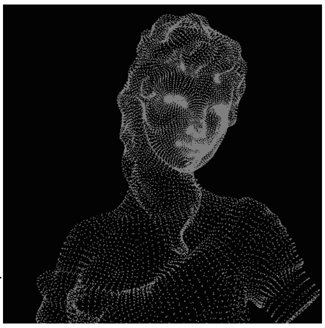
02 Chapter

Chapter 2: The Beginnings of Perception



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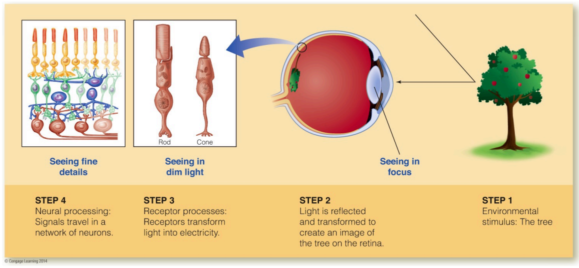
02 Chapter

We'll see the first three steps of the perceptual process for vision



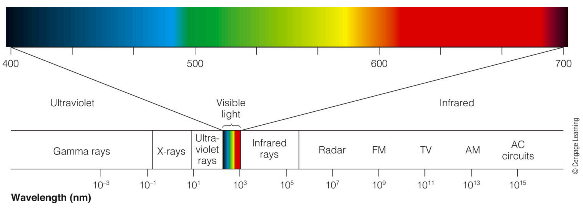
2

Figure 2-1 p22

02 Chapter

Electromagnetic spectrum

- Energy is described by **wavelength**.
- Spectrum ranges from short wavelength **gamma rays** to long wavelength **radio waves.**
- Visible spectrum for humans ranges from 400 to 700 nanometers.



wavelength is in nanometers (nm)

3

Figure 2-2 p23

02 Chapter

- The eye contains receptors for vision
- Light enters the eye through the pupil and is focused by the cornea and lens to a sharp image on the retina.
- Rods and cones are the visual receptors in the retina that contain visual pigment.
- The optic nerve carries information from the retina toward the brain.

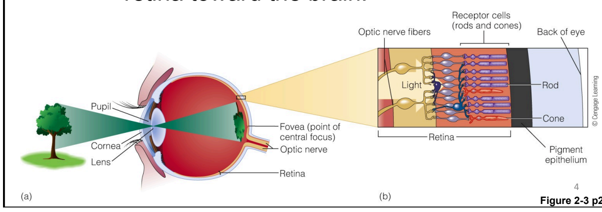


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Figure 2-3 p23

02 Chapter

Light is Focused by the Eye

- The cornea, which is fixed, accounts for about 80% of focusing.
- The lens, which adjusts shape for object distance, accounts for the other 20%. focusing for objects located at different distances.
  - Accommodation results because of the **ciliary muscles. They** causes the lens to thicken.
    - Light rays pass through the lens more sharply and focus near objects on retina.

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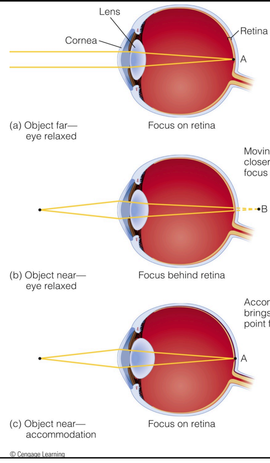

The focus point is at A on the retina

the image on the retina is out of focus. The image is blur.

focus point is pulled back to A to create a sharp image on the retina.

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Figure 2-4 p24

02 Chapter

Loss of Accommodation With Increasing Age

- The **near point** is the distance at which your lens can no longer accommodate to bring close objects into focus. The near point for most 20-year-olds is at about 10 cm. 14 cm by age 30, 22 cm at 40, and 100 cm at 60.
- Presbyopia - "old eye"
  - Distance of near point increases
  - Due to hardening of lens and weakening of ciliary muscles
  - Corrective lenses are needed for close activities, such as reading

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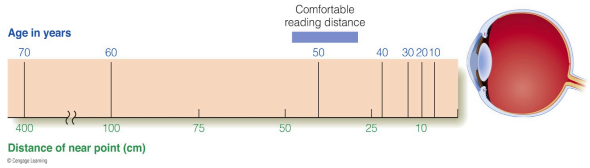
02 Chapter

corrective lenses (reading glasses) become necessary.



the near point (green numbers) increases with increasing age.

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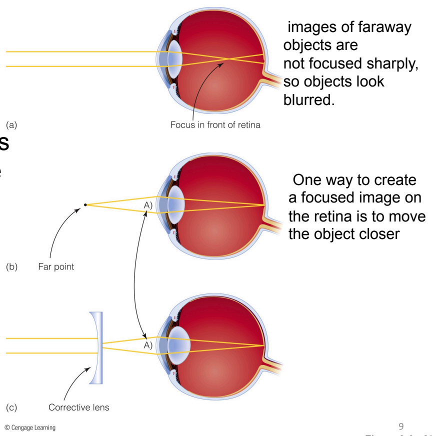
Figure 2-5 p25

02 Chapter

Myopia or nearsightedness - Inability to see distant objects clearly

Image is focused in front of retina



9

Figure 2-6 p25

02 Chapter

Focusing Images on Retina - continued

- Solutions for myopia
  - Move stimulus closer until light is focused on the retina
    - Distance when light becomes focused is called the far point.
  - Corrective lenses can also be used.

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02 Chapter

Hyperopia

- Hyperopia or farsightedness - inability to see nearby objects clearly
  - Focus point is behind the retina.
  - Usually caused by an eyeball that is too short
  - Constant accommodation for nearby objects can lead to eyestrain and headaches.

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02 Chapter

Transduction—the transformation of light energy into electrical energy—occurs in the receptors for vision: the rods and cones.

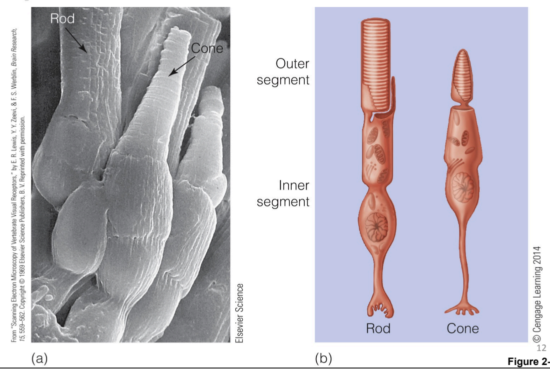

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Figure 2-7 p26

02 Chapter

Transforming of Light Energy Into Electrical Energy

- Receptors have outer segments, which contain:
  - **Visual pigment** molecules, which have two components:
    - Opsin - a long protein
    - Retinal - a light-sensitive molecule
- Visual transduction occurs when the retinal absorbs one photon.
  - Retinal changes its shape from being bent to straight, called **isomerization**.

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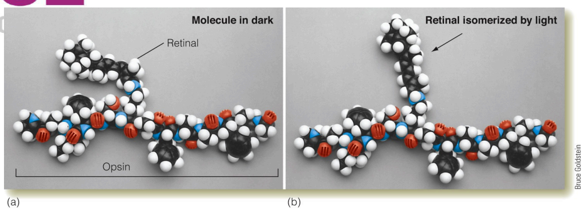
02 Chapter

Model of a visual pigment molecule.



The smaller molecule on top of the opsin is the light-sensitive retinal.

The retinal molecule's shape **after it absorbs light.**

Isomerization creates a chemical chain reaction, that activates thousands of charged molecules to create electrical signals in receptors.

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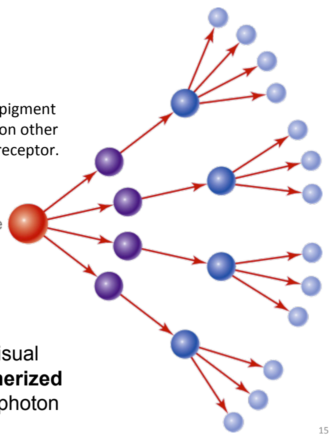
Figure 2-8 p27

02 Chapter

Isomerization of just one visual pigment molecule activates about a million other molecules, which activates the receptor.



The chain reaction that is triggered when a single visual pigment molecule is **isomerized** by absorption of a single photon of light.

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Figure 2-9 p27

02 Chapter

Transforming of Light Energy Into Electrical Energy - continued

- Current research in physiology and chemistry shows that isomerization triggers an enzyme cascade and this results in transduction from light energy to electrical energy in the retinal receptors.
  - **A cascade** means that a single reaction leads to increasing numbers of chemical reactions.
  - This is how isomerizing one pigment leads to the activation of a rod receptor.

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02 Chapter

Adapting to the Dark

- Dark adaption is the process of increasing sensitivity in the dark.
- Rod receptors and cone receptors adapt to the dark at different rates and that these differences occur because of differences in their visual pigments.

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02 Chapter

Distribution of Rods and Cones

- Differences between rods and cones
  - Shape
    - Rods - large and cylindrical
    - Cones - small and tapered
- One small area, the **fovea** , contains only cones. When we look directly at an object, the object's image falls on the fovea.
- The **peripheral retina** , which includes all of the retina outside of the fovea, contains both rods and cones but contains many **more rods** than cones.

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02 Chapter

Distribution of Rods and Cones - continued

- Macular degeneration
  - Fovea and small surrounding area are destroyed
  - Creates a "blind spot" on retina
  - Most common in older individuals

the fovea and surrounding area degenerate, so the person cannot see whatever he or she is looking at.

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02 Chapter

Distribution of Rods and Cones - continued

- Retinitis pigmentosa
  - Genetic disease
  - Rods are destroyed first
  - Severe cases result in complete blindness

the peripheral retina initially degenerates and causes loss of vision in the periphery.

sometimes called "tunnel vision."

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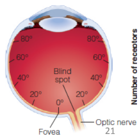
02 Chapter

Distribution of Rods and Cones - continued

- Blind spot - there are no receptors! This is the place where optic nerve leaves the eye.
  - We don't see it because:
    - one eye covers the blind spot of the other.
    - it is located at edge of the visual field.
    - the brain "fills in" the spot.



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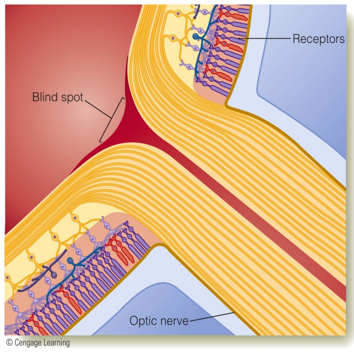
02 Chapter



There are no receptors at the place where the optic nerve leaves the eye. The absence of receptors in this area creates the blind spot.

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Figure 2-12 p29

02 Chapter

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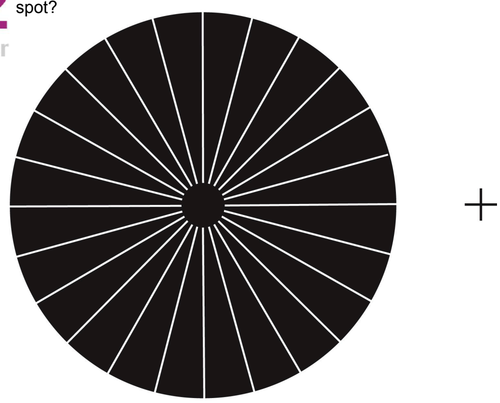
23

Figure 2-13 p29

02 Chapter

What happens when the center of the wheel falls on your blind spot?



Adapted from "Blind Spot" by Vilaynaur S. Ramachandran. Copyright © 1992 by Scientific American, Inc. All rights reserved.

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Figure 2-14 p29

02
Chapter

the brain "fills in" the spot.

The brain creates a perception that matches the surrounding pattern—the white page in the first demonstration, and the spokes of the wheel in the second one.

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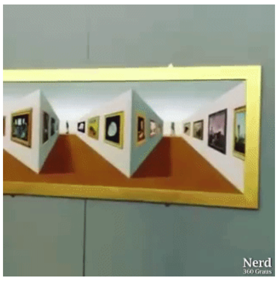
Figure 2-14 p29

02
Chapter



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02
Chapter

Measuring the Dark Adaptation Curve

- Three separate experiments are used.
- Method used in all three experiments:
  - Observer look at a small fixation point while paying attention to a flashing test light that is off to the side.
  - Because the observer is looking directly at the fixation point, its image falls on the fovea, so the image of the test light falls on the peripheral retina, which contains both rods and cones.

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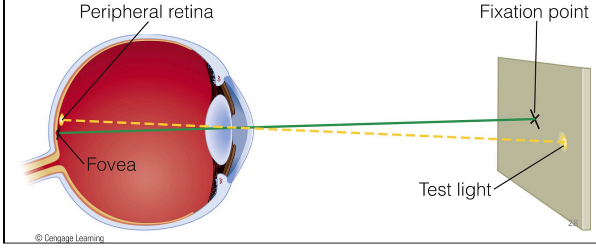
02
Chapter

Measuring the Dark Adaptation Curve

- While still in the light, the observer measures his or her threshold for seeing the light by turning a knob that adjusts the intensity of the flashing light until it can just barely be seen.



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02 Chapter — Measuring the Dark Adaptation Curve

- The sensitivity measured in the light is called the **light-adapted sensitivity**, because it is measured while the eyes are adapted to the light.
- Once the light-adapted sensitivity to the flashing test light is determined, the adapting light is extinguished so the observer is in the **dark**.
- The observer continues adjusting the intensity of the flashing light so it can just barely be seen, tracking the increase in sensitivity that occurs in the dark**. As the observer becomes more sensitive to the light, he or she must decrease the light's intensity to keep it just barely visible.**

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02 Chapter — Measuring the Dark Adaptation Curve - continued

- Experiment for rods and cones:
  - Observer looks at fixation point but pays attention to a test light to the side.
  - Results show a dark adaptation curve:
    - Sensitivity increases in two stages.
    - Stage one takes place for three to four minutes.
    - Then sensitivity levels off for seven to ten minutes - the rod-cone break.
    - Stage two shows increased sensitivity for another 20 to 30 minutes.

Pirate's eye patch

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02 Chapter

The place where the rods begin to determine the dark adaptation curve is called the **rod–cone break.**

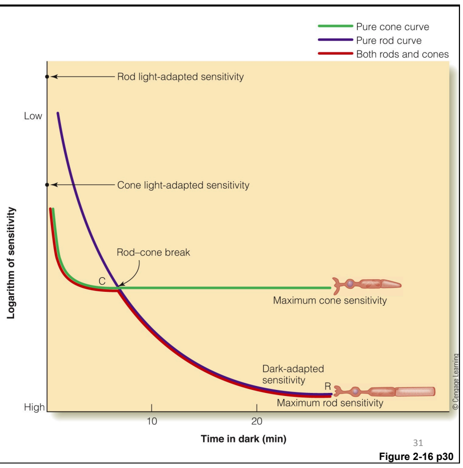

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Figure 2-16 p30

02 Chapter — Measuring the Dark Adaptation Curve - continued

- Experiment for cone adaptation
  - To measure dark adaptation of the cones alone, we have to ensure that the image of the test light falls **only on cones**
  - The observer look directly at the test light so its image will fall on the **all-cone fovea**.
  - Results show that (green line) sensitivity increases for three to four minutes and then levels off.

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02 Chapter — Measuring the Dark Adaptation Curve - continued

- Experiment for rod adaptation
  - Because the cones are more sensitive to light at the beginning of dark adaptation, they control our vision during the early stages of adaptation, so we can't see what the rods are doing!
  - To do this, we must use a rod monochromat pp who have no cones.
  - Results show that sensitivity increases for about 25 minutes and then levels off.

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02 Chapter — Measuring the Dark Adaptation Curve - continued

- Summary:
- As soon as the light is extinguished, the sensitivity of both the cones and the rods begins increasing.
- We see with our cones right after the lights are turned out because the cones are much more sensitive than the rods at the beginning of dark adaptation.
- However, after about 3 to 5 minutes in the dark, the cones have reached their maximum sensitivity.
- Meanwhile, the rods are still adapting, behind the scenes, and by about 7 minutes in the dark.
- The rods then become more sensitive than the cones, and rod adaptation, indicated by the second branch of the dark adaptation curve, becomes visible.

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02 Chapter — Measuring the Dark Adaptation Curve - continued

- Why do the rods take about 20 to 30 minutes to reach their maximum sensitivity, compared to only 3 to 4 minutes for the cones?

- The answer to this question involves a process called visual pigment regeneration, which occurs more rapidly in the cones than in the rods.

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02 Chapter — Visual Pigment Regeneration

- Light causes the **retinal** part of the visual pigment molecule to change its shape. Eventually, after this shape change, the retinal separates from the opsin part of the molecule.
- This change in shape and separation from the opsin causes the molecule to become lighter in color, a process called **visual pigment bleaching**.

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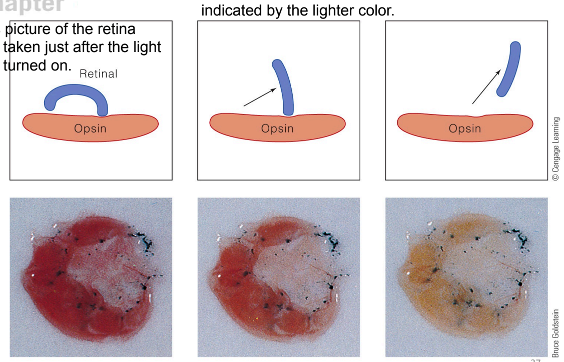
02 Chapter

As the pigment isomerizes, the retinal and opsin break apart, and the retina becomes *bleached*, as indicated by the lighter color.

This picture of the retina was taken just after the light was turned on.



(a) (b) (c)

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Figure 2-17 p32

02 Chapter

Visual Pigment Regeneration

- When the pigments are in their lighter bleached state, they are no longer useful for vision.
- Separated retinal and opsin should recombined again to do their jobs.
- The **retinal** needs to return to its bent shape and become reattached to the opsin.
- This process of reforming the visual pigment molecule is called **visual pigment regeneration**.
- Cone pigment regenerates in 6 minutes.
- Rod pigment takes over 30 minutes to regenerate.

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02 Chapter

Cones Have Better Acuity Than the Rods

DEMONSTRATION

Foveal Versus Peripheral Acuity

D I H C N R L A Z I F W N S M Q P Z K D **X**

- Acuity: The ability to see and discriminate details.
- Visual acuity is highest in the **fovea**; objects that are imaged on the peripheral retina are not seen as clearly.
- See the curveball illusion.

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02 Chapter

how acuity changes during during dark adaptation.

When our cones are controlling vision, the books on the top shelf represent the details we see when viewing the books in the light.

The books on the bottom shelf represent the poor detail vision of the rods.

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Figure 2-34 p43

02
Chapter

Infant Visual Acuity

- **Preferential looking (PL) technique:**

"Can you tell the difference between the stimulus on the left and the one on the right?" The way infants answer this question is by looking more at one of the stimuli.

In the preferential looking (PL) technique, two stimuli are presented, and the experimenter watches the infant's eyes to determine where the infant is looking.

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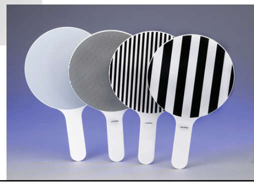
02

To test acuity with gratings in infants.



2-38 p46

02
Chapter

Visual evoked potential (VEP) :

-provides an objective measure of the visual system's ability to detect details.

-is recorded by electrodes placed on the infant's head over the visual cortex.

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02
Chapter

The VEP usually indicates better acuity than does preferential looking.

The blue curve indicates acuity determined by VEP.

the VEP provides an objective measure of the visual system's ability to detect details.

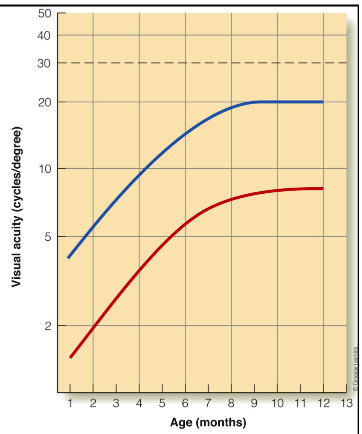

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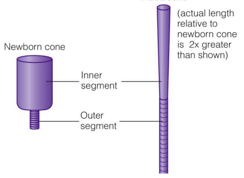
Figure 2-39 p46

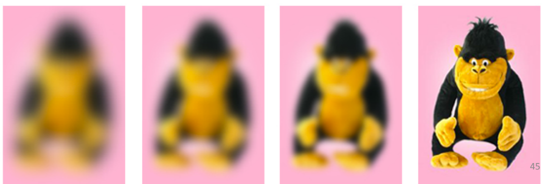
02
Chapter

The newborn's cones contain less visual pigment and therefore do not absorb light as effectively as adult cones.

Another reason for the infant's poor acuity is that the visual area of the brain is poorly developed at birth, with fewer neurons and synapses than in the adult cortex.
The rapid increase in acuity occurs over the first 6 to 9 months of life.



1 Month | 2 Months | 3 Months | Adult



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02
Chapter

Examples of Illusion

- T-rex Illusion: https://www.youtube.com/watch?v=A4QcyW-qTUg
- Beau Lotto-Optical illusions show how we see:

http://www.ted.com/talks/beau_lotto_optical_illusions_show_how_we_see?language=en#t-26659

Akiyoshi's illusion page: http://www.ritsumei.ac.jp/~akitaoka/index-e.html

- Lotto Lab

http://www.lottolab.org/articles/illusionsoflight.asp

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