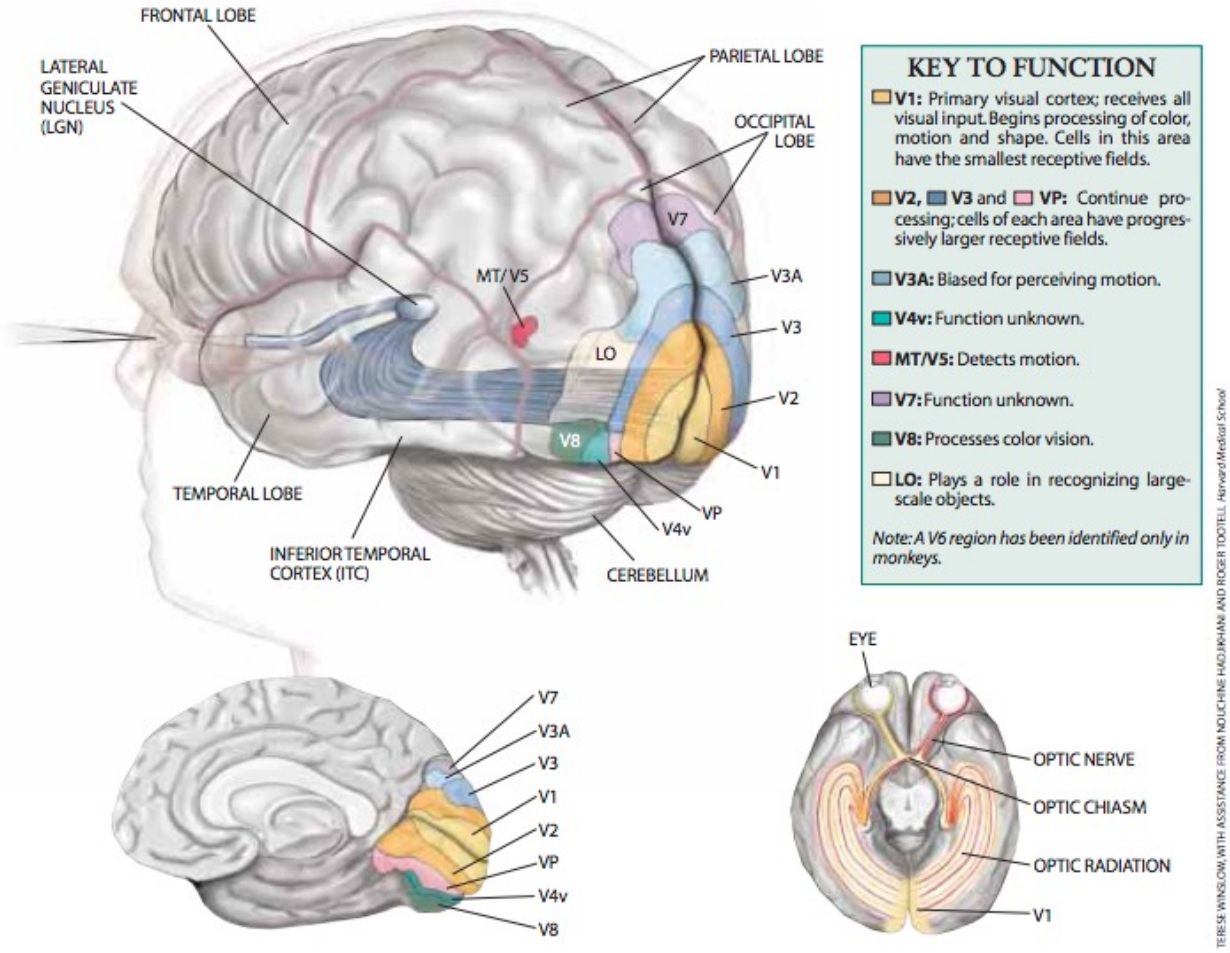

Eye Anatomy
conjunctiva
iris
lens
pupil
cornea
conjunctiva
sclera
ciliary body
vitreous body
anterior chamber
choroid
retina
macula
optic nerve
optic disc

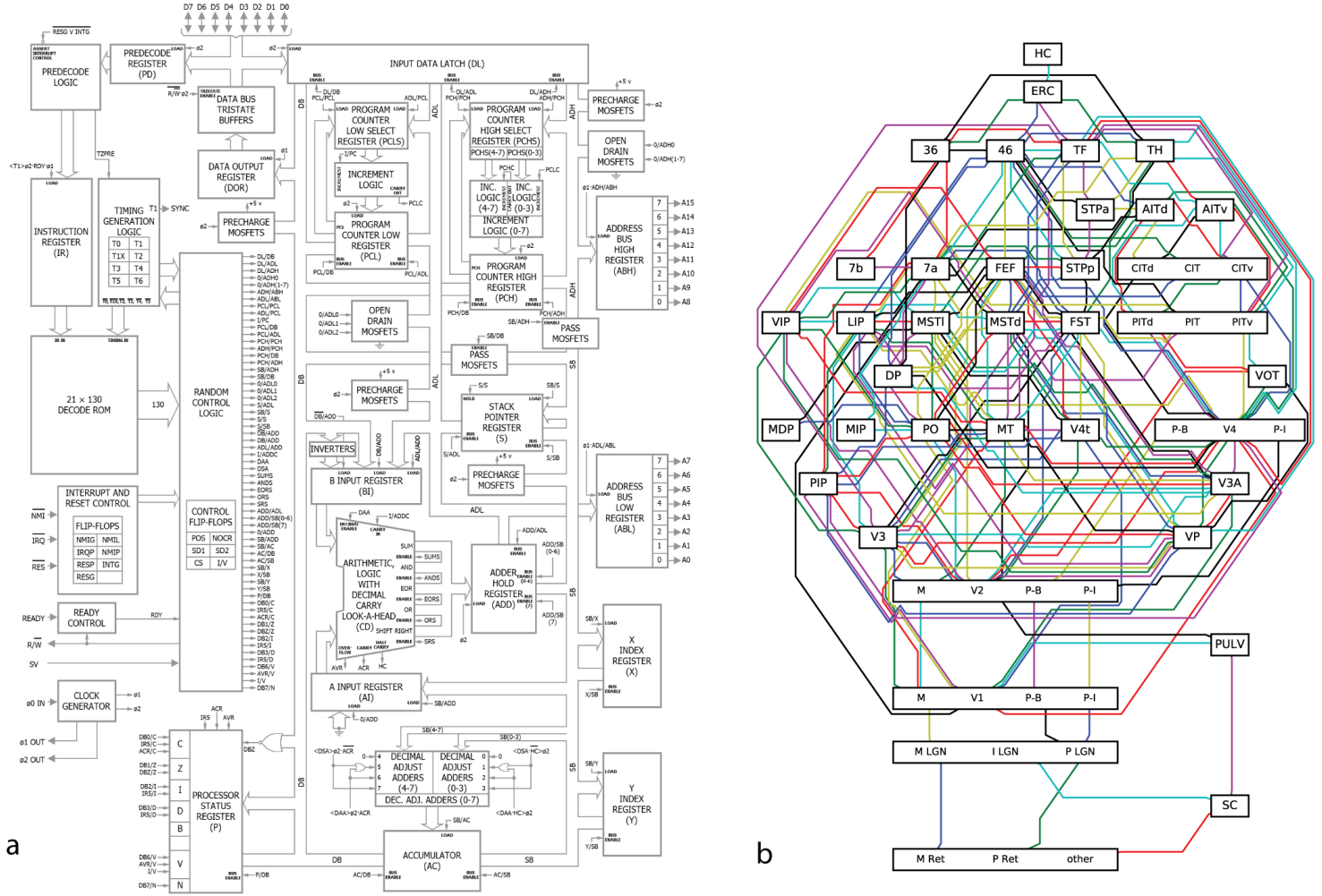
Eye muscles



Function	Name	Movement types
Move the eye	Inferior, superior, medial, & lateral rectus; inferior & superior oblique	saccades, pursuit, nystagmus, vergence
Alter pupil diameter	Sphincter pupillae	
Change lens thickness	Ciliary muscle	accommodation)

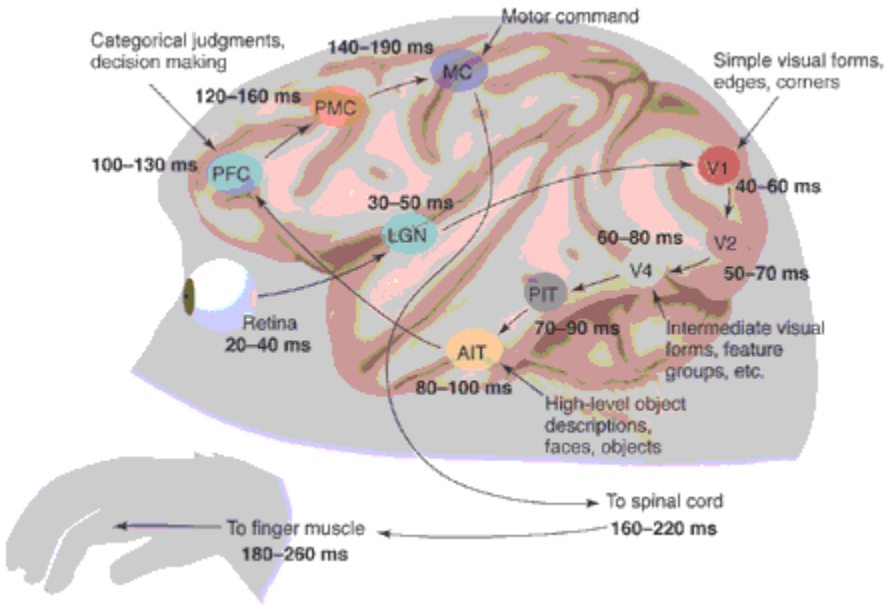
The visual brain has many sub-components





Jonas, E., & Kording, K. P. (2017). Could a Neuroscientist Understand a Microprocessor? PLoS computational biology, 13(1), e1005268. Public Library of Science. Retrieved January 3, 2018, from http://journals.plos.org/ploscompbiol/article/file?id=10.1371/journal.pcbi.1005268&type=printable

Visual centers connect to many other areas of the brain in serving behavior.



Why should X psychologists care about vision?

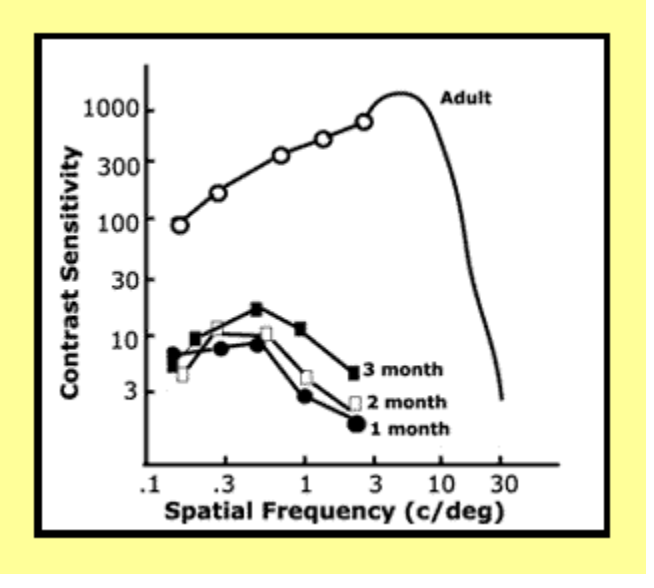
Cognitive psychologists...

Properties of computer-based displays used for experimental tasks

Relationship between overt (eye movement-based) and covert attention shifts

Developmental psychologists...

Vision develops throughout childhood.


Contrast Sensitivity
1000
300
100
30
10
3
Adult
3 month
2 month
1 month
.1
.3
1
3
10
30
Spatial Frequency (c/deg)

Social psychologists...

Much information about others is communicated visually.

© Mike Larremore

Clinical psychologists...

Some conditions may reveal themselves through perceptual characteristics.

Vision Research

Volume 49, Issue 22, 10 November 2009, Pages 2705-2739

Review

Vision in autism spectrum disorders

David R. Simmons ✉, Ashley E. Robertson, Lawrie S. McKay, Erin Toal, Phil McAleer, Frank E. Pollick

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https://doi.org/10.1016/j.visres.2009.08.005

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Break time

Discussion of Barlow 1972

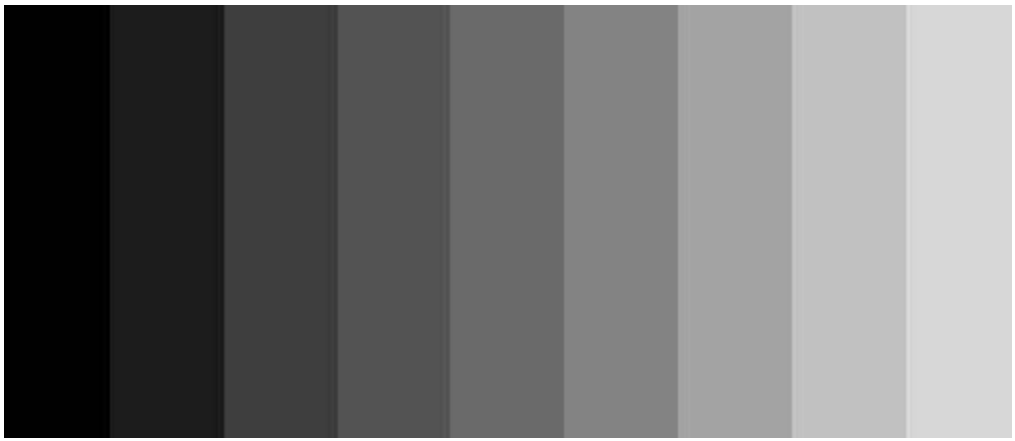
What question is Barlow trying to answer?

What question is Barlow trying to answer?

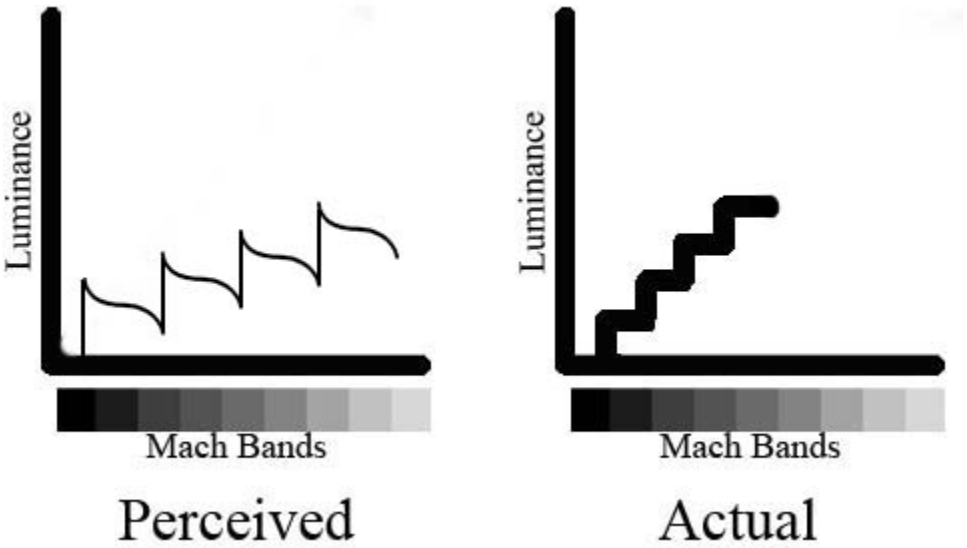
> *"I shall discuss the difficult but challenging problem of the relation between our subjective perceptions and the activity of the nerve cells in our brains..."*

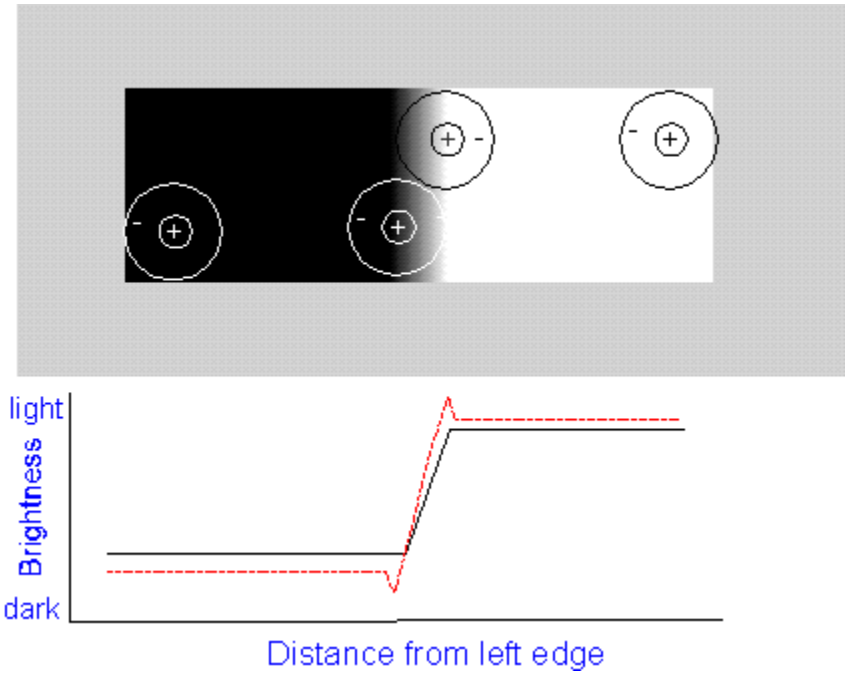
> *"...Müller's doctrine of specific nerve energies: the specificity of different sensations stems from the responsiveness of different nerve fibres to different types of stimulus..."*
>
> *"...sensory nerves usually adapt to a constant stimulus, and therefore signal sudden changes of stimulus energy better than sustained levels..."*

> *"...if the surrounding region is simultaneously stimulated the response of the cell is diminished or completely abolished (Barlow, 1953). This phenomenon is called lateral inhibition, or peripheral suppression, and such a physiological mechanism had already been postulated in order to account for simultaneous brightness and Mach bands (Mach, 1886; Fry, 1948). Thus the physiological experiment was really providing evidence in support of a psychological hypothesis..."*



Mach bands


Luminance
Mach Bands
Perceived
Luminance
Mach Bands
Actual


light
Brightness
dark
Distance from left edge

> *"two important concepts from the frog's retina: it transmits a map, not of the light intensities at each point of the image, but of the trigger features in the world before the eye, and its main function is not to transduce different luminance levels into different impulse frequencies, but to continue responding invariantly to the same external patterns despite changes of average luminance."*

> *"In the cortex Hubel and Wiesel (1962) found that some of the higher level neurons responded to the same trigger feature over a considerable range of positions. The modality specificity of peripheral neurons indicates how one can, for instance, detect warmth at any point on the body surface, and we now see that the organized pattern specificity of a set of cortical neurons can in the same way produce positional invariance for pattern perception."*

> *"If sensory messages are to be given a prominence proportional to their informational value, mechanisms must exist for reducing the magnitude of representation of patterns which are constantly present, and this is presumably the underlying rationale for adaptive effects"*

> *"Individual nerve cells were formerly thought to be unreliable, idiosyncratic, and incapable of performing complex tasks without acting in concert and thus overcoming their individual errors. This was quite wrong, and we now realise their apparently erratic behaviour was caused by our ignorance, not the neuron's incompetence."*

> *"...a prime function of sensory centres is to code efficiently the patterns of excitation that occur, thus developing a less redundant representation of the environment."*

Barlow's Five Dogmas

1. To understand nervous function one needs to look at interactions at a cellular level, rather than either a more macroscopic or microscopic level, because behaviour depends upon the organized pattern of these intercellular interactions.
2. The sensory system is organized to achieve as complete a representation of the sensory stimulus as possible with the minimum number of active neurons.
3. Trigger features of sensory neurons are matched to redundant patterns of stimulation by experience as well as by developmental processes.
4. Perception corresponds to the activity of a small selection from the very numerous high-level neurons, each of which corresponds to a pattern of external events of the order of complexity of the events symbolized by a word.
5. High impulse frequency in such neurons corresponds to high certainty that the trigger feature is present.

Next time...

Methods

Slides created via the R package **xaringan**. Rendered HTML and supporting files are pushed to GitHub where GitHub's 'pages' feature is used to host and serve the course website.