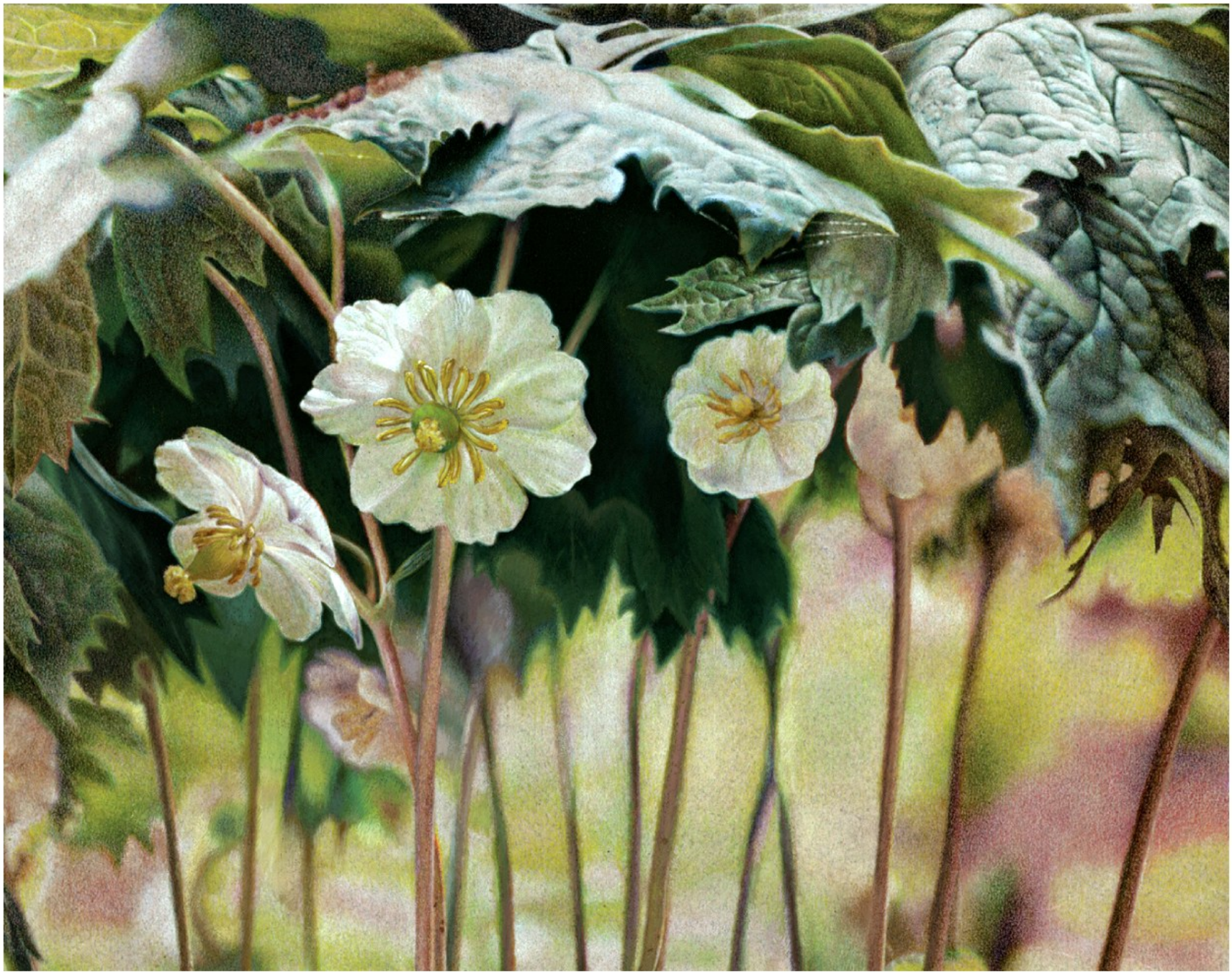
Ray F. Evert • Susan E. Eichhorn

Raven Biology of Plants

Eighth Edition

CHAPTER 1

Botany: An Introduction



Introduction

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Mayapple (*Podophyllum peltatum*)

- Open woods & pastures in E. U.S. and Canada
- Blooms in May
- Yellowish fruit (a berry) is edible in small amounts when ripe (may cause indigestion)
- Rhizome, leaves and roots are poisonous (podophyllotoxin)
- Used by Native Americans as food, emetic, cathartic and anthelminthic
- (Wikipedia)

Chapter 1 Opener

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Nymphaea 'Fabiola' (Fabiola Hardy Water Lily)

- A hybrid
- Secondarily evolved for life in water
- Water-resistant waxy outer layer, or cuticle
- Stomata – gas exchange
- Highly—developed internal transport system
- Named after 4th C. saint from Rome
- Patron of Divorced people, difficult marriages, victims of abuse; adultery; unfaithfulness, widows; Hospice Movement
- (Wikipedia)

Chapter Outline

- Evolution of Plants
- Evolution of Communities
- Appearance of Human Beings

Main Points of this Chapter

- Photosynthesis is the process by which the sun's energy is captured to form organic molecules
- The chemical building blocks of life accumulated in the early oceans
- Heterotrophic organisms evolved before autotrophic organisms, prokaryotes before eukaryotes, and unicellular organisms before multicellular organisms
- Colonization of the land was associated with the evolution of structures to obtain water and minimize water loss
- Ecosystems are relatively stable, integrated units that are dependent on photosynthetic organisms
- Genetic engineering allows scientists to transfer genes between entirely different species

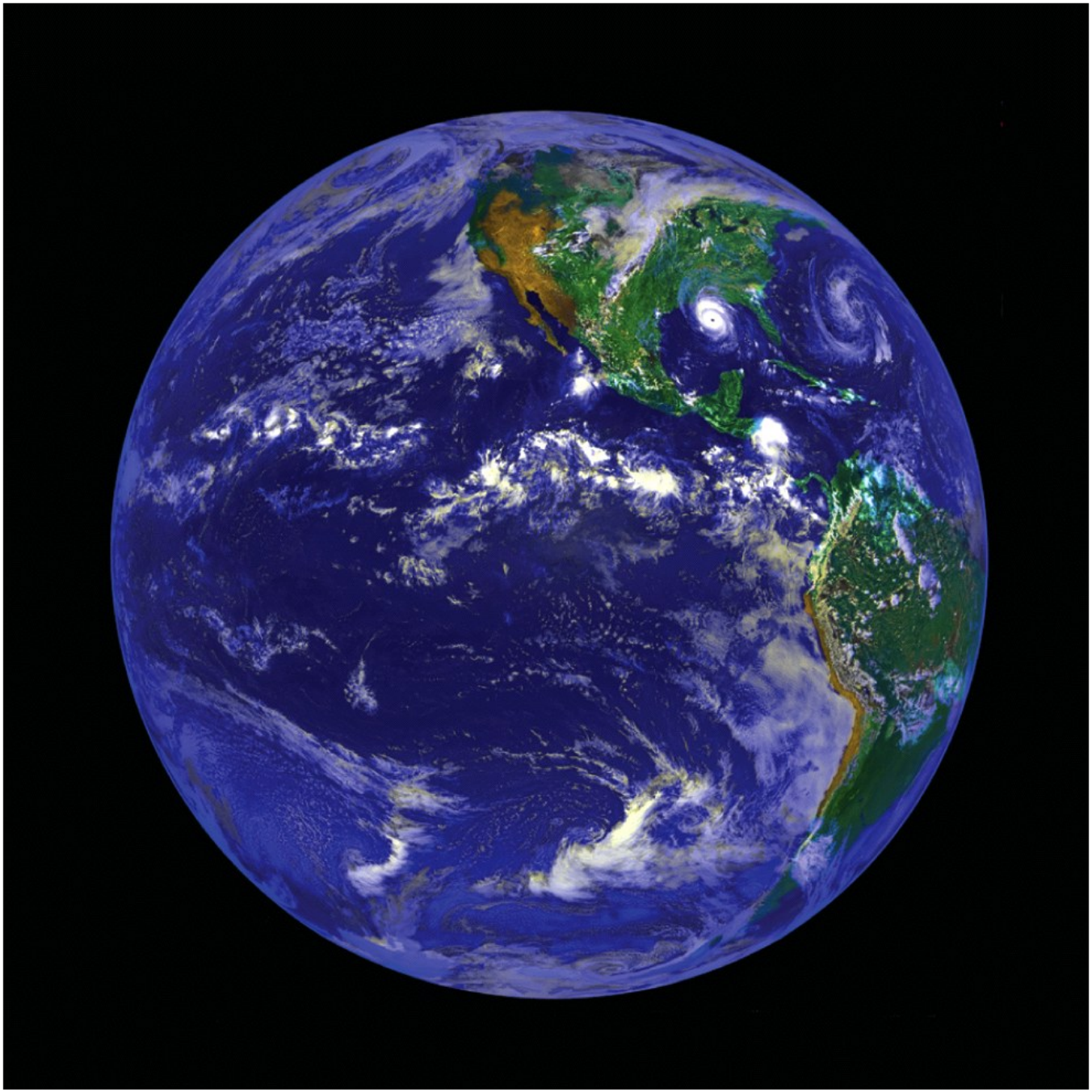

Figure 1-1
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View of Earth from a camera on V-2 #13, launched October 24, 1946. (White Sands Missile Range/Applied Physics Laboratory)

http://www.airspacemag.com/space/the-first-photo-from-space-13721411/?no-ist

Evolution of Plants

Life on Earth

- Of nine planets in our solar system, only earth is known to have life
- From a distance, Earth appears blue (from the water), green (from chlorophyll), and shiny (from sunlight reflected off the atmospheric gases)
- Life, as we know it, depends upon these features

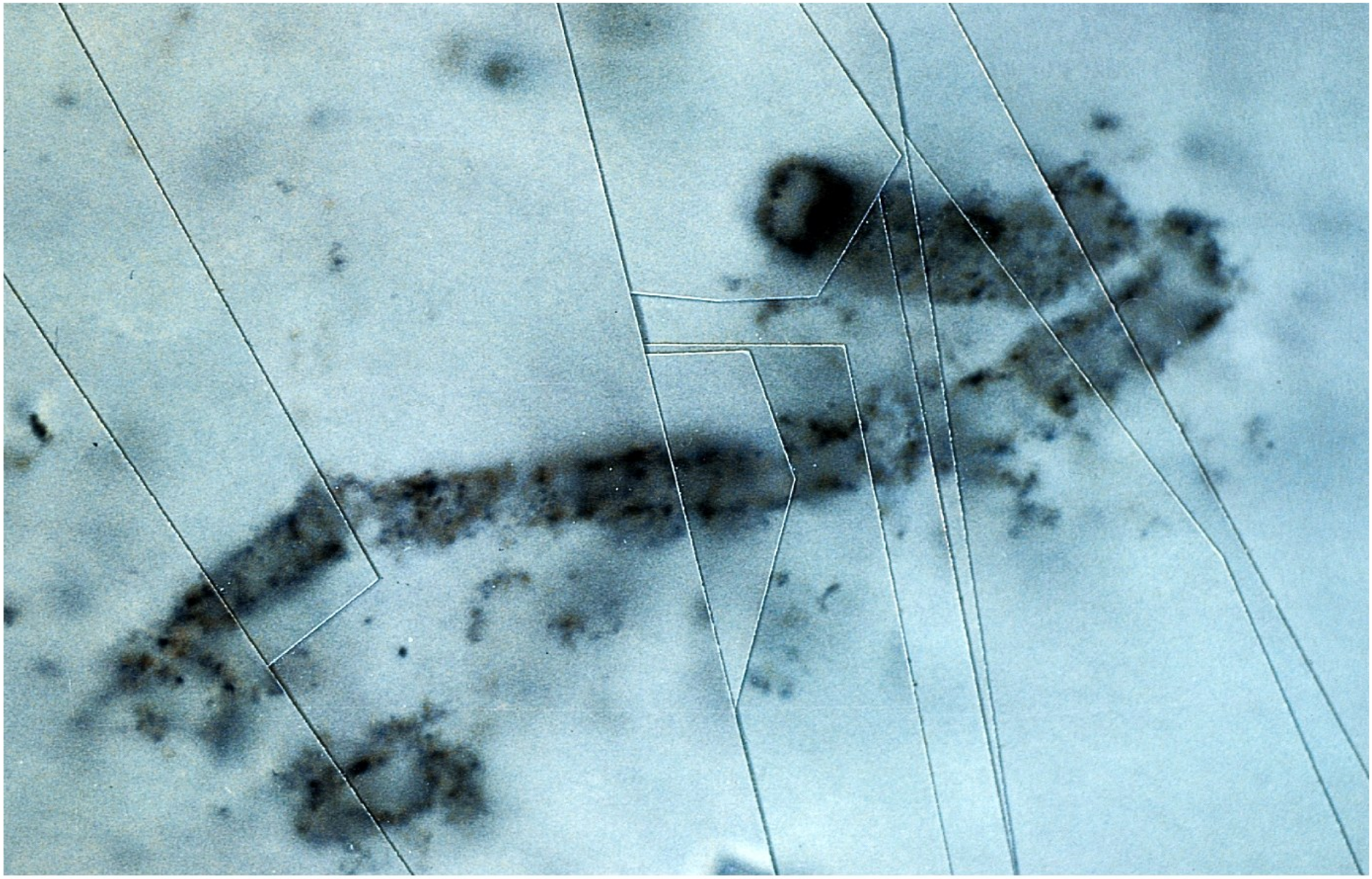

Figure 1-2
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Earliest Known Fossils

- From ancient rocks in northwestern Western Australia
- Fossilized prokaryotes
- 3.5 billion years old
- (Earth is 4.5 billion years old)
- (Eukaryotes evolved ca. 2.1 billion years ago)
- Image is highly magnified

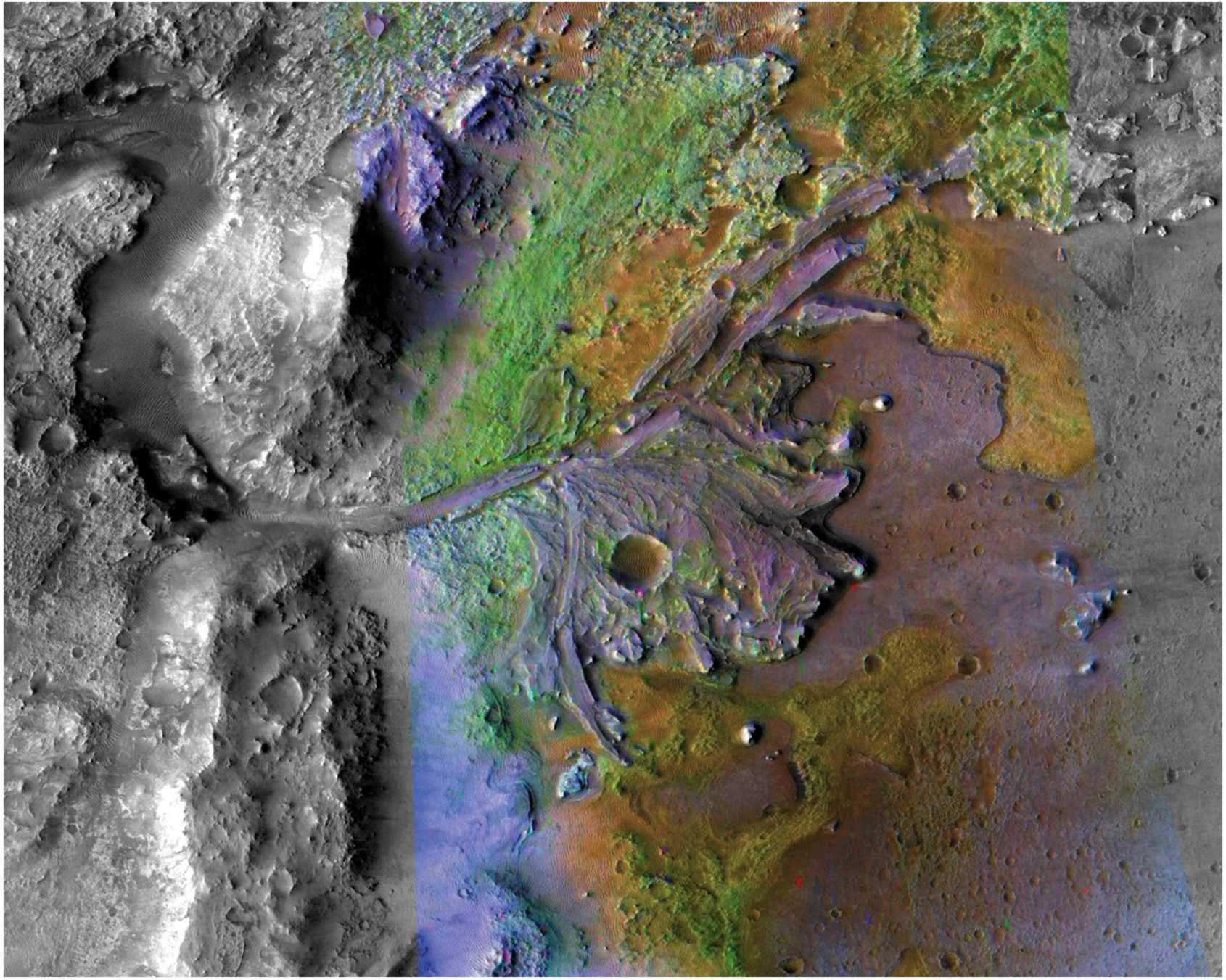

Figure 1-3
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Life on Mars?

- Color-enhanced image of Jezero Crater
- 25-mile-wide impact crater on northern Mars
- Once held a lake
- Claylike minerals (green) carried by ancient rivers into the lake, forming a delta
- Clays trap and preserve organic matter
- Promising area for search for life on Mars

Most likely, the forerunners of the first cells were simple aggregations of molecules

Autotrophic organisms make their own food, but heterotrophic organisms must obtain their food from external sources

Figure 1-4
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A Modern Heterotroph

- An orange-cap bolete, Aspen mushroom (*Leccinum insigne*, <old Italian word meaning fungus + a distinguishing mark, sign, or badge)
- Growing on forest floor in Colorado
- Edibility is questionable
- Absorbs food, often from other organisms; a heterotroph ("other-feeder")
- Boletaceae (Bolete Family)
- Scaber stalks (for small, rigid projections on stipes)
- *L. aurantiacum* (pictured, < L. aurántium, orange)
- (Image: Wikipedia)

Figure 1-5
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Photosynthetic Autotrophs

- Large-flowered trilliums *(Trillium grandiflorum*), of deciduous woods of eastern and midwestern N.A.; growing at base of birches (*Betula*)
- (*T. ovatum*, Pacific trillium pictured here)
- Rooted in soil
- Photosynthesis occurs mainly in leaves
- Emerge early before leaves of surrounding trees emerge
- Rhizomes involved in reproduction and overwintering
- Seeds dispersed by ants; myrmecochorous (ant dispersal, <"ants" + "circular dance"), elaiosomes (<"olive oil" + "body") (Mesler & Lu, 1983)
- (Image: Wikipedia)

https://www.youtube.com/watch?v=yQocN_aVeXU

Photosynthesis altered Earth's atmosphere, which in turn influenced the evolution of life

Figure 1-6
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Banded Iron Formations

- Jasper Knob, Michigan
- 2-billion-year-old red bands of iron oxide (rust)
- Evidence of oxygen accumulation
- Prior to 2.2 billion years ago, oxygen released by photosynthetic organisms and deposited first into water (then reacted with iron and precipitated as iron oxide)
- Ca. 2.2-2.7 billion years ago, oxygen began to accumulate in atmosphere; began to approach modern levels ca. 570-510 million years ago

The seashore environment was important in the evolution of photosynthetic organisms

Figure 1-7
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Evolution of Multicellular Organisms

- Early in the course of their evolution, multicellular photosynthetic organisms anchored themselves to rocky shores
- Kelp *(Durvillaea potatorum*), along coast of Victoria and Tasmania, Australia
- Brown algae (Class Phaeophyceae)
- [*Durvillaea* <Jules Dumont d'Urville (1790-1842), French explorer, botanist and cartographer (Wikipedia)]
- [*potatorum* < potator, "of the drinkers," "a drinker;" used by Aboriginal people of Tasmania to transport water (*Bioregion Fact Sheet About*, 2013)]

Colonization of the land was associated with the evolution of structures to obtain water and minimize water loss

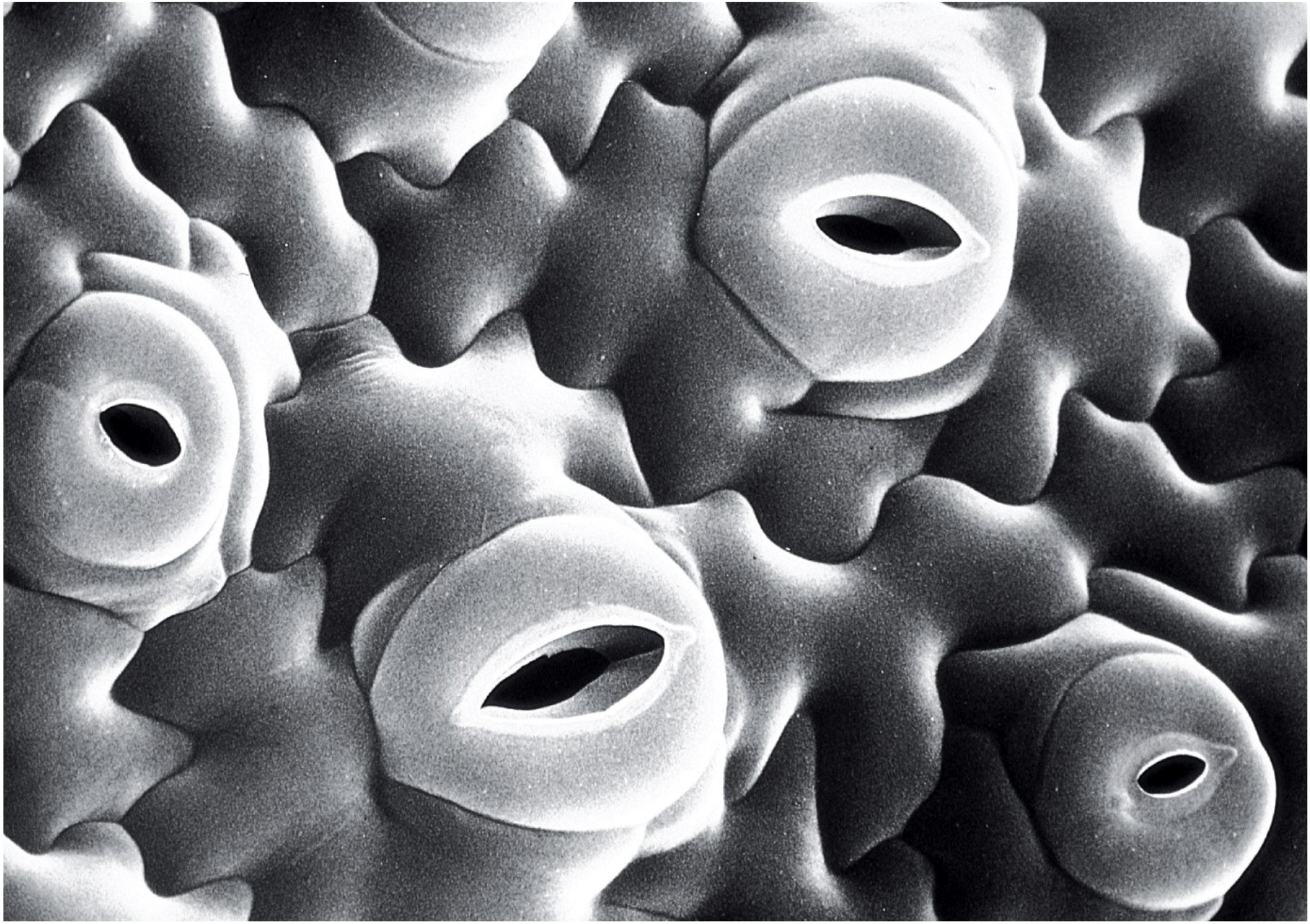

Figure 1-8
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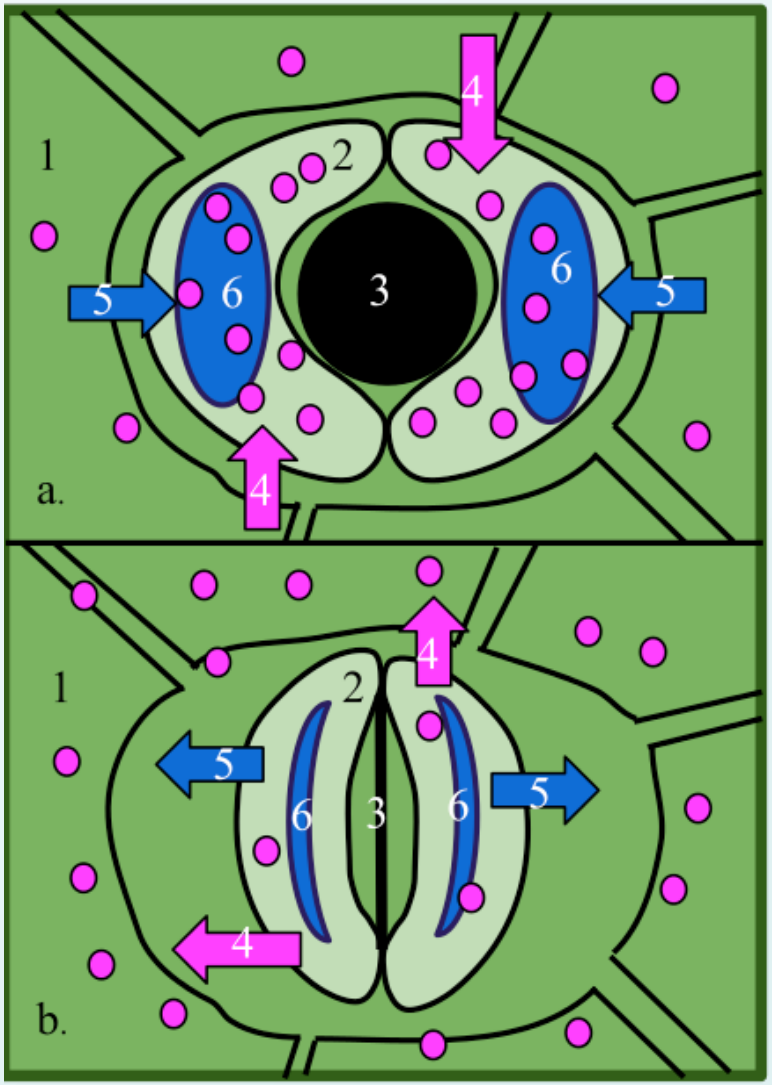
Stomata

- Open stomata on the surface of a tobacco (*Nicotiana tabacum*) leaf
- Each stoma in aerial plant parts is regulated by two guard cells
- Tobacco (<Taino and/or Arabic?)
- *Nicotiana* (<Jean Nicot [ca. 1530-1600], French ambassador to Portugal, who sent tobacco seeds and powdered leaves back to France 1561)
- (Image: Wikipedia)



An open stoma (a) and a closed stoma (b)
1 Epidermal cell
2 Guard cell
3 Stoma
4 K+ ions
5 Water
6 Vacuole

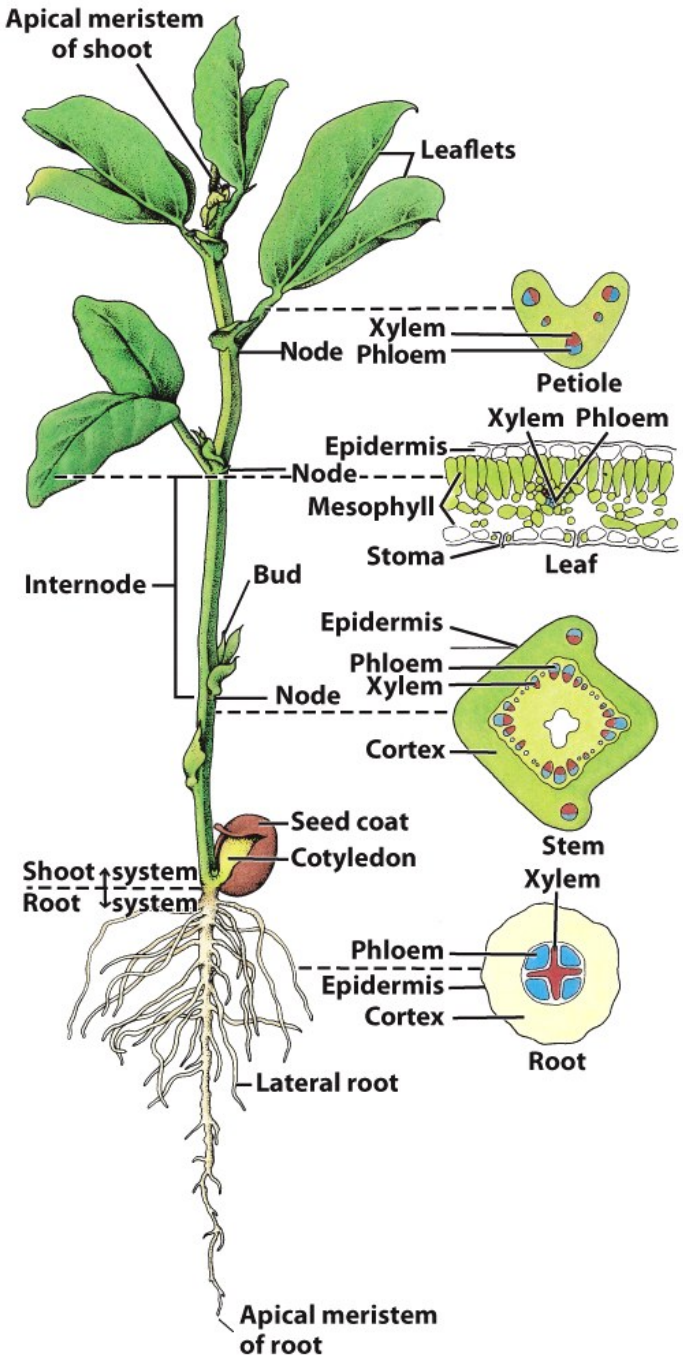


Figure 1-9

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A Modern Vascular Plant

- *Vicia faba* (broad bean)
- Principal organs and tissues of the modern vascular plant body
- Organs: Stems, roots, and leaves - composed of tissues
- Tissues – groups of cells with distinct structures and functions
- Roots = root system
- Stems and leaves = shoot system; divided into nodes and internodes
- Vascular system continuous throughout the plant body
- Mesophyll tissue of leaves specialized for photosynthesis

Figure 1-10a
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Evolution of Communities

Ecosystems are relatively stable, integrated units that are dependent on photosynthetic organisms

Examples of the Enormous Diversity of Biomes on Earth

- Temperate deciduous forest
- Covers most of eastern U.S. and southeastern Canada
- Dominated by trees that lose leaves in cold winters
- Paper birches and red maple in early autumn in Adirondack Mountains of New York State

Figure 1-10b
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Examples of the Enormous Diversity of Biomes on Earth, continued

- Arctic tundra
- Underlain with permafrost
- Treeless
- Short growing season
- Autumn view in Tombstone Valley, Yukon, Canada

Figure 1-10c
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Examples of the Enormous Diversity of Biomes on Earth, continued

- Savannas in Africa
- Inhabited by huge herds of grazing animals
- Zebras and wildebeests
- Trees include acacias

Figure 1-10d
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Examples of the Enormous Diversity of Biomes on Earth, continued

- Moist tropical forests
- For example, in Costa Rica
- Richest, most diverse biome on Earth
- Perhaps half of all species of organisms found there

Figure 1-10e
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Examples of the Enormous Diversity of Biomes on Earth, continued

- Deserts
- Typically receive less than 25 centimeters of rain per year
- Sonoran Desert in Arizona
- Dominant plant is giant saguaro cactus
- Adapted for life in a dry climate
- Shallow, wide-spreading roots and thick stems for storing water

Figure 1-10f
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Examples of the Enormous Diversity of Biomes on Earth, continued

- Mediterranean climates
- Rare on a world scale
- Cool, moist winters – when plants grow
- Hot, dry summers – plants become dormant
- Evergreen oak woodland on Mount Diablo in California

Appearance of Human Beings

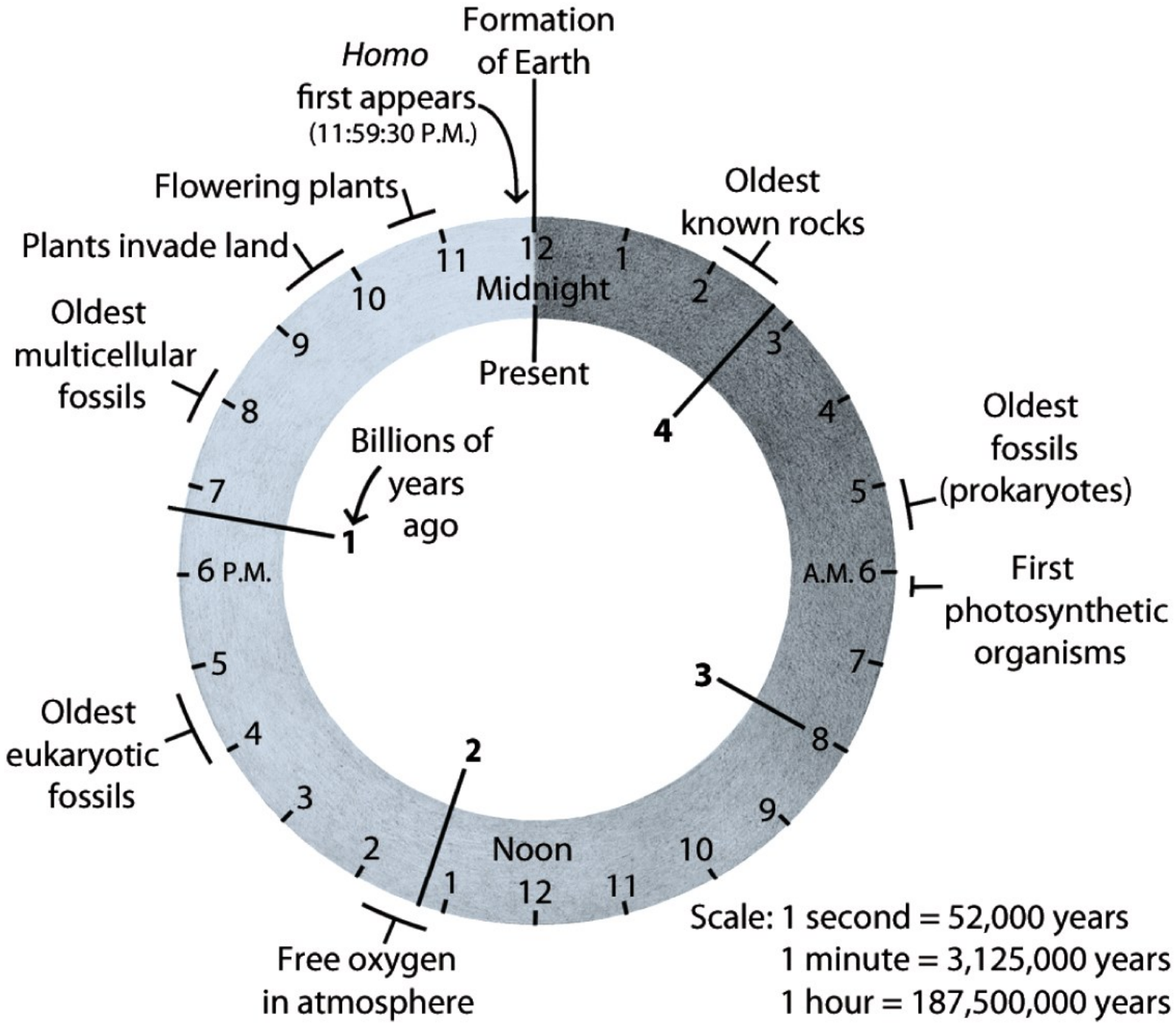

Figure 1-11
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The Clock Face of Biological Time

- Life appeared relatively early in Earth's history
- Sometime before 6:00 A.M. on a 24-hour scale
- First multicellular organisms do not appear until twilight of that 24-hour day
- *Homo* is a very late arrival—less than a minute before midnight

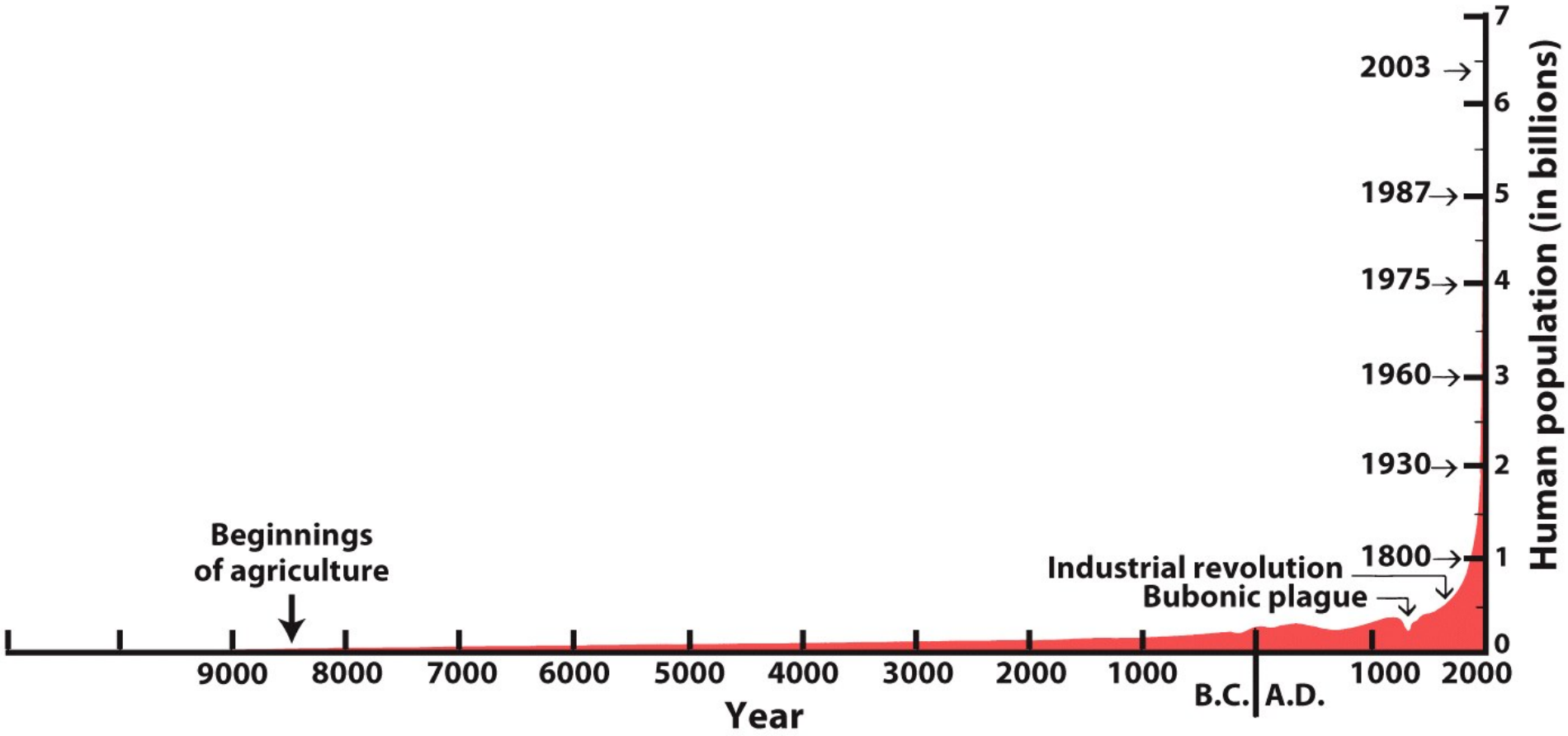

Figure 1-12 part 1
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Plant Biology Includes Many Different Areas of Study

- Plant physiology – study of how plants capture and transform energy and how they grow and develop
- Plant morphology – form of plants
- Plant anatomy – internal structures
- Plant taxonomy and systematics – naming and classifying plants and their interrelationships
- Cytology – cell structure, function, and life histories
- Genetics – heredity and variation
- Genomics – content, organization, and function of genetic information in whole genomes
- Molecular biology – structure and function of biological molecules
- Economic botany – past, present, and future uses of plants by people
- Ethnobotany – uses of plants for medicinal and other purposes by indigenous peoples
- Paleobotany – biology and evolution of fossil plants

A Knowledge of Botany

Is important for dealing with today's—and tomorrow's—problems

Growth of the Human Population

- Over the last 10,000 years
- Human population has grown from several million to ca. 6.5 billion
- Significant increase in population growth occurred as a result of the cultivation of plants as crops
- An even more dramatic increase began with the advent of the Industrial Revolution, starting in mid-eighteenth century and continues to the present

Figure 1-12 part 2
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Growth of the Human Population, continued

- Consequences of rapid human growth are many and varied
- In the U.S. and other parts of the developed world, they include sheer numbers of people and …

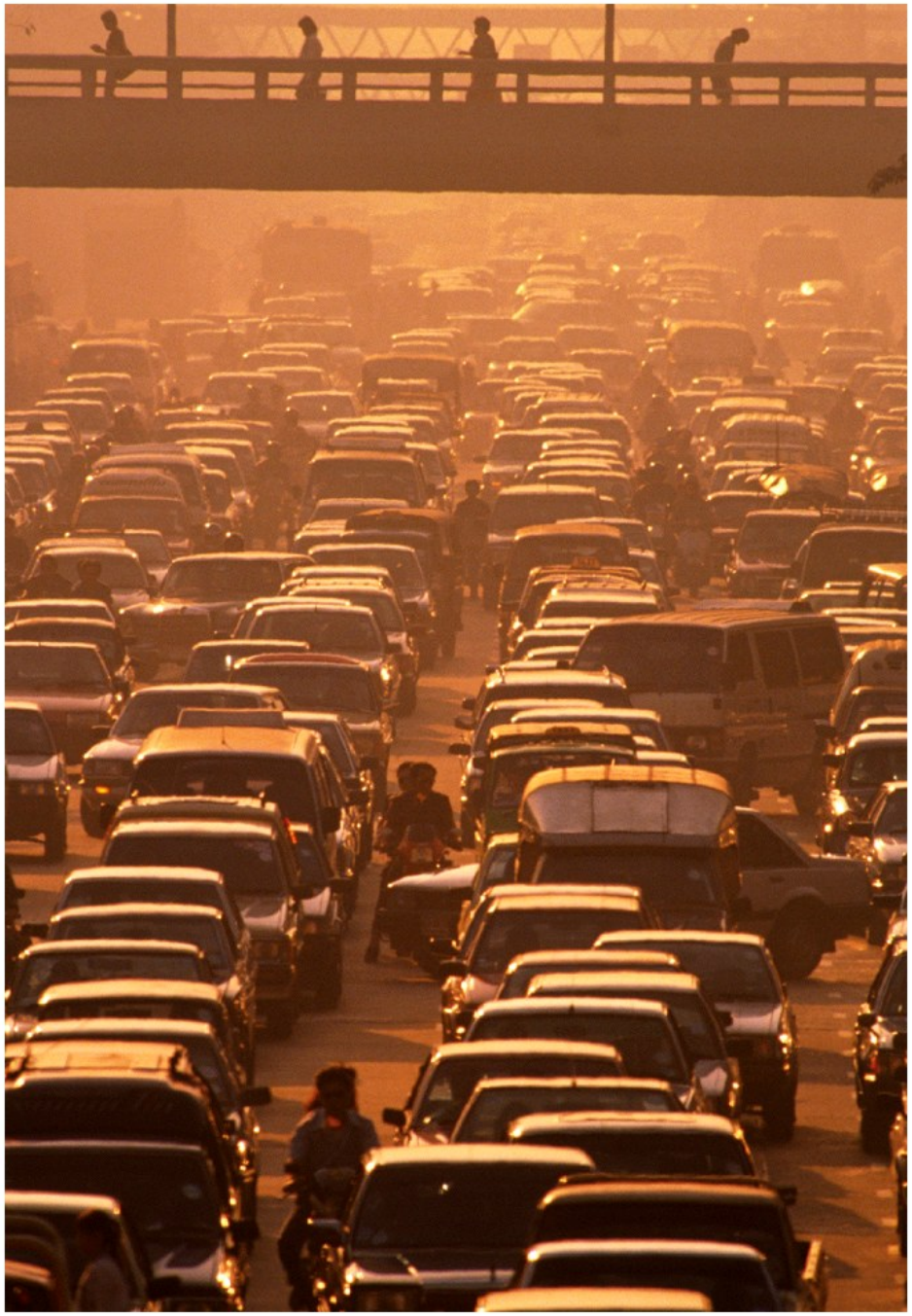

Figure 1-12 part 3
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Growth of the Human Population, continued

- … heavy consumption of nonrenewable fuels and resulting pollution …
- … both as fuels are burned and as a result of accidents such as oil spills at drilling sites and during transport

Figure 1-12 part 4
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Growth of the Human Population, continued

- In less developed parts of the world, consequences include malnutrition, starvation, and continuing vulnerability to infectious diseases
- Consequences for other organisms include direct effects of pollution and—most important—loss of habitat

Figure 1-13a
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Phytoremediation

- Sunflowers growing on a lake contaminated with radioactive cesium and strontium following the 1986 Chernobyl nuclear disaster in Ukraine, then part of the USSR
- Suspended from Styrofoam rafts, the sunflower's roots are able to remove up to 90% of the contaminants in 10 days

Figure 1-13b
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Phytoremediation, continued

- Poplar (*Populus* spp.) and willow (*Salix* spp.) trees growing on a fuel-contaminated site in Elizabeth, North Carolina
- Deep-rooted trees draw the contaminants up through their stems and leaves, reducing the need for mechanical pumping and treatment of of contaminated groundwater

Figure 1-13c
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Phytoremediation, continued

- Naturally occurring selenium accumulates in ditches containing run-off from irrigated croplands, creating bodies of standing water that are poisonous to wildlife, especially migrating birds
- Plants grown in the high-selenium soil that results from evaporation of the water are toxic
- Pickleweed (*Salicornia bigelovii*), a salt marsh plant, is highly efficient at removing selenium, which is absorbed by the plant and then released into the atmosphere to be dispersed by prevailing winds
- For the endangered salt marsh harvest mouse, pickleweed is a staple food

Figure 1-14
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Transgenic Plants

- Citrus seedlings were transformed by insertion of flower-initiating genes from *Arabidopsis*, the small flowering plant of the mustard family that is widely used for genetic research
- The sis-month-old transgenic seedling on the right has developed flowers
- The control seedling on the left has not and will take years to flower and set fruit

Figure 1-15a
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Greening of Abandoned Industrial Sites

- The High Line in New York City
- Built on an abandoned railroad track elevated above a newly resurrected neighborhood of restaurants, galleries, and shops
- Remnants of the original track can be seen among the shrubs, perennials, grasses, and trees planted along the popular promenade

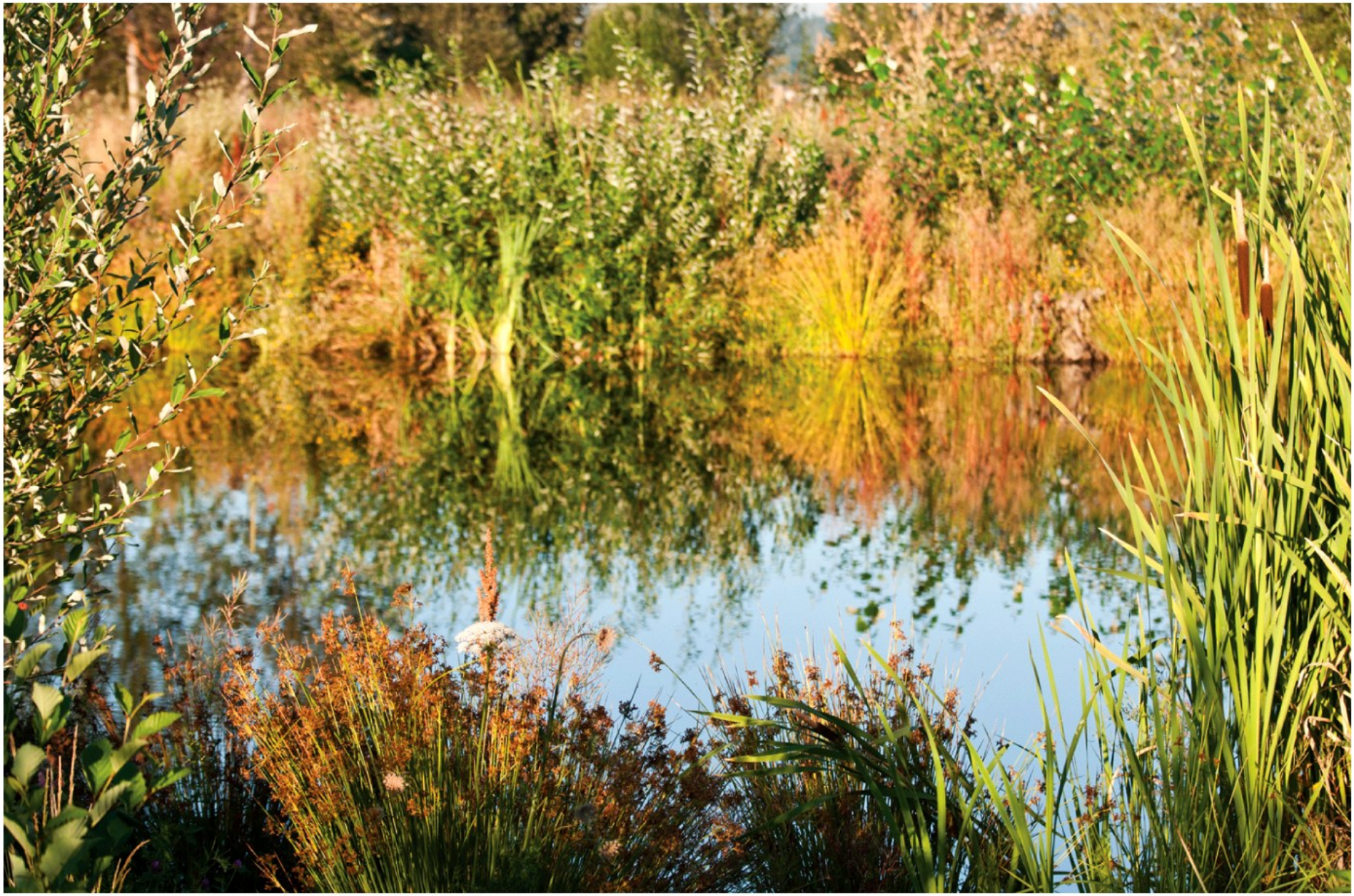

Figure 1-15b
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Greening of Abandoned Industrial Sites, continued

- A recently created wetlands situated on a former airbase in Magnuson Park in Seattle, WA
- A rich habitat of native plants and various species of wildlife
- Includes dragonflies, frogs, ducks owls, hawks shorebirds, and warblers

Summary of Main Points of this Chapter

- Photosynthesis is the process by which the sun's energy is captured to form organic molecules
- The chemical building blocks of life accumulated in the early oceans
- Heterotrophic organisms evolved before autotrophic organisms, prokaryotes before eukaryotes, and unicellular organisms before multicellular organisms
- Colonization of the land was associated with the evolution of structures to obtain water and minimize water loss
- Ecosystems are relatively stable, integrated units that are dependent on photosynthetic organisms
- Genetic engineering allows scientists to transfer genes between entirely different species

References

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- Also:
  - Etymonline.com for etymological information
  - Wikipedia, as indicated throughout