

UNIVERSITÀ
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Image processing introduction

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Images

- An image may be defined as a two-dimensional function, $f(x, y)$, where x and y are spatial (plane) coordinates, and the amplitude of f at any pair of coordinates (x, y) is called the intensity or gray level of the image at that point.
- When x , y , and the intensity values of f are all finite, discrete quantities, we call the image a digital image.
- The field of digital image processing refers to processing digital images by means of a digital computer.
- A digital image is composed of a finite number of elements, each of which has a particular location and value.
- These elements are called *picture elements*, *image elements*, *pels*, and *pixels*.
- Pixel is the term used most widely to denote the elements of a digital image.

Vision

- Vision is the most advanced of our senses, so it is not surprising that images play the single most important role in human perception.
- However, unlike humans, who are limited to the visual band of the electromagnetic (EM) spectrum, imaging machines cover almost the entire EM spectrum, ranging from gamma to radio waves.
- They can operate on images generated by sources that humans are not accustomed to associating with images.
- These include ultrasound, electron microscopy, and computer-generated images.
- Thus, digital image processing encompasses a wide and varied field of applications.

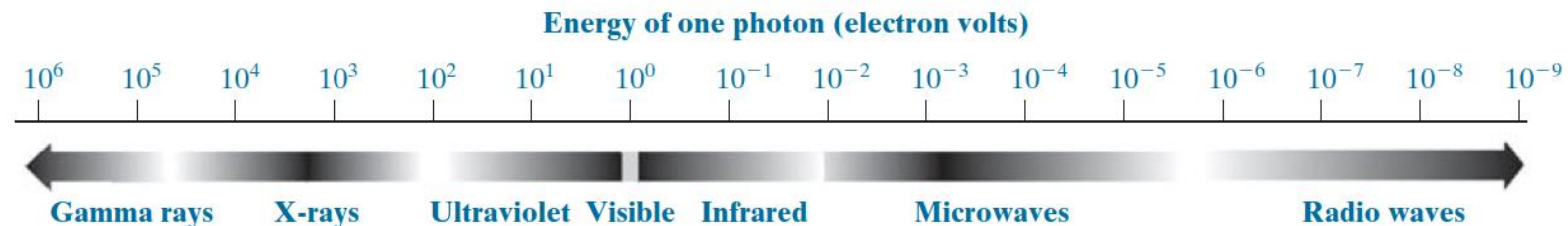


FIGURE 1.5 The electromagnetic spectrum arranged according to energy per photon.

Gamma-ray imaging

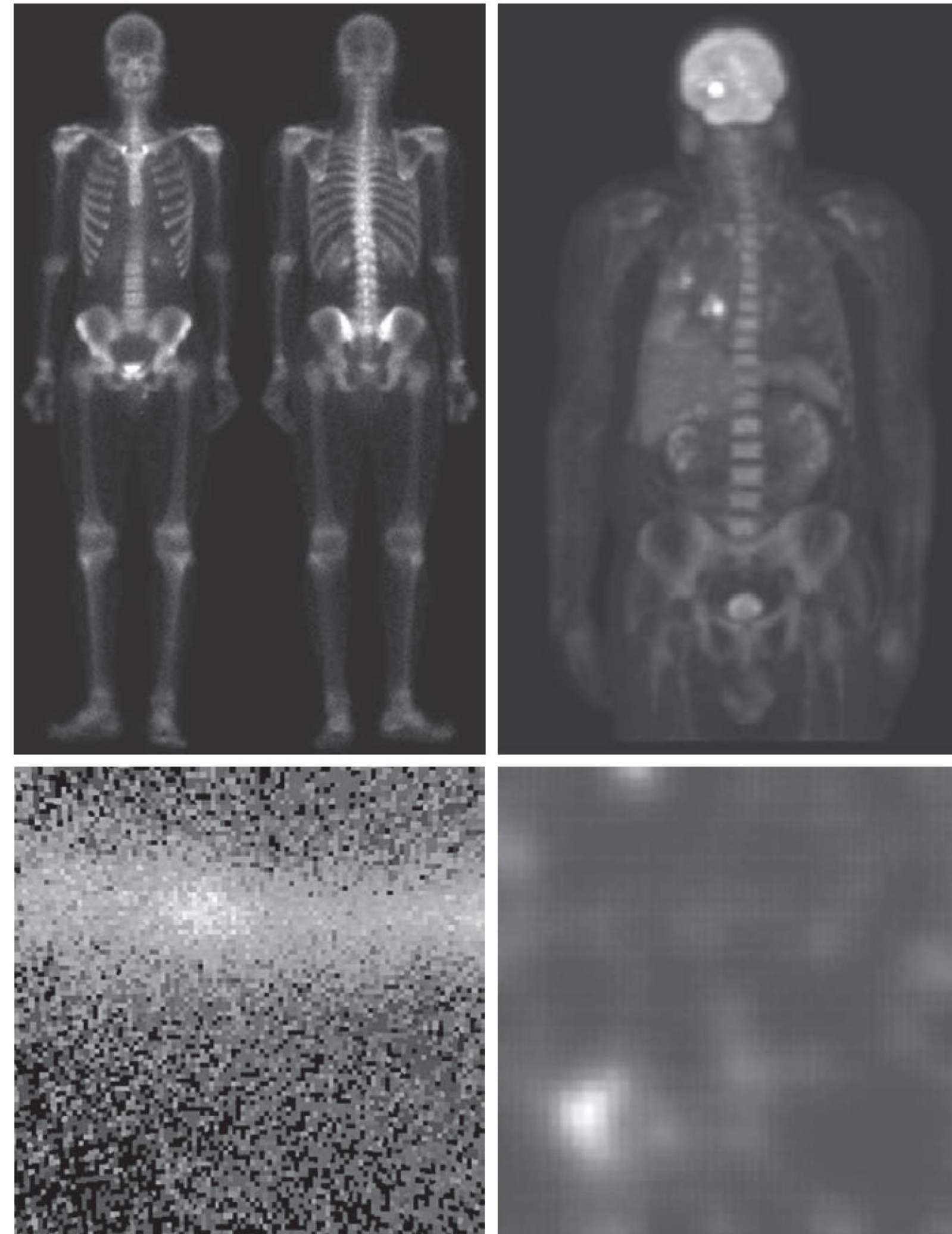
a b
c d

FIGURE 1.6

Examples of gamma-ray imaging.

- (a) Bone scan.
- (b) PET image.
- (c) Cygnus Loop.
- (d) Gamma radiation (bright spot) from a reactor valve.

(Images courtesy of (a) G.E. Medical Systems; (b) Dr. Michael E. Casey, CTI PET Systems; (c) NASA; (d) Professors Zhong He and David K. Wehe, University of Michigan.)



X-ray imaging

a	d
c	
b	e

FIGURE 1.7

Examples of X-ray imaging.

(a) Chest X-ray.

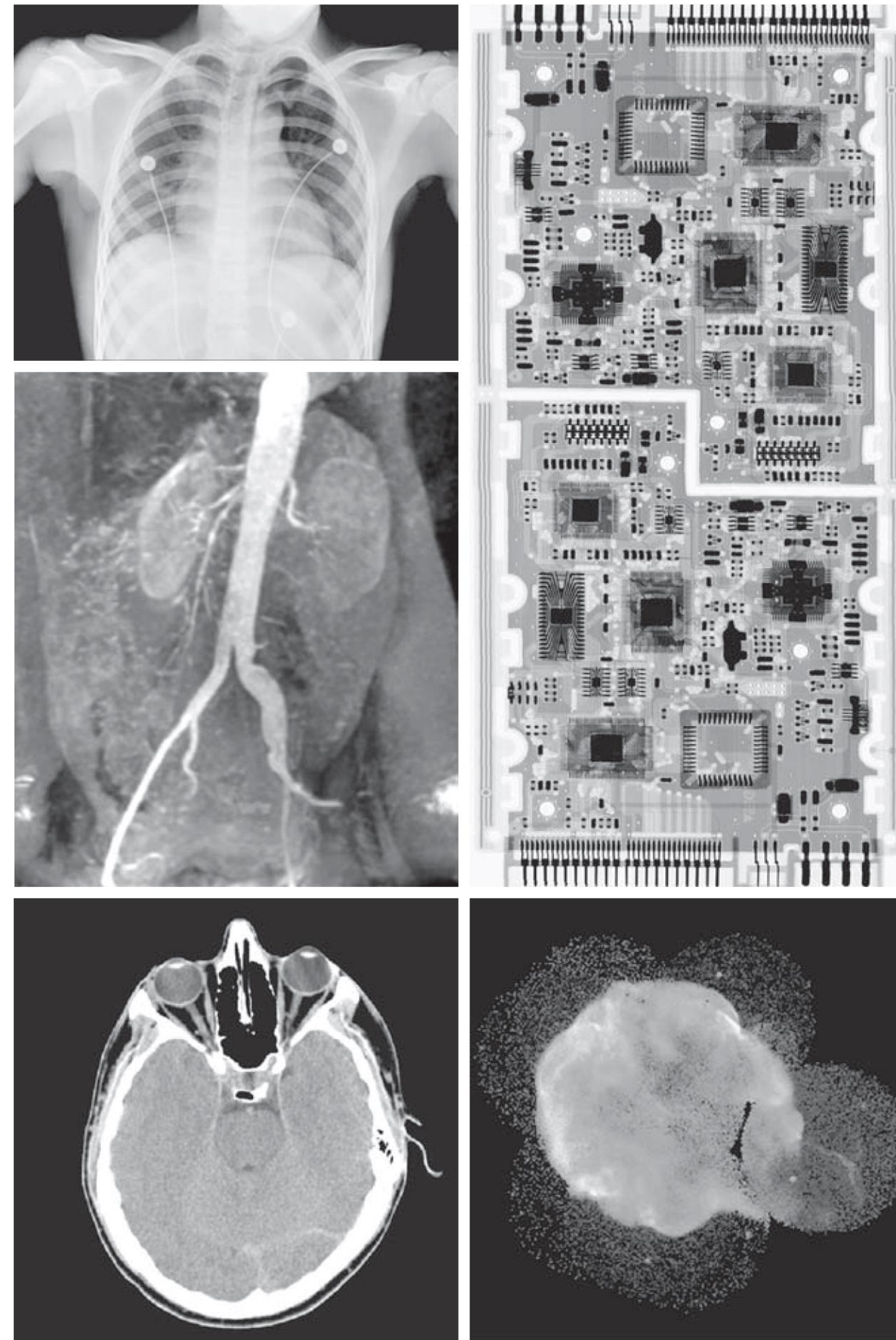
(b) Aortic angiogram.

(c) Head CT.

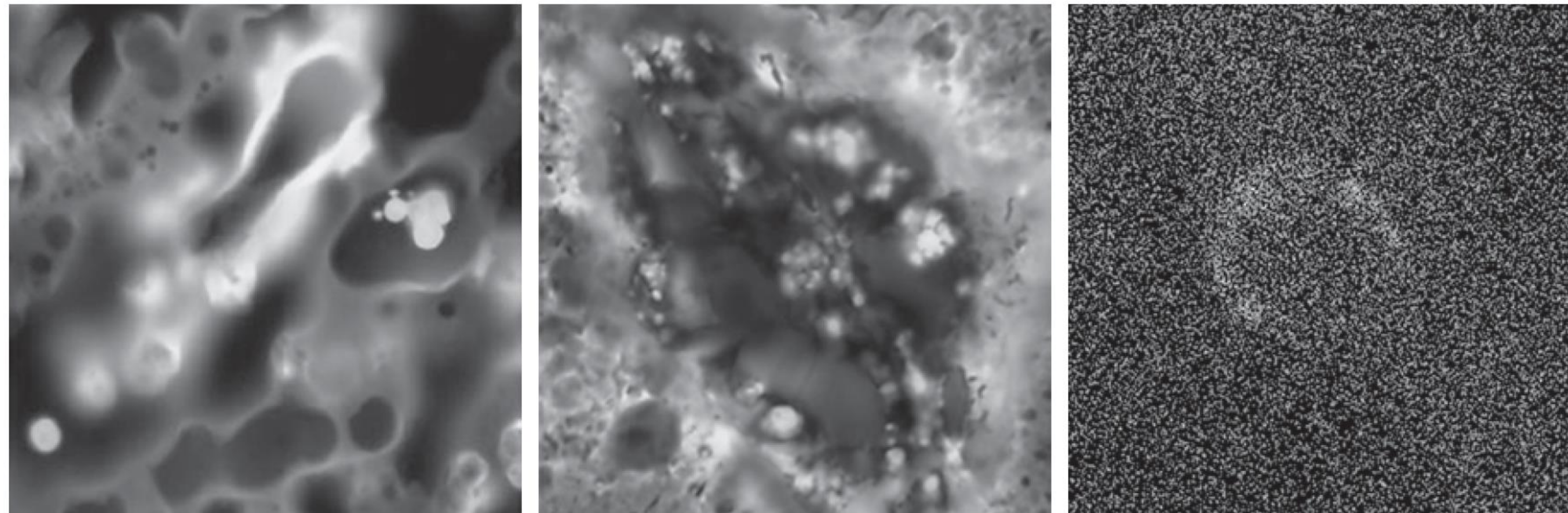
(d) Circuit boards.

(e) Cygnus Loop.

(Images courtesy of (a) and (c) Dr. David R. Pickens, Dept. of Radiology & Radiological Sciences, Vanderbilt University Medical Center; (b) Dr. Thomas R. Gest, Division of Anatomical Sciences, Univ. of Michigan Medical School; (d) Mr. Joseph E. Pascente, Lixi, Inc.; and (e) NASA.)



Imaging in the ultraviolet band



a b c

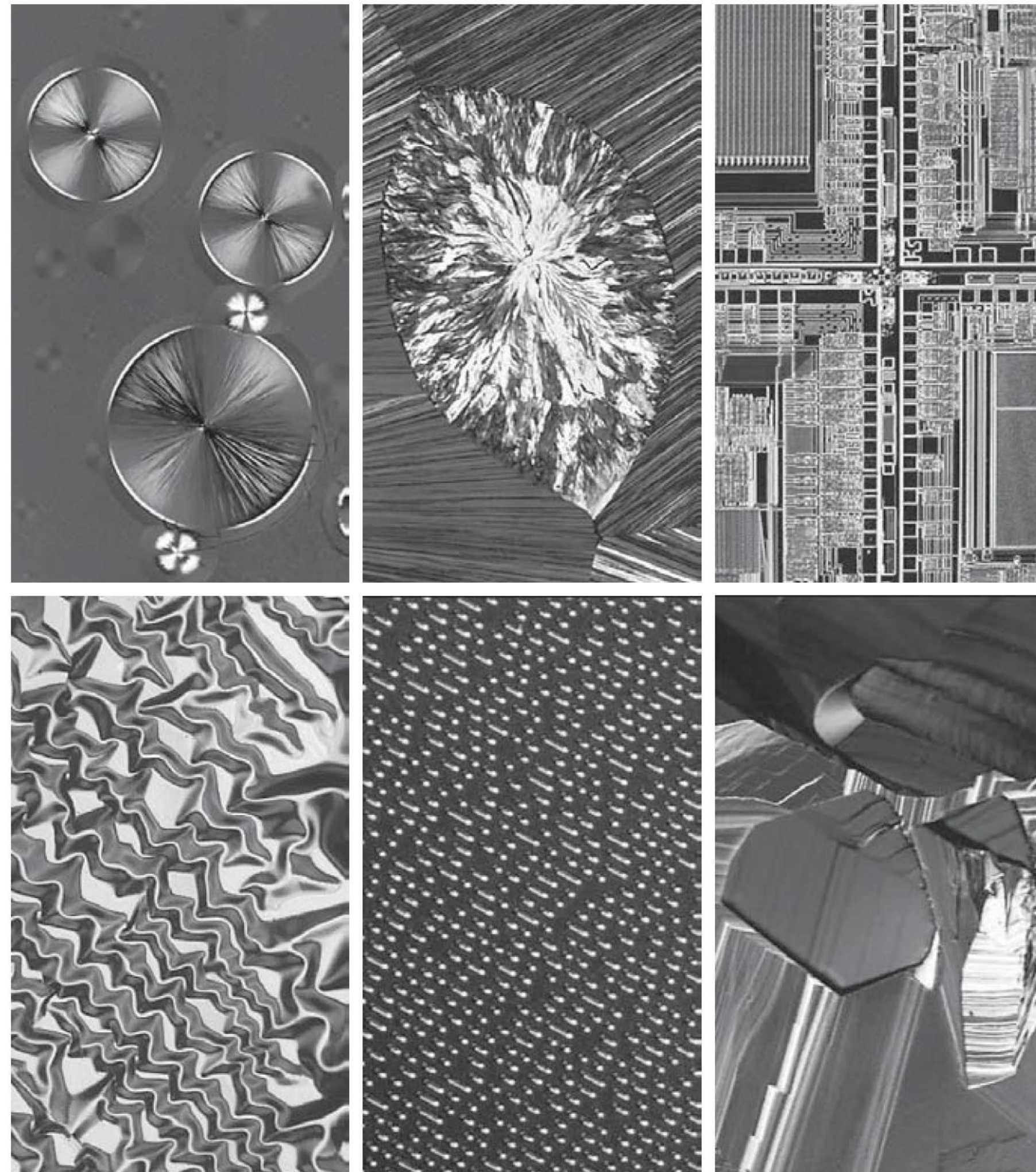
FIGURE 1.8 Examples of ultraviolet imaging. (a) Normal corn. (b) Corn infected by smut. (c) Cygnus Loop. (Images (a) and (b) courtesy of Dr. Michael W. Davidson, Florida State University, (c) NASA.)

Imaging in the visible and infrared bands

a b c
d e f

FIGURE 1.9

Examples of light microscopy images.
(a) Taxol (anticancer agent), magnified 250 \times .
(b) Cholesterol—40 \times .
(c) Microprocessor—60 \times .
(d) Nickel oxide thin film—600 \times .
(e) Surface of audio CD—1750 \times .
(f) Organic superconductor—450 \times .
(Images courtesy of Dr. Michael W. Davidson, Florida State University.)



Imaging in the visible and infrared bands

TABLE 1.1
Thematic bands
of NASA's
LANDSAT
satellite.

Band No.	Name	Wavelength (μm)	Characteristics and Uses
1	Visible blue	0.45–0.52	Maximum water penetration
2	Visible green	0.53–0.61	Measures plant vigor
3	Visible red	0.63–0.69	Vegetation discrimination
4	Near infrared	0.78–0.90	Biomass and shoreline mapping
5	Middle infrared	1.55–1.75	Moisture content: soil/vegetation
6	Thermal infrared	10.4–12.5	Soil moisture; thermal mapping
7	Short-wave infrared	2.09–2.35	Mineral mapping

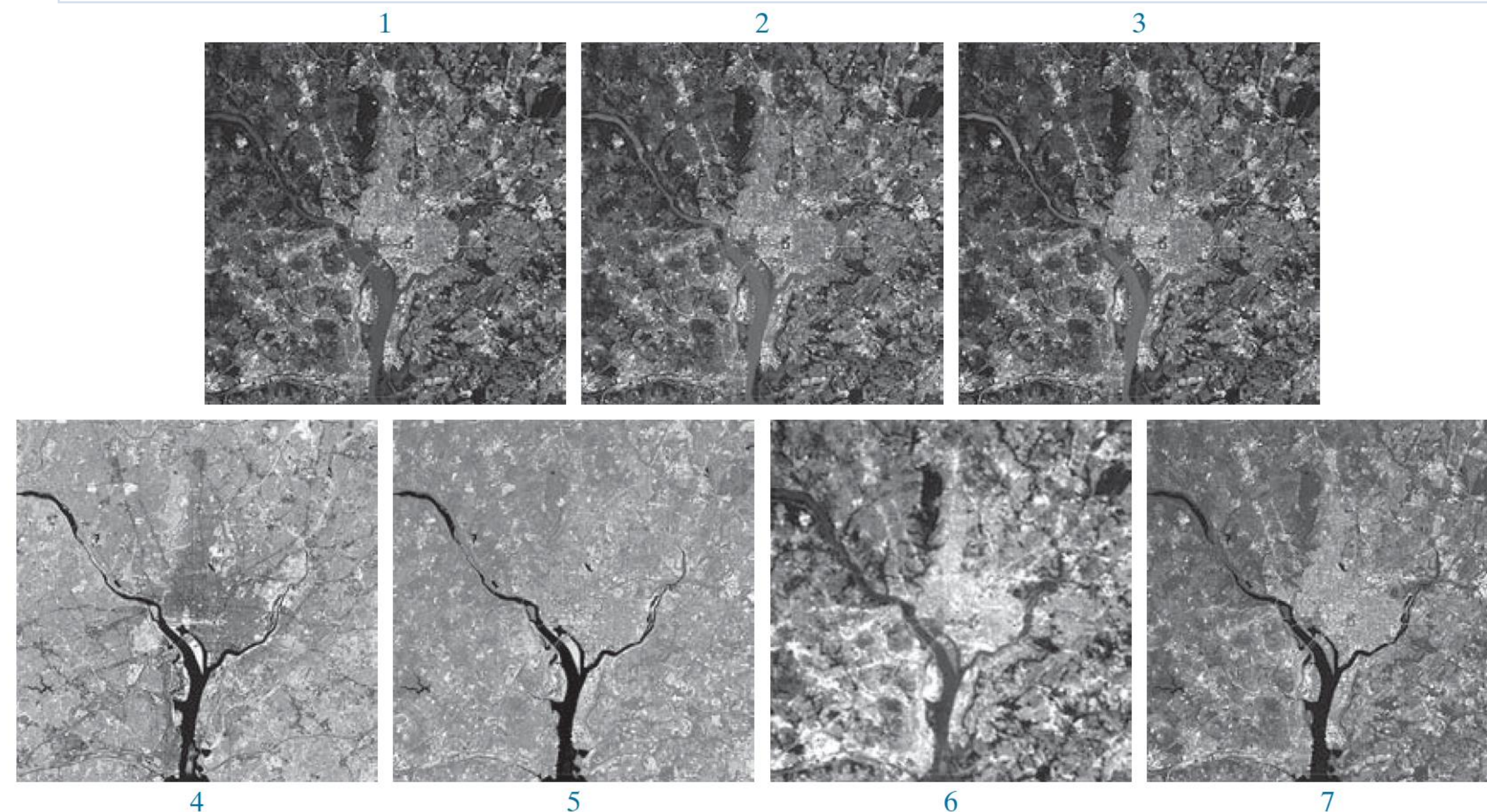


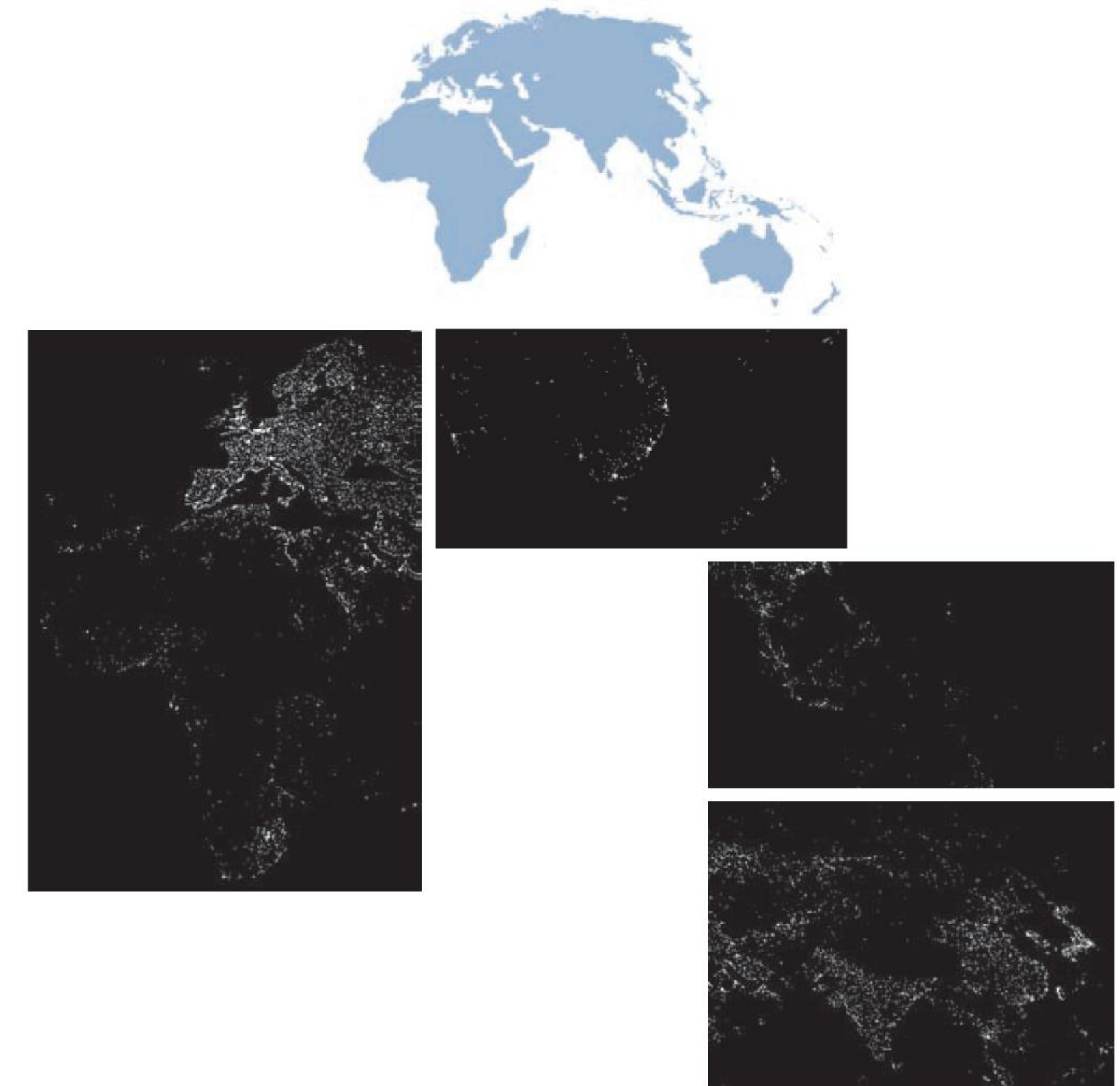
FIGURE 1.10 LANDSAT satellite images of the Washington, D.C. area. The numbers refer to the thematic bands in Table 1.1. (Images courtesy of NASA.)

Imaging in the visible and infrared bands

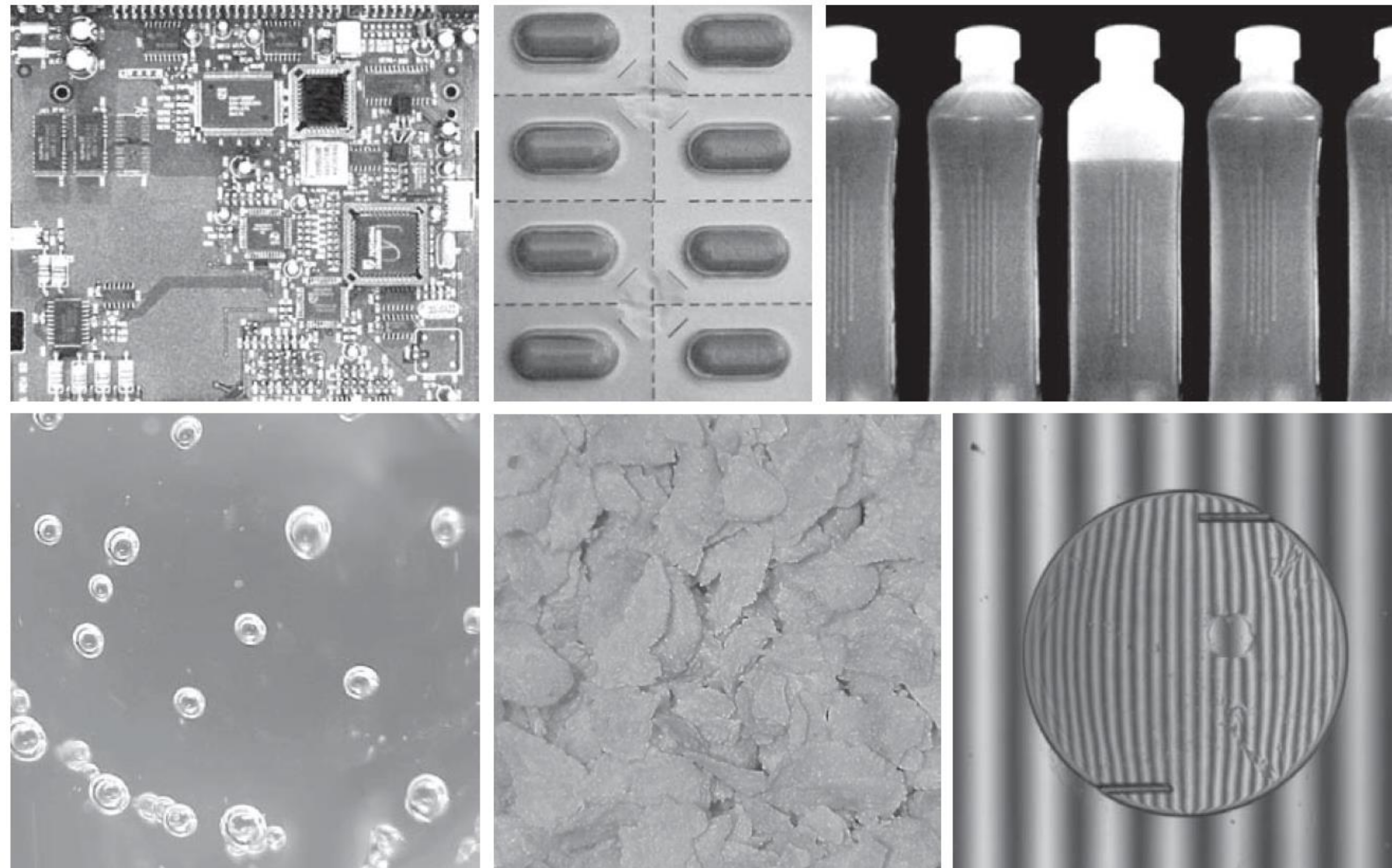
FIGURE 1.12
Infrared satellite images of the Americas. The small shaded map is provided for reference. (Courtesy of NOAA.)



FIGURE 1.13
Infrared satellite images of the remaining populated parts of the world. The small shaded map is provided for reference. (Courtesy of NOAA.)



Imaging in the visible and infrared bands



a b c
d e f

FIGURE 1.14 Some examples of manufactured goods checked using digital image processing. (a) Circuit board controller. (b) Packaged pills. (c) Bottles. (d) Air bubbles in a clear plastic product. (e) Cereal. (f) Image of intraocular implant. (Figure (f) courtesy of Mr. Pete Sites, Perceptics Corporation.)

Imaging in the visible and infrared bands

a b
c d

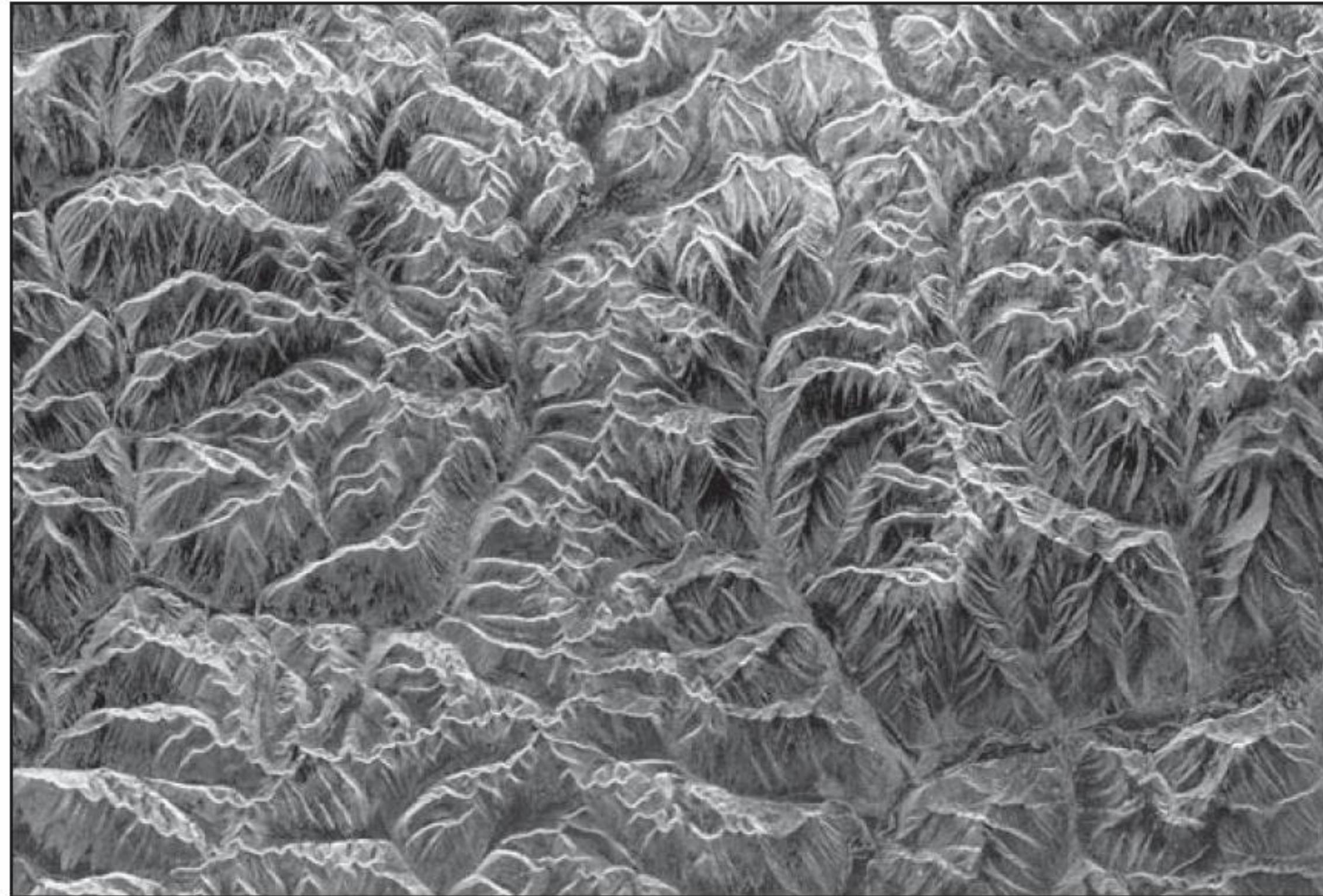
FIGURE 1.15
Some additional examples of imaging in the visible spectrum. (a) Thumb print. (b) Paper currency. (c) and (d) Automated license plate reading. (Figure (a) courtesy of the National Institute of Standards and Technology. Figures (c) and (d) courtesy of Dr. Juan Herrera, Perceptics Corporation.)



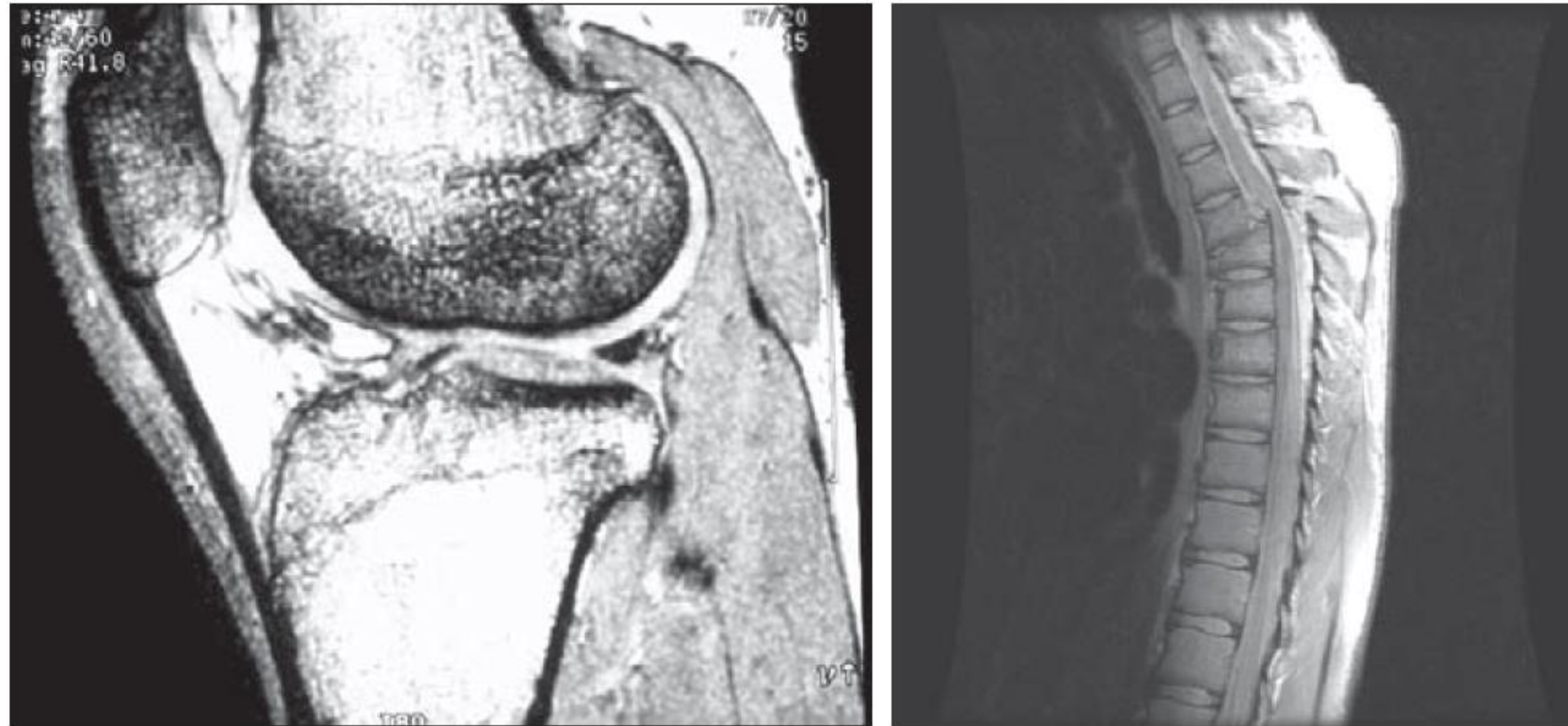
Imaging in the microwave band

FIGURE 1.16

Spaceborne radar image of mountainous region in southeast Tibet. (Courtesy of NASA.)



Imaging in the radio band



a b

FIGURE 1.17 MRI images of a human (a) knee, and (b) spine. (Figure (a) courtesy of Dr. Thomas R. Gest, Division of Anatomical Sciences, University of Michigan Medical School, and (b) courtesy of Dr. David R. Pickens, Department of Radiology and Radiological Sciences, Vanderbilt University Medical Center.)

Imaging in the radio band

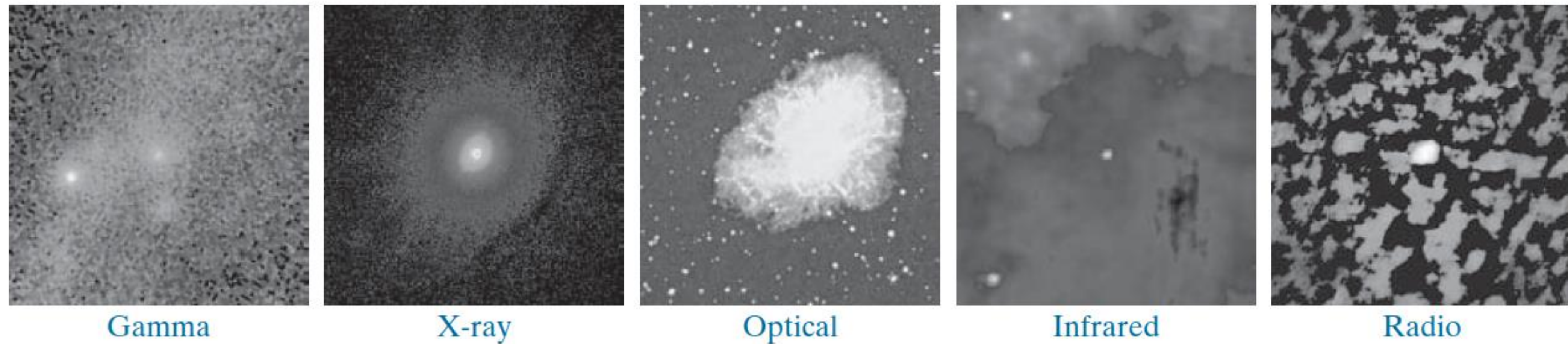
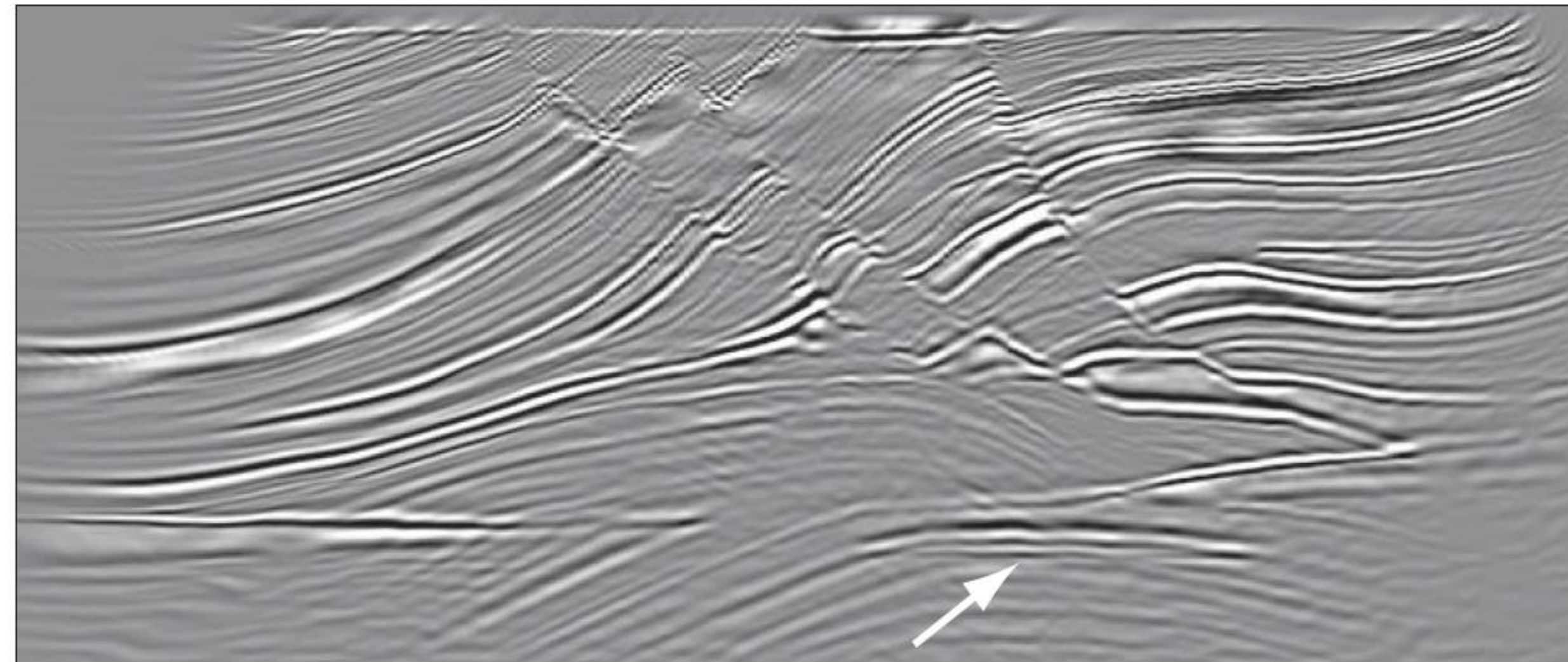


FIGURE 1.18 Images of the Crab Pulsar (in the center of each image) covering the electromagnetic spectrum. (Courtesy of NASA.)

Other imaging modalities

FIGURE 1.19

Cross-sectional image of a seismic model. The arrow points to a hydrocarbon (oil and/or gas) trap. (Courtesy of Dr. Curtis Ober, Sandia National Laboratories.)

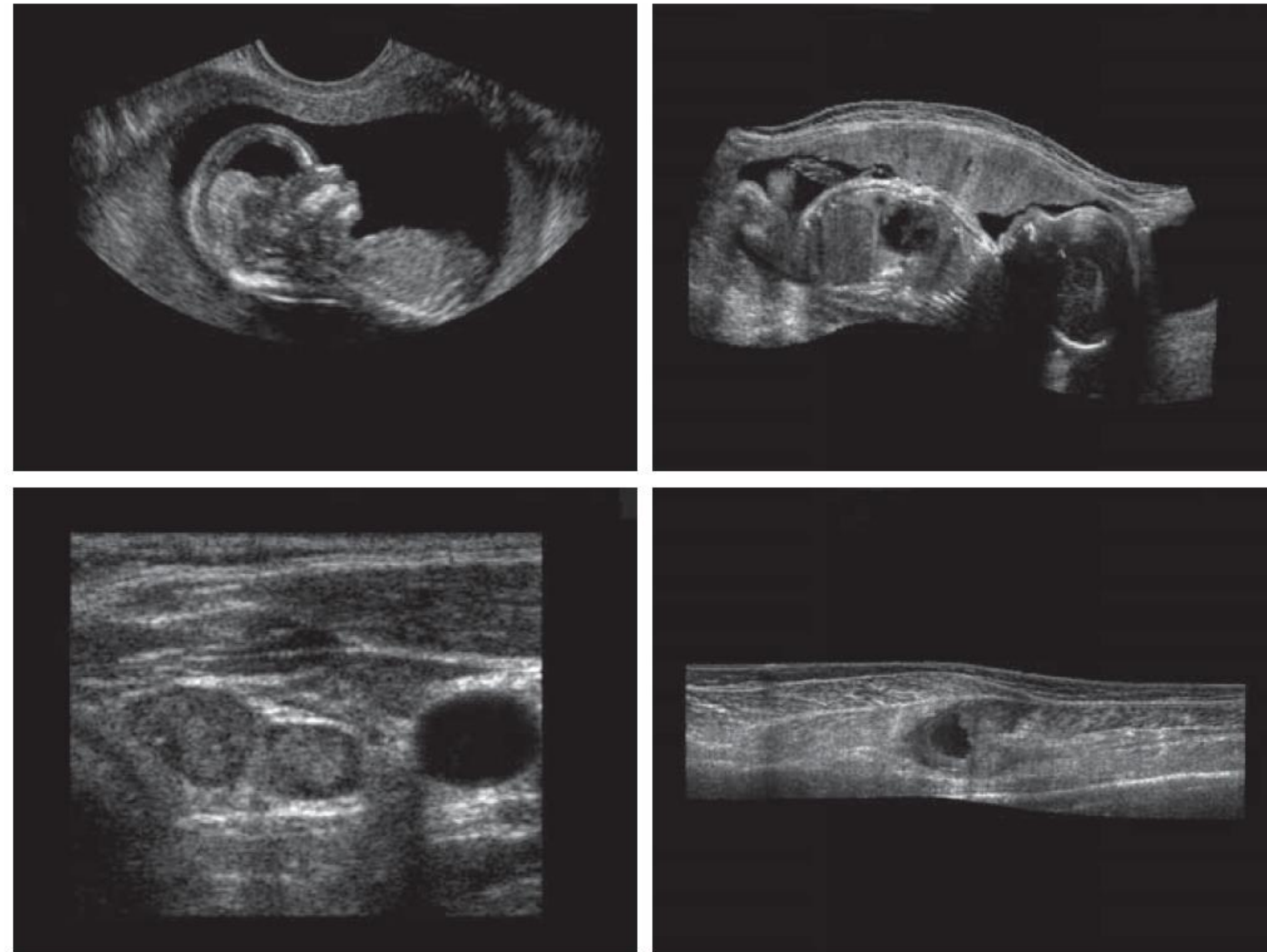


Other imaging modalities

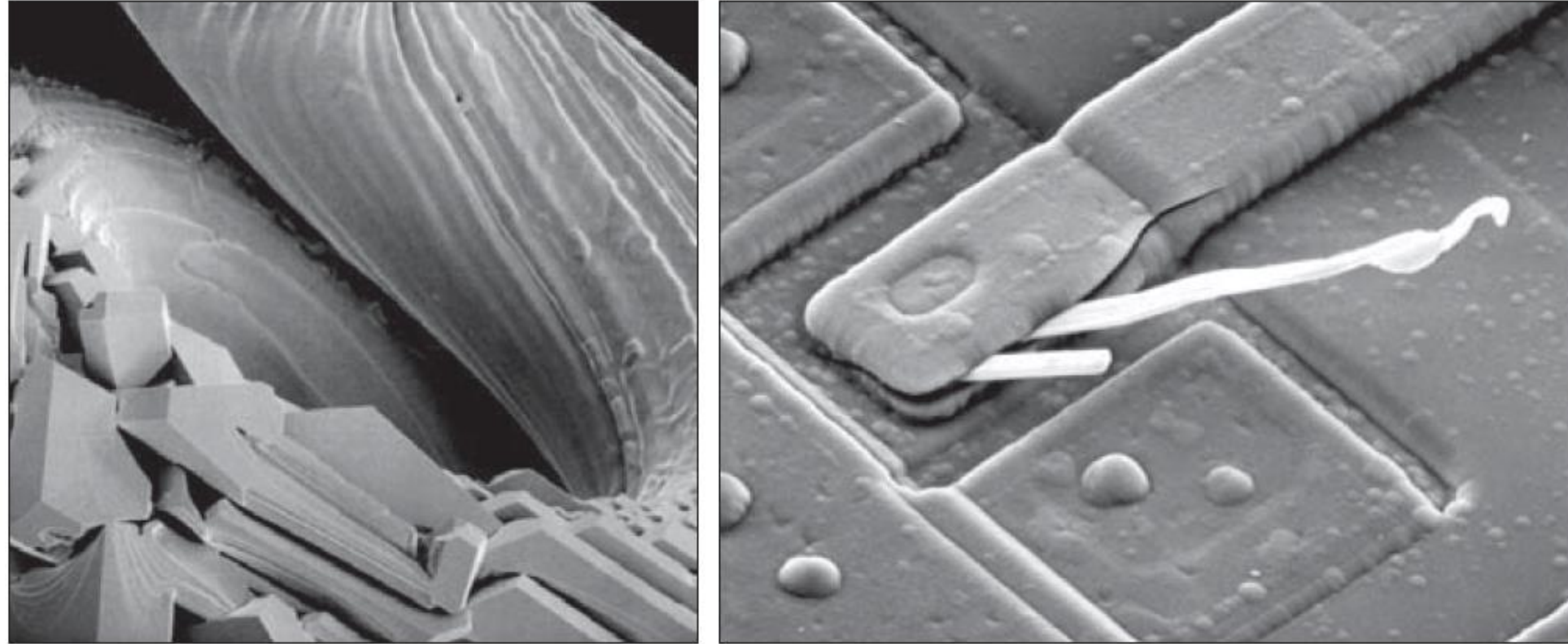
a	b
c	d

FIGURE 1.20

Examples of ultrasound imaging. (a) A fetus. (b) Another view of the fetus. (c) Thyroids. (d) Muscle layers showing lesion. (Courtesy of Siemens Medical Systems, Inc., Ultrasound Group.)



Other imaging modalities



a b

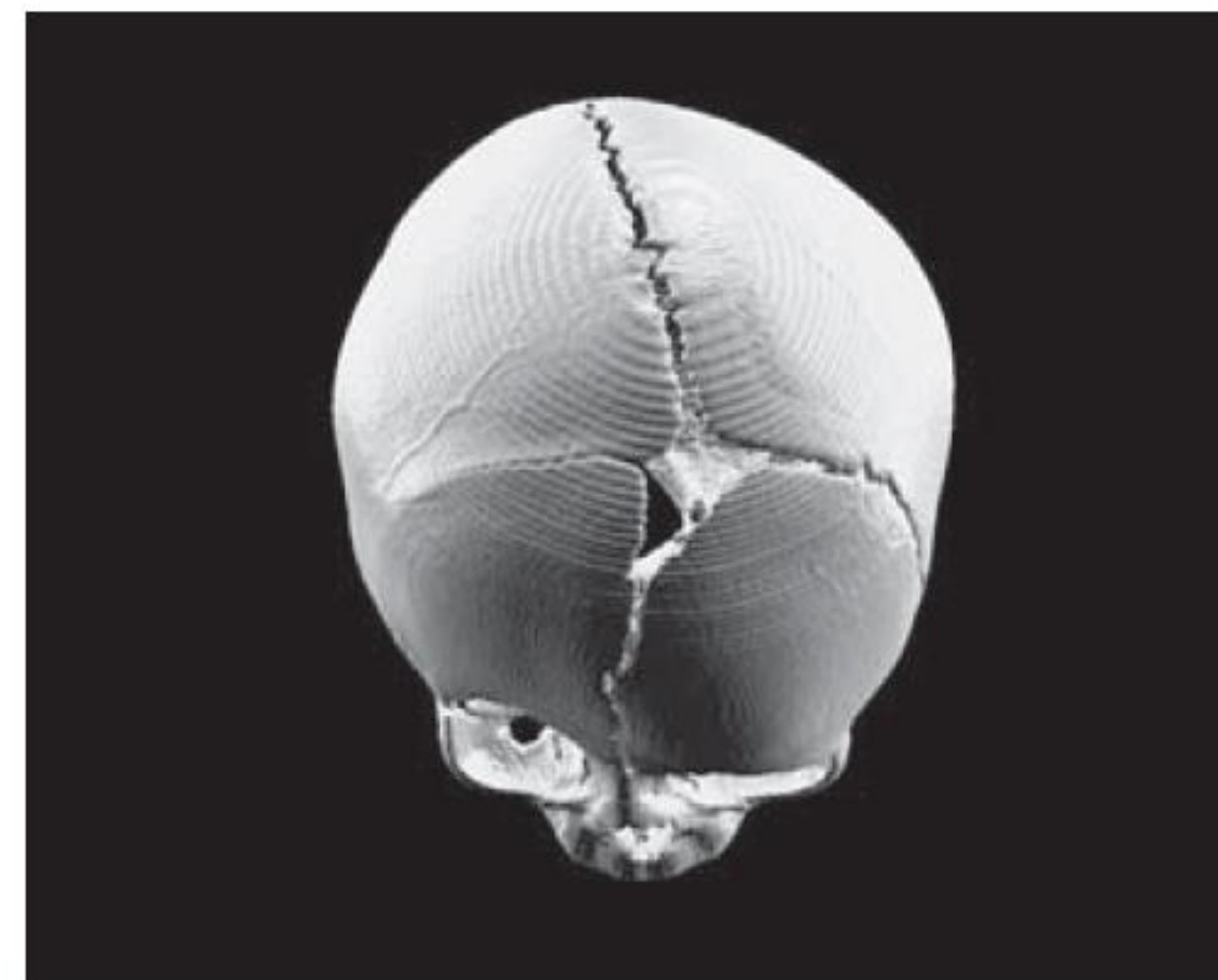
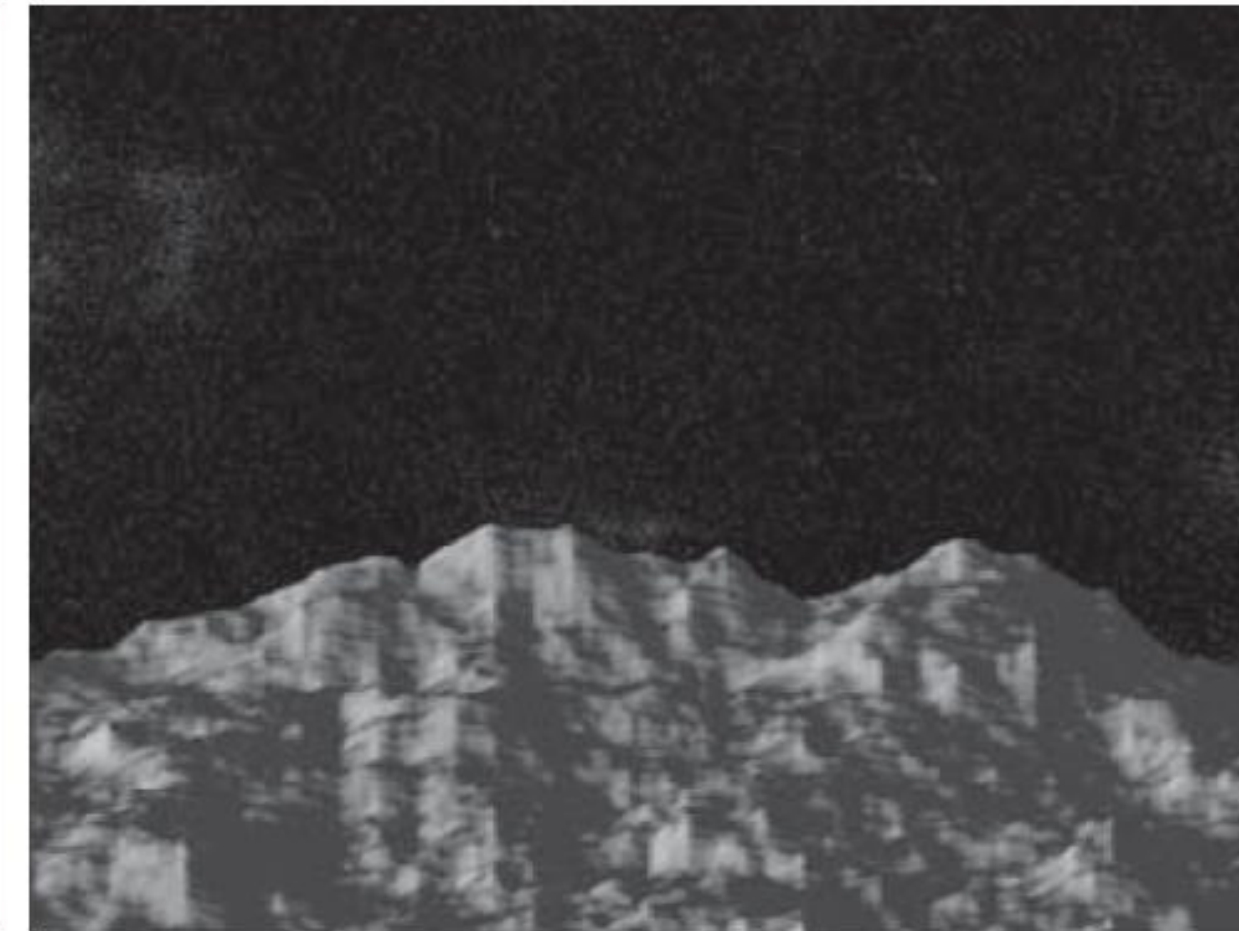
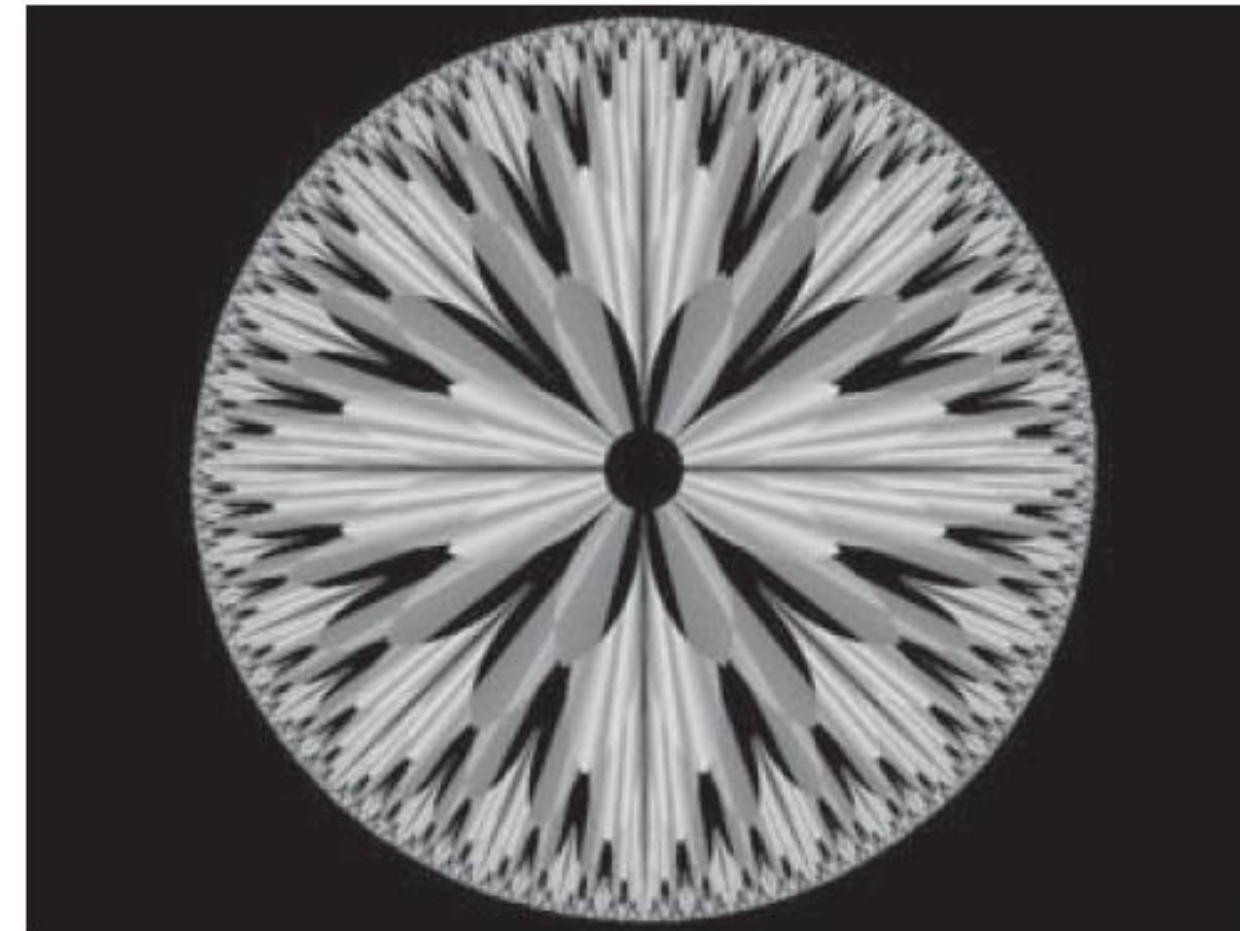
FIGURE 1.21 (a) $250\times$ SEM image of a tungsten filament following thermal failure (note the shattered pieces on the lower left). (b) $2500\times$ SEM image of a damaged integrated circuit. The white fibers are oxides resulting from thermal destruction. (Figure (a) courtesy of Mr. Michael Shaffer, Department of Geological Sciences, University of Oregon, Eugene; (b) courtesy of Dr. J. M. Hudak, McMaster University, Hamilton, Ontario, Canada.)

Other imaging modalities

a	b
c	d

FIGURE 1.22

(a) and (b) Fractal images.
(c) and (d) Images generated from 3-D computer models of the objects shown. (Figures (a) and (b) courtesy of Ms. Melissa D. Binde, Swarthmore College; (c) and (d) courtesy of NASA.)



Study:

- Rafael Gonzalez, Richard Woods, “Digital Image Processing”, 4th edition, Pearson, 2018
 - Chapter 1.1, 1.3

