EEE-6512: Image Processing and Computer Vision

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Lecture #3: Digital Image Fundamentals
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Outline

Section 2.1: Elements of Visual Perception

Section 2.2: Light and the Electromagnetic Spectrum

Section 2.3: Image Sensing and Acquisition

Section 2.4: Image Sampling and Quantization

Section 2.5: Some Basic Relationships Between Pixels

Elements of Visual Perception

Elements of Visual Perception

- Diameter of about 20mm
- Inner most membrane is the retina (light is imaged on retina)
- Two types of light receptors are distributed over the retina's surface (Cones and Rods)
- Cones are primary located in the fovea region
- Cones are responsible for photopic or bright light vision
- Rods are responsible for scotopic or dim-light vision

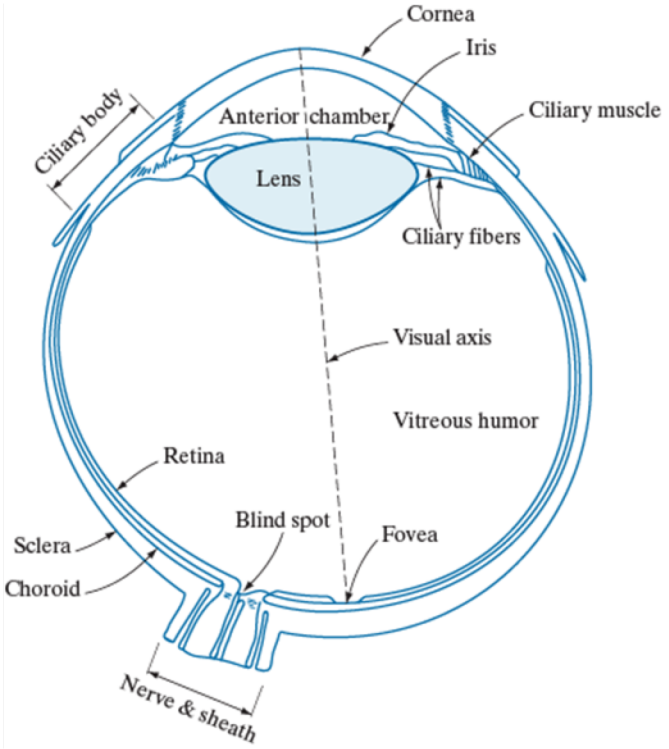


FIGURE 2.1
Simplified diagram of a cross section of the human eye.

Elements of Visual Perception

- Cones – 6-7 million
- Rods – 75-150 million
- Cones allow humans to resolve fine detail because each cone is connect to a nerve end.
- Cones are concentrated in fovea region

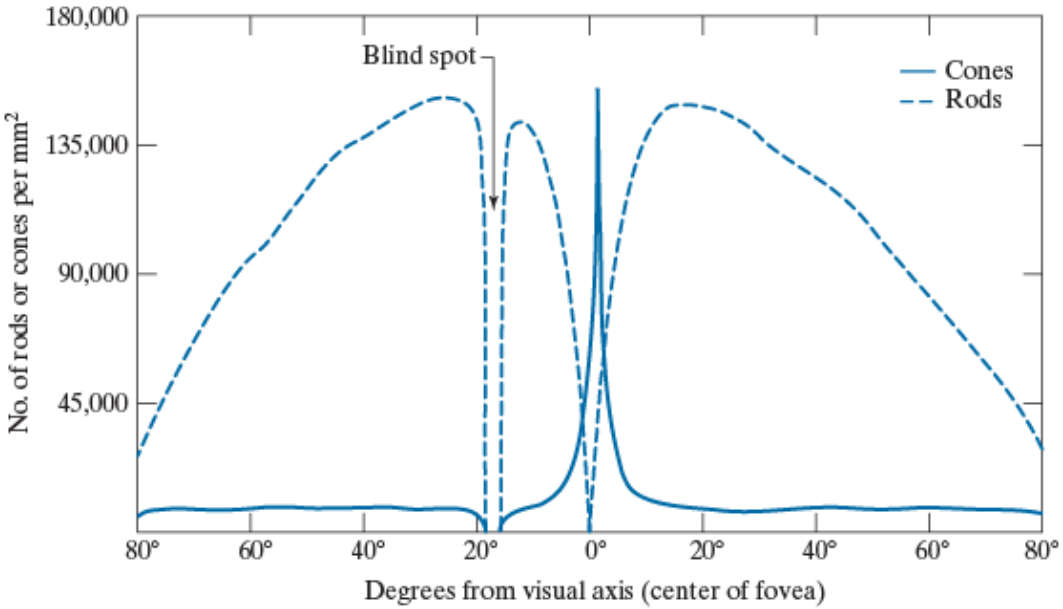


Image Formation in the Eye

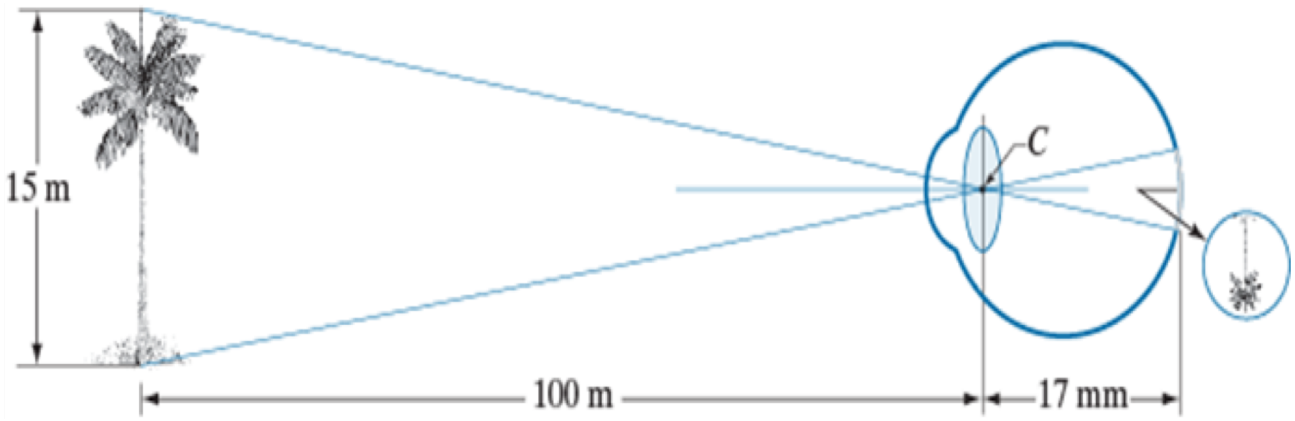


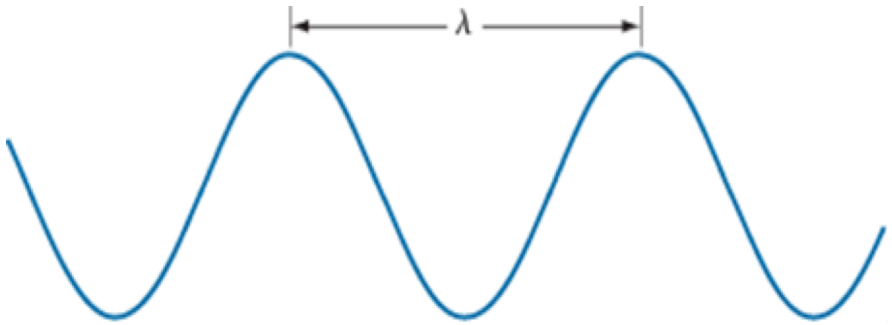
FIGURE 2.3
Graphical representation of the eye looking at a palm tree. Point *C* is the focal center of the lens.

- Human visual system can adapt to on the order of 10^{10} light levels
- However the visual system can not adapt to this range simultaneously

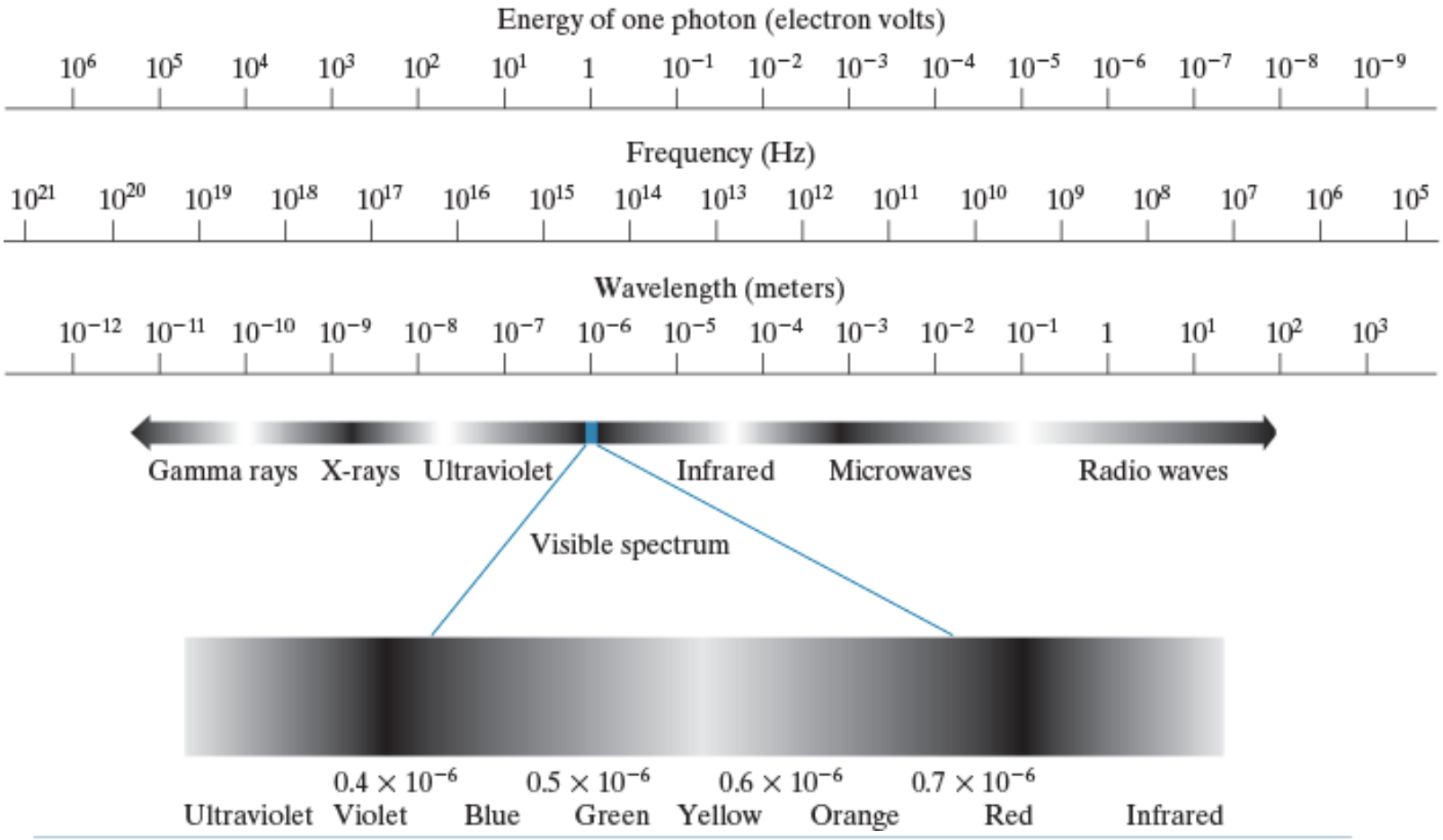
Light and the Electromagnetic Spectrum

Light and the Electromagnetic Spectrum

- Can be visualized as propagating sinusoidal waves
- Units of wavelength are meters (microns, nanometers)
- Frequency is measured in hertz.
- High energy electromagnetic radiation is harmful to humans



Light and the Electromagnetic Spectrum



Light and the Electromagnetic Spectrum

- Colors perceived by an object are determined by the nature of the light reflected.
- A body that reflects light relatively balanced in all visible waveforms is perceived as white.
- Light that is void of color is called monochromatic light. (Varies from black to shades of gray)
- Chromatic light spans from .43 - .79 μm and is described by:
    - Luminance – the amount of energy the observer perceives
    - Radiance - the total amount of energy that flows from light source
    - Brightness – subjective descriptor of light perception (Impossible to measure)

Image Sensing and Acquisition

Image Sensing and Acquisition

a
b
c

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

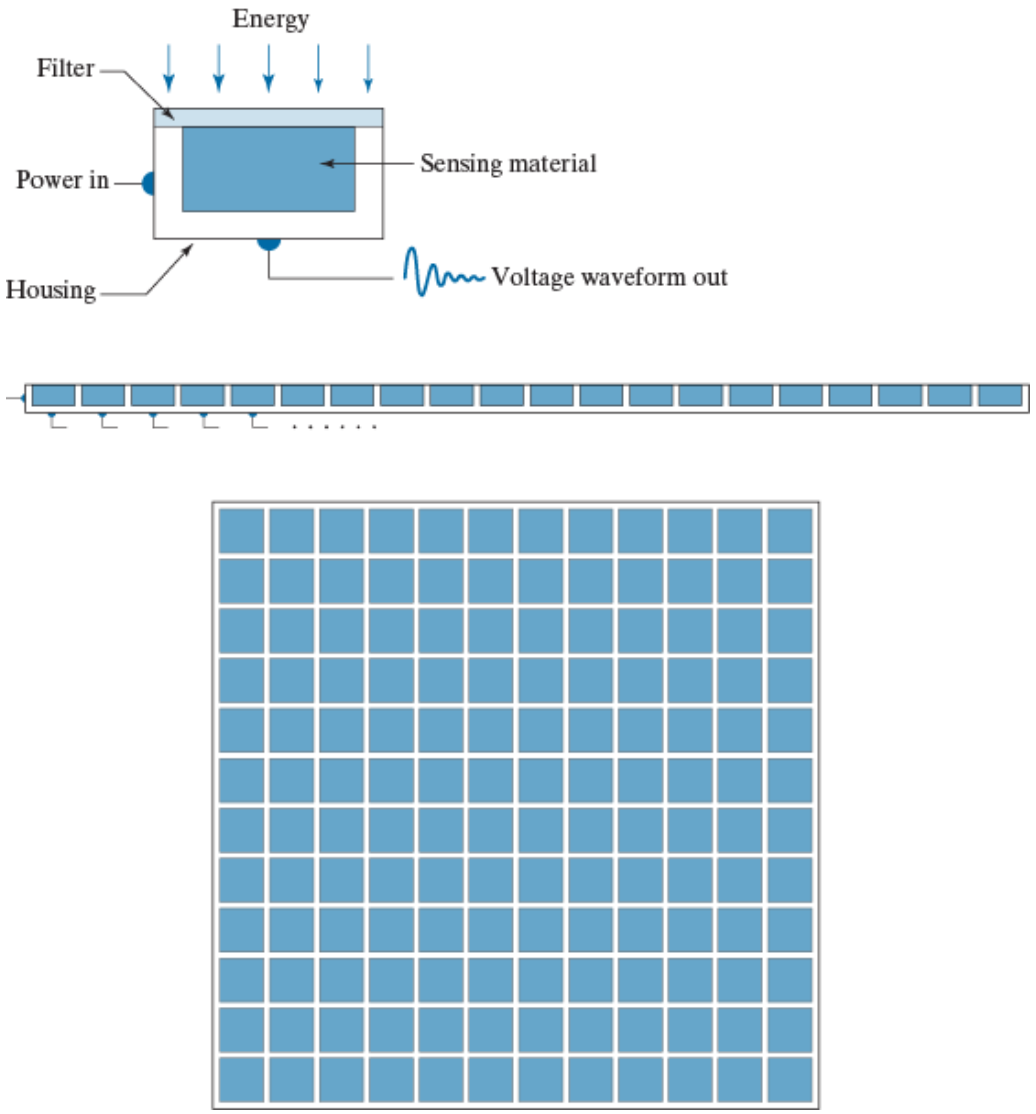


Image Sensing and Acquisition

FIGURE 2.13
Combining a single sensing element with mechanical motion to generate a 2-D image.

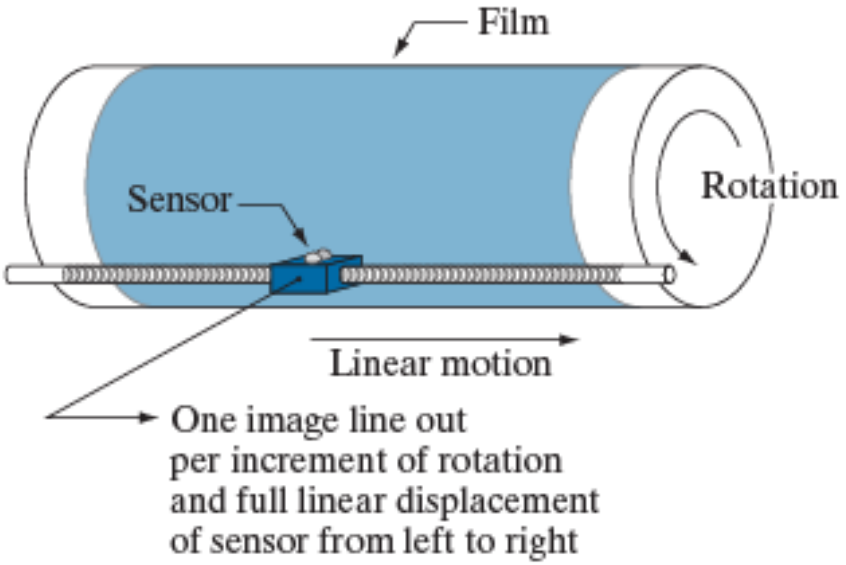
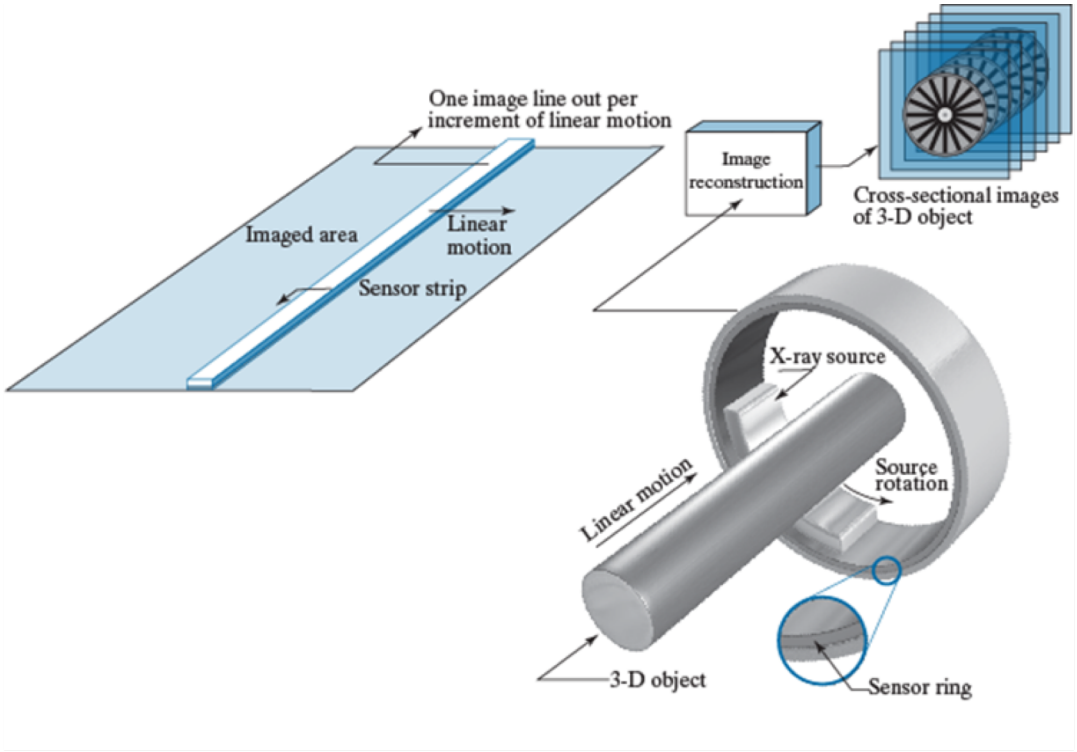


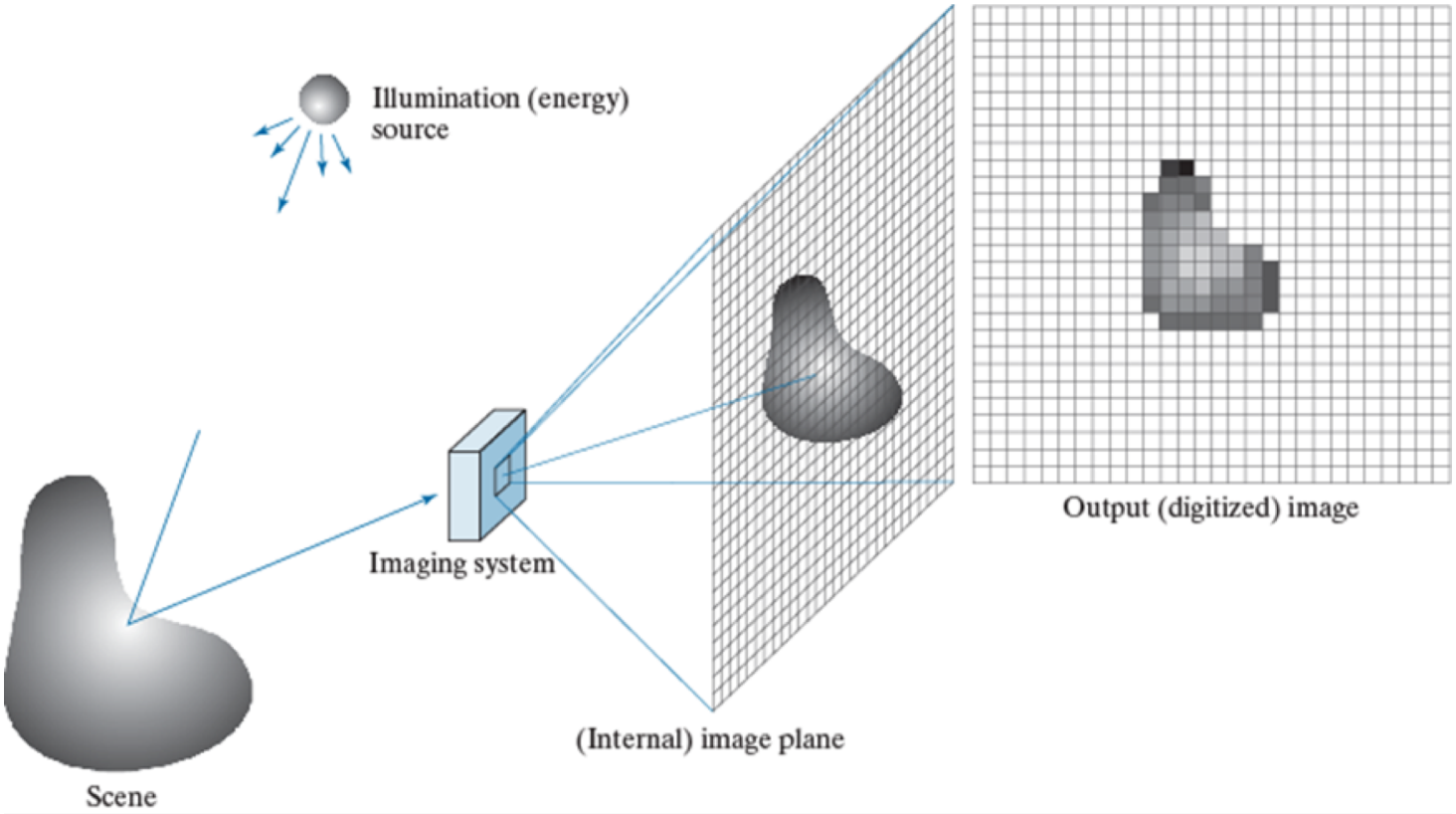
Image Sensing and Acquisition



a b

FIGURE 2.14 (a) Image acquisition using a linear sensor strip. (b) Image acquisition using a circular sensor strip.

Image Sensing and Acquisition



a
b c d e

FIGURE 2.15 An example of digital image acquisition. (a) Illumination (energy) source. (b) A scene. (c) Imaging system. (d) Projection of the scene onto the image plane. (e) Digitized image.

Image Sampling and Quantization

Image Sampling and Quantization

a b
c d

FIGURE 2.16
(a) Continuous image. (b) A scan line showing intensity variations along line *AB* in the continuous image. (c) Sampling and quantization. (d) Digital scan line. (The black border in (a) is included for clarity. It is not part of the image).

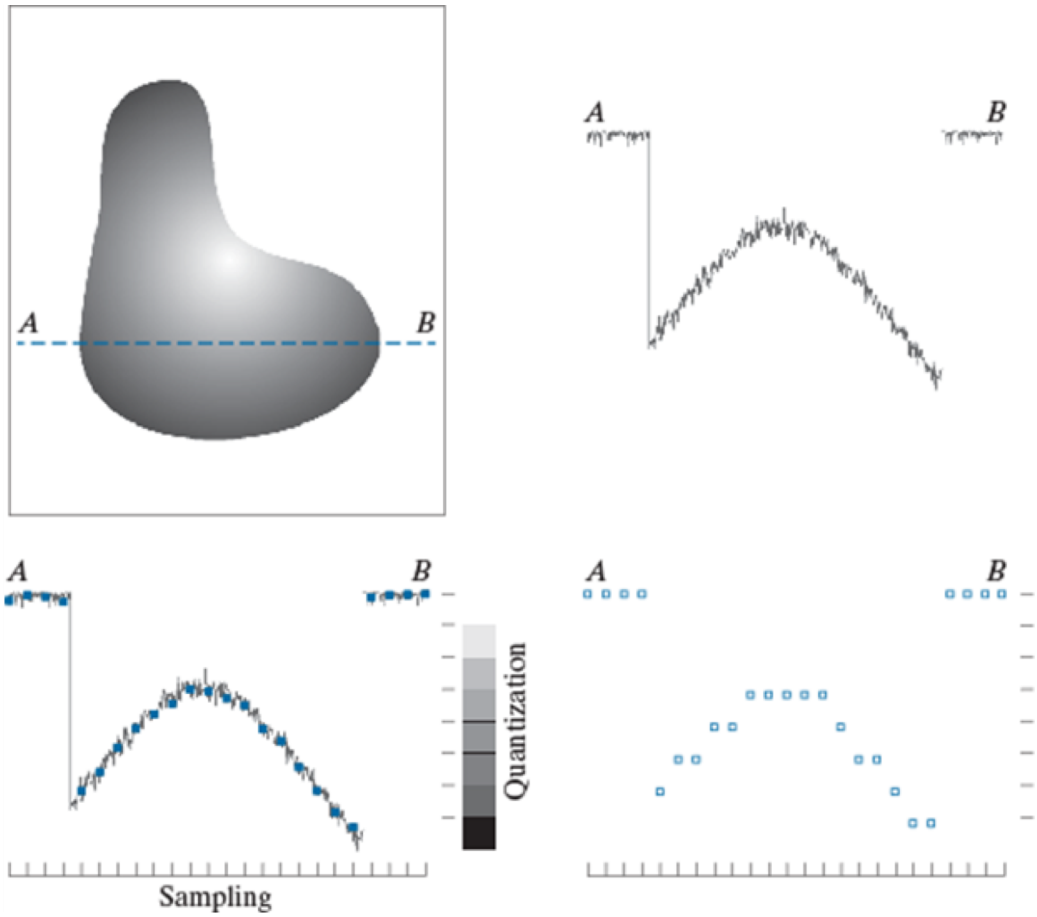


Image Sampling and Quantization

a b

FIGURE 2.17
(a) Continuous image projected onto a sensor array. (b) Result of image sampling and quantization.

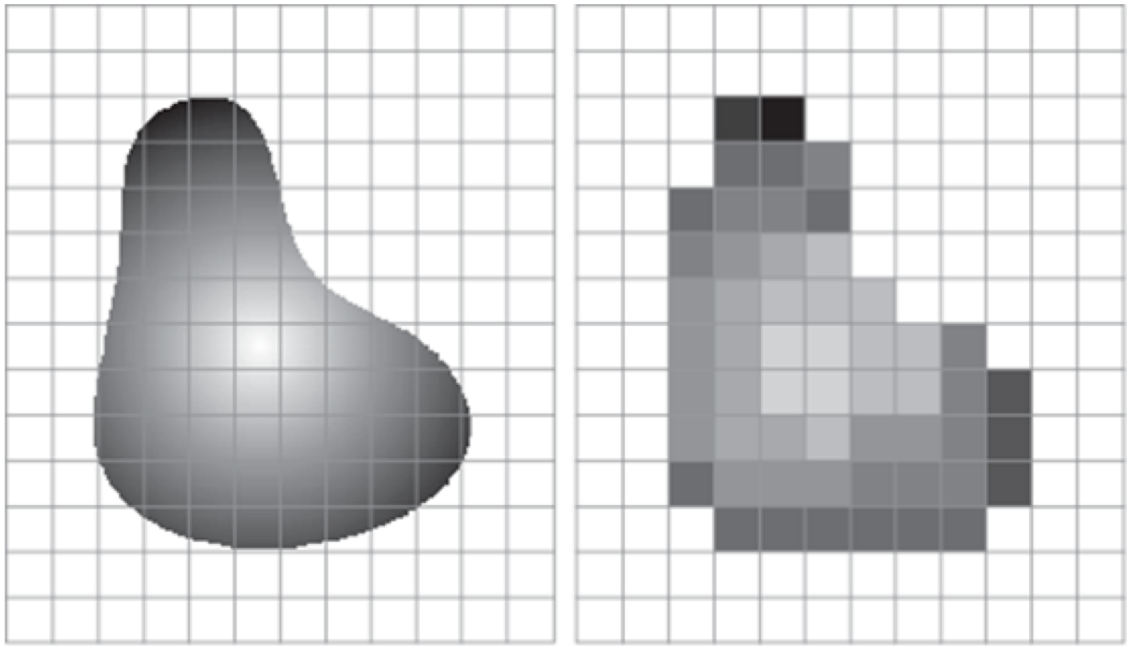


Image Sampling and Quantization

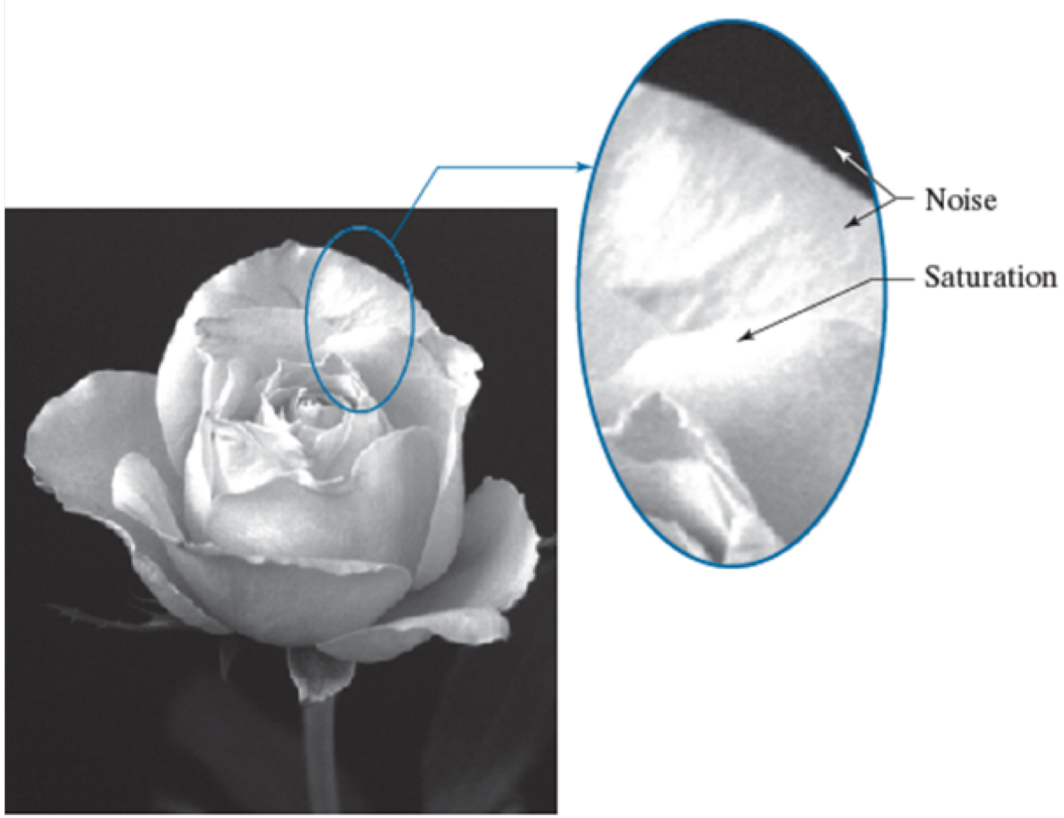


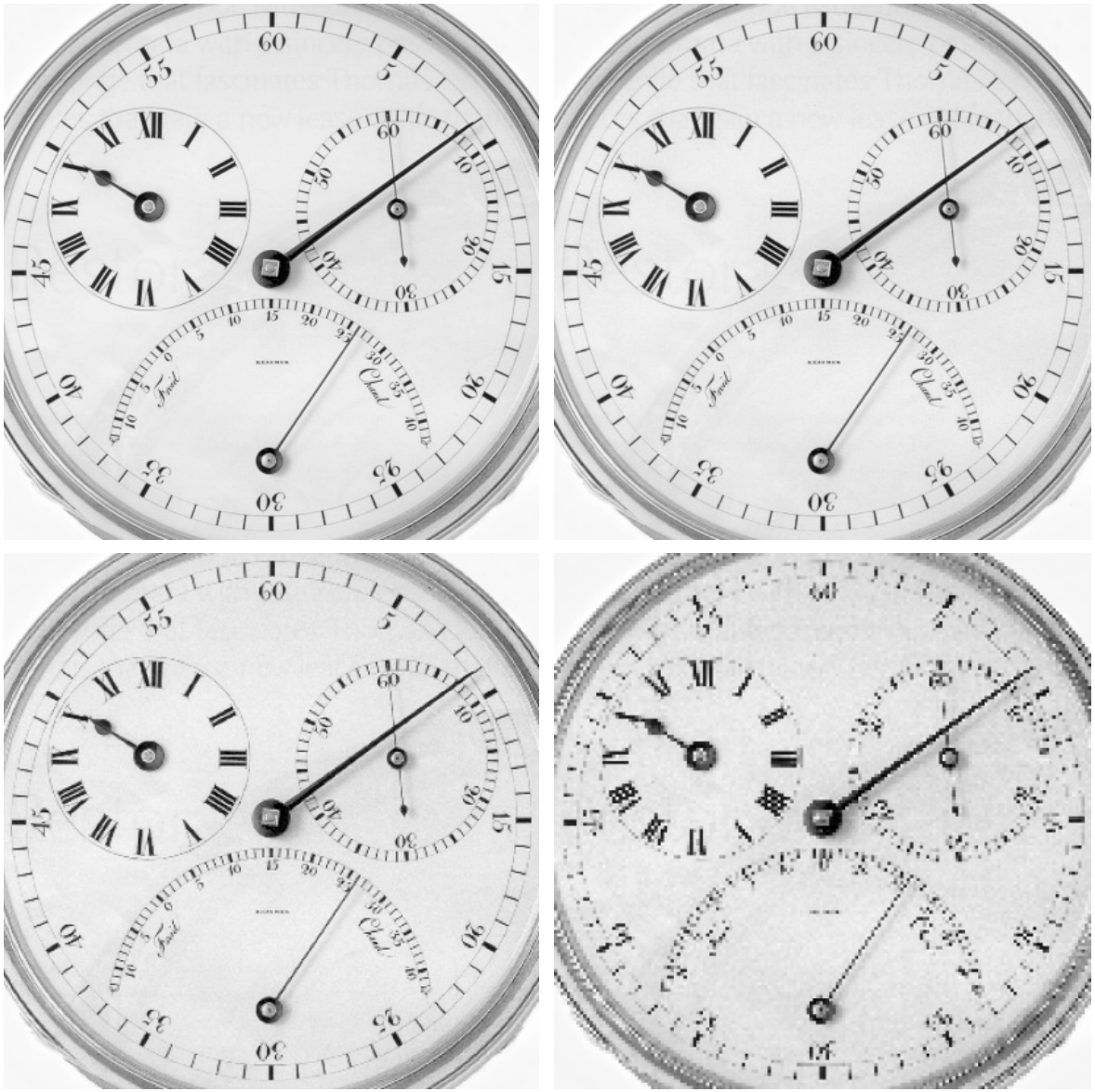
FIGURE 2.20
An image exhibiting saturation and noise. Saturation is the highest value beyond which all intensity values are clipped (note how the entire saturated area has a high, constant intensity level). Visible noise in this case appears as a grainy texture pattern. The dark background is noisier, but the noise is difficult to see.

Image Sampling and Quantization

Spatial and Intensity Resolution

- Spatial resolution is the smallest discernible detail in an image (eg. dots per unit distance, DPI).
- Intensity resolution is the smallest discernible change in intensity level (usually an integer power of 2)

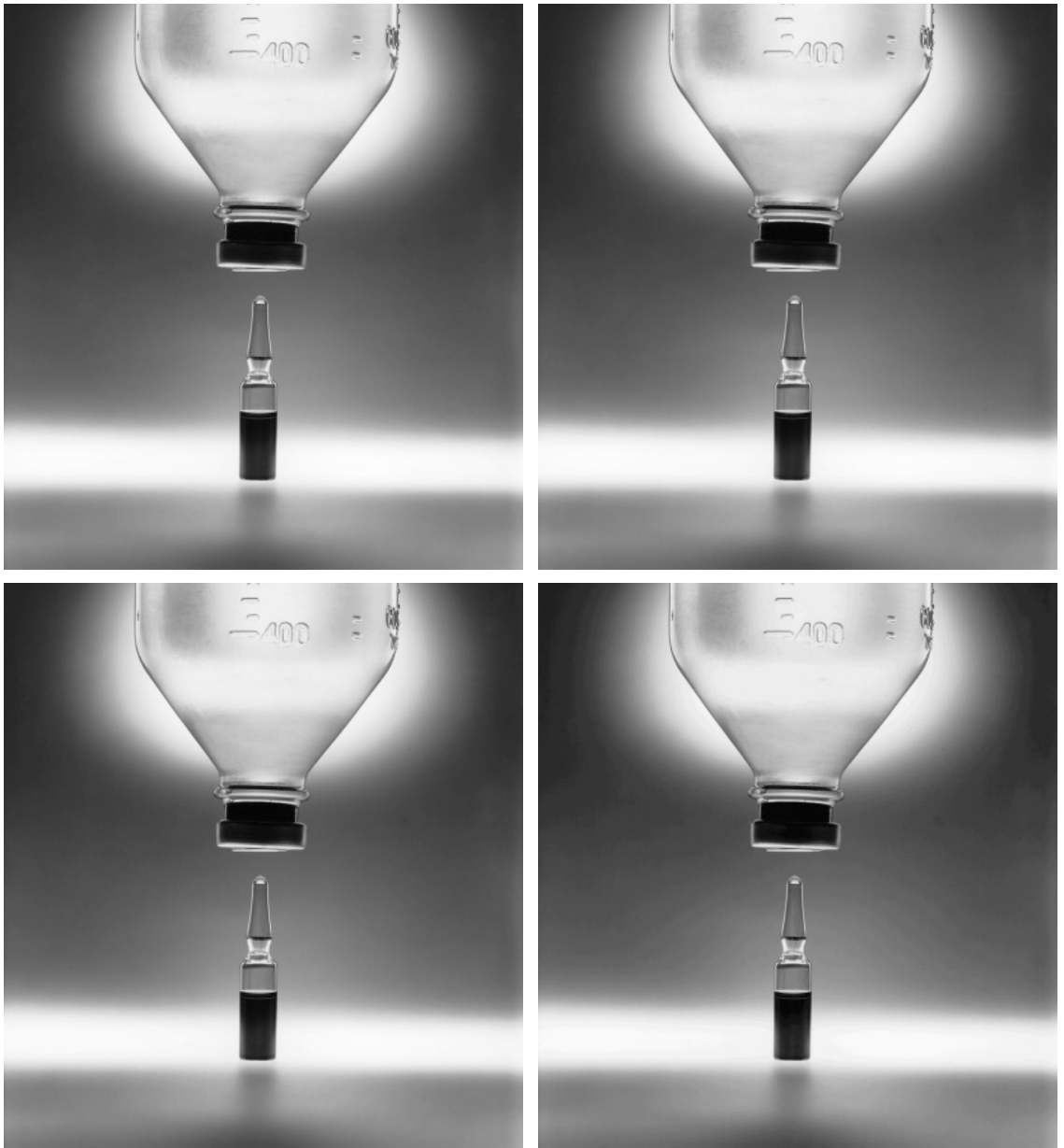
Image Sampling and Quantization



a b
c d

FIGURE 2.23
Effects of reducing spatial resolution. The images shown are at:
(a) 930 dpi,
(b) 300 dpi,
(c) 150 dpi, and
(d) 72 dpi.

Image Sampling and Quantization



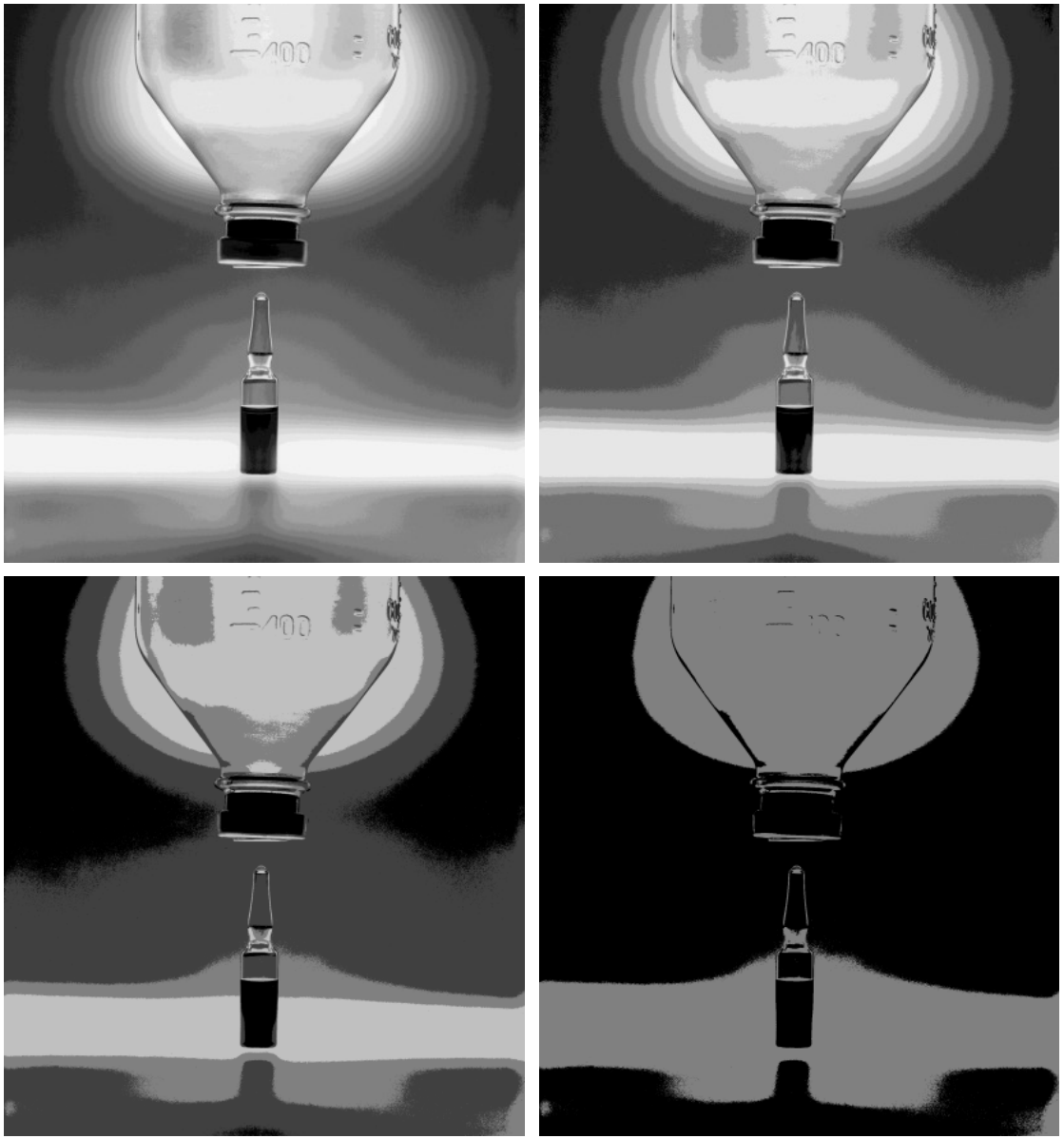
a b
c d

FIGURE 2.24
(a) 2022 × 1800, 256-level image. (b)-(d) Image displayed in 128, 64, and 32 intensity levels, while keeping the image size constant. (Original image courtesy of the National Cancer Institute.)

Image Sampling and Quantization

e f
g h

FIGURE 2.24
(*Continued*)
(e)-(h) Image displayed in 16, 8, 4, and 2 intensity levels. (Original image courtesy of the National Cancer Institute.)



Questions?