Digital Image Processing

Lecture # 1
Introduction & Fundamentals

Contents

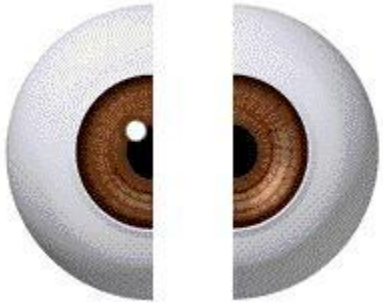
- Human Eye
- Image Perception
- Digital Images
- Image formation

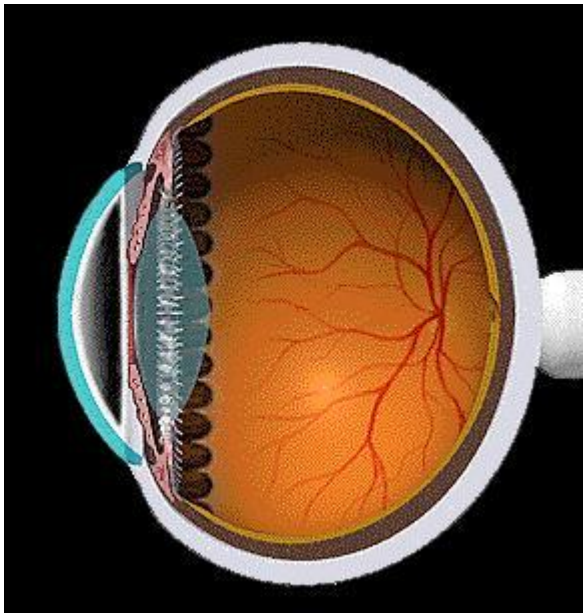
Human and Image Perception

- We can’t think of image processing without human vision system.
- We observe and evaluate the images that we process with our visual system.
- Without taking this elementary fact into consideration, we may be much misled in the interpretation of images.

Human and Image Perception

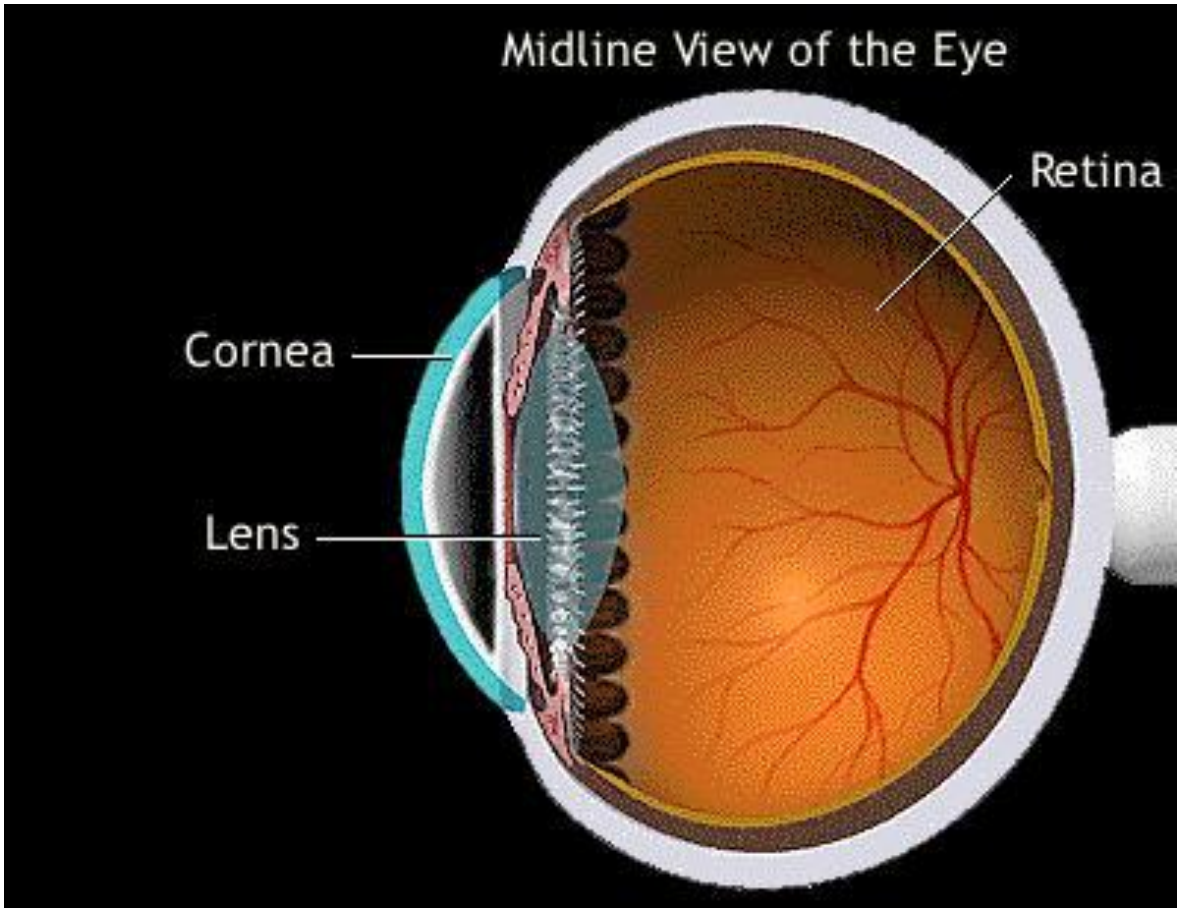
Eye Basic Anatomy: Eye can be “extracted” and “disassembled” (for study)

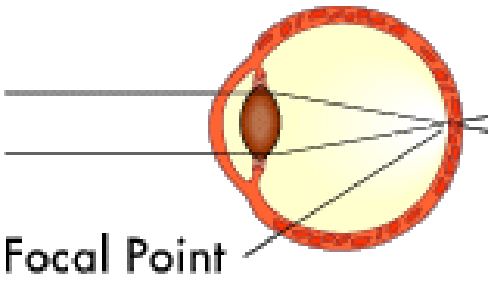




Human and Image Perception

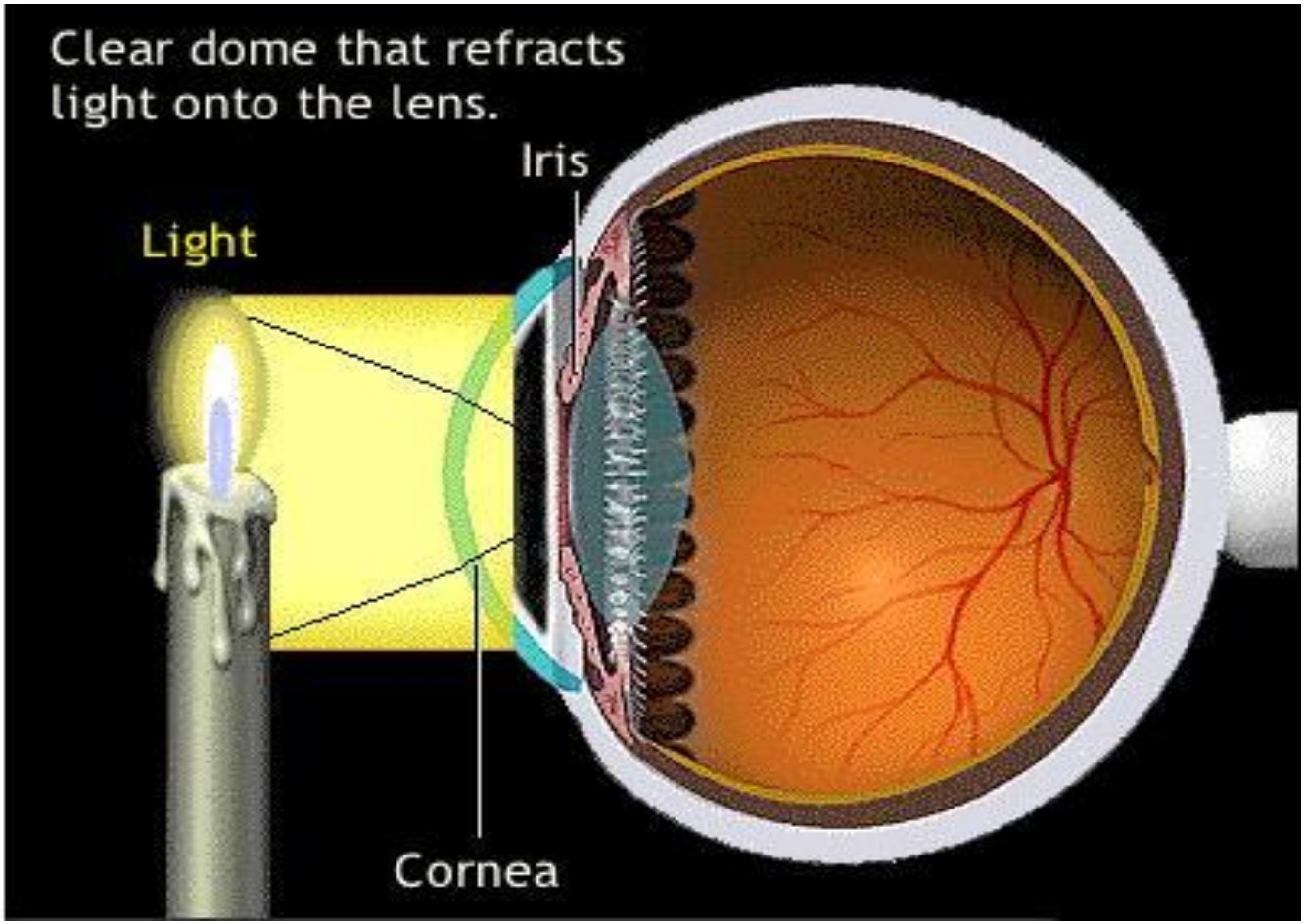
Simplified Midline View of the Eye (To explain how eye focuses)



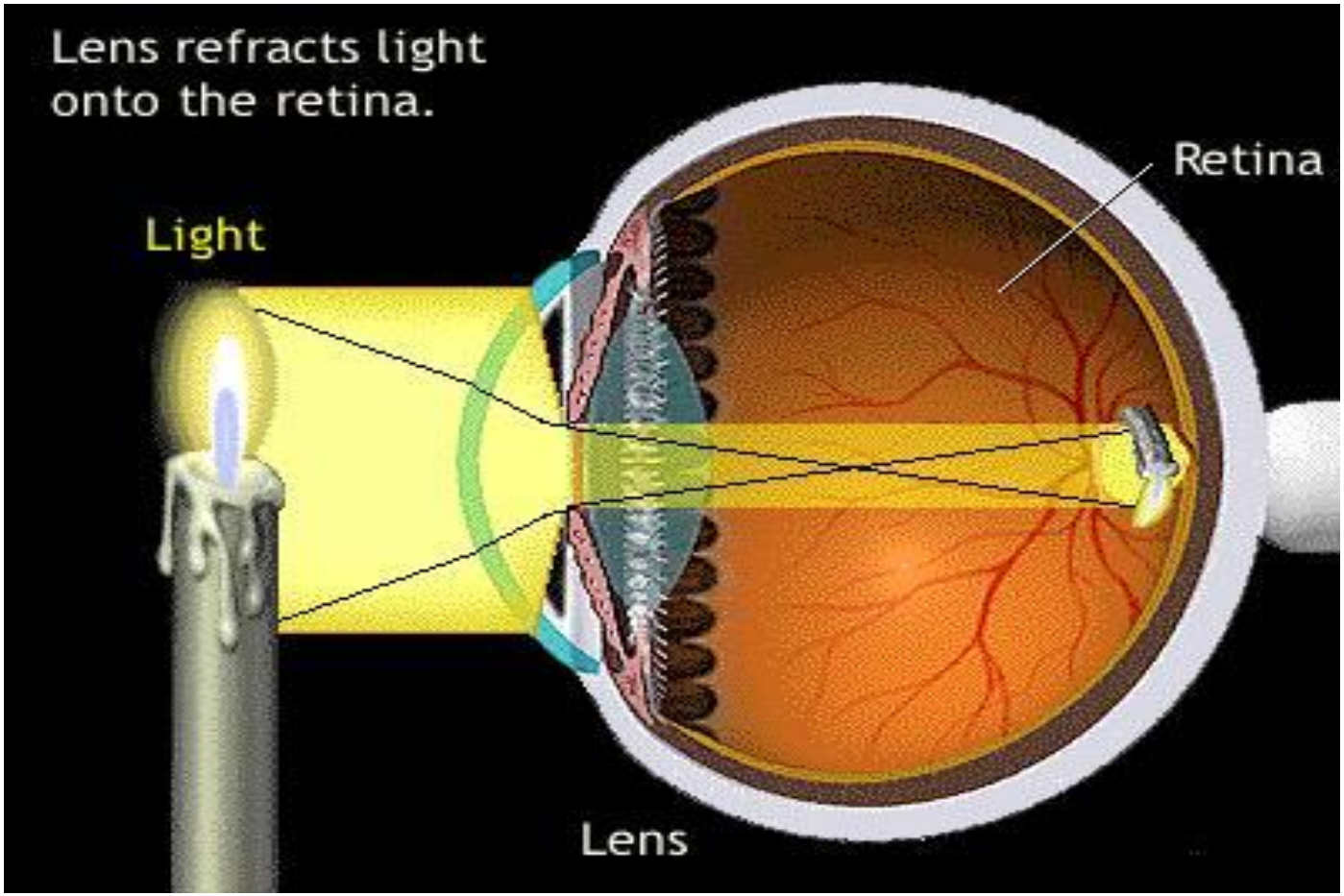


Human and Image Perception

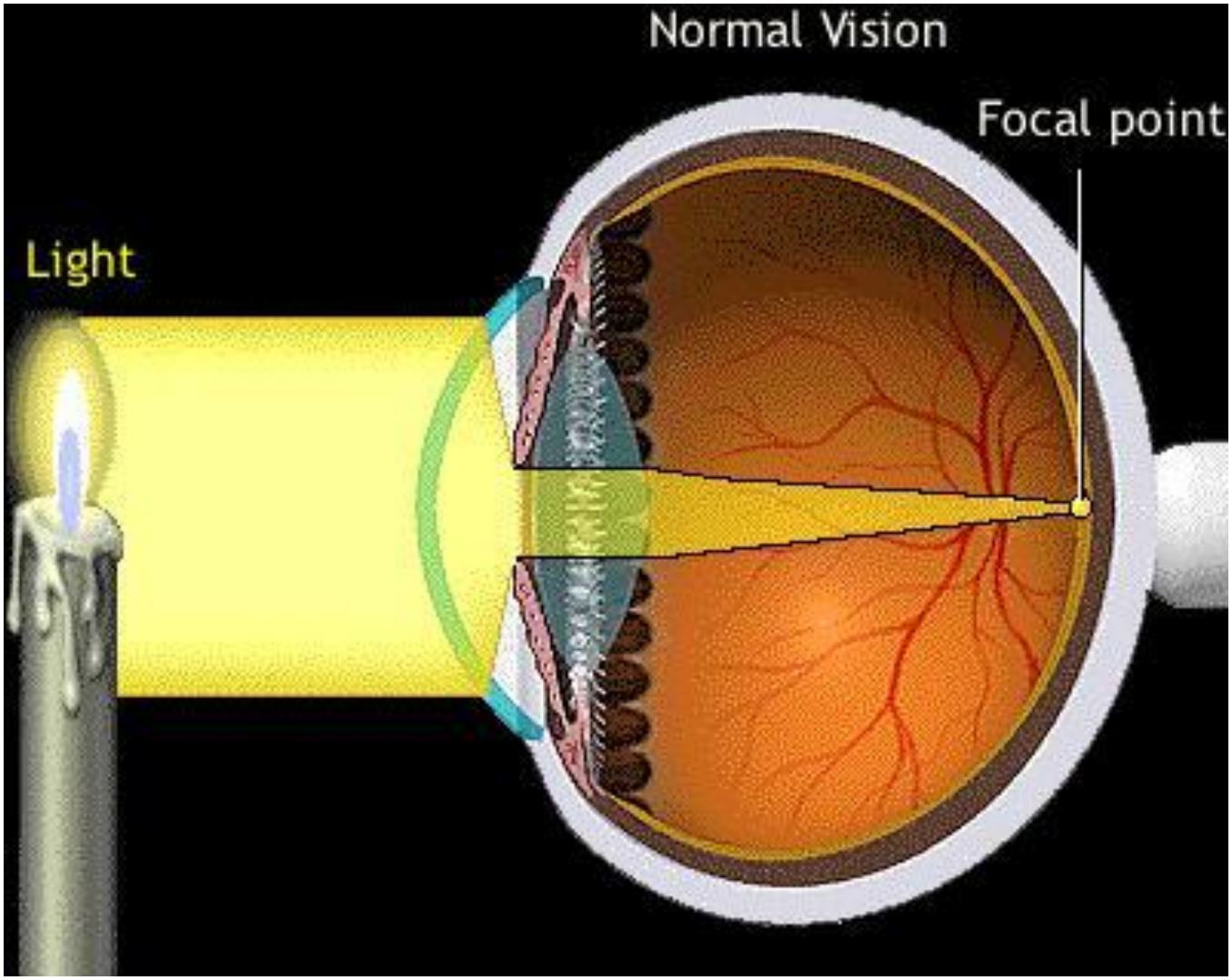
How eye focuses



Human and Image Perception

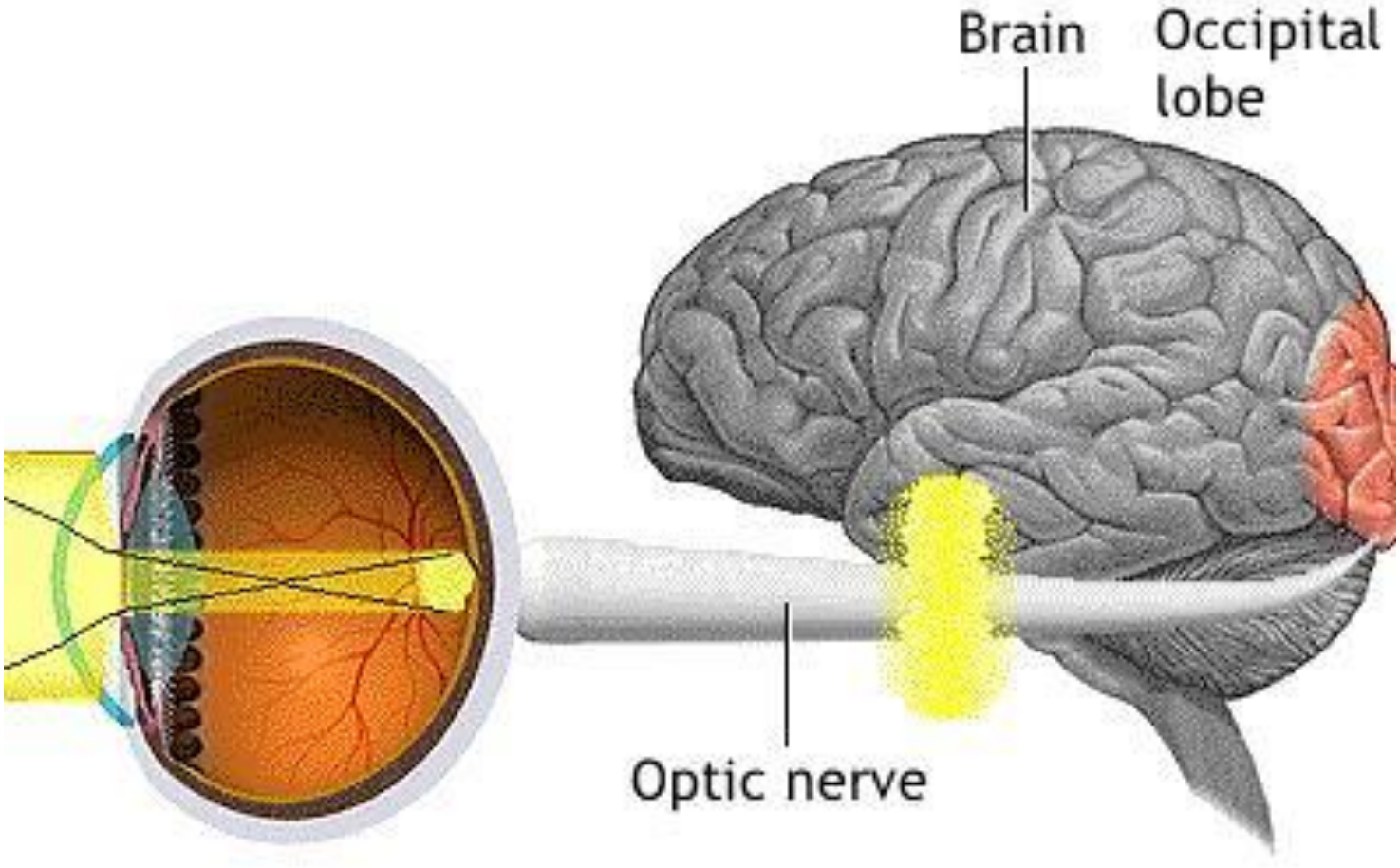


How eye focuses: Normal Vision-Focusing on the Retina

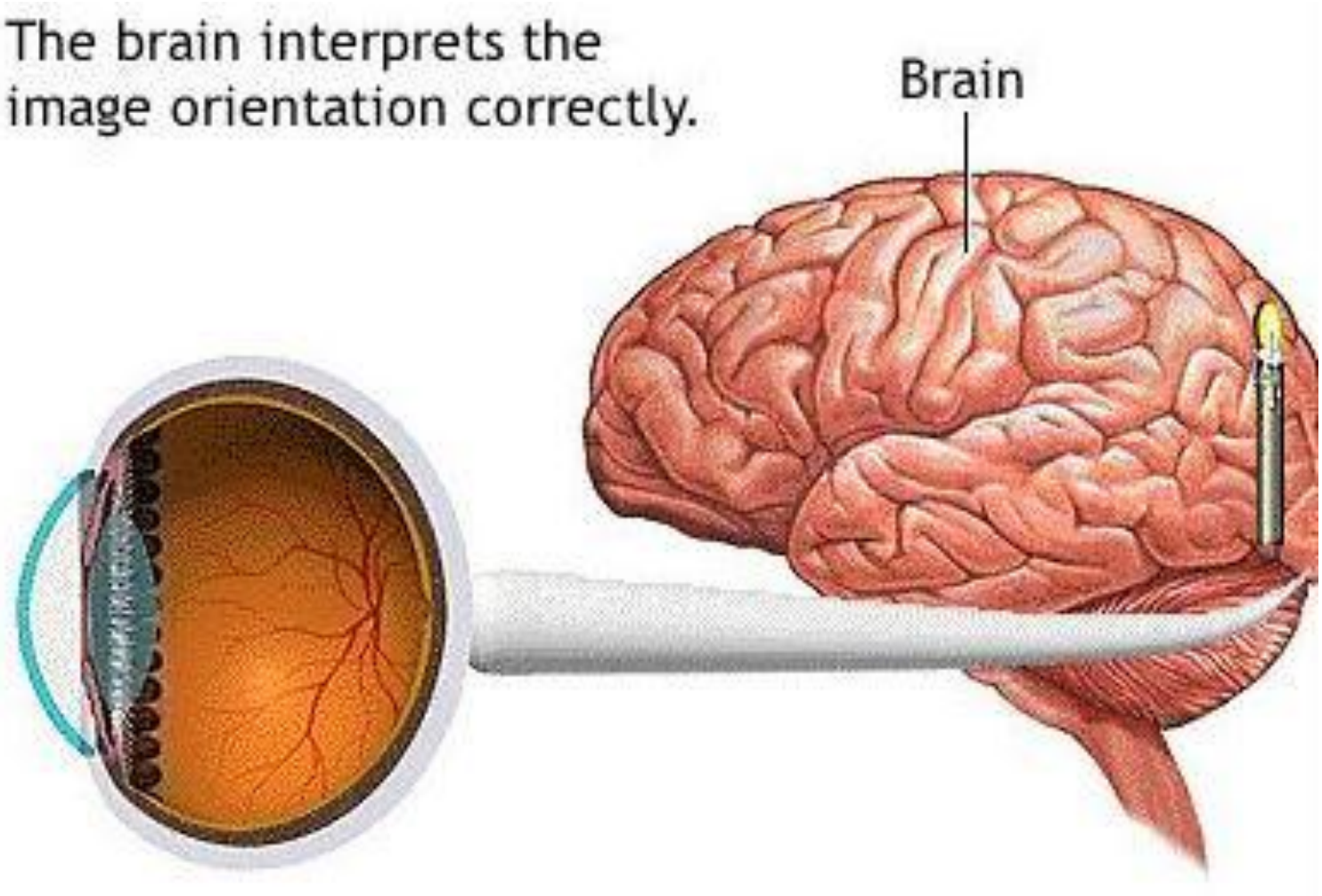


From Eye to the Brain

How does our brain receive this information?
Once the image is clearly focused on the sensitive part of the retina, energy in the light that makes up that image creates an electrical signal. Nerve impulses can then carry information about that image to the brain through the optic nerve.

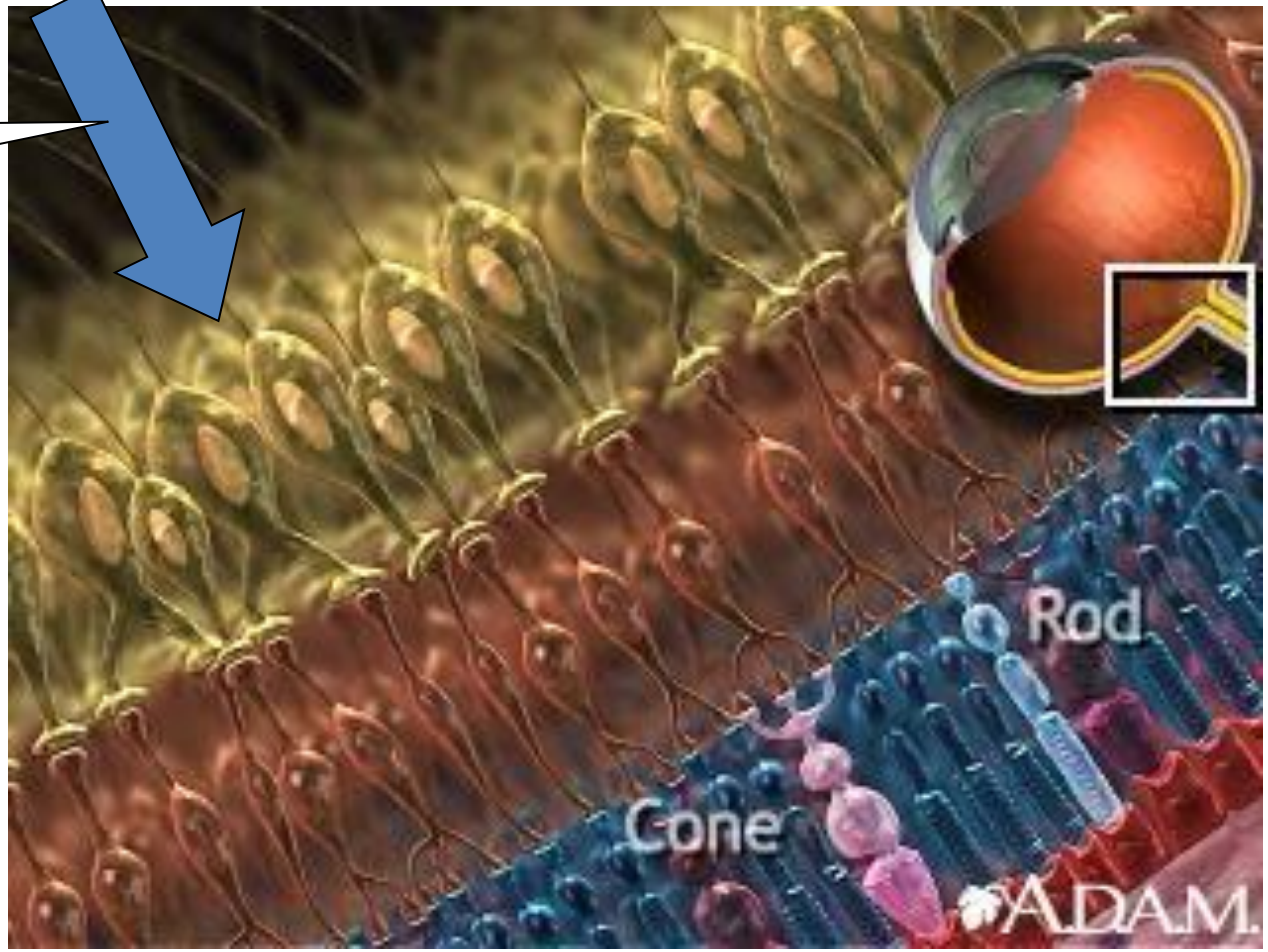


What we really “see” (after a number of days after the birth)



Retina: Contains specialized cells: (photo) receptors *{converts light into electrical signals}*
Rods – Black & White (Gray) images in low light (night)
Cones – Color Vision in bright light (day)

Direction of Light

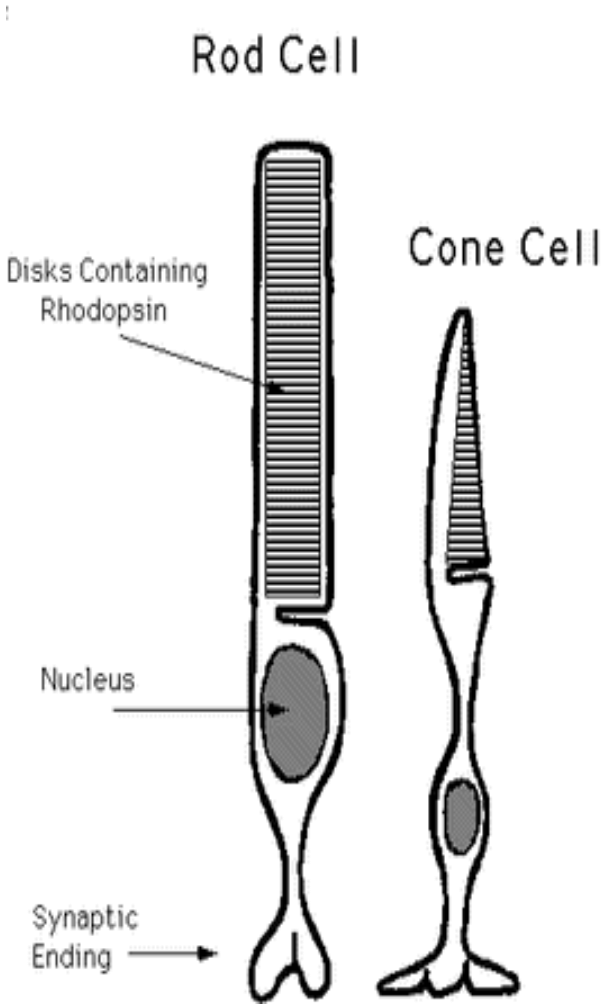


What happens when light reaches the retina?

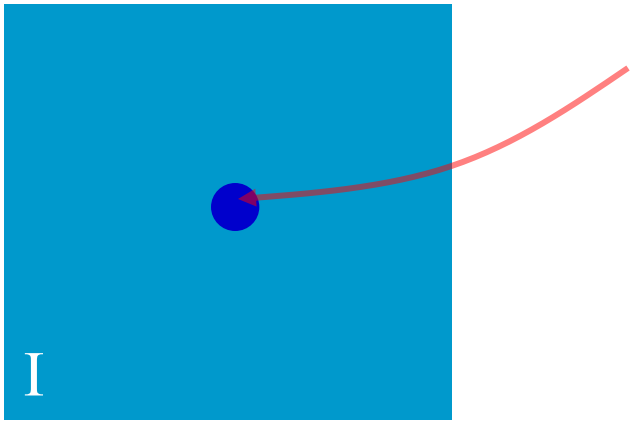
It is packed with photosensitive cells called rods and cones.

- Cones are the cells responsible for daylight vision there are three different kinds – each responding to a different wavelength of light
- One responds to red light, one to green light and one to blue light.
- It is these cones which allow us to see in colour and detail
- Rods, on the other hand, are responsible for night vision.
- They are sensitive to light but not to wavelength information (colour)

In darkness, the cones do not function at all– so we need rods in order to see thingseven if it is only in shades of grey



CONTRAST SENSITIVITY



Weber's ratio: $\Delta I_c/I$

Good brightness discrimination

⇨ $\Delta I_c/I$ is small.

Bad brightness discrimination

⇨ $\Delta I_c/I$ is large.

- The ability of the eye to discrimination b/w changes in brightness at any specific adaptation level is of considerable interest.
- I is uniformly illuminated on a flat area large enough to occupy the entire field of view.
- ΔI_c is the change in the object brightness required to just distinguish the object from the background

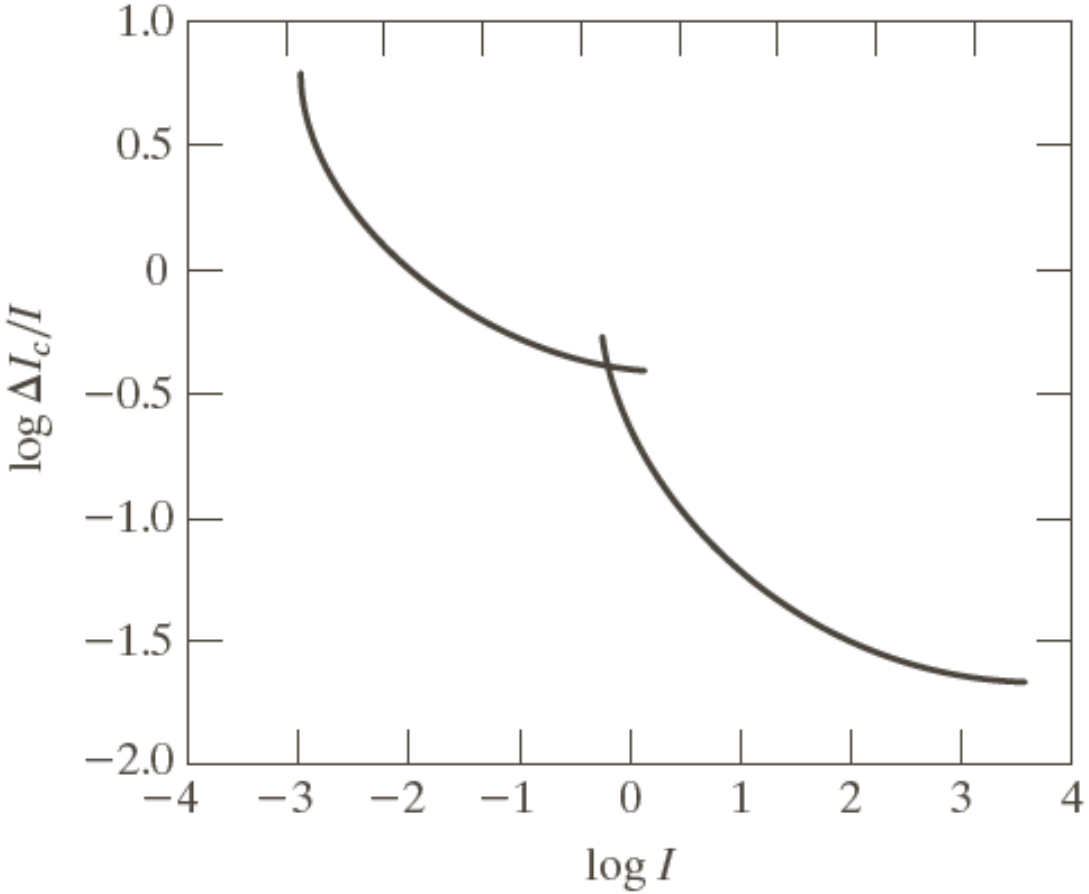


FIGURE 2.6
Typical Weber ratio as a function of intensity.

IMAGE FORMATION MODEL

- Image refers to a 2d light-intensity function, f*(x, y)*
- The amplitude of f at spatial coordinates *(x, y)* gives the intensity (brightness) of the image at that point.
- Light is a form of energy thus f*(x, y)* must be nonzero and finite.

$$0 < f(x, y) < \infty.$$

IMAGE FORMATION MODEL

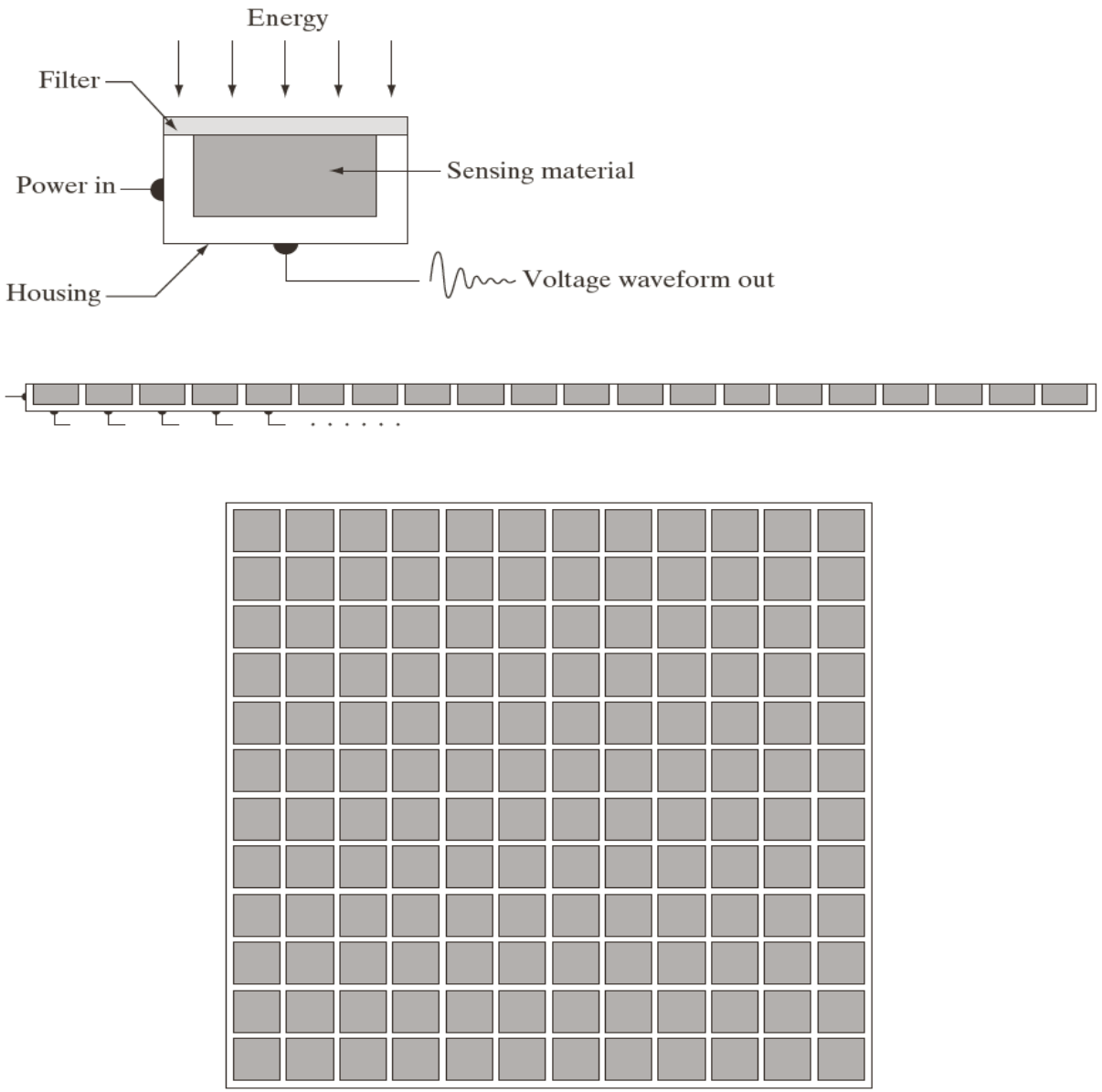
- The function f(x, y) may be characterized by two components:
  - The amount of source light incident on the scene being viewed ⇨ illumination.
  - The amount of light reflected by the objects in the scene ⇨ reflectance.

$$f(x, y) = i(x, y)r(x, y)$$

$$0 < i(x, y) < \infty$$

$$0 < r(x, y) < 1.$$

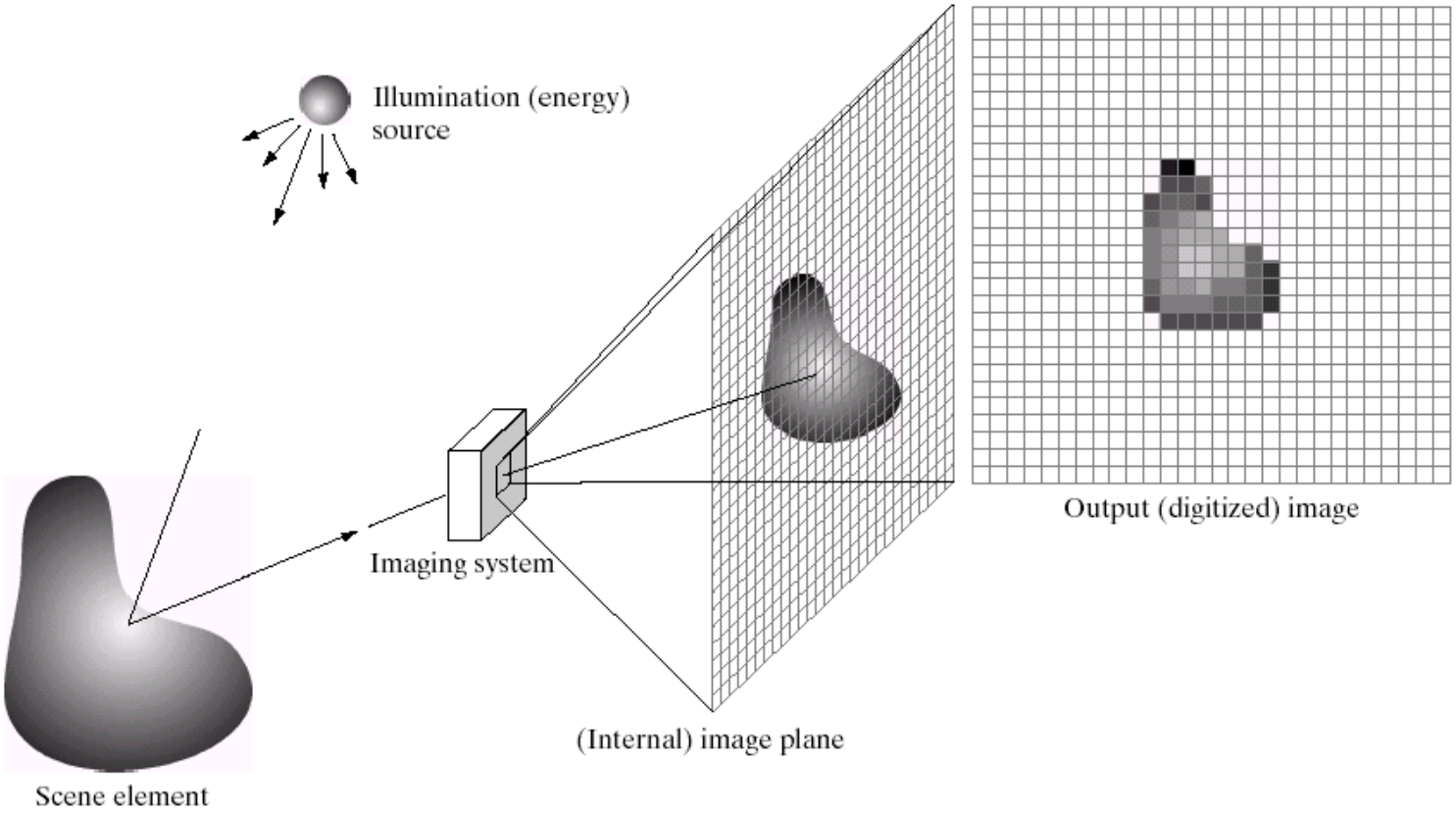
Image Acquisition



a
b
c

FIGURE 2.12
(a) Single imaging sensor.
(b) Line sensor.
(c) Array sensor.

Image Acquisition



a
b c d e

FIGURE 2.15 An example of the digital image acquisition process. (a) Energy ("illumination") source. (b) An element of a scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

Sampling and Quantization

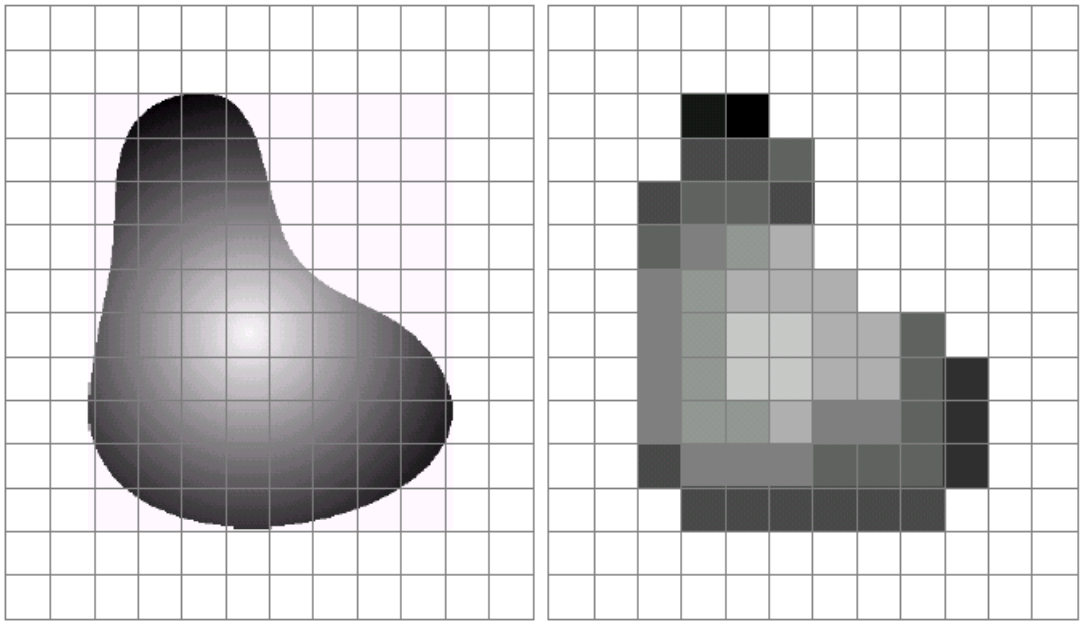
- Sampling:
  - Digitization of the spatial coordinates (x,y)
- Quantization:
  - Digitization in amplitude (also known as gray level quantization)

Sampling and Quantization

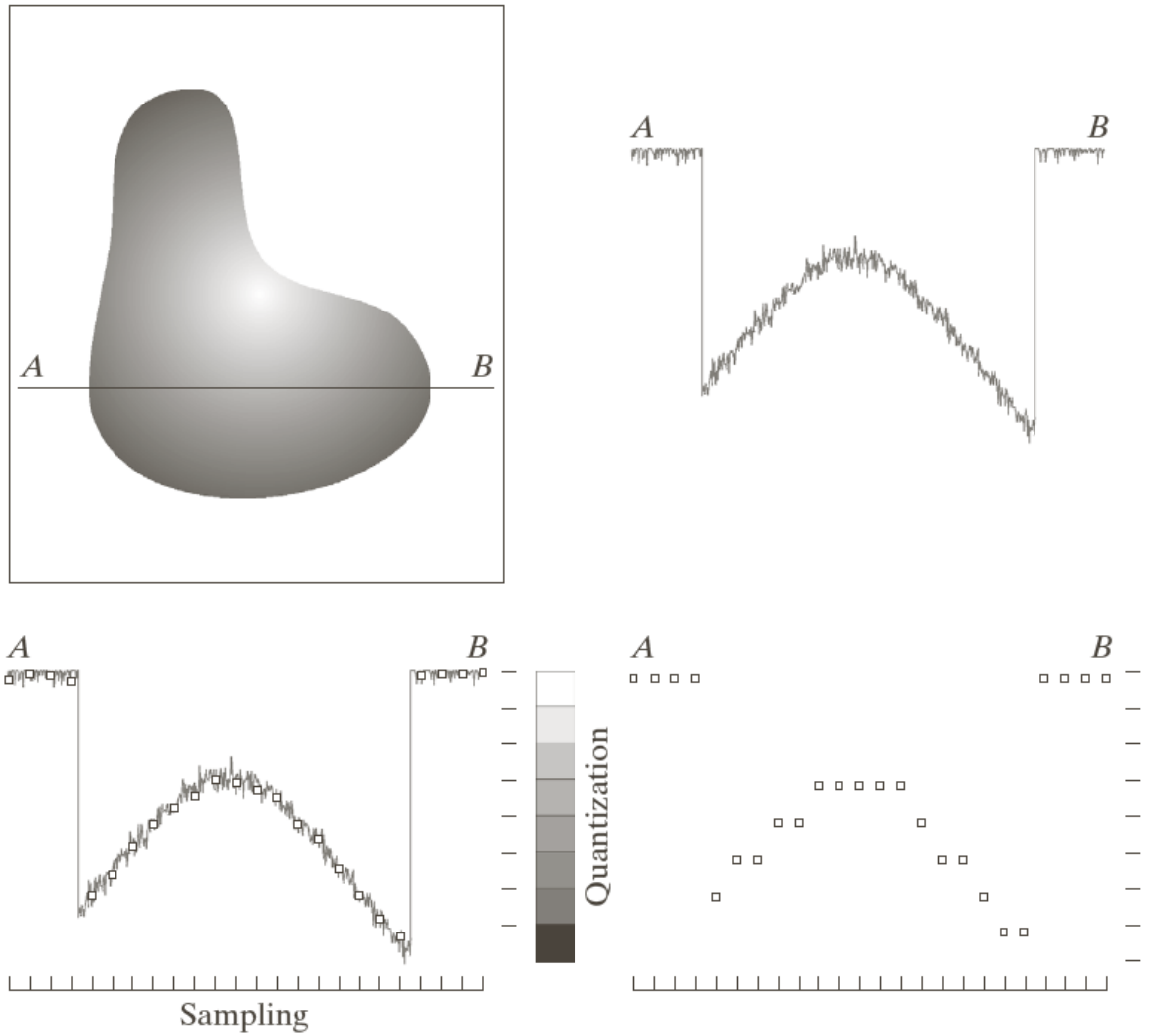
- Quantization
  - 8 bit quantization: 2^8 =256 gray levels (0: black, 255: white)
  - 1 bit quantization: 2 gray levels (0: black, 1: white) – binary
- Sampling
  - Commonly used number of samples (resolution)
    - Digital still cameras: 640x480, 1024x1024, 4064 x 2704
    - Digital video cameras: 640x480 at 30 frames/second (fps)

Sampling and Quantization

- Digital Image is an approximation of a real world scene



Sampling and Quantization



a b
c d

FIGURE 2.16 Generating a digital image. (a) Continuous image. (b) A scan line from *A* to *B* in the continuous image, used to illustrate the concepts of sampling and quantization. (c) Sampling and quantization. (d) Digital scan line.

Image Formation

- Digital Image is an approximation of a real world scene

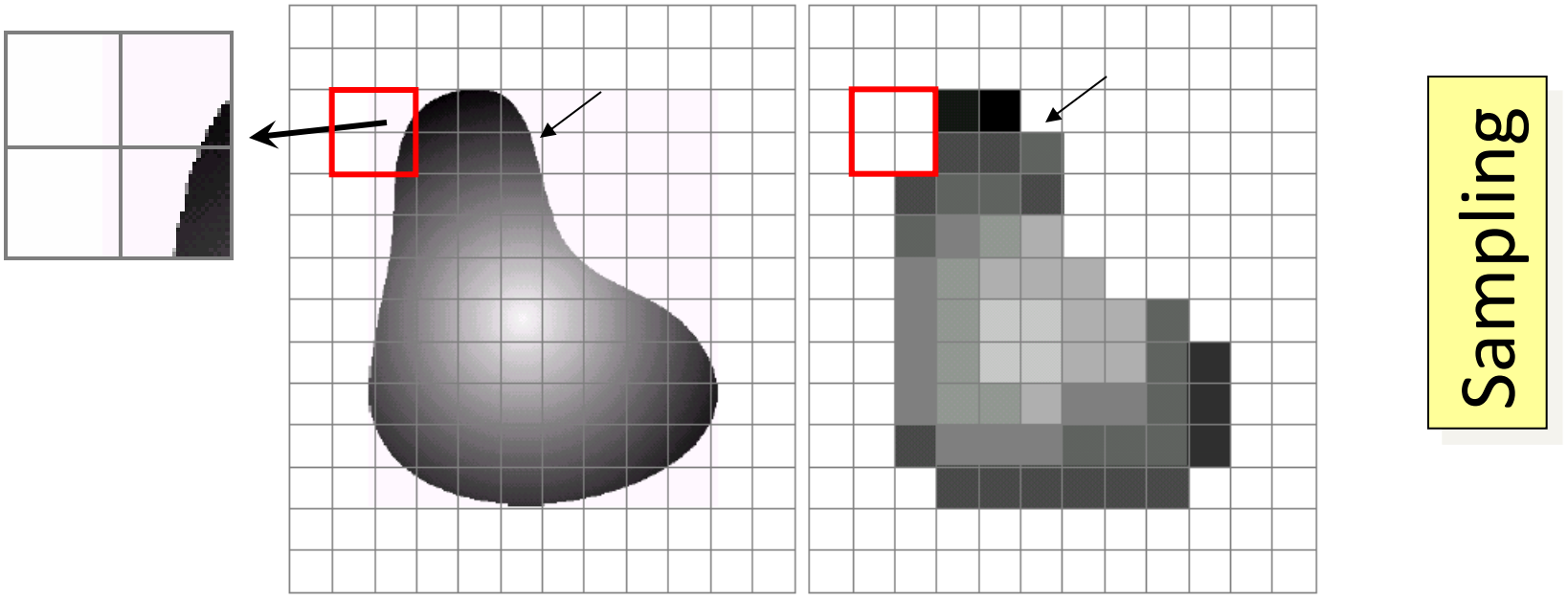


Image Formation

- Digital Image is an approximation of a real world scene