

# Paper assignment

- Paper assignment instructions are now online.
- Exam is next Thursday

- Davis Glasser office hours
  - Meliora Hall 242
    - Tuesday: 3 - 4pm
    - Wednesday: 2 - 3pm

- Ruyuan Zhang office hours
  - Meliora Hall 242
    - Monday: 2 - 3pm
    - Tuesday: 2 - 3pm

- No office hours for Dr. Tadin this Thursday



"And here are trees and I know their gnarled surface, water, and I feel its taste. These scents of grass and stars at night, certain evenings when the heart relaxes -- how shall I negate this world whose power and strength I feel? Yet all the knowledge on earth will give me nothing to assure me that this world is mine. You describe it to me and you teach me to classify it. You enumerate its laws and in my thirst for knowledge I admit that they are true. You take apart its mechanism and my hope increases ... What need had I of so many efforts? The soft lines of these hills and the hand of evening on this troubled heart teach me much more."

ALBERT CAMUS, *The Myth of Sisyphus* (1942)

"The keenness of our vision depends not on how much we can see, but on how much we feel. Nor yet does mere knowledge create beauty. Nature sings her most exquisite songs to those who love her. She does not unfold her secrets to those who come only to gratify facts, but to those who see in her manifold phenomena suggestions of lofty, delicate sentiments."

HELEN KELLER, *The World I Live In* (1904)

## Paper assignment

As you do these things, keep a journal of your observations. For your assignment, you will need to turn in a "paper" with five such observations. The **TOTAL** length should be at least 1,000 words (each observation can be of different length). Observations do not have to be related.

Due in class Thursday, November 17<sup>th</sup>.

### Grading (10 points total):

- 1 point for each relevant observation (5 max).
- up to 3 points for insightfulness, creativity, and/or originality.
- up to 2 points for linking your observations with class lectures and/or readings. Assume that the reader has the class knowledge -- that is, do not explain class materials.

**Best strategy:** start early!

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## EXPLORING PERCEPTION OUTSIDE OF CLASS

The two quotes above remind us that the study of perception is vacuous without insight provided by our own perceptual experiences: the richest source of information for understanding perception is provided by your own everyday experiences. During this semester, take time to discover things that, in a sense, you already know.

- Learn to pay attention to the sights, sounds, tastes and smells that populate your perceptual world. Relate those experiences to what you learn in the class.
- Note how art and perception are related.
- Pay attention to the news that is related to our perception. Search online for perception related topics like illusions, ESP, animal perception, ...
- Conduct your own simple experiments. Participate in perceptual experiments at the UR. Think about those experiments in the context of this course.
- Read a research article on a perceptual topic that interests you.
- .... Feel free to be creative!

### One possible online source:

Some perceptual experiences can be "created" by setting up simple demonstrations and exercises. This website offers lots of ideas for testing different aspects of sensory function (the website was created for primary and secondary school students, but don't let that keep you from trying out some of the demos).

<http://faculty.washington.edu/chudler/ciscense.html>

## Introduction to vision

- general overview
- what is it that we see
- the eye
  - general overview
  - eyes and behavior
- the optics of the eye
  - corrective problems
  - adaptive optics

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## Vision, figuratively speaking

- "I **see** what you mean"
- "**See** for yourself"
- "**Seeing** is believing"
- "**See** you next week"
- "Out of **sight**, out of mind"
- "She's a **far-sighted** person, a real visionary"
- "He has a **vision** for the future"
- "I **see** where you're coming from"
- "A **sight** for sore eyes"
- "Give someone the **eye**"
- "**blind** to the truth"
- "an **illuminating** example"
- "it sheds **light** on the problem"
- "a **light-bulb** went off above my head"
- "it **dawned** on me that ...."
- "**light** at the end of the tunnel"

and the omnipresent "**look...**"

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## Vision Seems Automatic & Effortless



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## Who Is It?



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## Seeing: What could be easier?

“We just point our eyes where we want them to go, and gather in whatever there is to see... The world is flooded with light, and everything is available to be seen.” James Elkins

“If in good illumination, my eyes alight upon an everyday scene, then I just see things as they are and where they are. End of story.” Martha Farrah

“On difficulty in the psychological sciences lies in the familiarity of the phenomena with which they deal. One is inclined to take them for granted.” Noam Chomsky

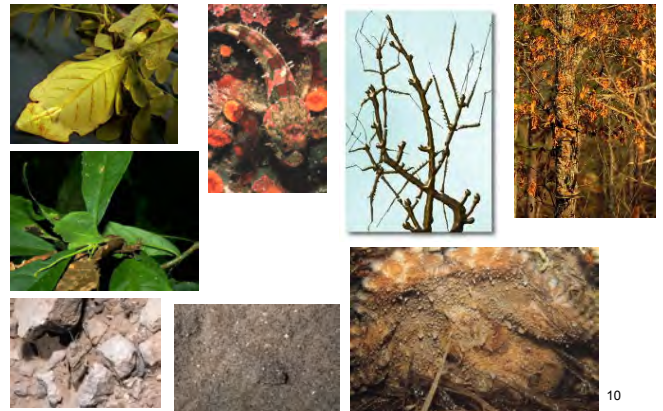
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## In a world full of acoustic, mechanical and chemical energy, why vision?

- touch and taste only work when an organism comes in contact with objects, at which time it may be too late to react
- smell helps only with objects that release volatile molecules
- hearing works only when objects make sounds, and lots of important biological objects (e.g., fruit) don't make sounds; for purposes of navigation, hearing is very limited
- Vision, unlike the other senses, can specify the colors, sizes and shapes of objects in 3D space, and how those objects are moving relative to one another
- Visual information can be harder to “conceal”

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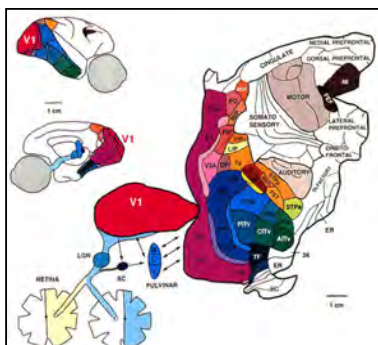
## Visual Camouflage



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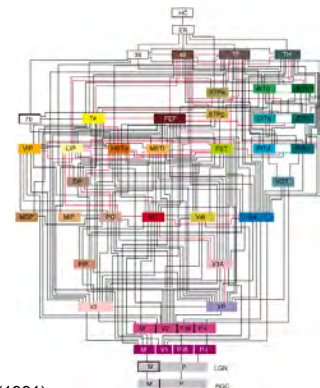
## We are visual creatures

- 70% of all sensory receptors are photoreceptors
- 80% of primate brain activated by visual input
- Blindness generally considered to be the most debilitating sensory loss



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## We are visual creatures



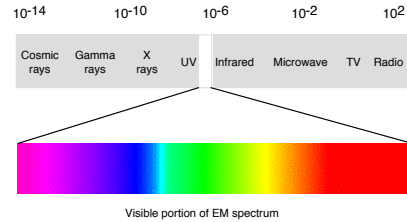
Felleman and van Essen (1991)

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# Introduction to vision

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# What is light?



Out of the whole world, we see almost nothing.

Why this band of wavelengths?

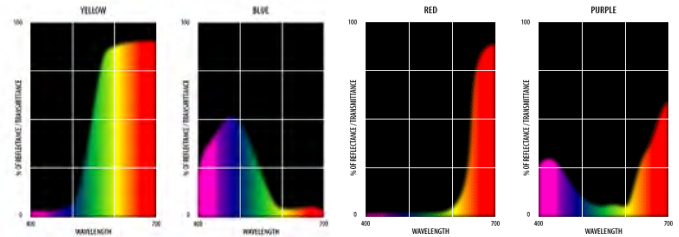
# Interaction of Light and Matter

- When light strikes an object, it will be
  - It will be wholly or partly transmitted.
  - It will be wholly or partly reflected.
  - It will be wholly or partly absorbed.
  - Physical surface properties dictate what happens
- When we see an object as blue or red or purple,
  - what we're really seeing is a **partial reflection** of light from that object.
  - The color we see is what's left of the spectrum after part of it is absorbed by the object.



# Interaction of Light and Matter

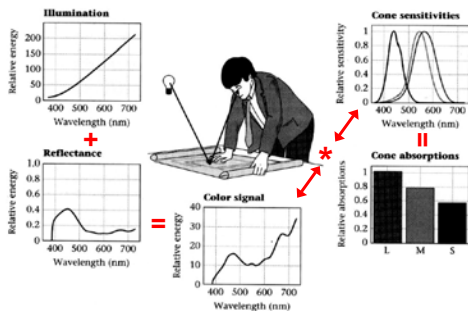
- Reflectance curves for objects that appear to be:



The wavelengths reflected from an object characterize the **visual stimulus** and are (in part) responsible for our **subjective sensation of color**.

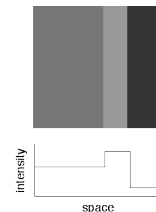
# What Do We 'See'?

Factors involved:  
Light Sources  
Surface Reflectance  
Eye sensitivity



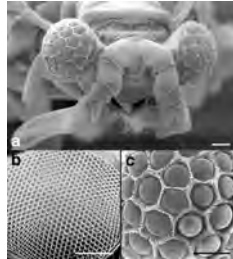
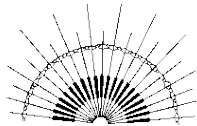
# What does it mean to "see"?

- Image-based vision
  - concerned with spatial distribution of light reflected from surfaces



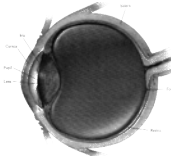
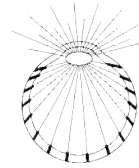
## What does it mean to “see”?

- Image-based vision
  - concerned with spatial distribution of light reflected from surfaces
  - Requires optical components to form image on photoreceptors
    - Compound eyes



## What does it mean to “see”?

- Image-based vision
  - concerned with spatial distribution of light reflected from surfaces
  - Requires optical components to form image on photoreceptors
    - Compound eyes
    - Chambered eyes



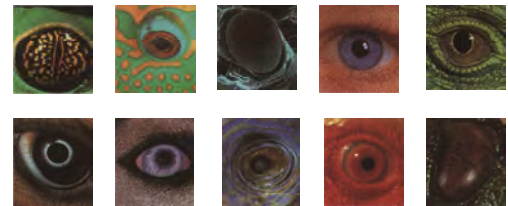
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## Variety of eyes in nature



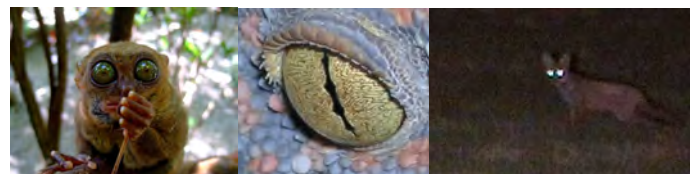
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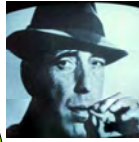
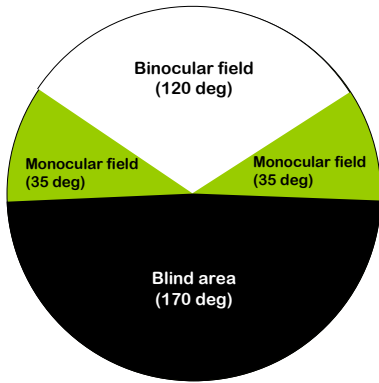
## What the eyes reveal about an animal’s vision and its lifestyle



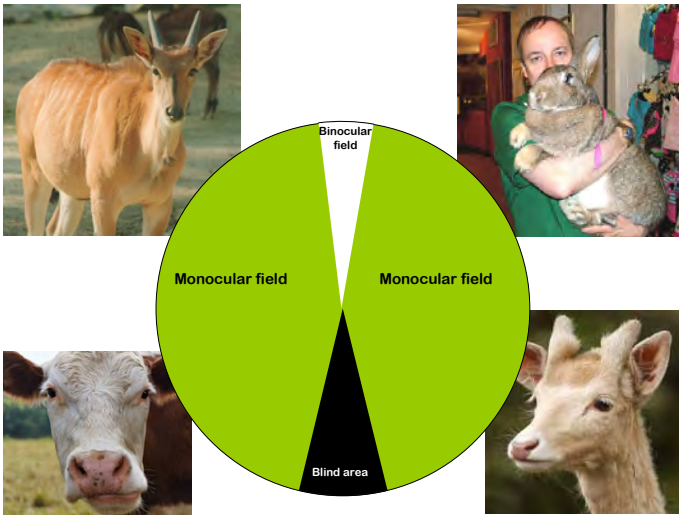
## What the eyes reveal about an animal’s vision and its lifestyle

- Size of the eye
- Shape of the pupil
- Dynamic range of the pupil
- Presence of ‘eye-shine’ (e.g., cats)
- Extent to which the eyes move in the head
- Location of eyes in the head





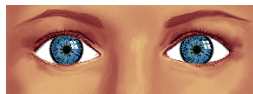
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**predators** typically have both eyes on the front of their heads, and consequently have large binocular visual fields. In contrast, **prey** typically have one eye on either side of their heads, and consequently have small, if any, binocular visual fields



## Watching the Eyes Move

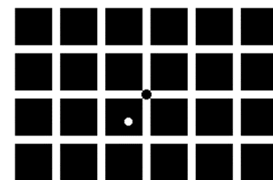


Take turns watching each other's eyes move:

1. Saccades
2. Pursuit/tracking movements
3. Simulated tracking movements
4. Vergence movements
5. Microsaccades (demo)

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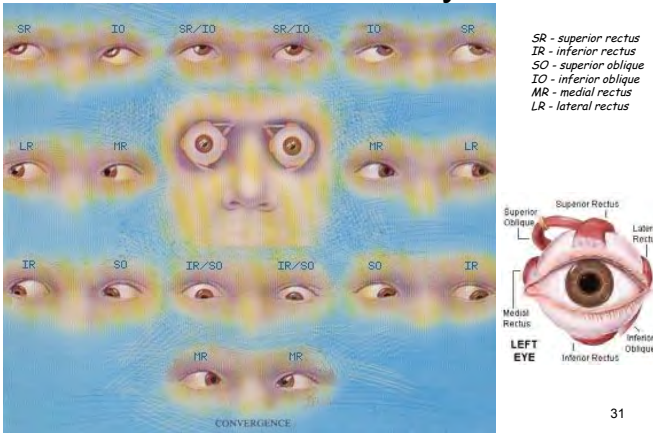
## Your Eyes Never Stand Still



Stare at the black dot for a minute, holding your gaze as steady as possible. Then shift your fixation to the white dot. Notice how the resulting afterimage "jitters" even though you're trying to hold your eyes still

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# Muscles Make the Eyes Move



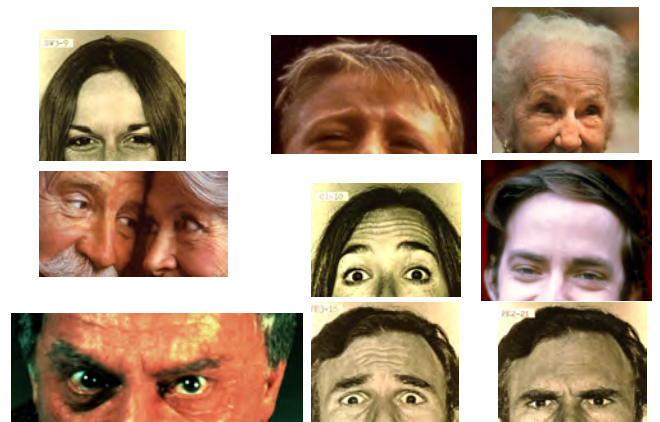
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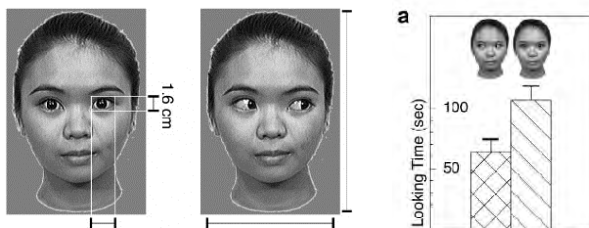
# What is this Person Feeling?



# Eyes Can Reveal Your Emotions



# Infants Know When You're Looking at Them



# Eye Contact Between People Can Be Uncomfortable



Cyclophobia -- fear of eyes

## Autistic Individuals Avoid Eye Contact



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## Social Phobic Individuals Show Abnormal Fixation Patterns

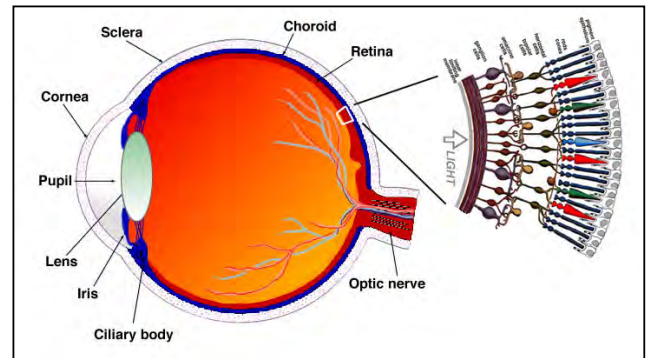


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## Introduction to vision

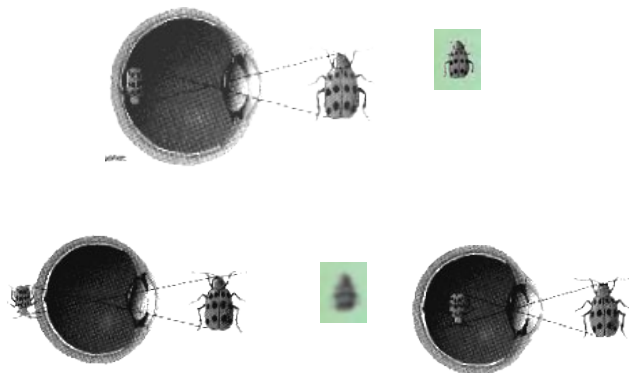
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- Pupil** The opening through which light enters the eye
- Iris** The colored aperture that controls the amount of light entering the eye
- Cornea** Accounts for 2/3 of eye's refraction (light-focusing)
- Lens** Adjustable light refraction on the retina.
- Retina** The lining of the back of the eye containing photoreceptors and neurons
- Optic nerve** Connects retina to the brain

## Image-based vision needs good optics



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## Image-based vision needs good optics

In order to have a sharp image, the film (or receptor surface) must be located at the appropriate focal distance for the object to be photographed



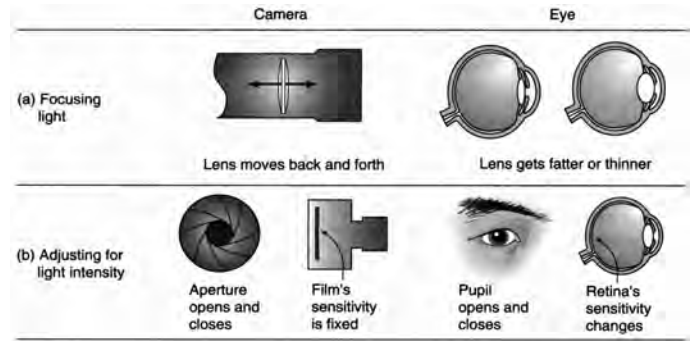
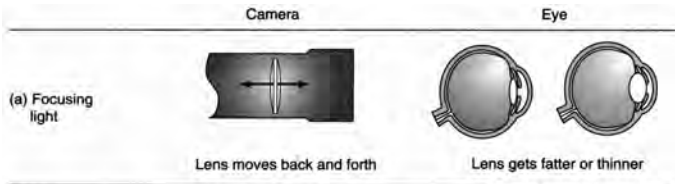
Film is at the focal distance of the camera lens

Film is not in the focal distance of the camera lens

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# The Eye is like a Camera

# The Eye is like a Camera

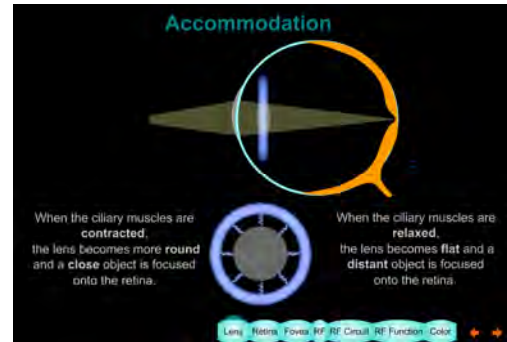
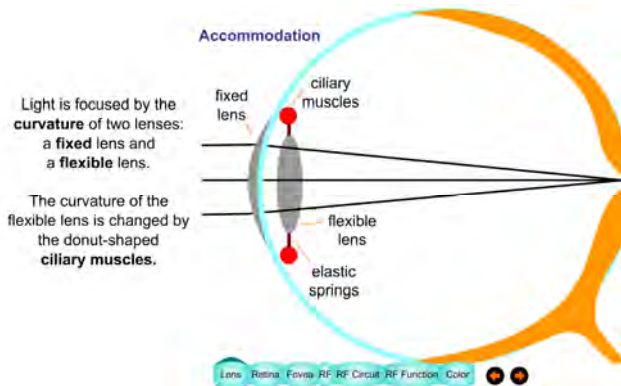


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<http://www.tutis.ca/Senses/L1Eye/L1eye.swf>

In the human eye, focal distance is manipulated by altering the shape of an adjustable lens

This is achieved by contracting the ciliary muscles



The ability to increase the curvature of the lens is called **accommodation**.

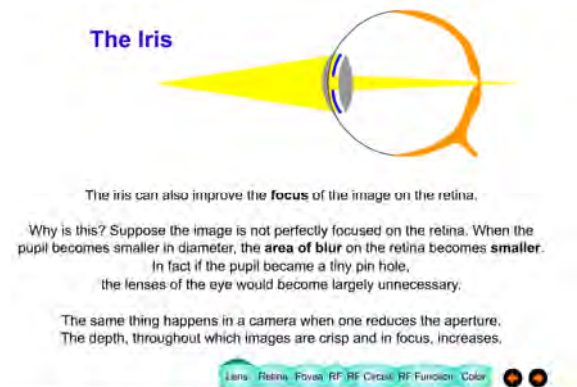
As we get older, the flexibility of the lens is reduced, which makes it difficult to bring near objects into focus. This condition is called **presbyopia**.

The amount of light entering the eye is controlled by an adjustable aperture called the pupil.

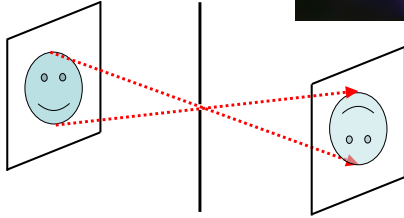
Making the pupil small also helps focus the image. This is why people often squint when they read without glasses. Note how the spread of light on the fovea is reduced with pupil size.



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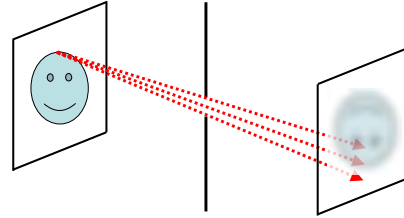


Pinhole camera effect



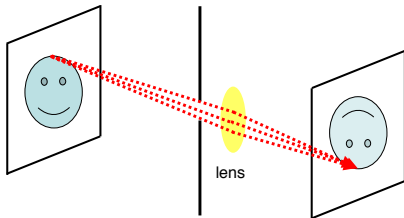
- Pinhole camera: camera using very small apertures (similar to the eye in bright light)
- The smaller the hole, the **sharper** the image, but the **dimmer** the projected image.
- Usually requires long exposure time (to collect enough light)
- More light can be gathered by increasing the size of the aperture.....but that... 49

Pinhole camera effect



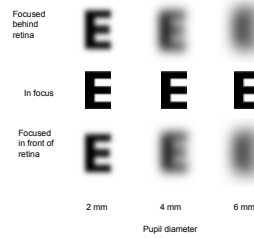
.... but that can blur the image.

Pinhole camera effect



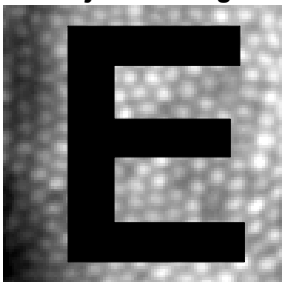
.... Blur can be eliminated by using an appropriate lens to focus the light.  
Focusing also increases brightness (think grass & magnifying glass)

Depth of focus is a function of pupil size



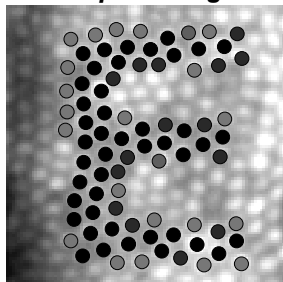
When eye's optics are working correctly, what is the smallest thing we can see?

Projected Image



20/20 letter

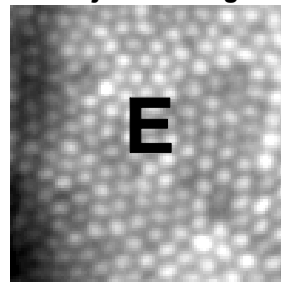
Sampled Image



5 arc minutes

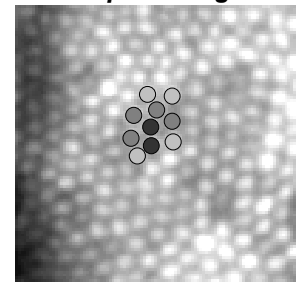
When eye's optics are working correctly, what is the smallest thing we can see?

Projected Image



20/5 letter

Sampled Image



5 arc minutes

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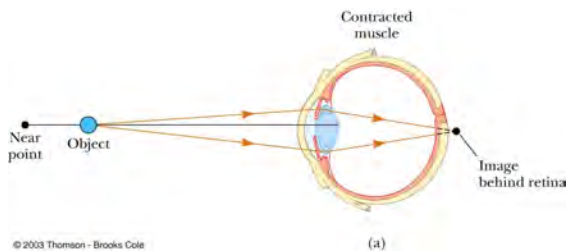
## Conditions of the Eye

- Vision can be impaired if the image is not focused correctly.
- This can occur if the eyeball is too short or long relative to the shape of the lens.
- Also if there is a mismatch between the focusing power of the lens-cornea system and the length of the eye



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## Farsightedness

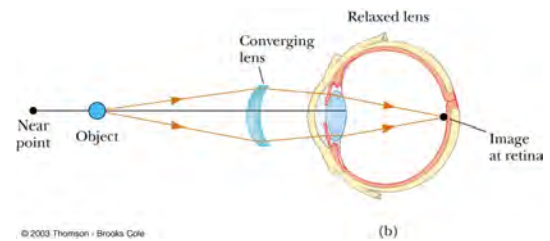


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- Also called hyperopia
- The image focuses behind the retina
- Can see far away objects clearly, but not nearby objects

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## Correcting Farsightedness

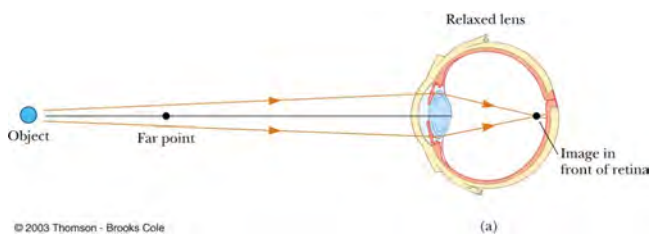


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- A **converging** lens placed in front of the eye can correct the condition
- The lens refracts the incoming rays more toward the principle axis before entering the eye
  - This allows the rays to converge and focus on the retina

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## Nearsightedness

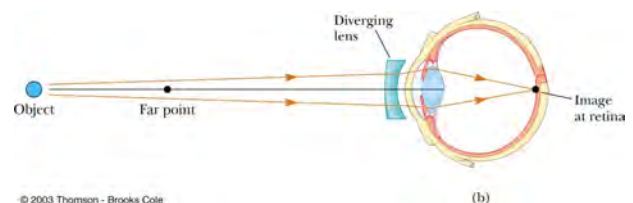


© 2003 Thomson - Brooks Cole

- Also called myopia
- In *axial myopia* the nearsightedness is caused by the lens being too far from the retina
- In *refractive myopia*, the lens-cornea system is too powerful for the normal length of the eye
- The image focuses in front of the retina
- Can see nearby objects clearly, but not far away objects

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## Correcting Nearsightedness



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- A **diverging** lens can be used to correct the condition
- The lens refracts the rays away from the principle axis before they enter the eye
  - This allows the rays to focus on the retina

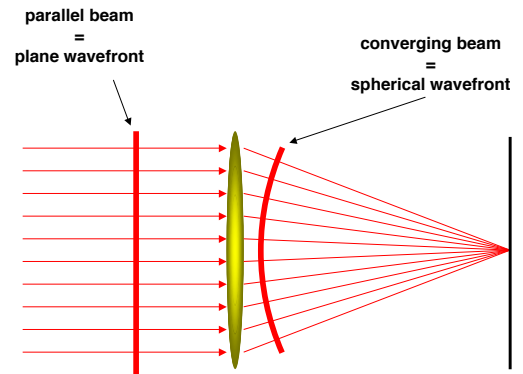
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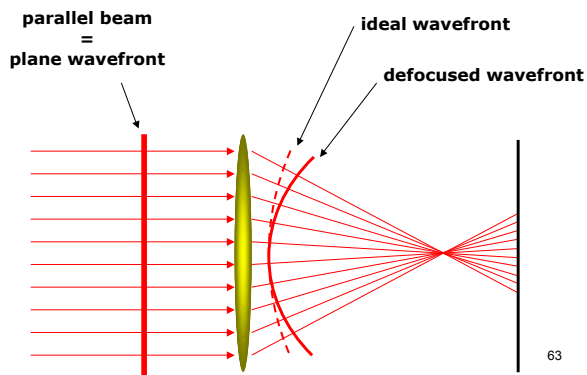
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## Wavefront



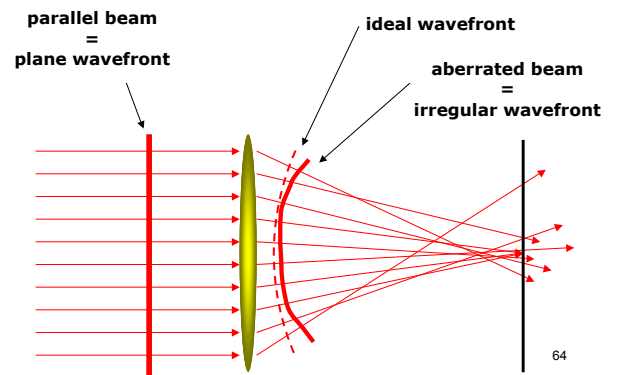
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## Wavefront



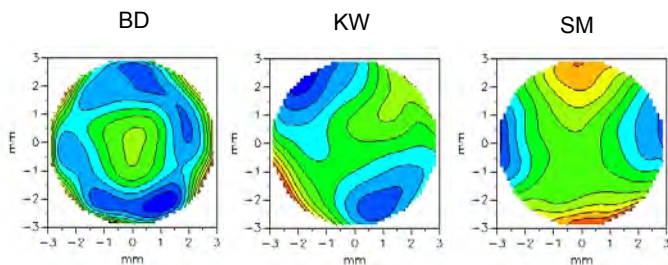
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## Wavefront aberration



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## Wavefront aberration



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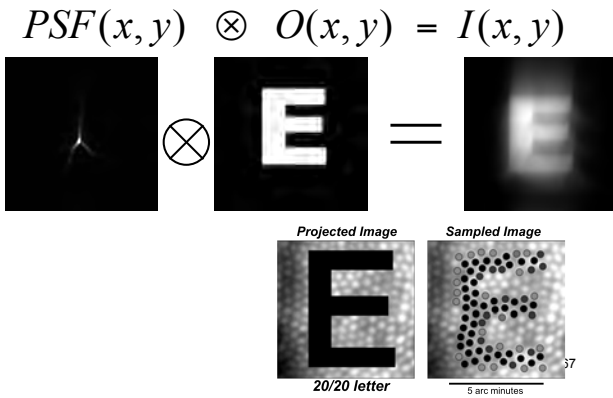
## Effects of Wavefront aberration

### Point Spread Function

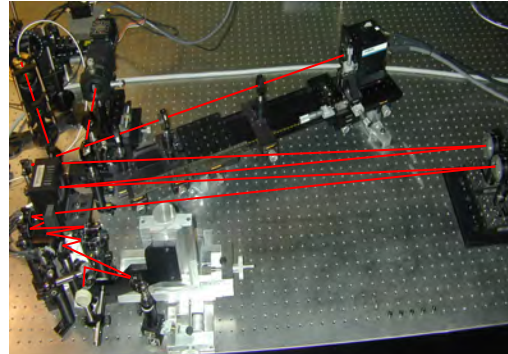
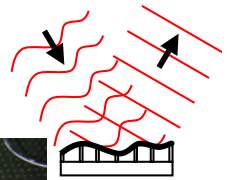


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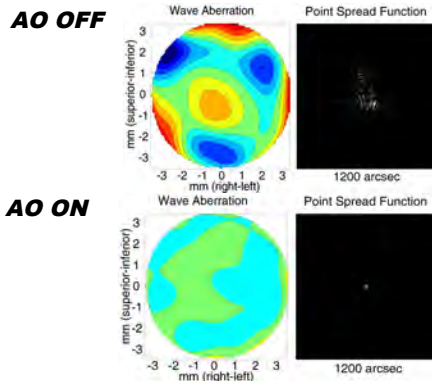
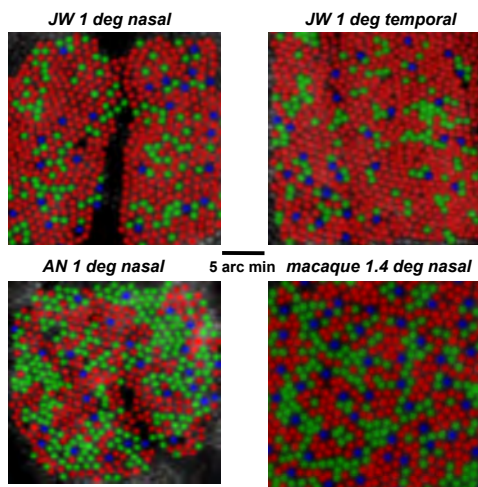
# Effects of Wavefront aberration



# Wavefront aberration Adaptive optics correction



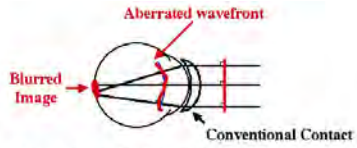
# Wavefront aberration Adaptive optics correction

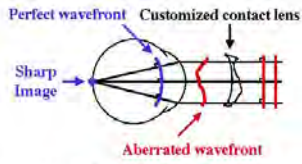
# Wavefront Correcting Refractive Surgery

Laser refractive surgery to compensate the aberrations of the eye is booming. All major companies have custom surgery systems and results are promising.

# Wavefront Correcting Contacts



**Eye corrected with conventional contact,  
but with higher order aberrations**



**Eye corrected with customized contact lens  
to eliminate higher order aberrations**