

Digital Image Processing

Digital Image Fundamentals

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- 1) Understanding human vision
- 2) Image sampling and quantization
- 3) Resolution and effects on image appearance
- 4) Geometric relationships between image processing

FIGURE 2.1

Simplified diagram of a cross section of the human eye.

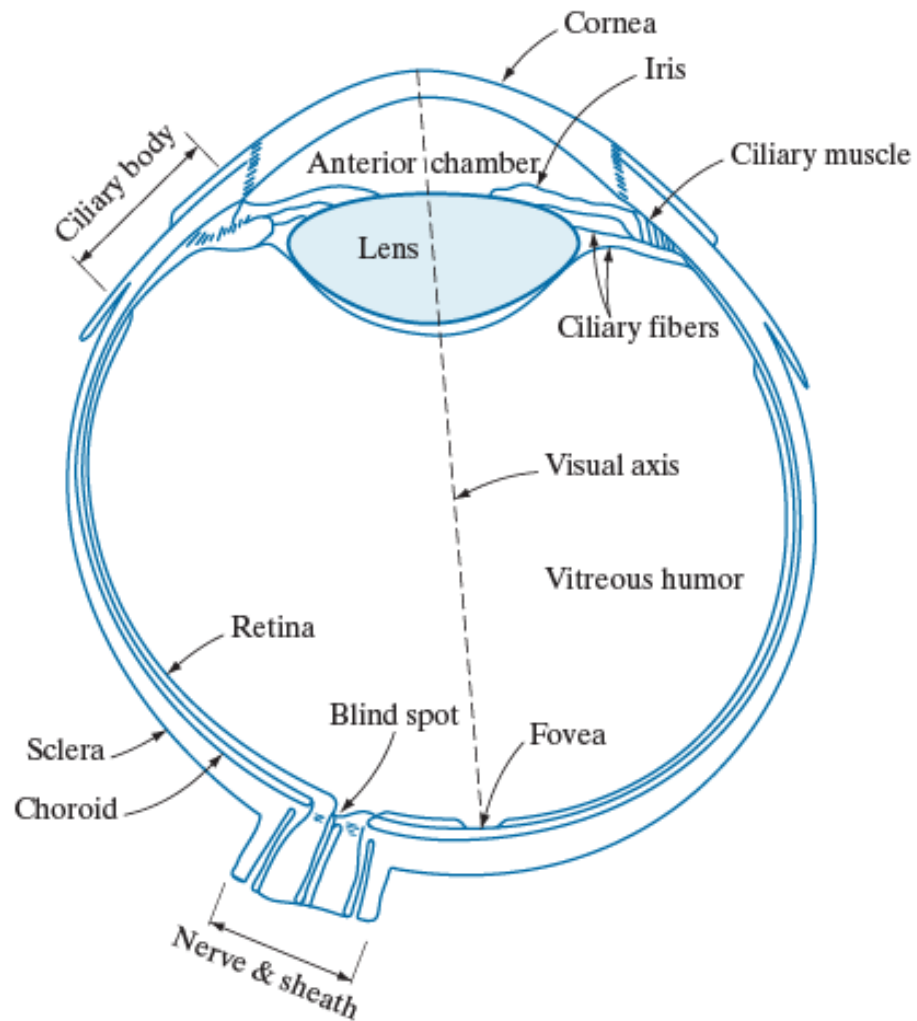


FIGURE 2.2
Distribution of
rods and cones in
the retina.

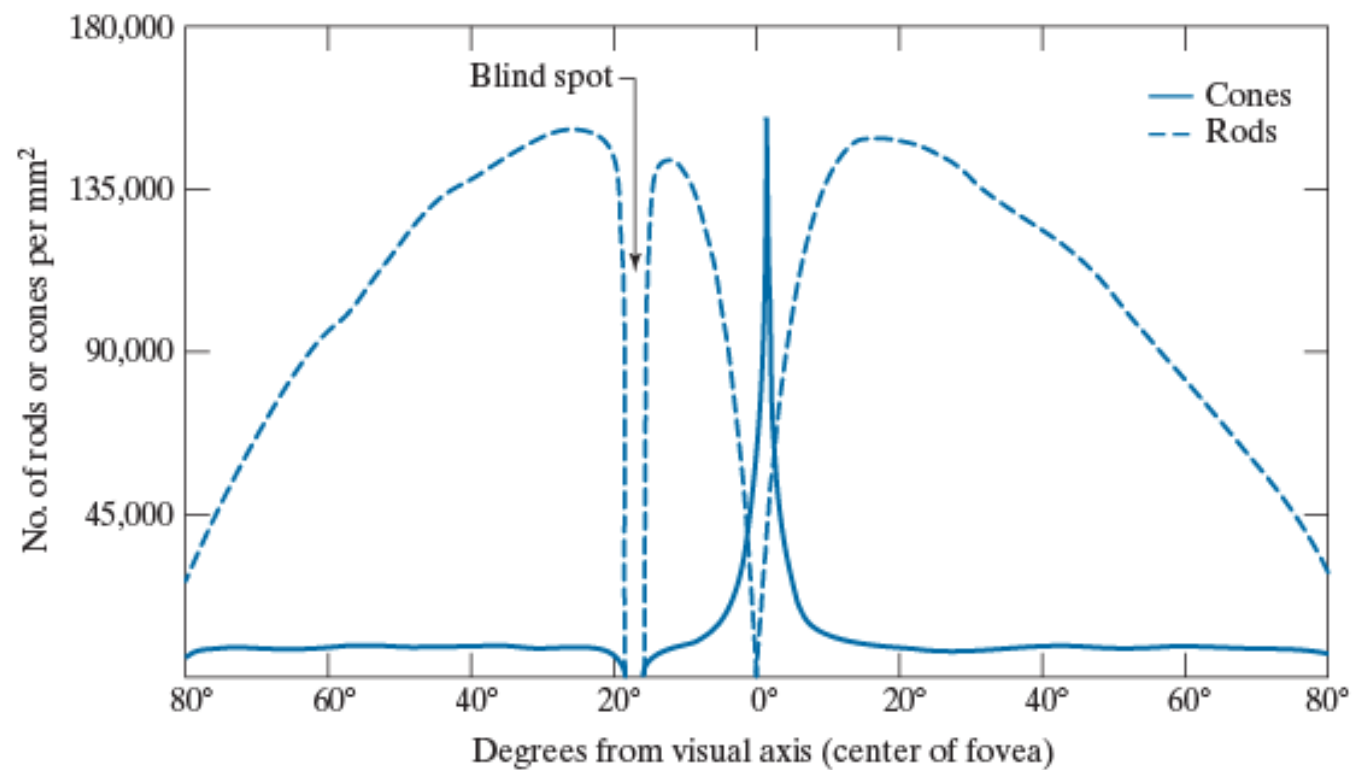


FIGURE 2.3

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

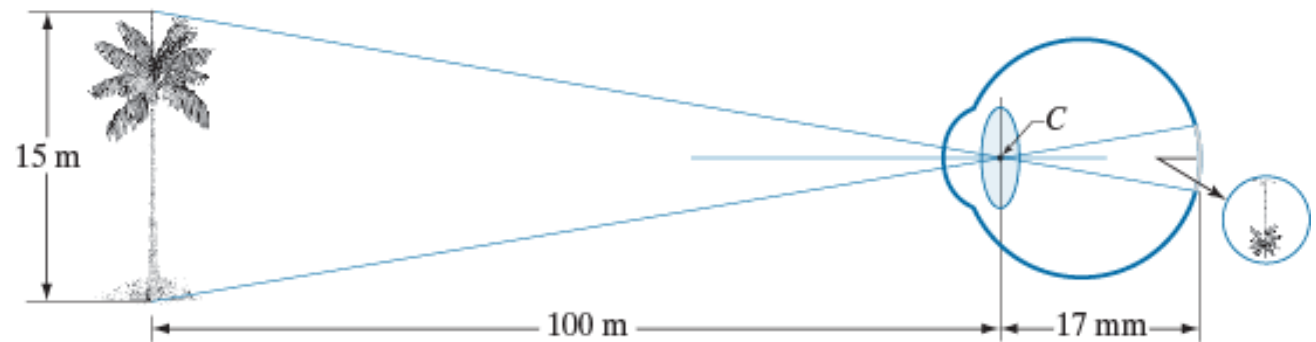


FIGURE 2.4

Range of subjective brightness sensations showing a particular adaptation level, B_a .

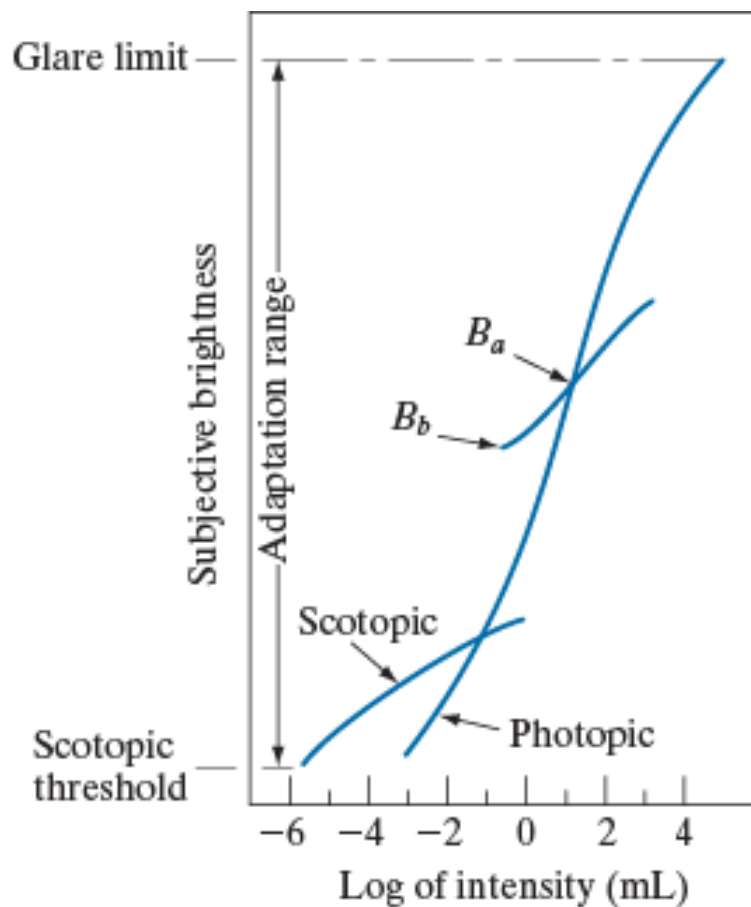


FIGURE 2.5

Basic
experimental
setup used to
characterize
brightness
discrimination.

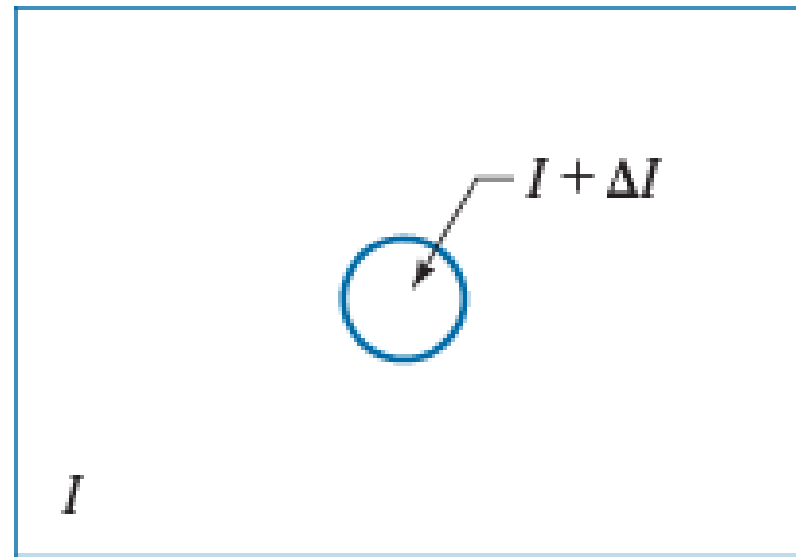
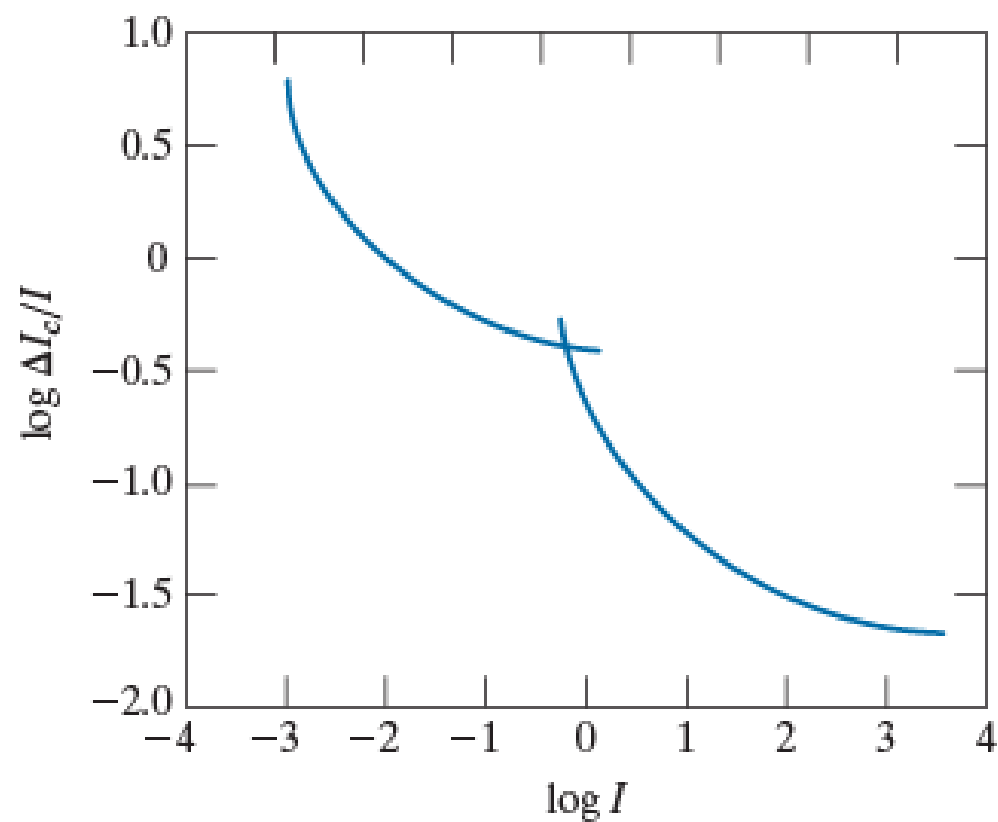


FIGURE 2.6

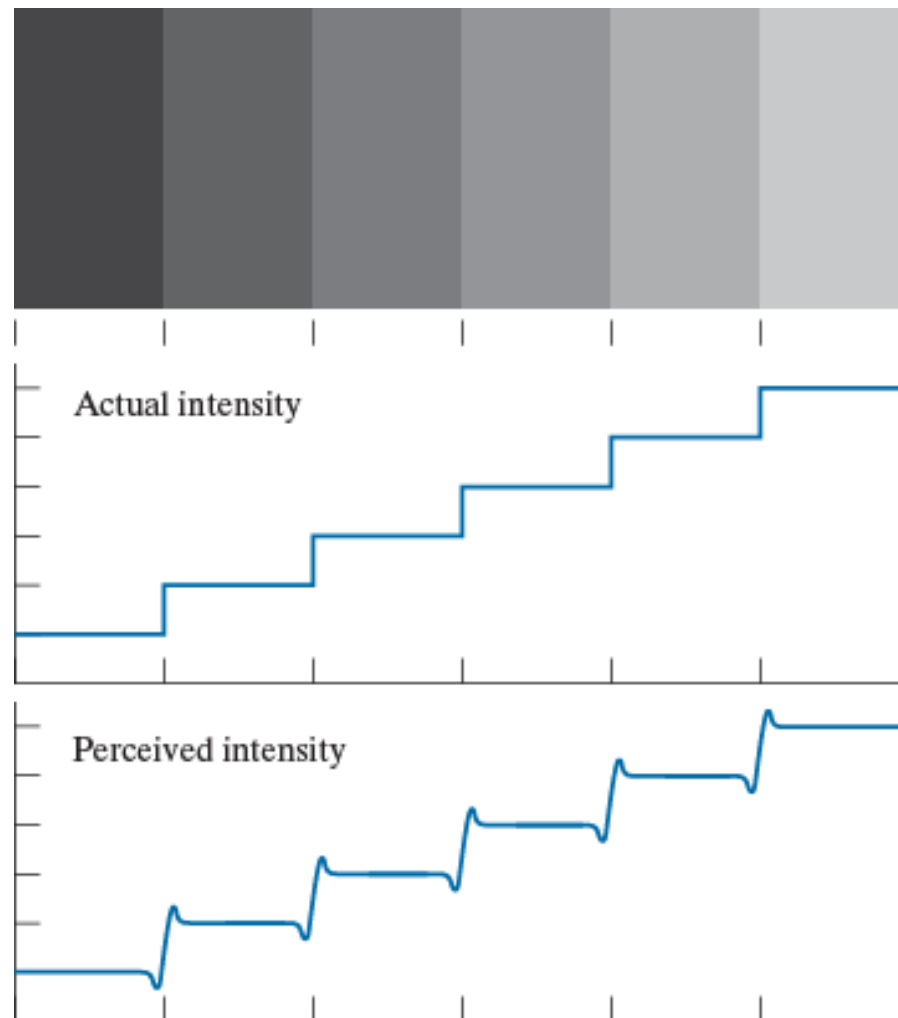
A typical plot of the Weber ratio as a function of intensity.

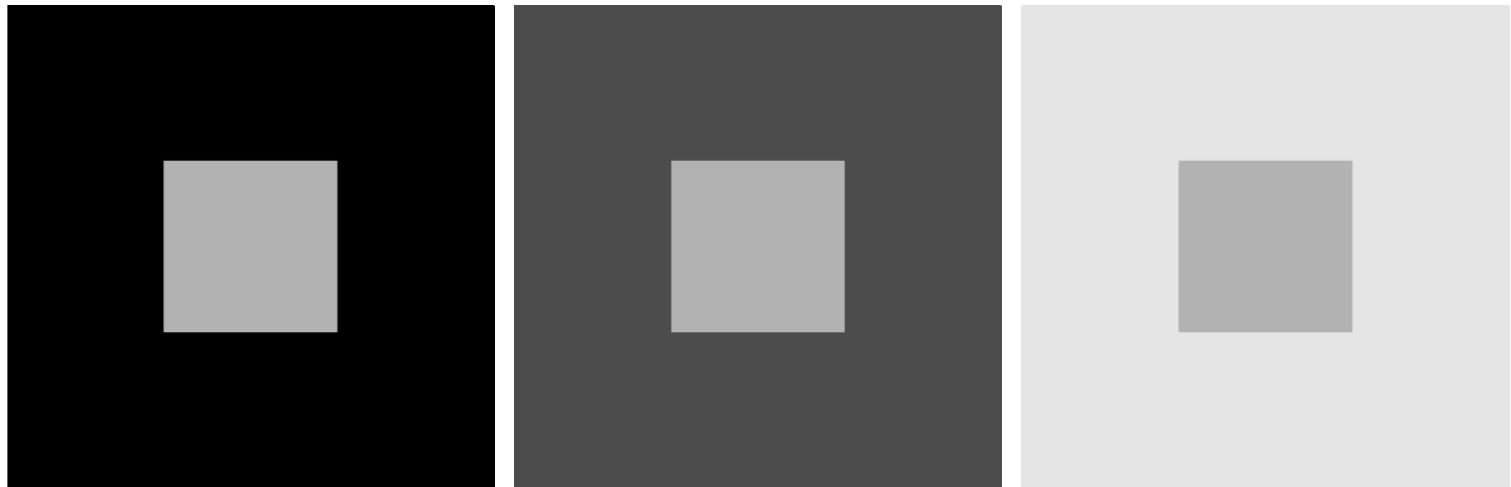


a
b
c

FIGURE 2.7

Illustration of the
Mach band effect.
Perceived
intensity is not a
simple function of
actual intensity.





a b c

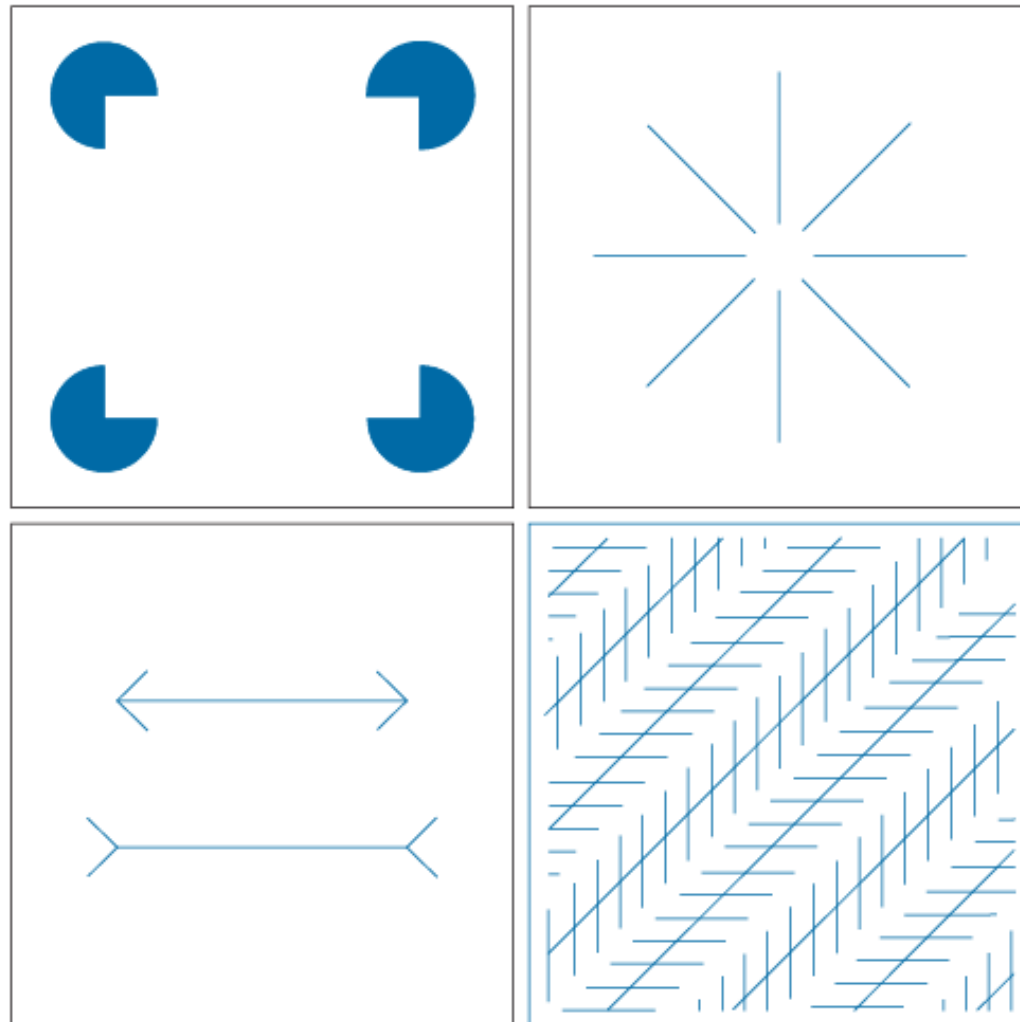
FIGURE 2.8 Examples of simultaneous contrast. All the inner squares have the same intensity, but they appear progressively darker as the background becomes lighter.

Optical illusion

<https://www.youtube.com/watch?v=tVgOLWVYytM>

a b
c d

FIGURE 2.9 Some well-known optical illusions.



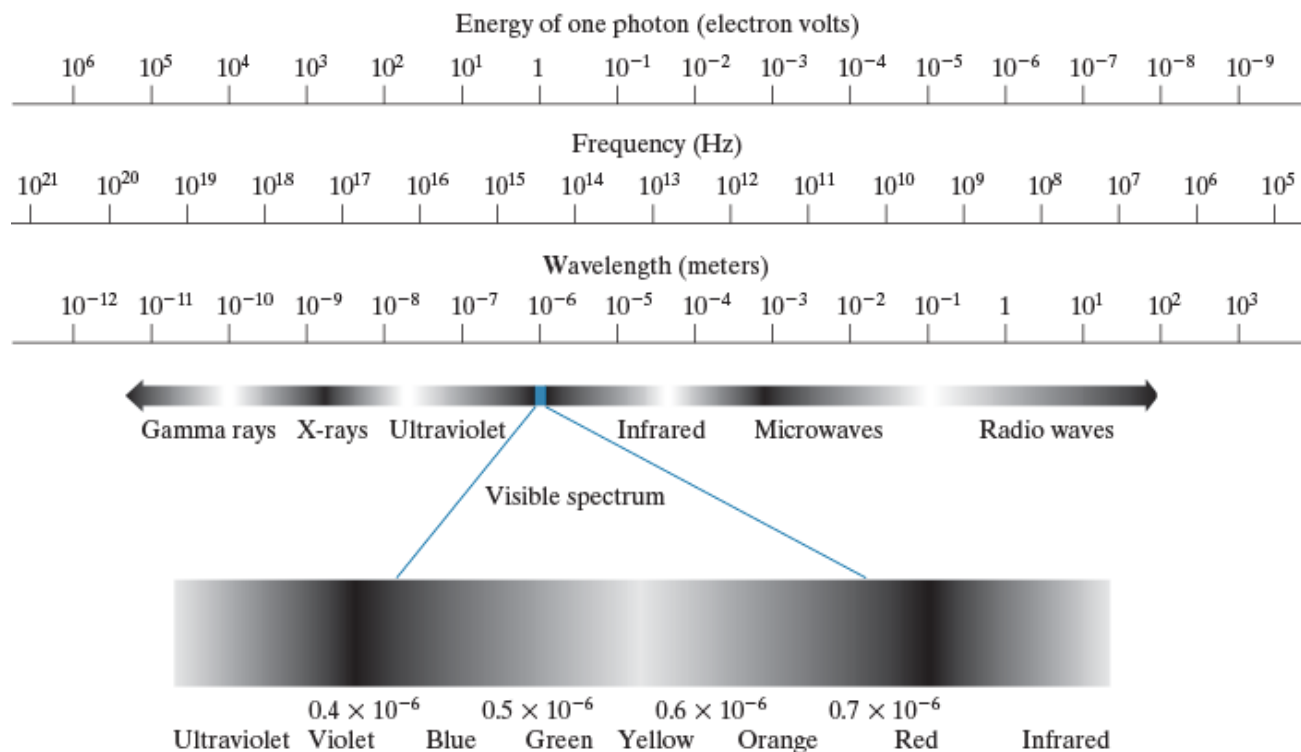
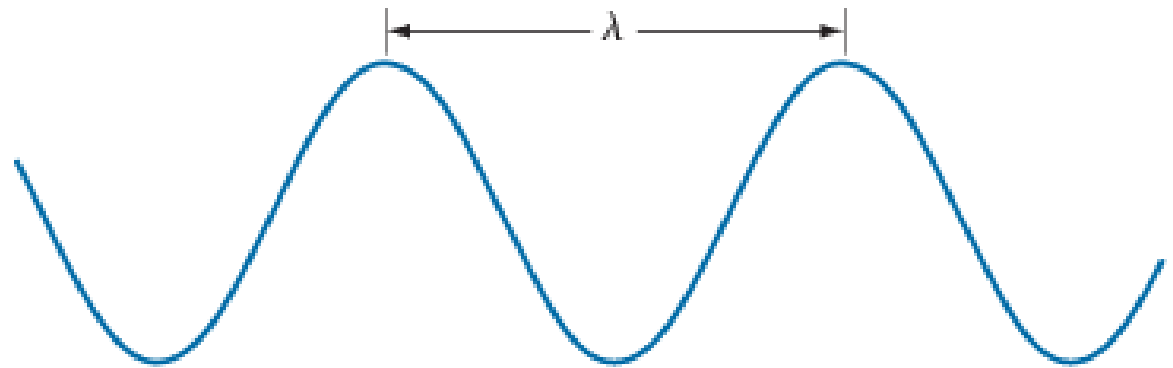


FIGURE 2.10 The electromagnetic spectrum. The visible spectrum is shown zoomed to facilitate explanations, but note that it encompasses a very narrow range of the total EM spectrum.

FIGURE 2.11
Graphical
representation of
one wavelength.



a
b
c

FIGURE 2.12

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

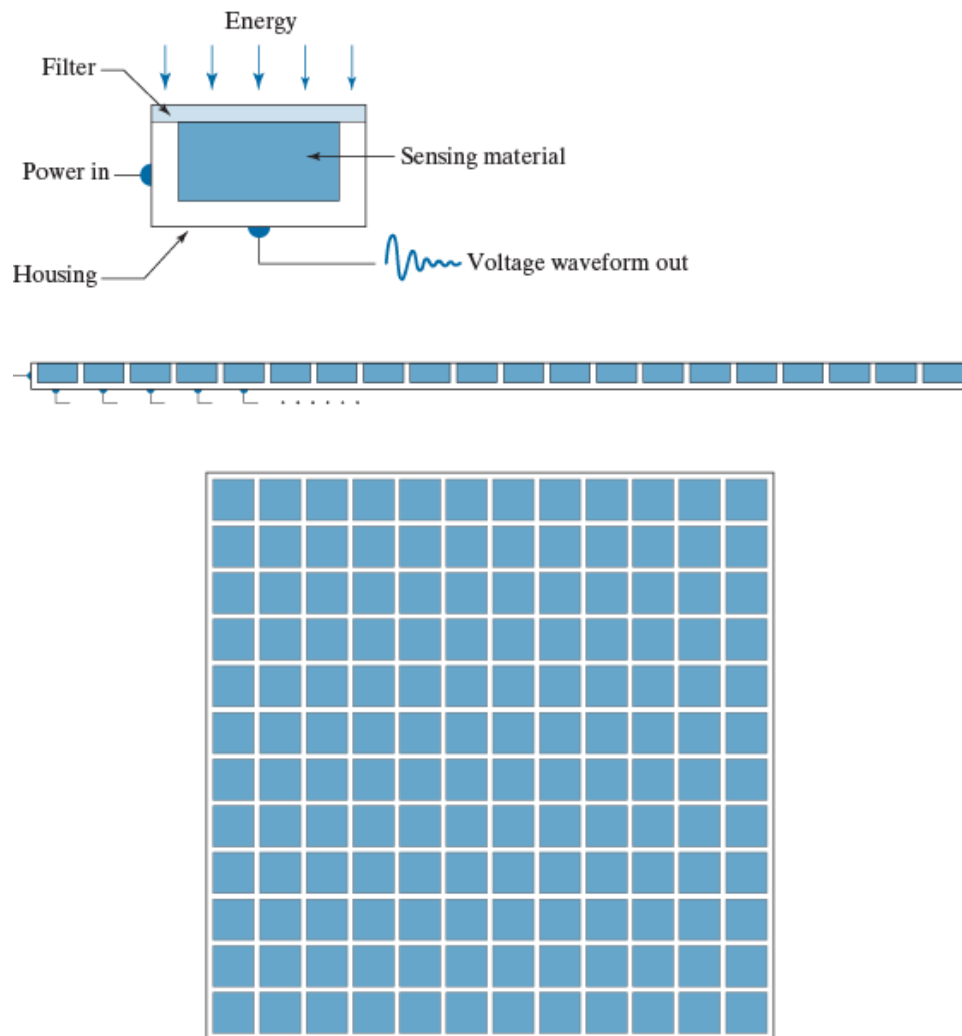
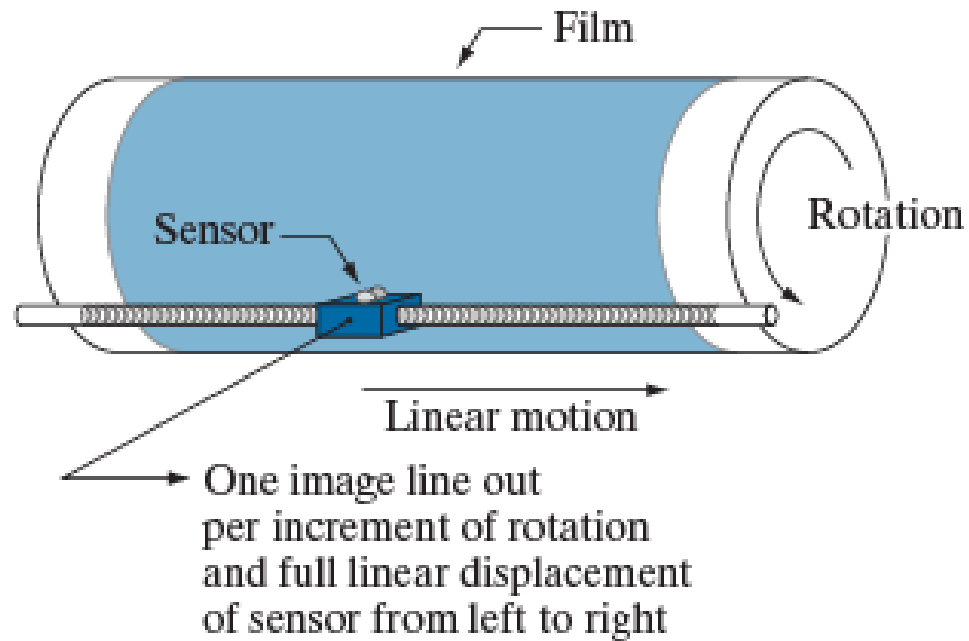
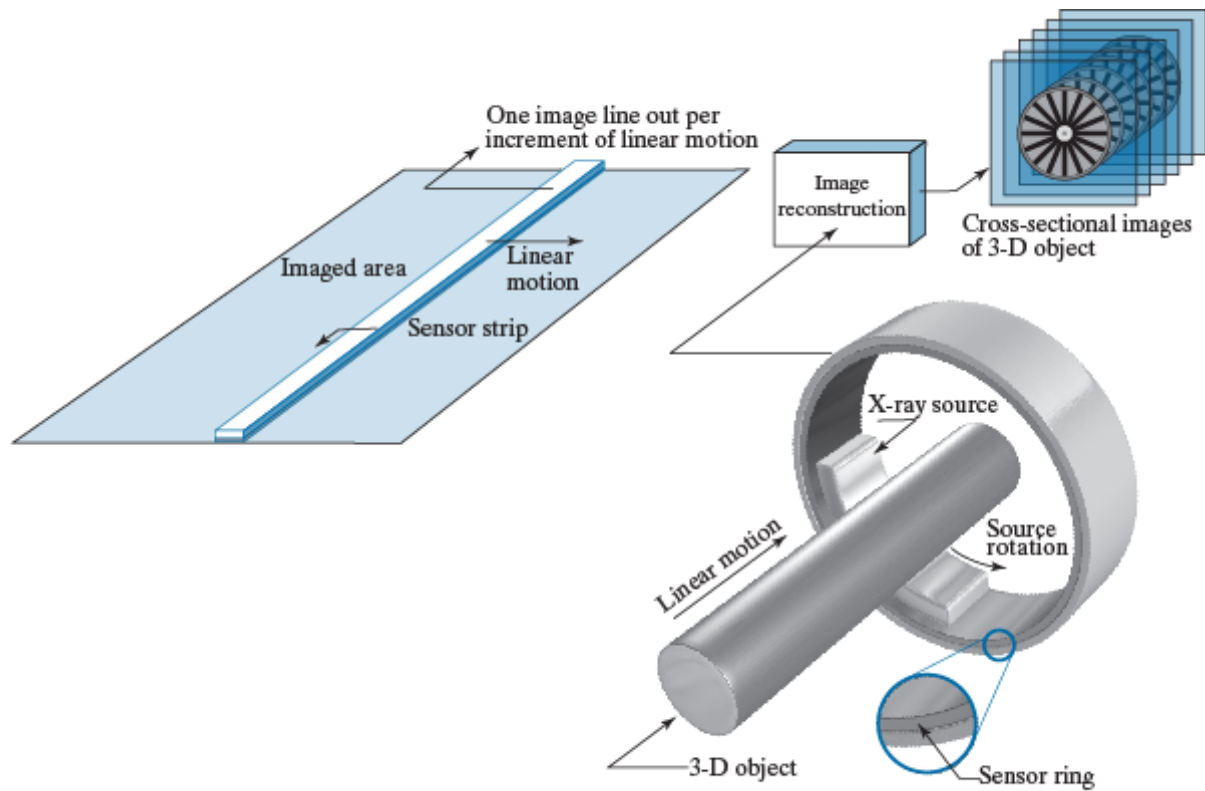


FIGURE 2.13

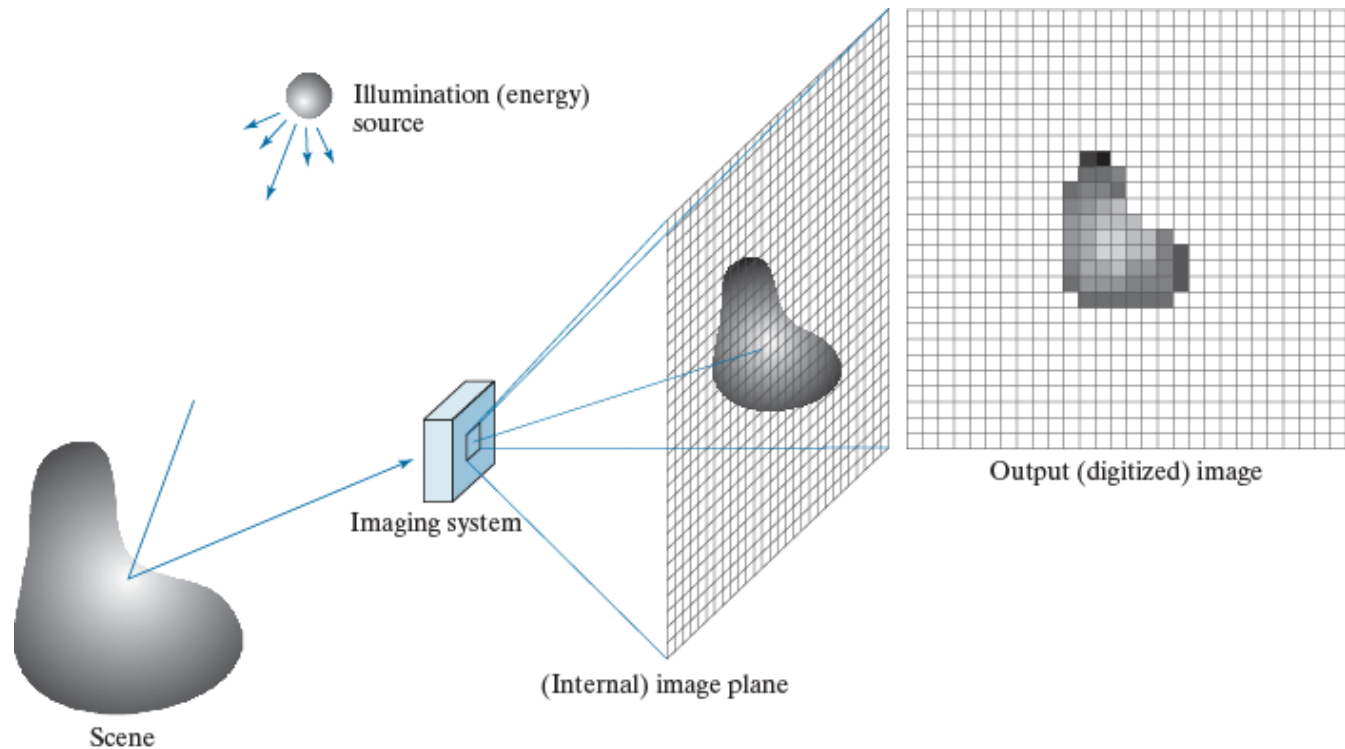
Combining a single sensing element with mechanical motion to generate a 2-D image.





a b

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



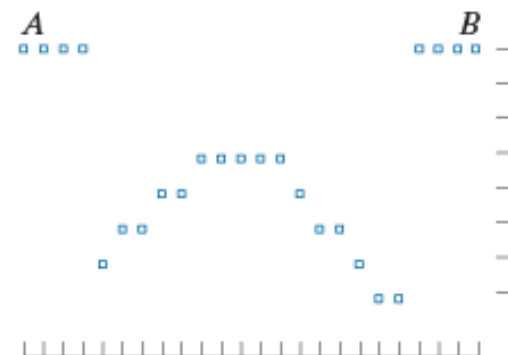
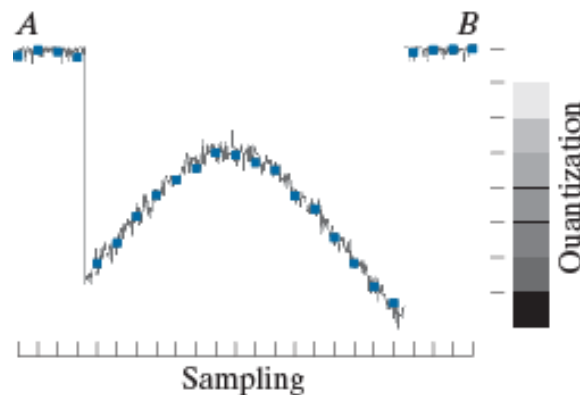
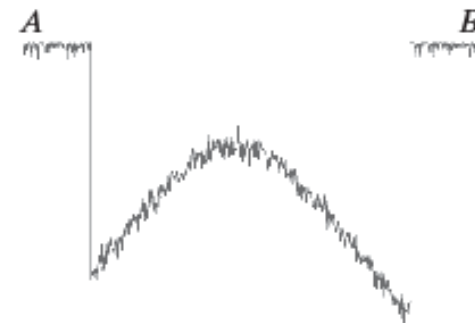
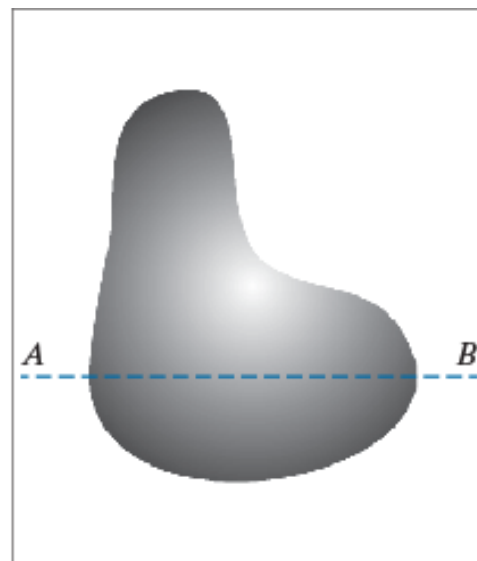
a b c d e

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.

a b
c d

FIGURE 2.16

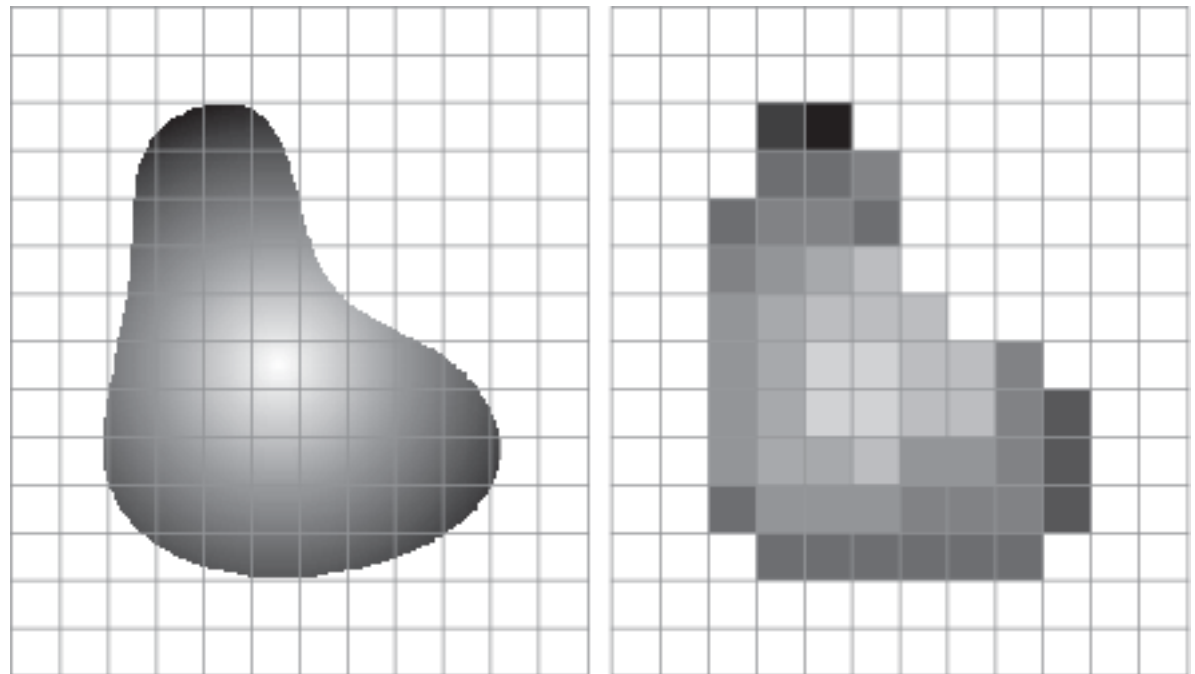
(a) Continuous image. (b) A scan line showing intensity variations along line AB in the continuous image. (c) Sampling and quantization. (d) Digital scan line. (The black border in (a) is included for clarity. It is not part of the image).



a b

FIGURE 2.17

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



(a) Image plotted as a surface. (b) Image displayed as a visual intensity array. (c) Image shown as a 2-D numerical array. (The numbers 0, .5, and 1 represent black, gray, and white, respectively.)

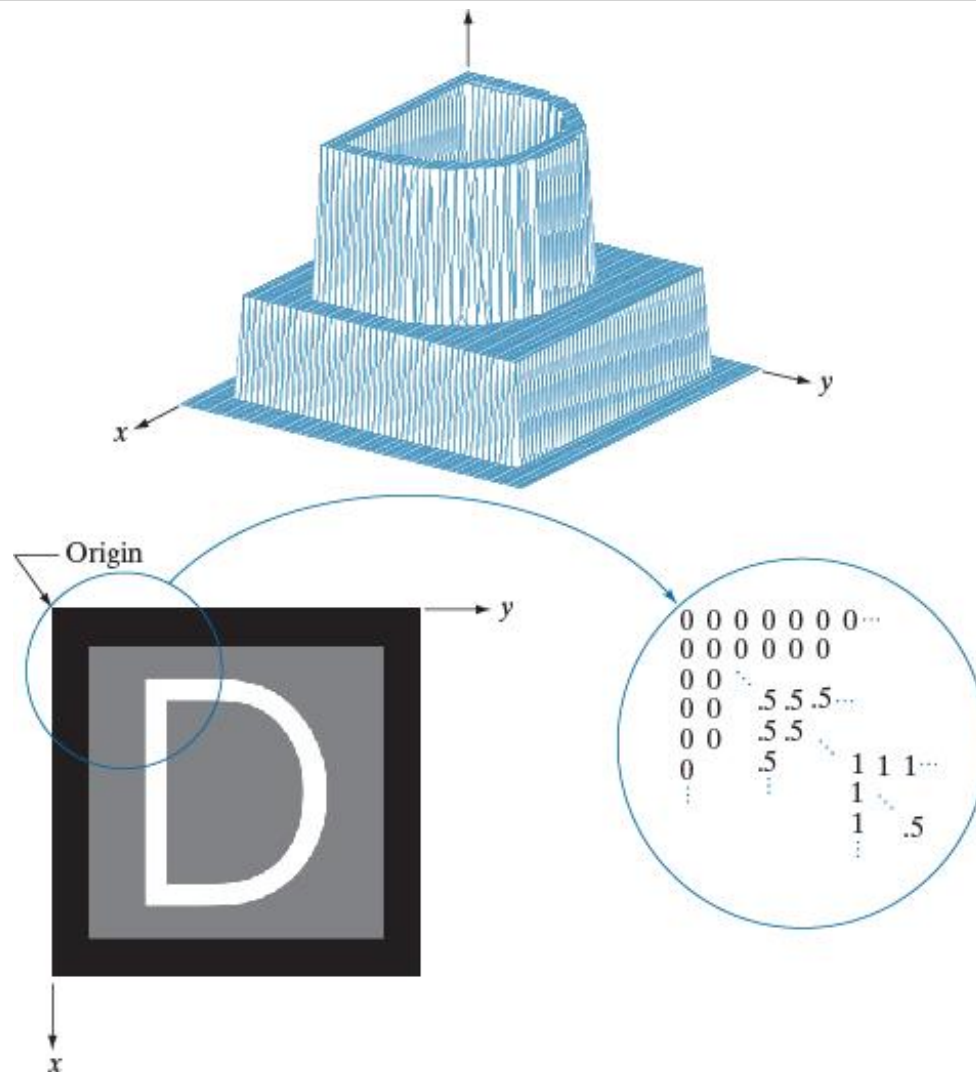
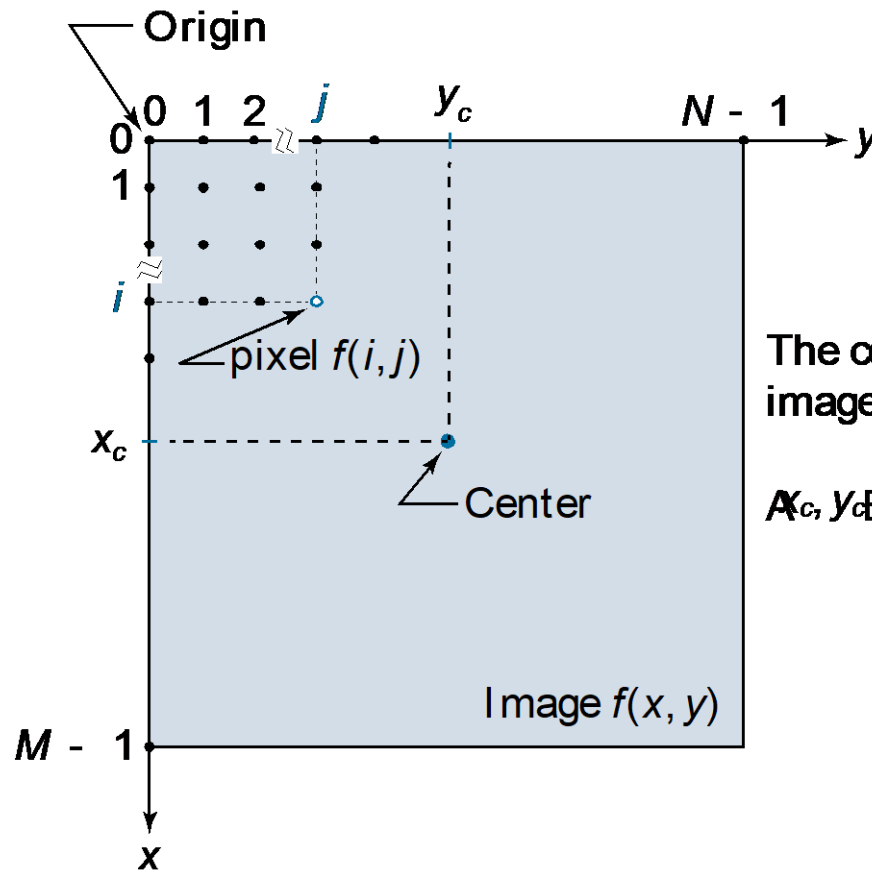


FIGURE 2.19

Coordinate convention used to represent digital images. Because coordinate values are integers, there is a one-to-one correspondence between x and y and the rows (r) and columns (c) of a matrix.



The coordinates of the image center are

$$x_c, y_c = \left\lfloor \frac{M}{2} \right\rfloor, \left\lfloor \frac{N}{2} \right\rfloor$$

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.

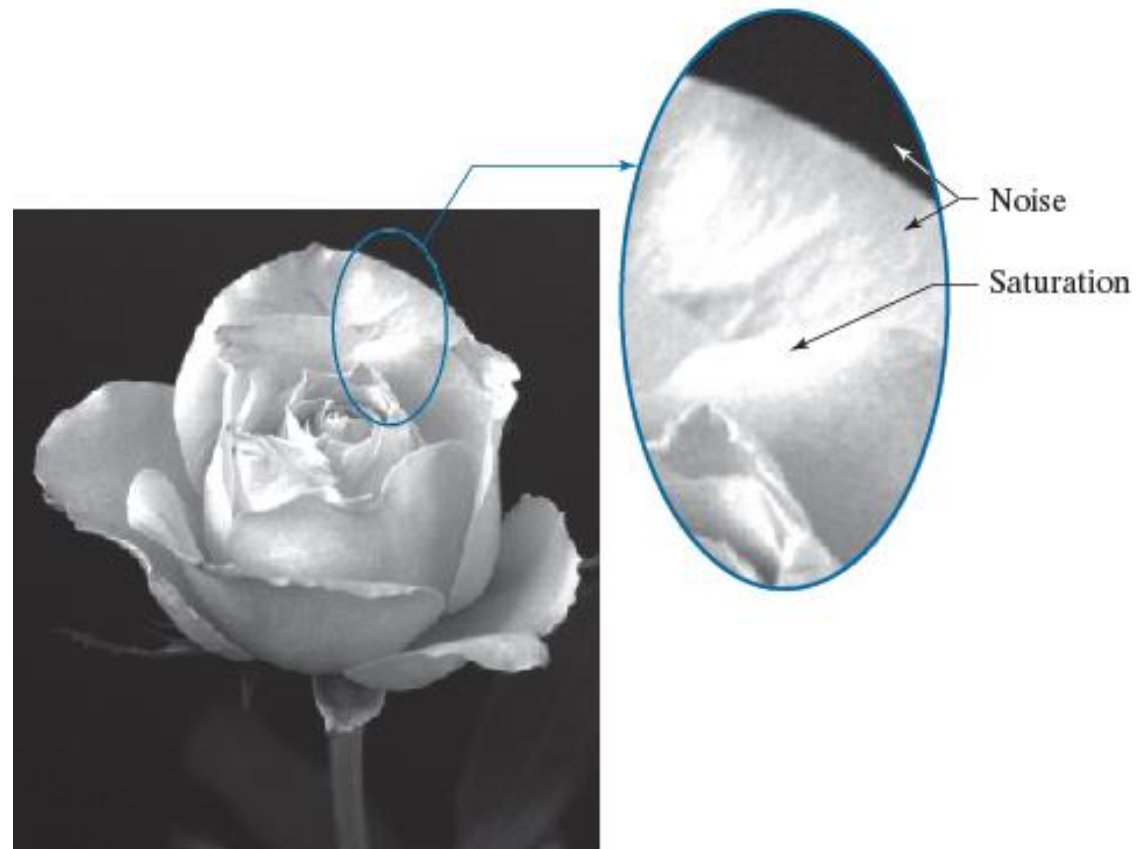


FIGURE 2.21
Number of
megabytes
required to store
images for
various values of
 N and k .

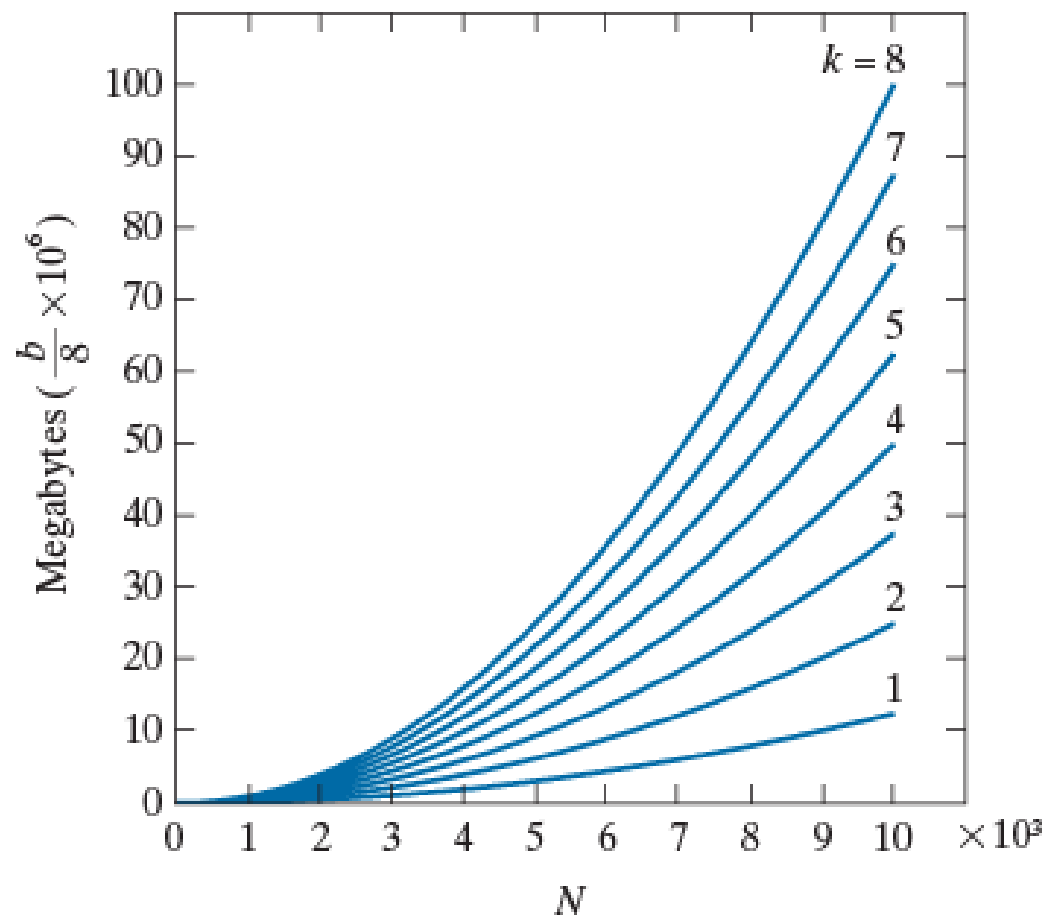
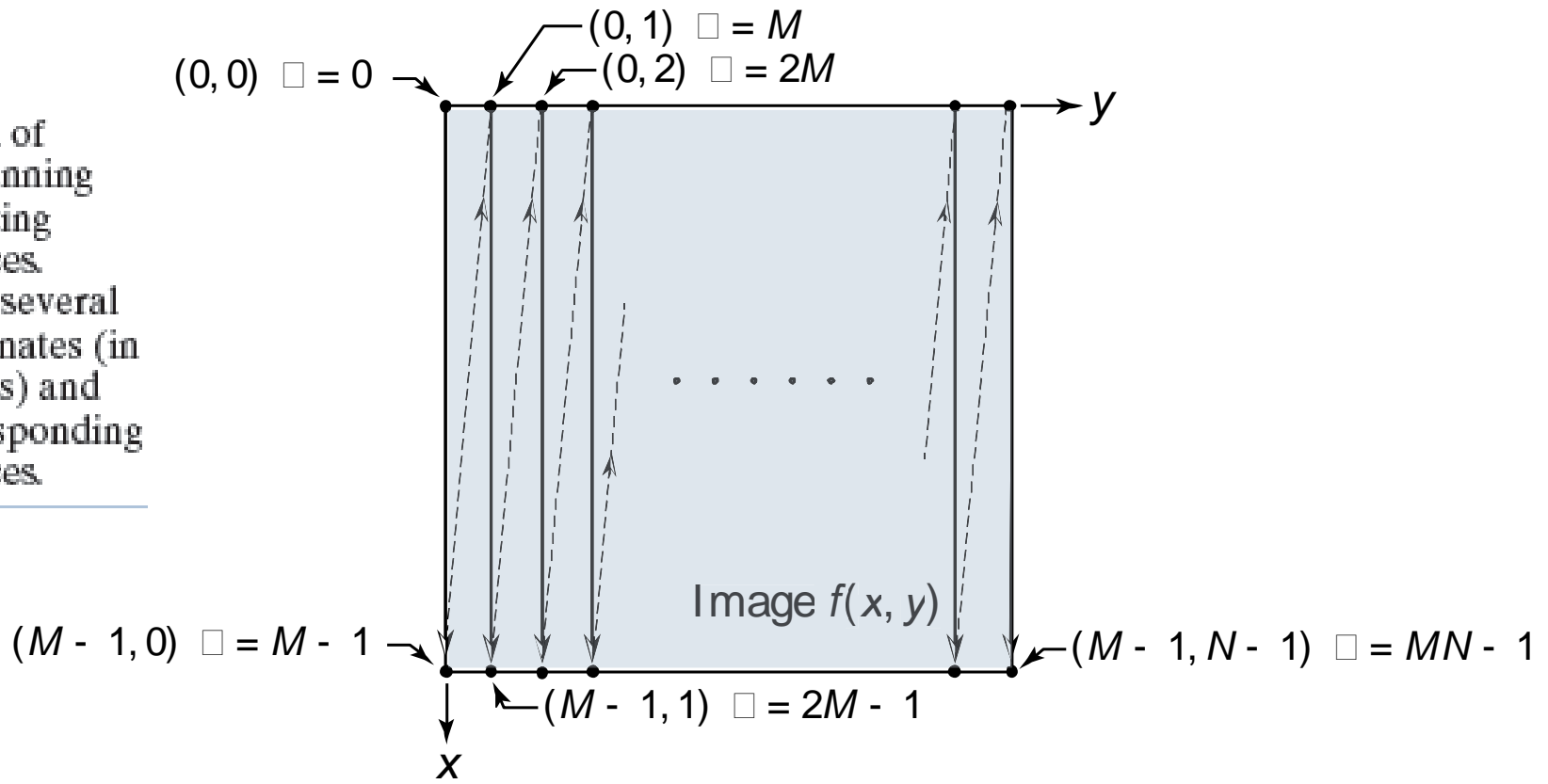


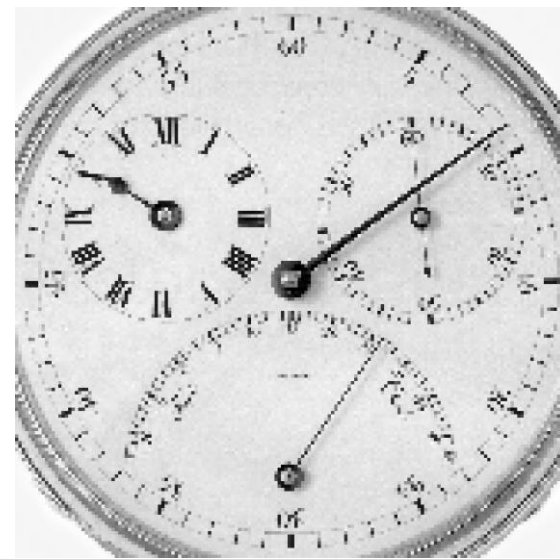
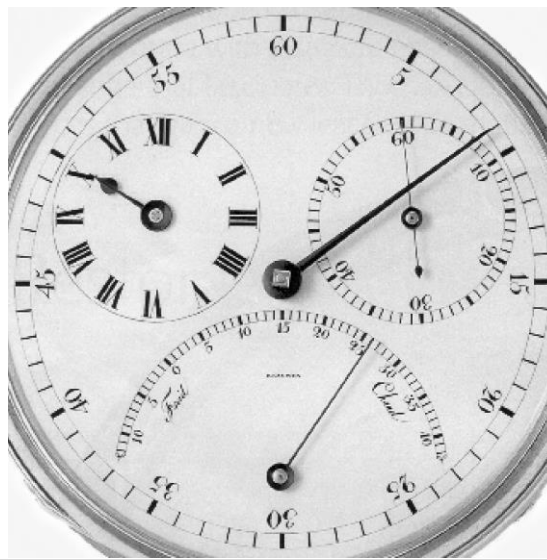
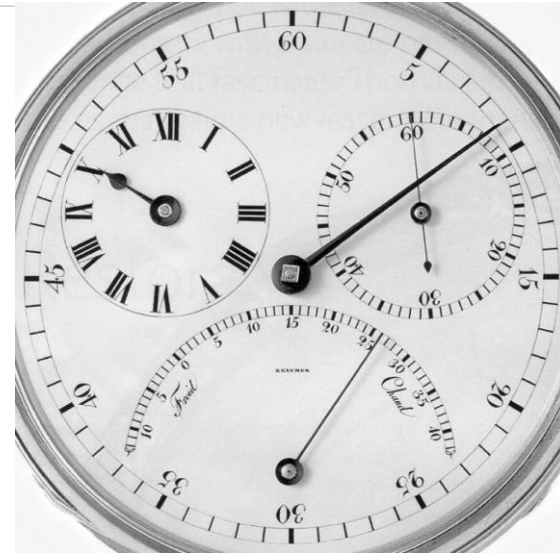
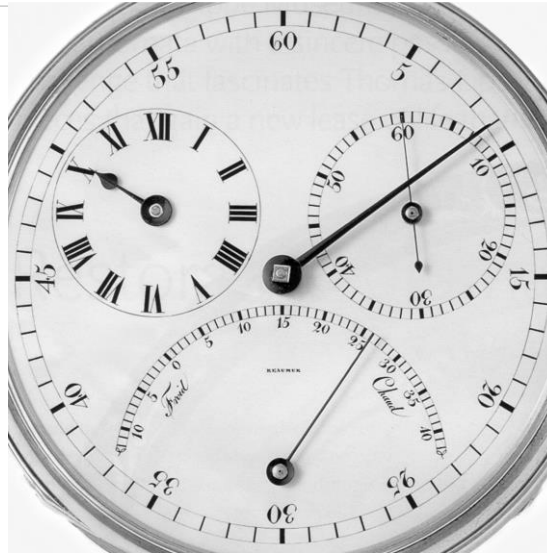
FIGURE 2.22

Illustration of column scanning for generating linear indices. Shown are several 2-D coordinates (in parentheses) and their corresponding linear indices.



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.



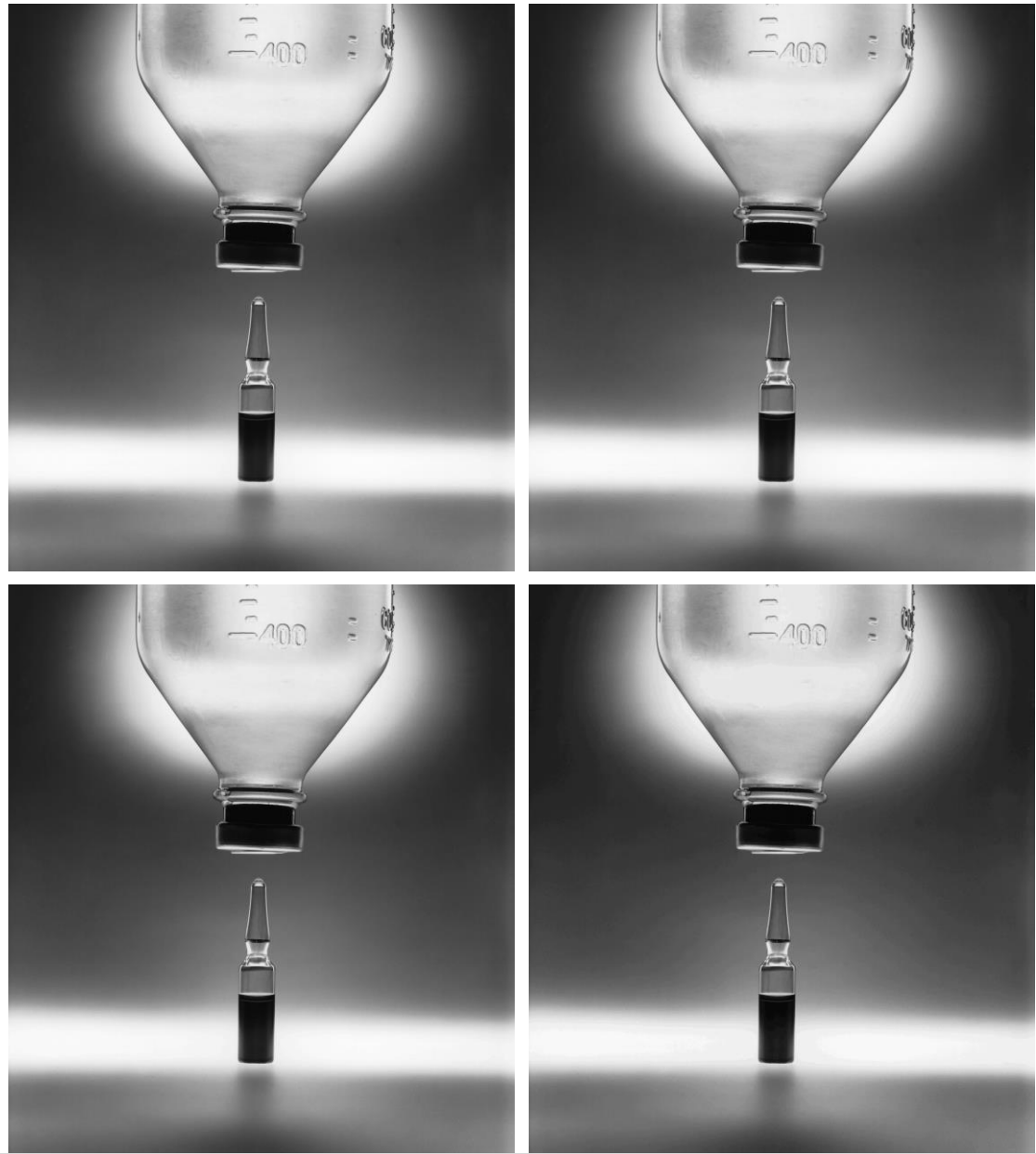
a b
c d

FIGURE 2.24

(a) 2022×1800 ,
256-level image.

(b)-(d) Image
displayed in 128,
64, and 32 inten-
sity levels, while
keeping the image
size constant.

(Original image
courtesy of the
National
Cancer Institute.)

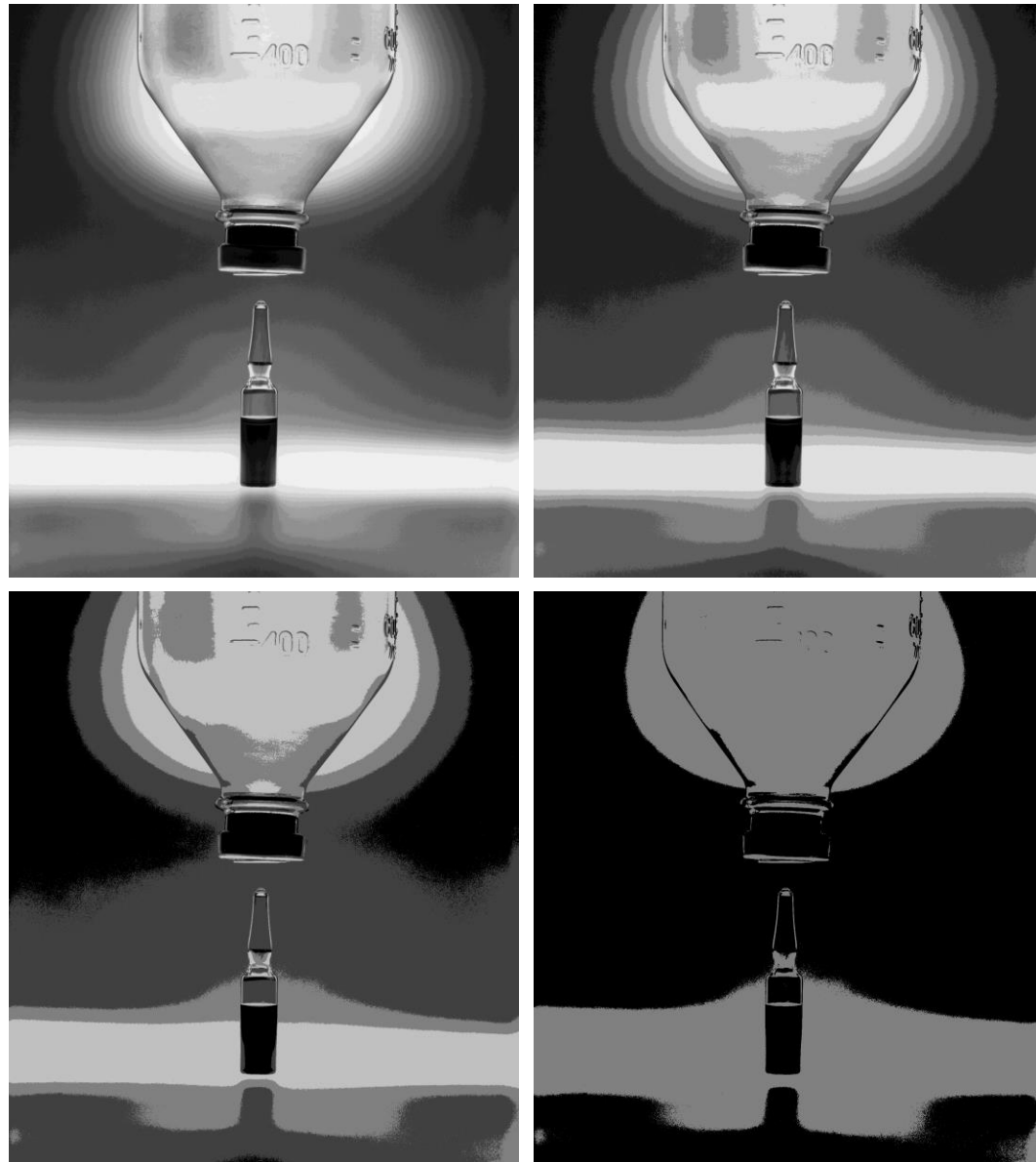


e f
g h

FIGURE 2.24

(Continued)

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

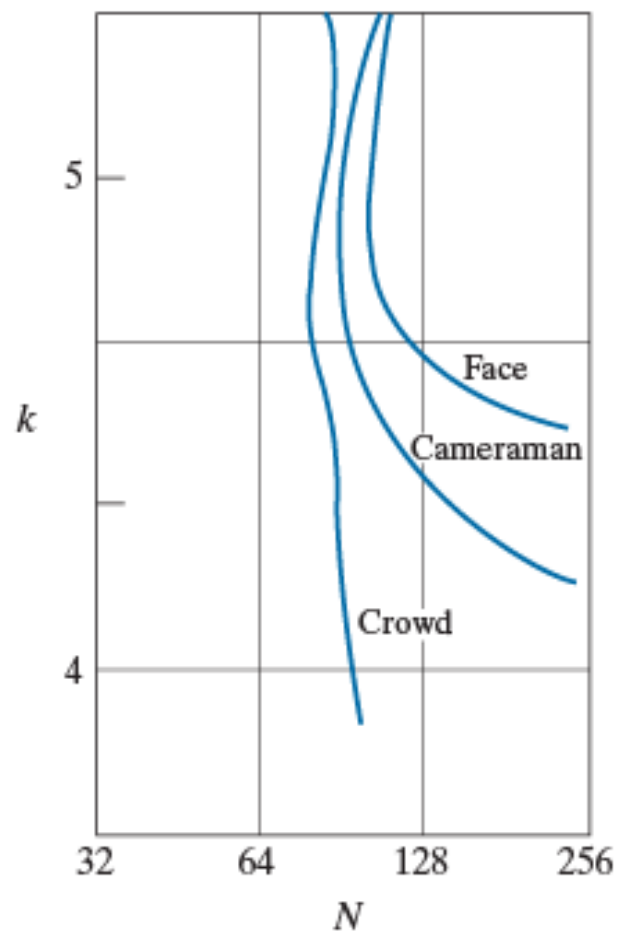




a b c

FIGURE 2.25 (a) Image with a low level of detail. (b) Image with a medium level of detail. (c) Image with a relatively large amount of detail. (Image (b) courtesy of the Massachusetts Institute of Technology.)

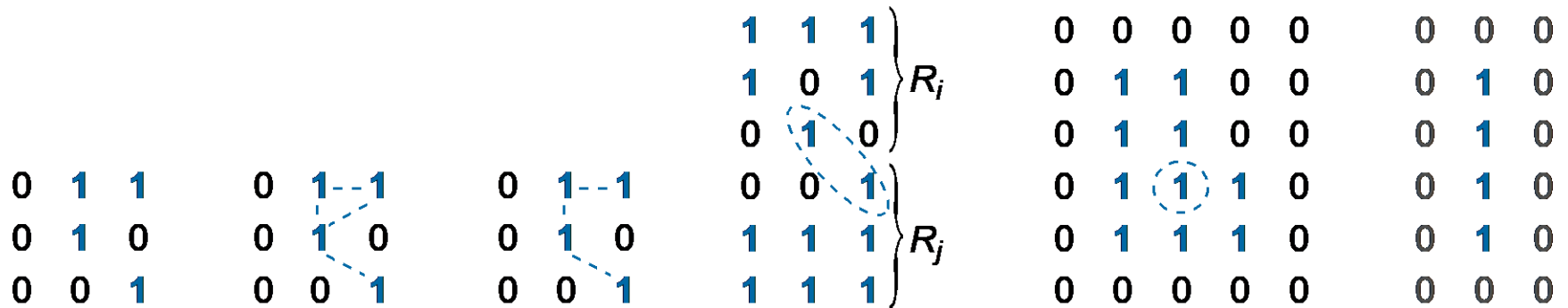
FIGURE 2.26
Representative
isopreference
curves for the
three types of
images in
Fig. 2.25.





a b c

FIGURE 2.27 (a) Image reduced to 72 dpi and zoomed back to its original 930 dpi using nearest neighbor interpolation. This figure is the same as Fig. 2.23(d). (b) Image reduced to 72 dpi and zoomed using bilinear interpolation. (c) Same as (b) but using bicubic interpolation.



a b c d e f

FIGURE 2.28 (a) An arrangement of pixels. (b) Pixels that are 8-adjacent (adjacency is shown by dashed lines). (c) m -adjacency. (d) Two regions (of 1's) that are 8-adjacent. (e) The circled point is on the boundary of the 1-valued pixels only if 8-adjacency between the region and background is used. (f) The inner boundary of the 1-valued region does not form a closed path, but its outer boundary does.