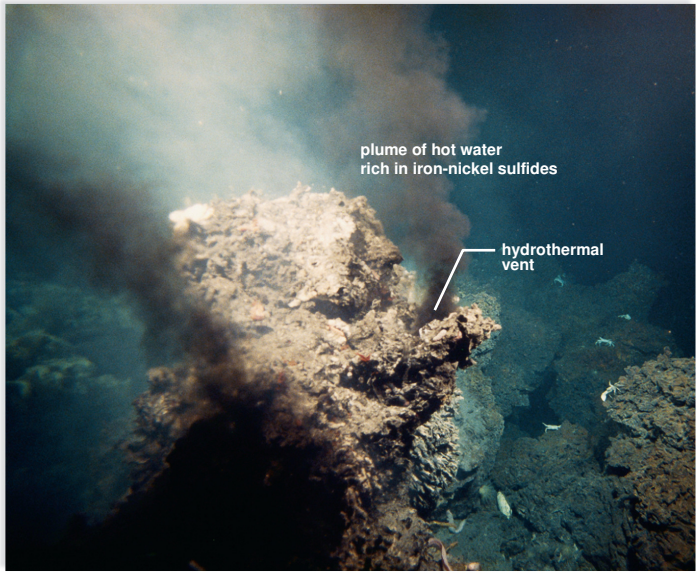
Chapter 18: pp. 317 - 336

Origin and History of Life

BIOLOGY

10th Edition

Sylvia S. Mader



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Origin of Life

- **Assignment: Read Evolution (1-71) on the school's website.**
- **Chemical evolution** is the increase in complexity of chemicals that led to the first cells.
  - Today, we say that "life only comes from life."
  - However, the first cells had to arise from an increased complexity of chemicals.

The Primitive Earth

- The Earth came into being about 4.6 BYA (BYA).
- The Earth's mass provides a gravitational field to hold an atmosphere
- Primitive atmosphere:
  - Most likely consisted of:
    - Water vapor
    - Nitrogen
    - Carbon dioxide
    - Small amounts of hydrogen and carbon monoxide
  - Little free oxygen
  - Originally too hot for liquid water to form
  - Earth cooled and water vapor condensed to liquid water

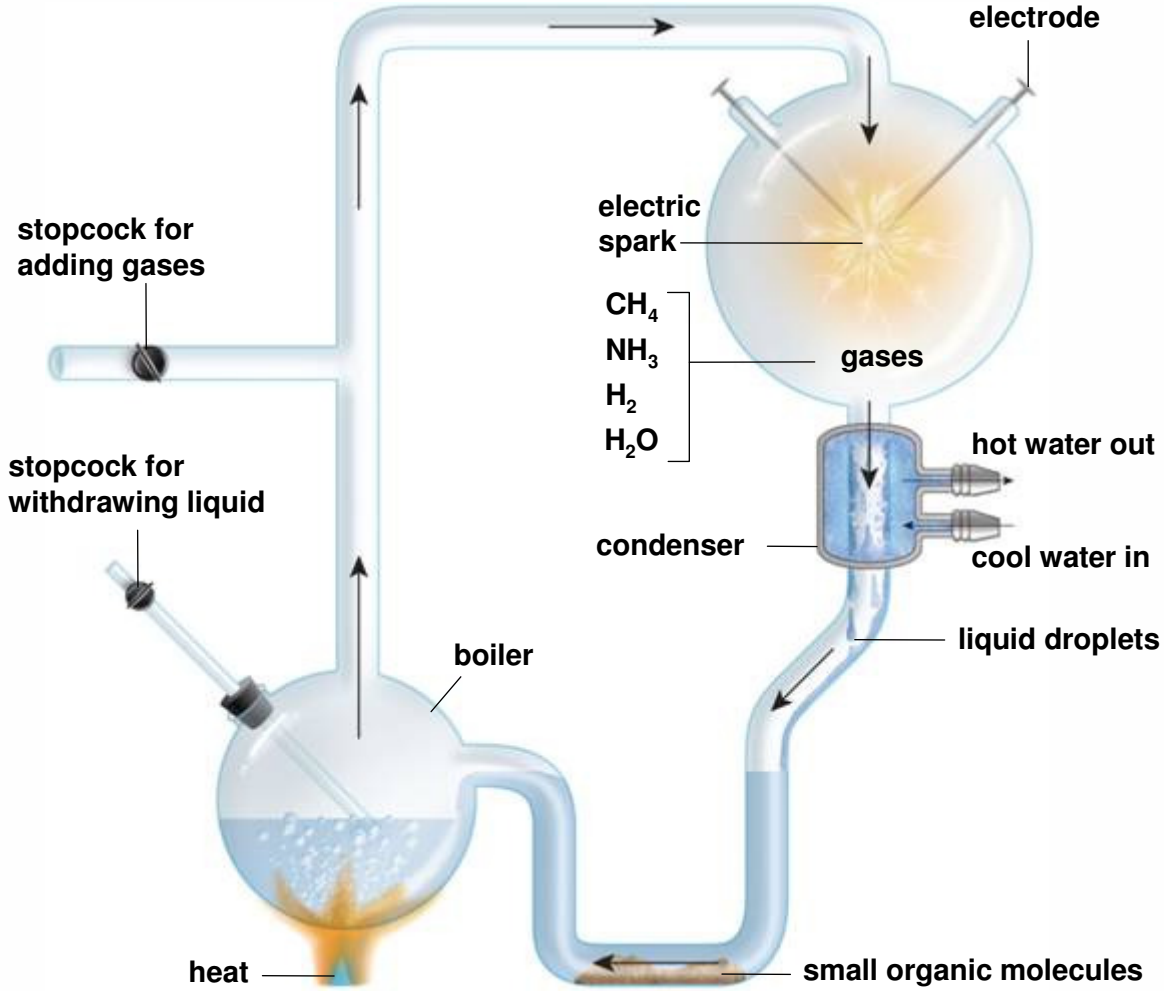
Monomers Evolve

- Comets and meteorites, perhaps carrying organic chemicals, have pelted the Earth throughout history.
  - This may have fossilized bacteria.
- Oparin/Haldane Hypothesis (1920s)
  - Suggested organic molecules could be formed in the presence of outside energy sources using atmospheric gases

Monomers Evolve

- Stanley Miller (1953)
  - Conducted an experiment
    - Showed that gases (methane, ammonia, hydrogen, water) can react with one another to produce small organic molecules (amino acids, organic acids).
    - Strong energy sources
- Led to theory of the Hot Thin Soup

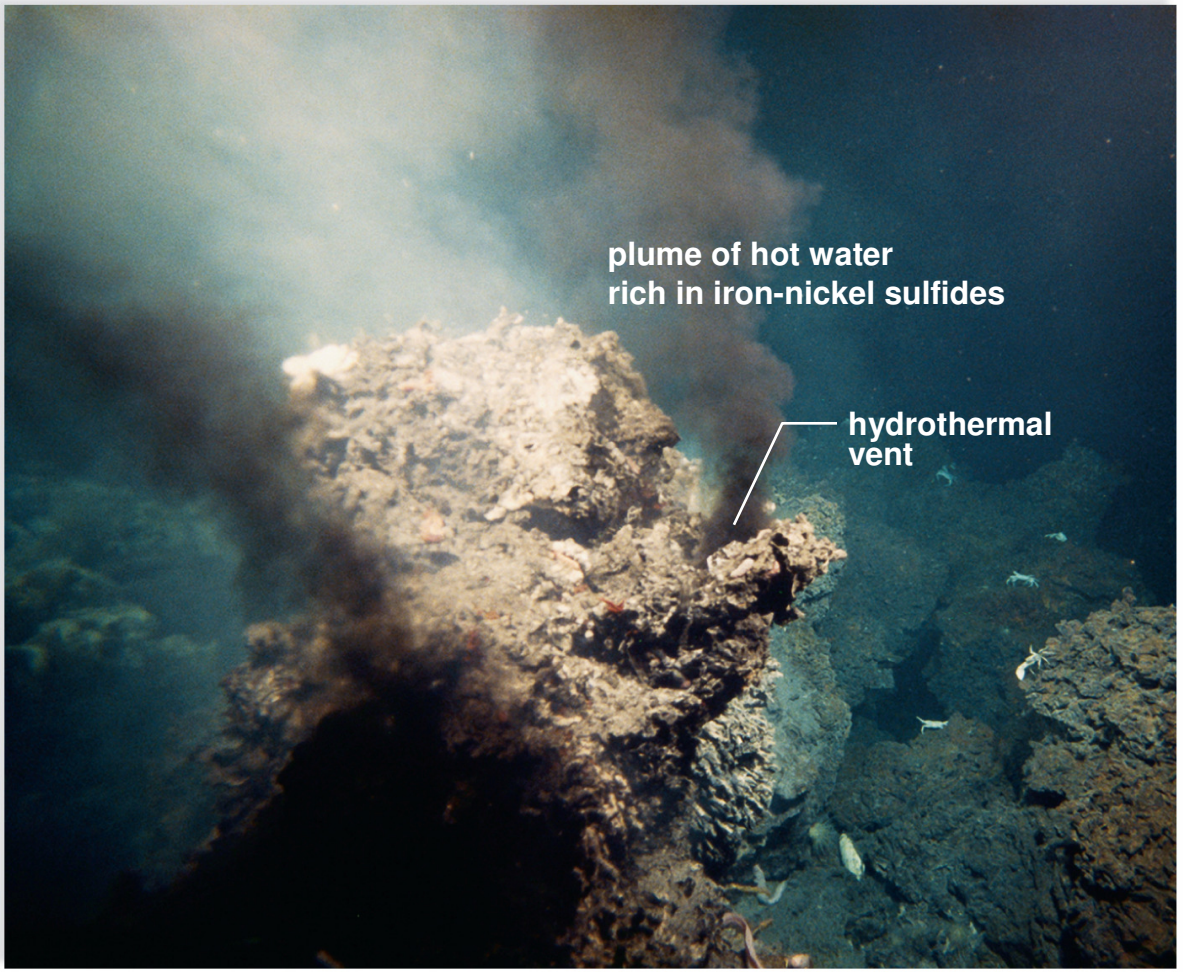
Miller's & Urey's Apparatus & Experiment



Polymers Evolve

- Monomers join to form polymers in the presence of enzymes
  - Protein-First Hypothesis:
    - Assumes protein enzymes arose first
    - DNA genes came afterwards
  - RNA-First Hypothesis:
    - Suggests only RNA was needed to progress toward formation of the first cell or cells
    - DNA genes came afterwards

Chemical Evolution at Hydrothermal Vents



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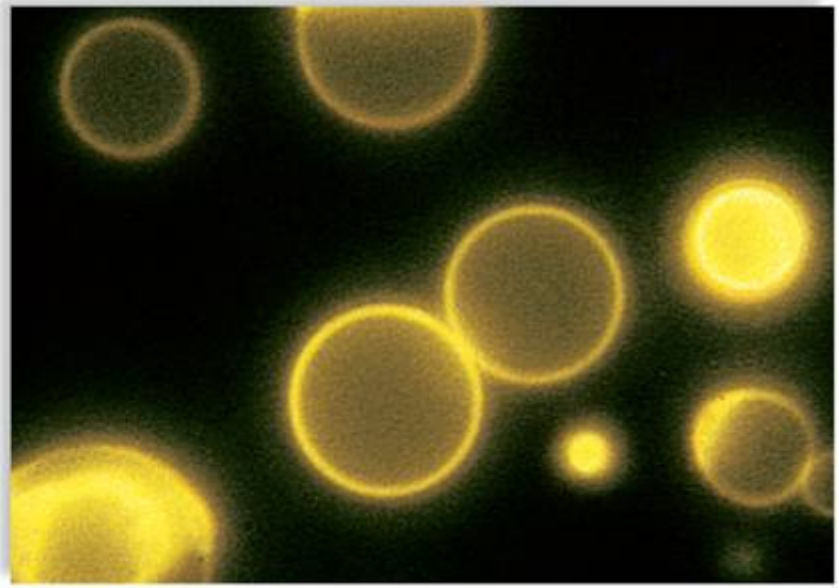
Protocell Evolves

- Before the first true cell arose, there would have been a **protocell** or **protobiont**.
- A protocell would have a lipid-protein membrane and carry on energy metabolism.
- Fox showed that if lipids are made available to microspheres, lipids become associated with microspheres producing a lipid-protein membrane.
- Protocells
  - Hypothesized precursors to the first true cells

Protocell Anatomy

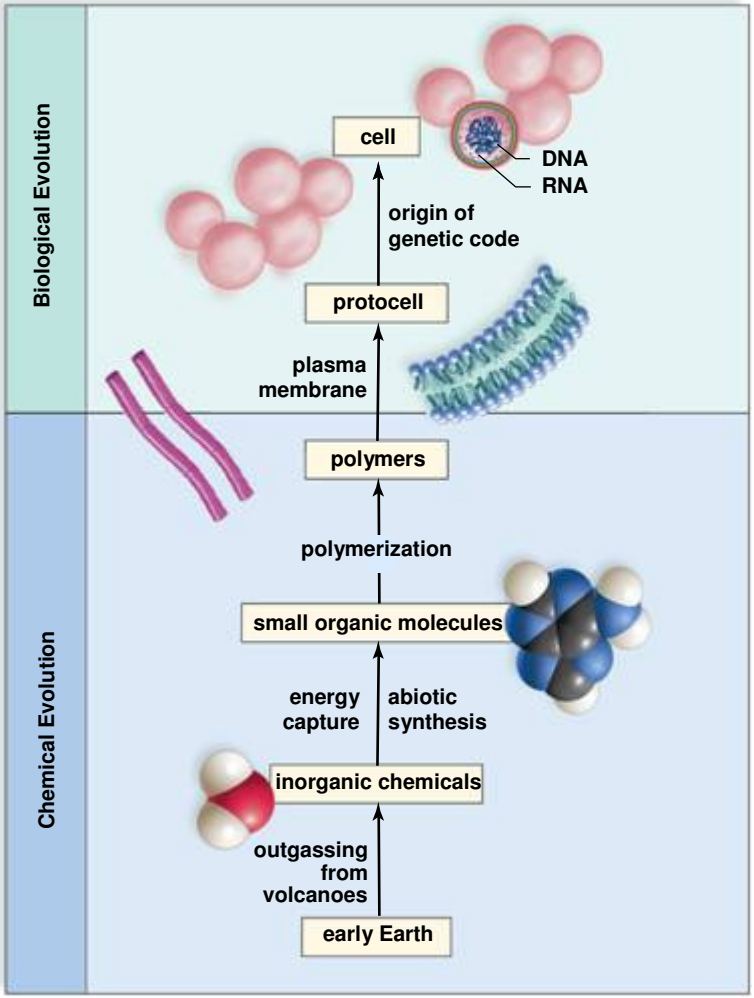
a.



b.

a: © Science VU/Visuals Unlimited; b: Courtesy Dr. David Deamer

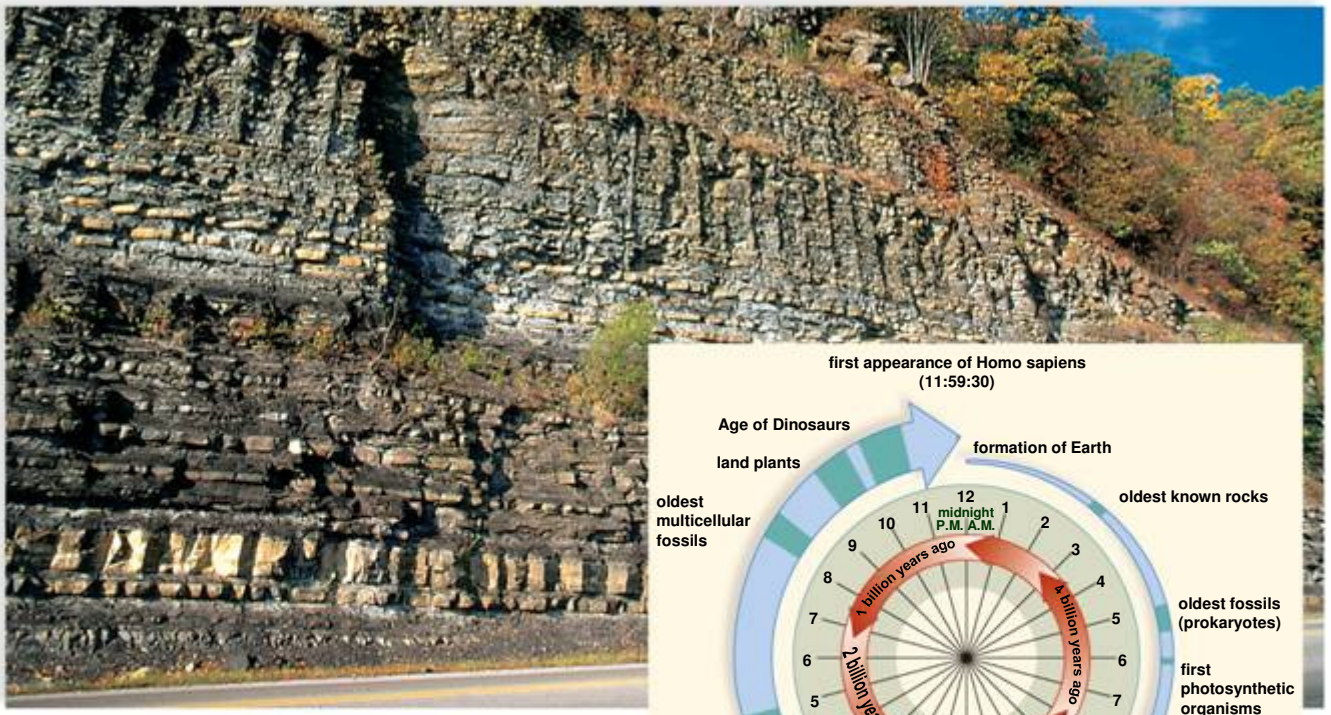
Origin of the First Cell(s)



Fossil Dating: Relative

- Remains and traces of past life
- Paleontology is the study of the fossil record
- Most fossils are traces of organisms embedded in sediments
  - Sediment converted to rock
  - Becomes recognizable stratum in stratigraphic sequence of rocks
  - Strata of the same age tend to contain the similar fossil assemblages
  - Helps geologists determine relative dates of embedded fossils despite upheavals

History of Life: Strata



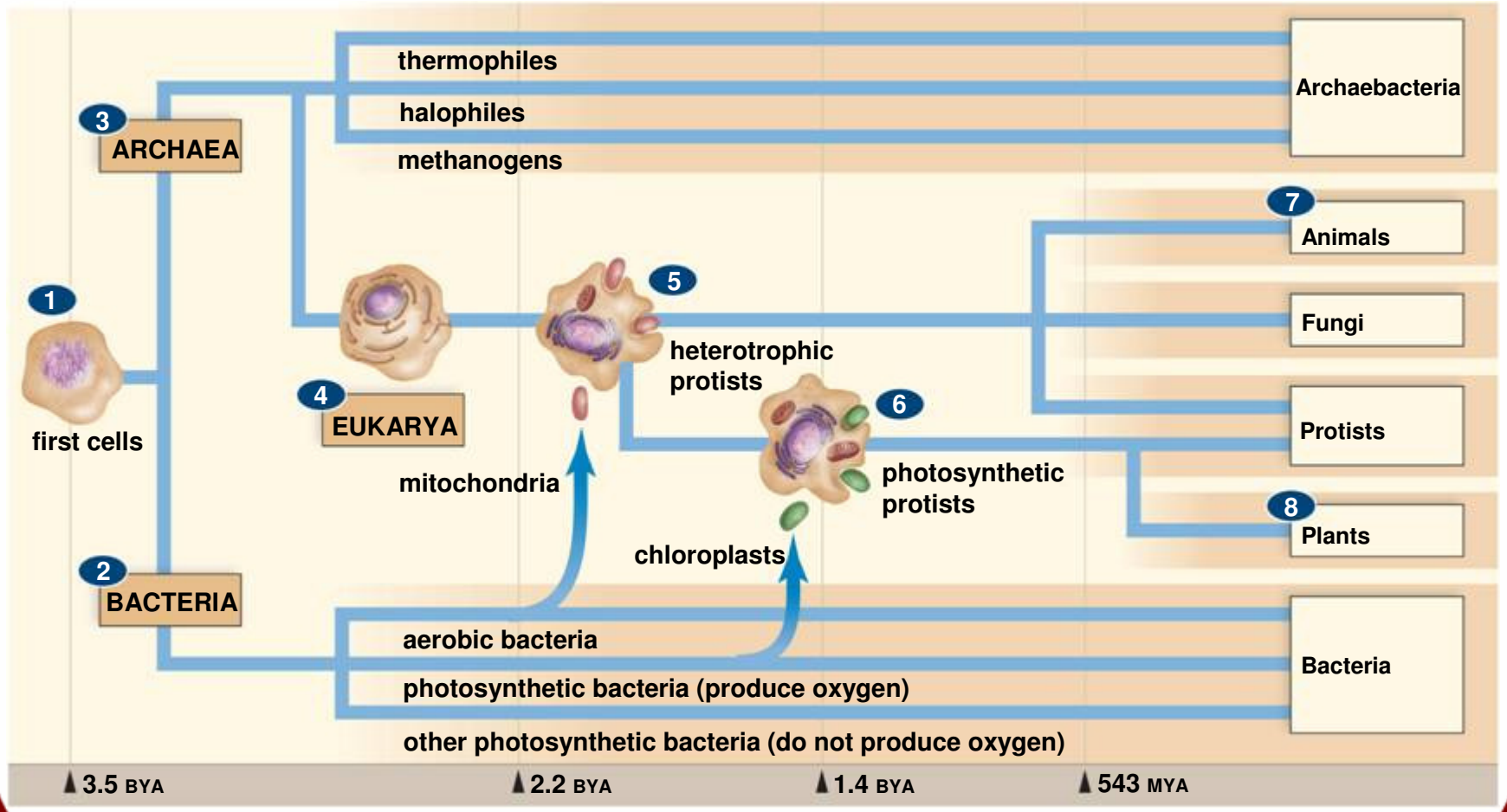
a.

b.

Fossils

(Trilobite): © Francois Gohier/Photo Researchers, Inc.; (Tusks): © AP Photo/Francis Latreille/Nova Productions; (Placoderm): © The Cleveland Museum of Natural History; (Fern): © George Bernard/Natural History Photo Agency; (Petrified wood): Courtesy National Park Service; (Ammonites): © Sinclair Stammers/SPL/Photo Researchers, Inc.; (Scorpion): © George O. Poinar; (Dinosaur footprint): © Scott Berner/Visuals Unlimited; (Ichthyosaur): © Natural History Museum, London

The Tree of Life



Fossil Dating: Absolute

- One absolute dating method relies on radio (radioactive) dating techniques
- Half-life:
  - The length of time required for half the atoms to change into something else
  - Unaffected by temperature, light, pressure, etc.
  - All radioactive isotopes have a dependable half life
    - Some only fractions of a second
    - Some billions of years
    - Most in between
- Many isotopes are used, and their combined half lives make them useful over all periods of interest

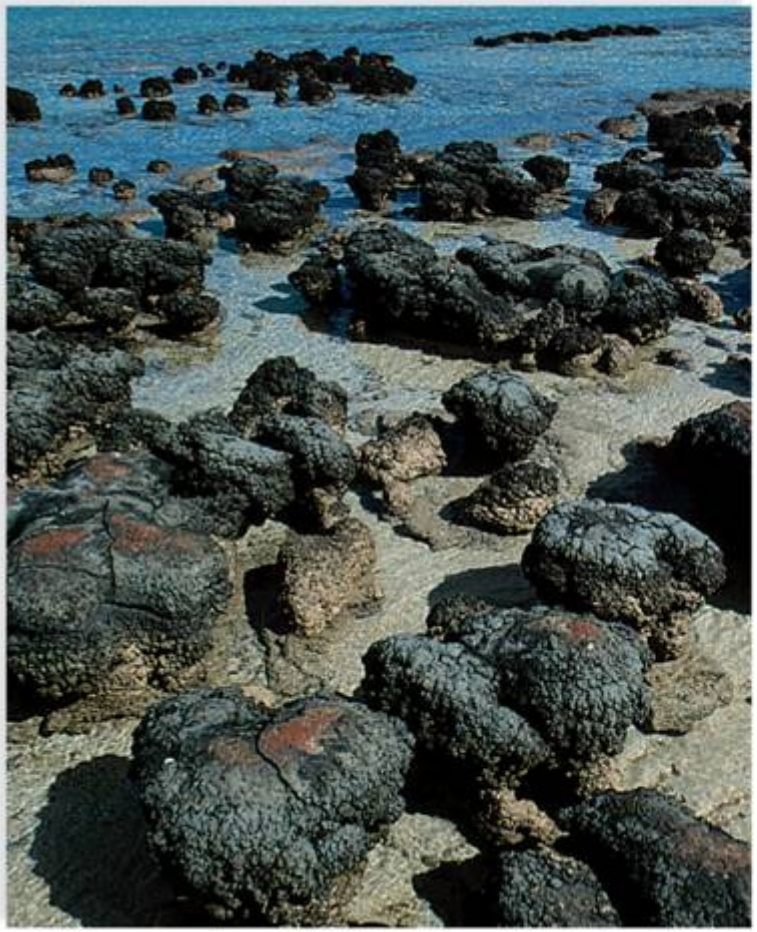
The Geologic Time Scale: Precambrian Times

- Includes about 87% of the geological timescale
  - Little or no atmospheric oxygen
  - Lack of ozone shield allowed UV radiation to bombard Earth
- First cells came into existence in aquatic environments
  - Prokaryotes
  - Cyanobacteria left many ancient stromatolites fossils
  - Added first oxygen to the atmosphere

Eukaryotic Cells Arise

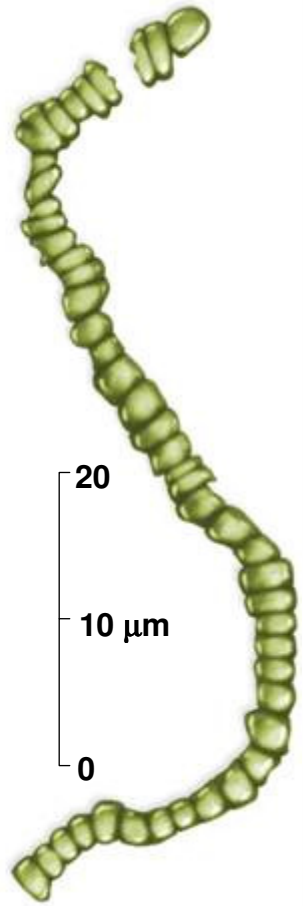
- Eukaryotic Cells Arise
  - About 1.8 bya
    - Most aerobic
    - Contains nucleus as well as other membranous organelles
  - Endosymbiotic Hypothesis
    - Mitochondria were probably once free-living aerobic prokaryotes.
    - Chloroplasts were probably once free-living photosynthetic prokaryotes.
    - A nucleated cell probably engulfed these prokaryotes that became various organelles.
    - Cilia and flagella may have originated from slender undulating prokaryotes that attached to the host cell.

Prokaryote Fossil of the Precambrian



a. Stromatolites

b. Primaevifilum



a: Courtesy J. William Schopf; b: © Francois Gohier/Photo Researchers, Inc.

Eukaryotic Cells Arise

- Multicellularity Arises
  - About 1.4 bya
  - Separating germ cells from somatic cells may have contributed to the diversity of organisms.
  - They lacked internal organs and could have absorbed nutrients from the sea.
  - It's possible that they practiced sexual reproduction

Cenozoic and Mesozoin Eras

TABLE 18.1

The Geologic Timescale: Major Divisions of Geologic Time and Some of the Major Evolutionary Events of Each Time Period

Era	*Period*	*Epoch*	*Millions of Years Ago (MYA)*	*Plant Life*	*Animal Life*
		Holocene	(0.01–0)	Human influence on plant life	Age of *Homo sapiens*
				Significant Mammalian Extinction	
	Quaternary	Pleistocene	(1.80–0.01)	Herbaceous plants spread and diversify.	Presence of Ice Age mammals. Modern humans appear.
		Pliocene	(5.33–1.80)	Herbaceous angiosperms flourish.	First hominids appear.
		Miocene	(23.03–5.33)	Grasslands spread as forests contract.	Apelike mammals and grazing mammals flourish; insects flourish.
Cenozoic*		Oligocene	(33.9–23.03)	Many modern families of flowering plants evolve.	Browsing mammals and monkeylike primates appear.
	Tertiary	Eocene	(55.8–33.9)	Subtropical forests with heavy rainfall thrive.	All modern orders of mammals are represented.
		Paleocene	(65.5–55.8)	Flowering plants continue to diversify.	Primitive primates, herbivores, carnivores, and insectivores appear.
				Mass Extinction: Dinosaurs and Most Reptiles	
	Cretaceous		(145.5–65.5)	Flowering plants spread; conifers persist.	Placental mammals appear; modern insect groups appear.
Mesozoic	Jurassic		(199.6–145.5)	Flowering plants appear.	Dinosaurs flourish; birds appear.
				Mass Extinction	
	Triassic		(251–199.6)	Forests of conifers and cycads dominate.	First mammals appear; first dinosaurs appear; corals and molluscs dominate seas.

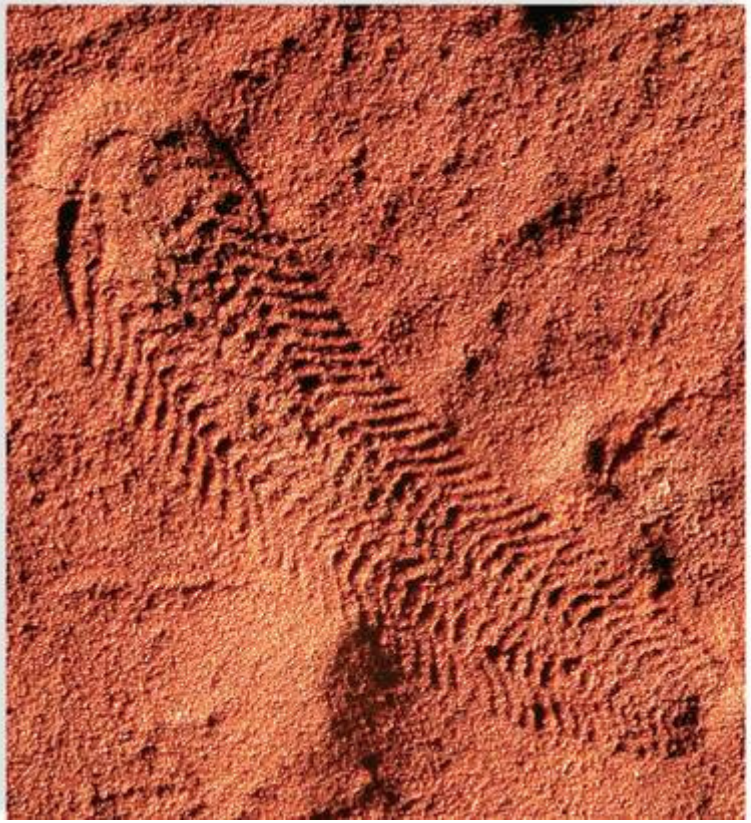
Paleozoic and Precambrian Time Eras

TABLE 18.1

The Geologic Timescale: Major Divisions of Geologic Time and Some of the Major Evolutionary Events of Each Time Period

			Mass Extinction	
	Permian	(299–251)	Gymnosperms diversify.	Reptiles diversify; amphibians decline.
	Carboniferous	(359.2–299)	Age of great coal-forming forests; ferns, club mosses, and horsetails flourish.	Amphibians diversify; first reptiles appear; first great radiation of insects.
			Mass Extinction	
Paleozoic	Devonian	(416–359.2)	First seed plants appear. Seedless vascular plants diversify.	First insects and first amphibians appear on land.
	Silurian	(443.7–416)	Seedless vascular plants appear.	Jawed fishes diversify and dominate the seas.
			Mass Extinction	
	Ordovician	(488.3–443.7)	Nonvascular land plants appear on land.	First jawless and then jawed fishes appear.
	Cambrian	(542–488.3)	Marine algae flourish.	All invertebrate phyla present; first chordates appear.
Precambrian Time		630	Soft-bodied invertebrates	
		1,000	Protists diversify.	
		2,100	First eukaryotic cells	
		2,700	O_2 accumulates in atmosphere.	
		3,500	First prokaryotic cells	
		4,570	Earth forms.	

Ediacaran Fossils



a.

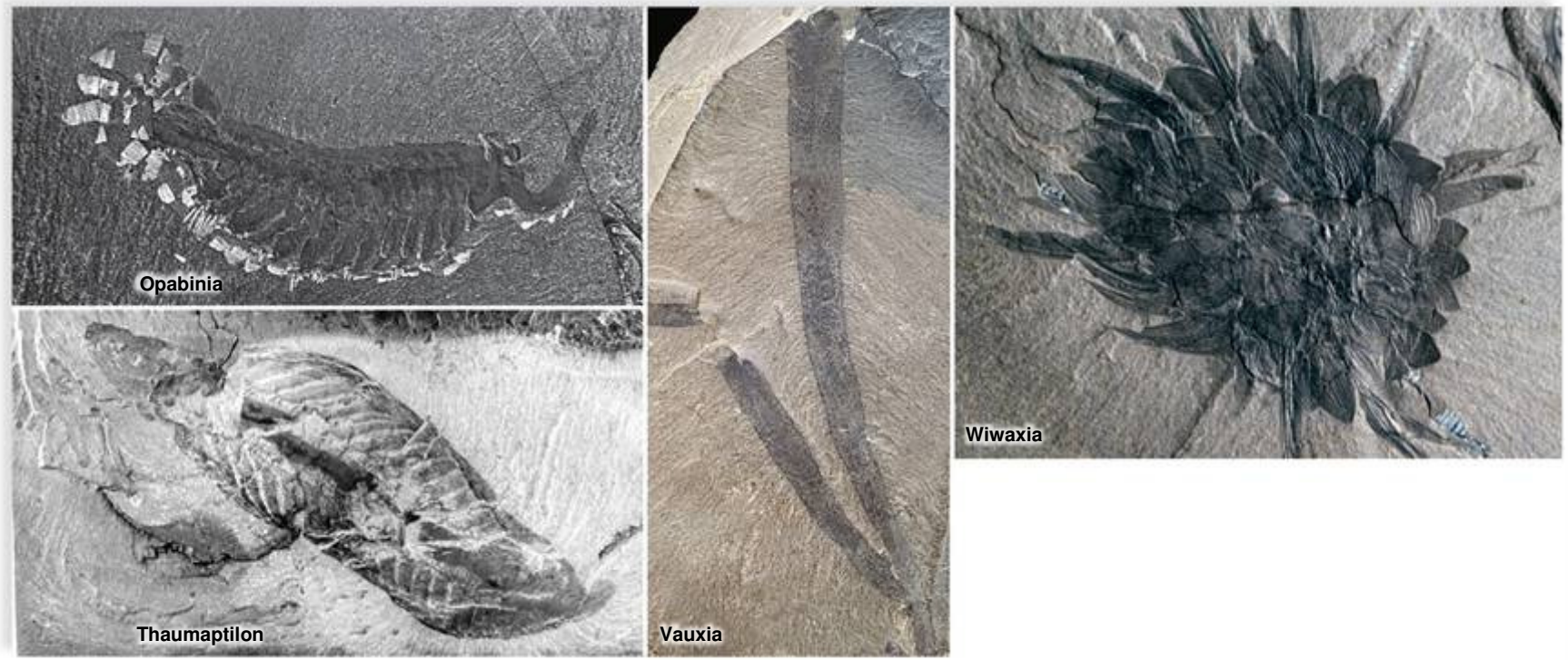
b.

a: Courtesy J. William Schopf; b: © Francois Gohier/Photo Researchers, Inc.

The Paleozoic Era

- Begins with Cambrian Period
- Thus all time previous is Pre-Cambrian
- Lasted over 300 million years
- Includes three major mass extinction events
  - Disappearance of a large number of taxa
  - Occurred within a relatively short time interval (compared to geological time scale)

Sea Life of the Cambrian Period



(Opabina): © A. J. Copley/Visuals Unlimited; (Thaumaptilon): © Simon Conway Morris, University of Cambridge;
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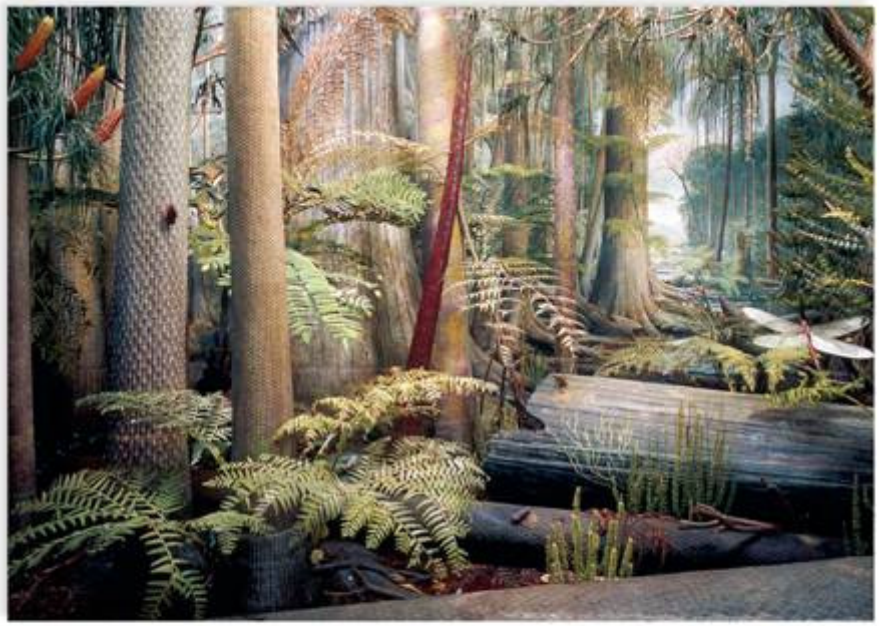
The Cambrian Period

- High diversity of the Cambrian may be due to the evolution of outer skeletons
- Molecular Clock:
  - Based on hypothesis that
    - Changes in base-pair sequences of certain DNA segments occur at fixed rate, and
    - The rate is not affected by natural selection or other external factors
  - When these base-pair sequences are compared between two species:
    - Count the number of base-pair differences
    - Count tells how long two species have been evolving separately

The Invasion of Land

- Plants
  - Seedless vascular plants date back to Silurian period
  - Later flourished in Carboniferous period
- Invertebrates
  - Arthropods were first animals on land
  - Outer skeleton and jointed appendages pre-adapted them to live on land
- Vertebrates
  - Fishes first appeared in Ordovician

Swamp Forests of the Carboniferous Period



a.

b.

c.

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The Mesozoic Era

- Triassic Period
  - Nonflowering seed plants became dominant
- Jurassic Period
  - Dinosaurs achieved enormous size
  - Mammals remained small and insignificant
- Cretaceous Period
  - Dinosaurs began precipitous decline
  - Mammals:
    - Began an adaptive radiation
    - Moved into habitats left vacated by dinosaurs

Dinosaurs of the Late Cretaceous Period

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The Cenozoic Era

- Mammals continued adaptive radiation
- Flowering plants already diverse and plentiful
- Primate evolution began

Mammals of the Oligocene Epoch

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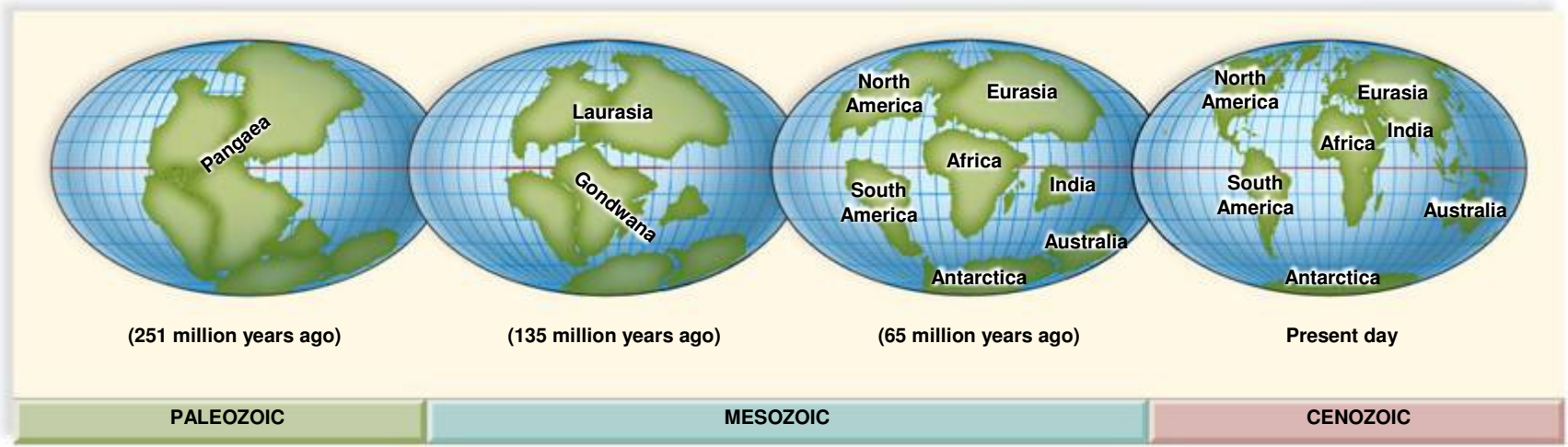
Woolly Mammoth of the Pleistocene Epoch

© Gianni Dagli Orti/Corbis

Factors That Influence Evolution

- Plate Tectonics
  - Positions of continents and oceans are not fixed
    - Earth's crust consists of slab-like plates
    - Tectonic plates float on a lower hot mantle layer
  - Movements of plates result in continental drift
- Modern mammalian diversity results from isolated evolution on separate continents

Continental Drift



Mass Extinctions

- Occurred at the end of the following periods:
- Ordovician
  - 438 mya
  - 75% of species disappeared
- Devonian
  - 360 mya
  - 70% of marine invertebrates disappeared
- Permian
  - 245 mya
  - 90% of ocean species disappeared
- Triassic
  - 208 mya
  - 60% of species disappeared
- Cretaceous
  - 66 mya
  - 75% of species disappeared

Mass Extinctions