Chapter 20: Life's Origin & Early Evolution

Looking for Life in All the Odd Places

Fig. 20-1a, p.318

Fig. 20-1b, p.318

Looking for Life in All the Odd Places

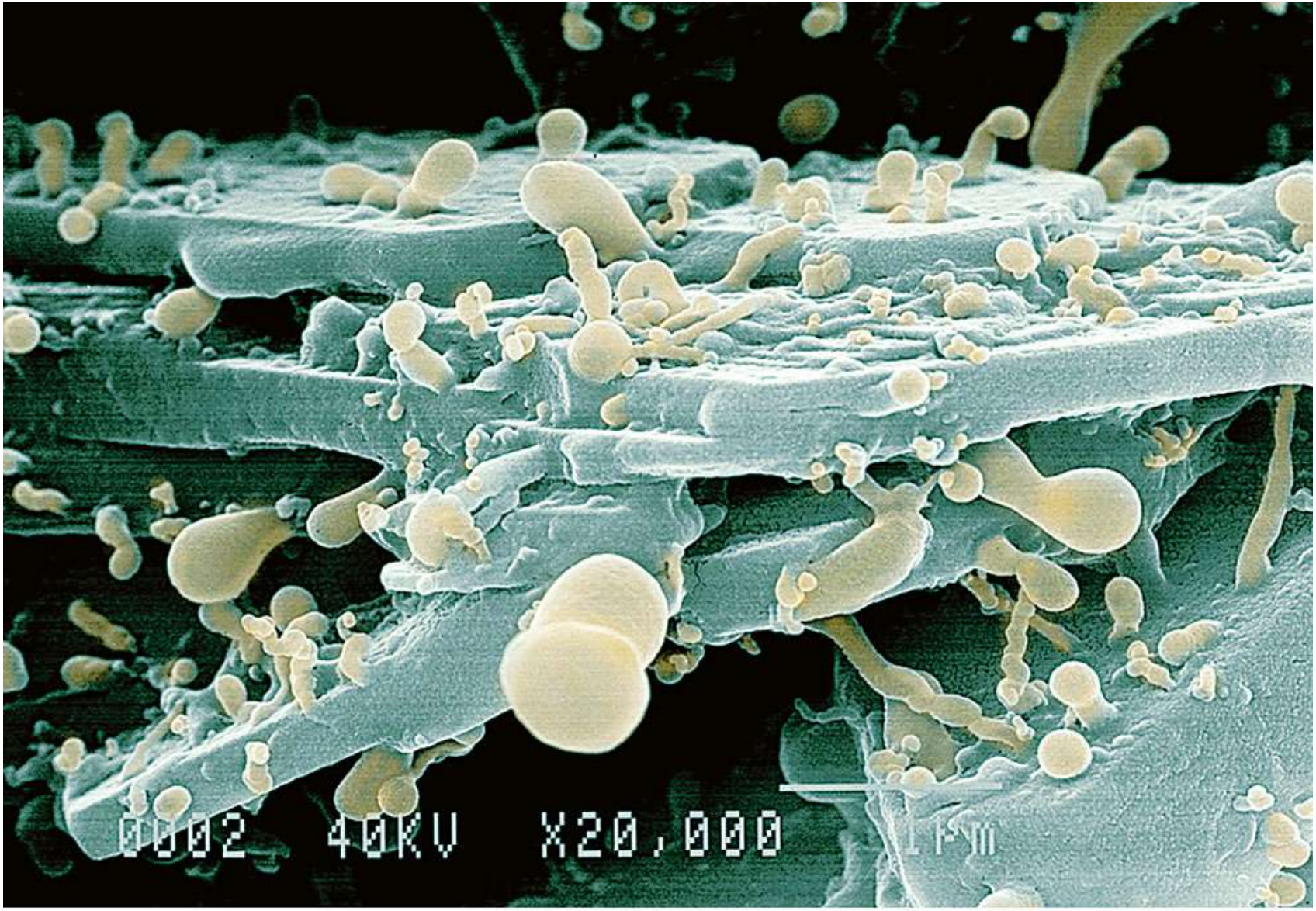


Fig. 20-2, p.319

The Big Bang

Fig. 20-3, p.320

The Big Bang Theory

- 12-15 billion years ago all matter was compressed into a space the size of our sun
- Sudden instantaneous distribution of matter and energy throughout the known universe

Archeon Eon and Earlier

- 4,600 mya: Origin of Earth
- 4,600 - 3,800 mya
  - Formation of Earth's crust, atmosphere
  - Chemical and molecular evolution
  - First cells (anaerobic bacteria)

Earth Forms

- About 4.6 and 4.5 billion years ago
- Minerals and ice orbiting the sun started clumping together
- Heavy metals moved to Earth's interior, lighter ones floated to surface
- Produced outer crust and inner mantle

Earth Is "Just Right" for Life

- Smaller in diameter, gravity would not be great enough to hold onto atmosphere
- Closer to sun, water would have evaporated
- Farther from sun, water would have been locked up as ice

First Atmosphere

- Hydrogen gas
- Nitrogen
- Carbon monoxide
- Carbon dioxide
- **No gaseous oxygen**

First Atmosphere

Fig. 20-4a, p.321

First Atmosphere

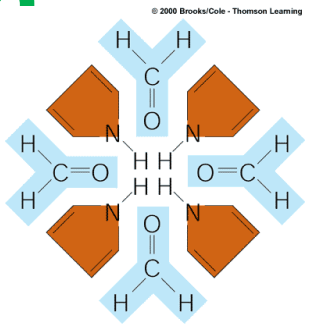
Fig. 20-4b, p.321

Origin of Organic Compounds

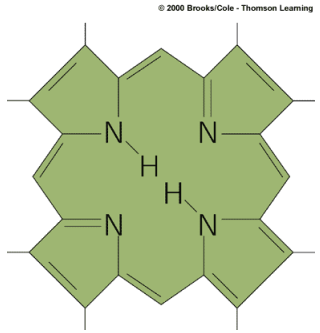
- **Amino acids, other organic compounds can form spontaneously under conditions like those on early Earth**
- **Compounds may have formed due to events like lightning, volcanoes, asteroid impacts**

Chemical Evolutior

- Spontaneous formation of porphyrin rings from formaldehyde
- Components of chlorophylls and cytochromes



formaldehyde



porphyrin ring system

chlorophyll *a*

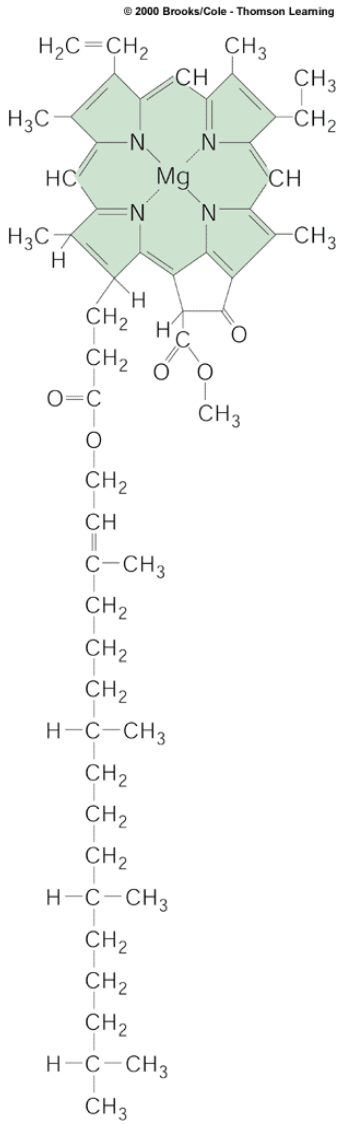


Fig. 20-5, p. 322

RNA World

- **RNA may have been first genetic material**
- **RNA can assemble spontaneously**
- DNA is genetic material now
- DNA-to-RNA-to-protein system is complicated
- How switch from RNA to DNA might have occurred is not known

Proto-Cells

- **Microscopic spheres of proteins or lipids can self assemble**
- Tiny sacs like cell membranes can form under laboratory conditions that simulate conditions in evaporating tidepools

Proto-Cells

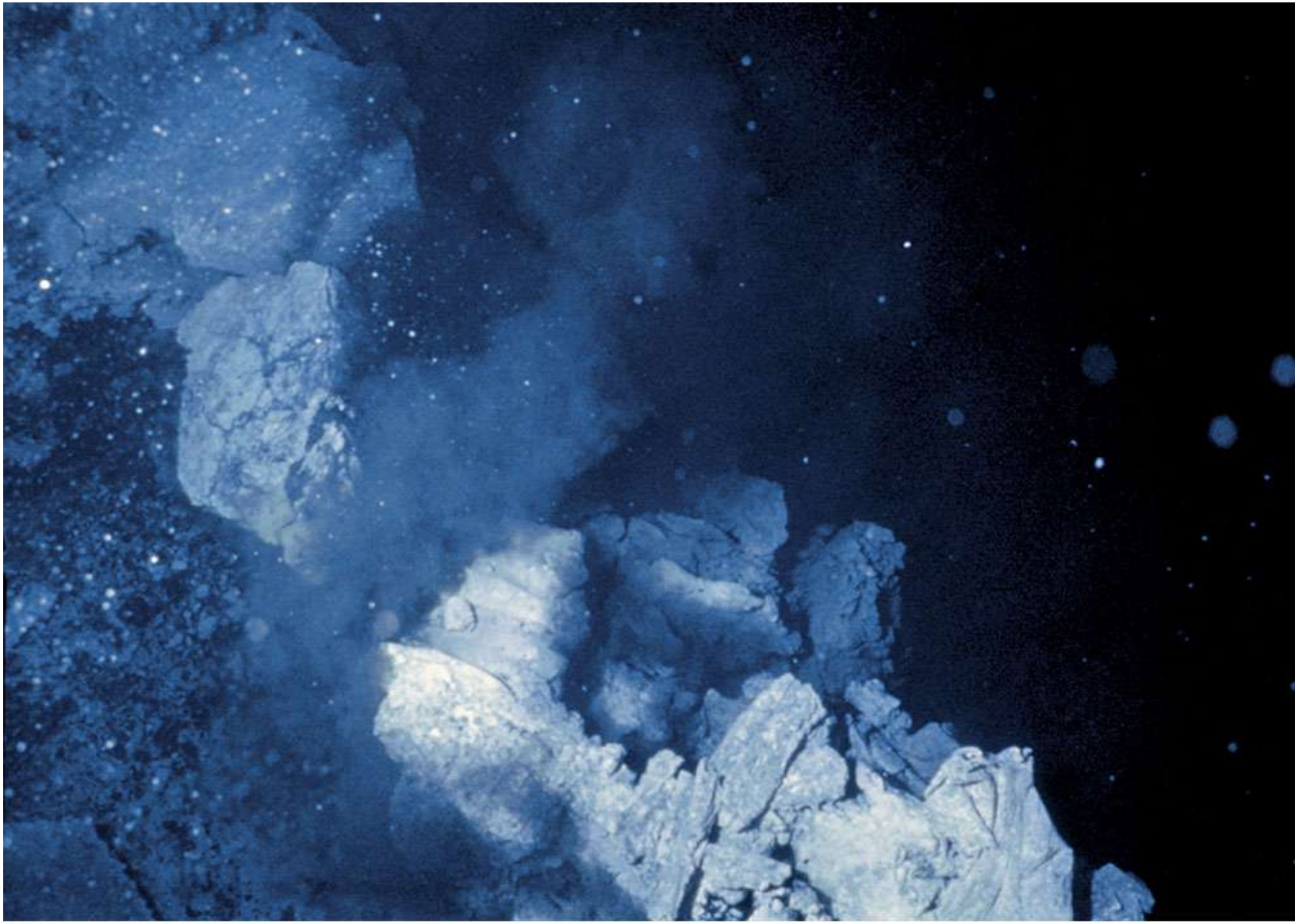
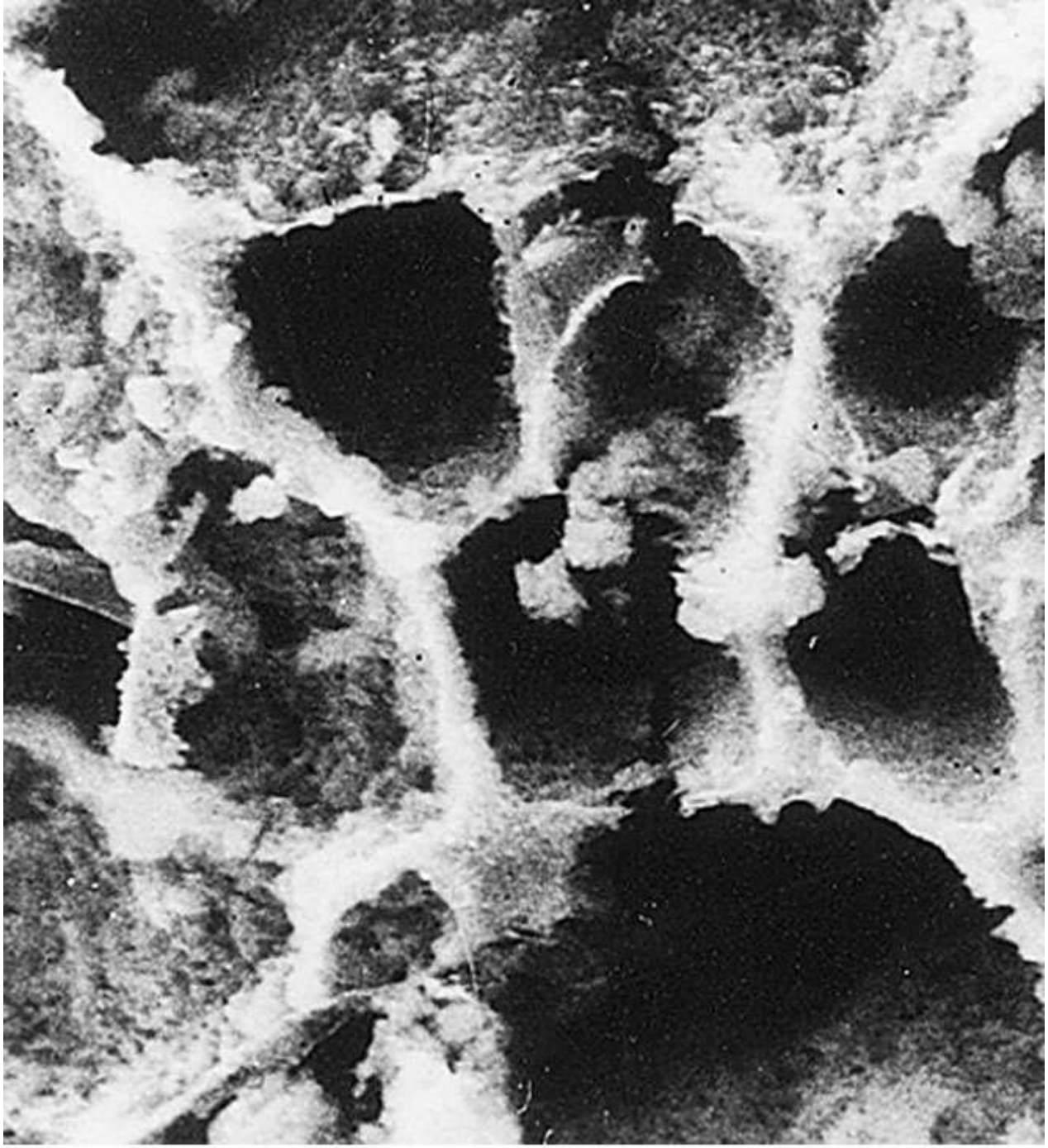
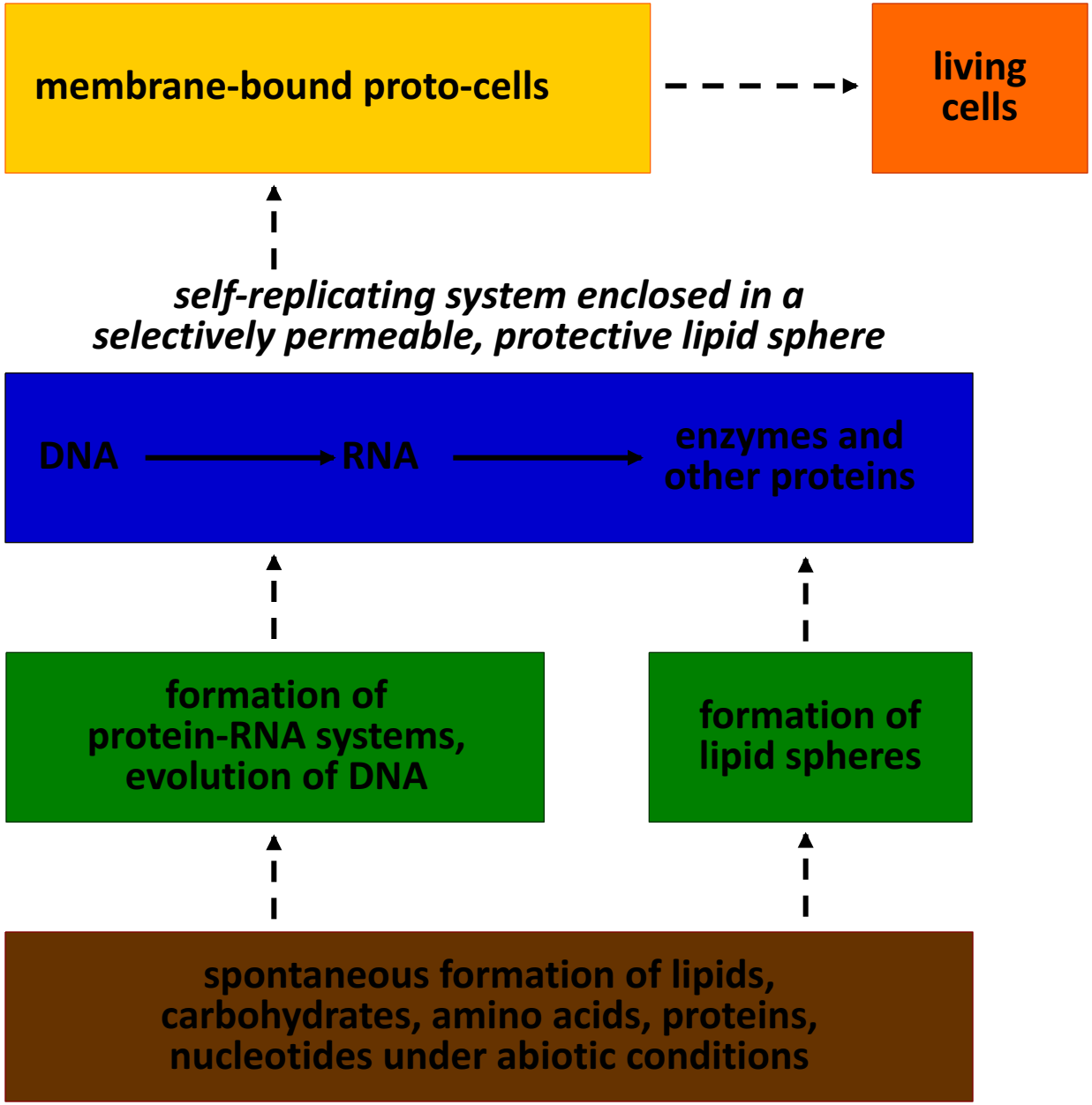


Fig. 20-6b, p.322



Proto-Cells

Fig. 20-6c, p.322



Stepped Art

Fig. 20-7c, p.323

Cambrian: Explosion of Life

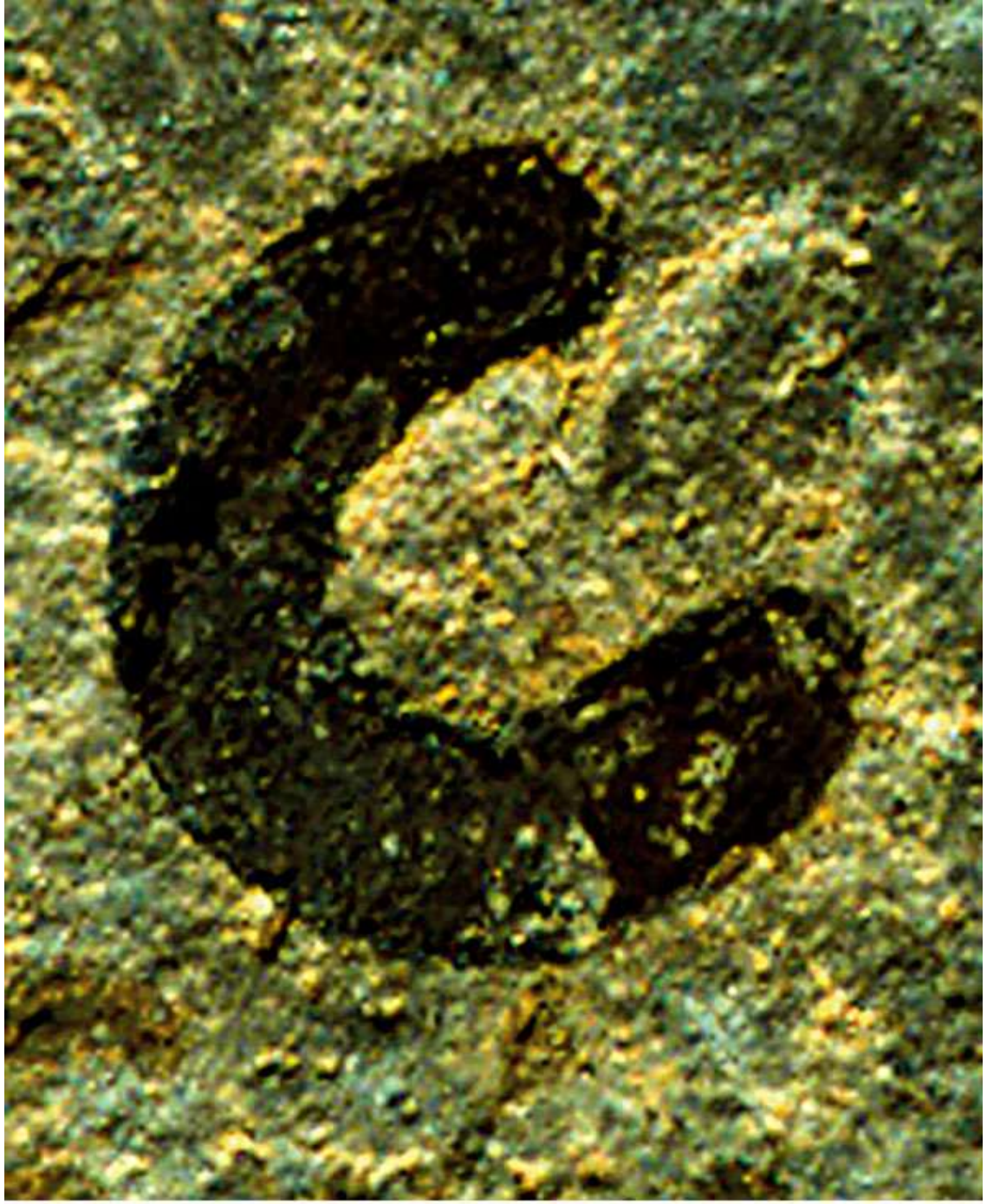
- Origin of photosynthetic Eubacteria
  - Noncyclic pathway first
  - Cyclic pathway next
- Oxygen accumulates in atmosphere
- Origin of aerobic respiration

The First Cells

- Originated in Archeon Eon
- **Were prokaryotic heterotrophs**
- **Secured energy through anaerobic pathways**
  - No oxygen present
  - Relied on glycolysis and fermentation

Prokaryotes

Fig. 20-8a, p.324



Prokaryotes

Fig. 20-8c, p.324

Prokaryotes

Fig. 20-7, p.324

Eukaryotes

- **The rise of Eukaryotes was thought to have stemmed from prokaryotes**

Eukaryotes

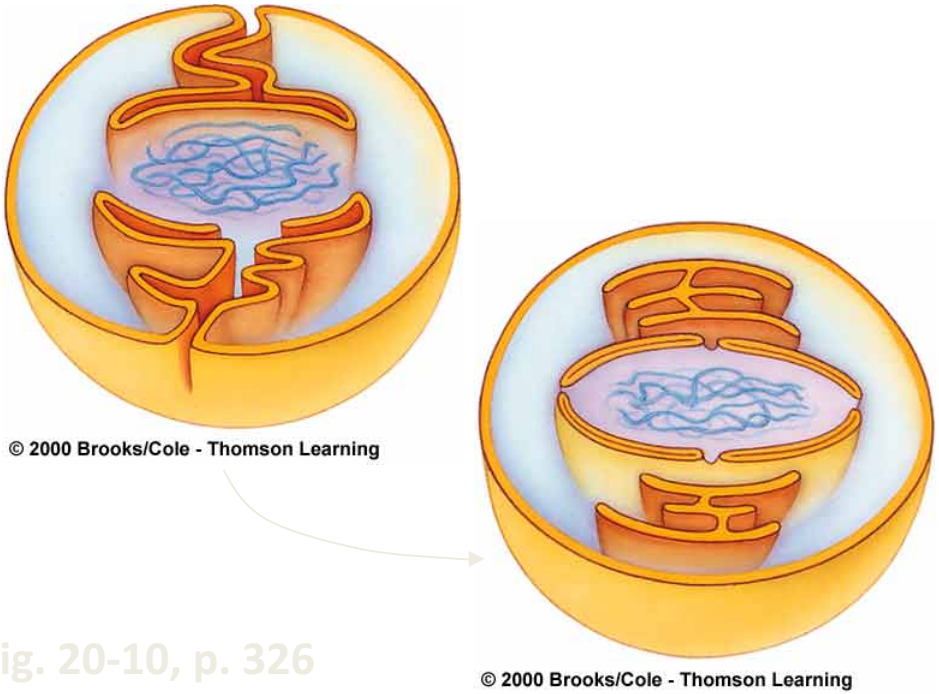
Fig. 20-9a, p.325

Eukaryotes

Fig. 20-9b, p.325

Advantages of Organelles

- Nuclear envelope may have helped to protect genes from competition with foreign DNA
- ER channels may have protected vital proteins



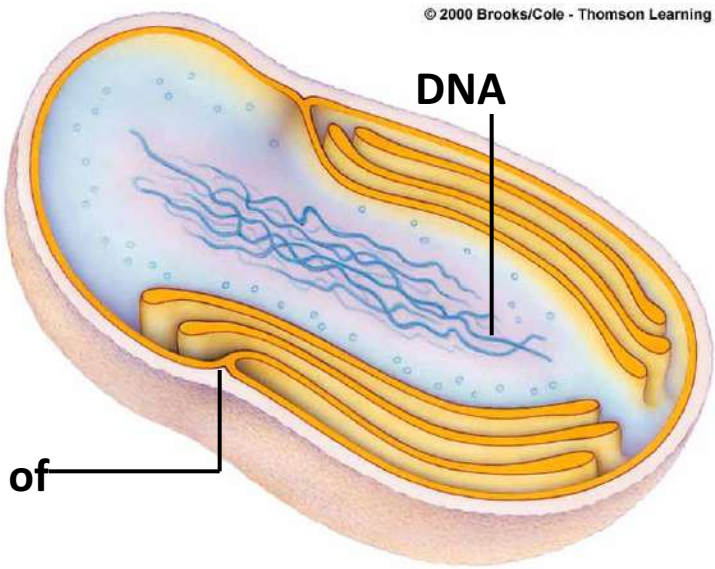


Fig. 20-10, p. 326

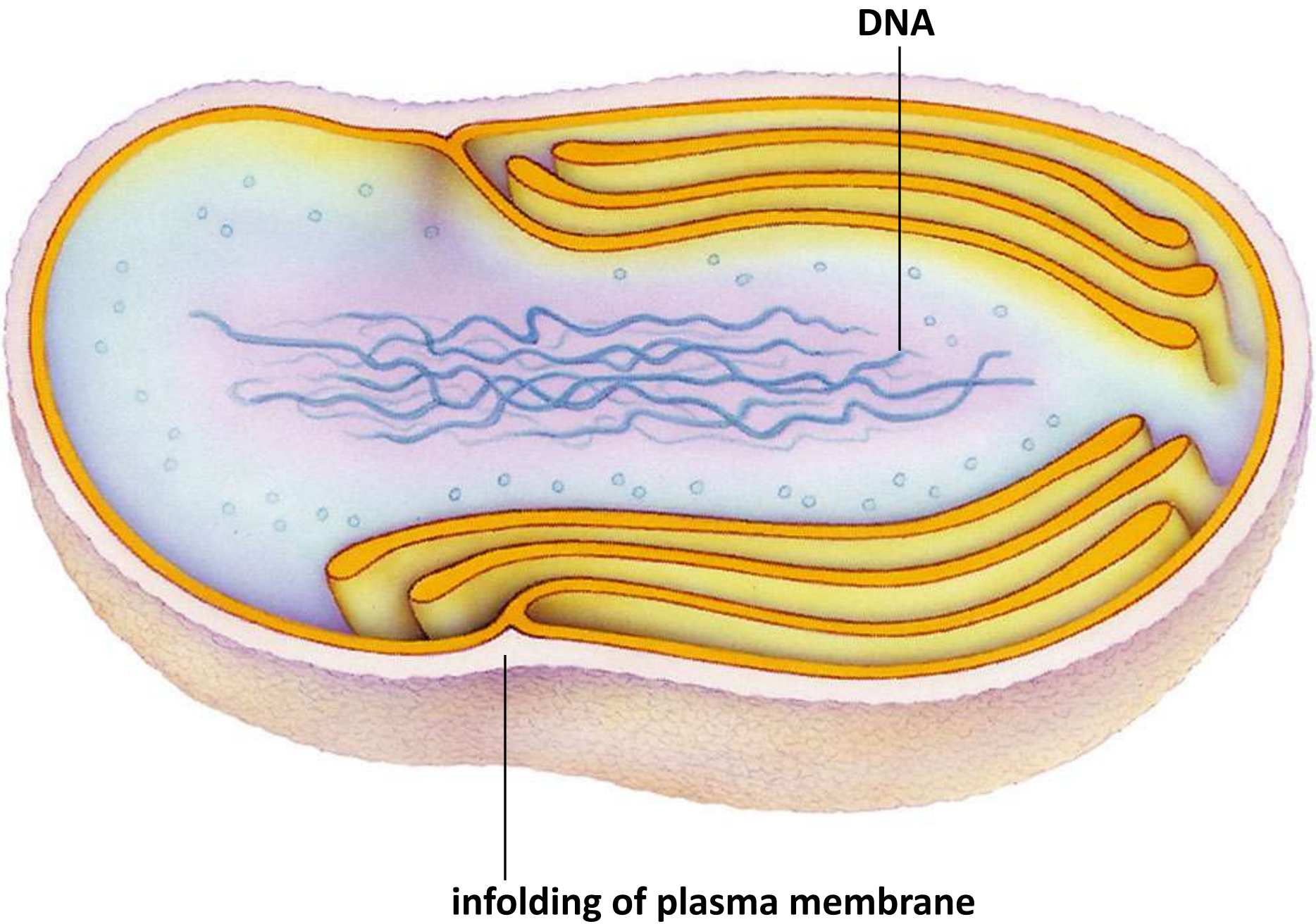


Fig. 20-10a, p.326

Theory of Endosymbiosis

- **Mitochondria and chloroplasts are the descendents of free-living prokaryotic organisms**
- **Prokaryotes were engulfed by early eukaryotes and became permanent internal symbionts**
- **Chloroplasts and Mitochondria have their own DNA**

Theory of Endosymbiosis

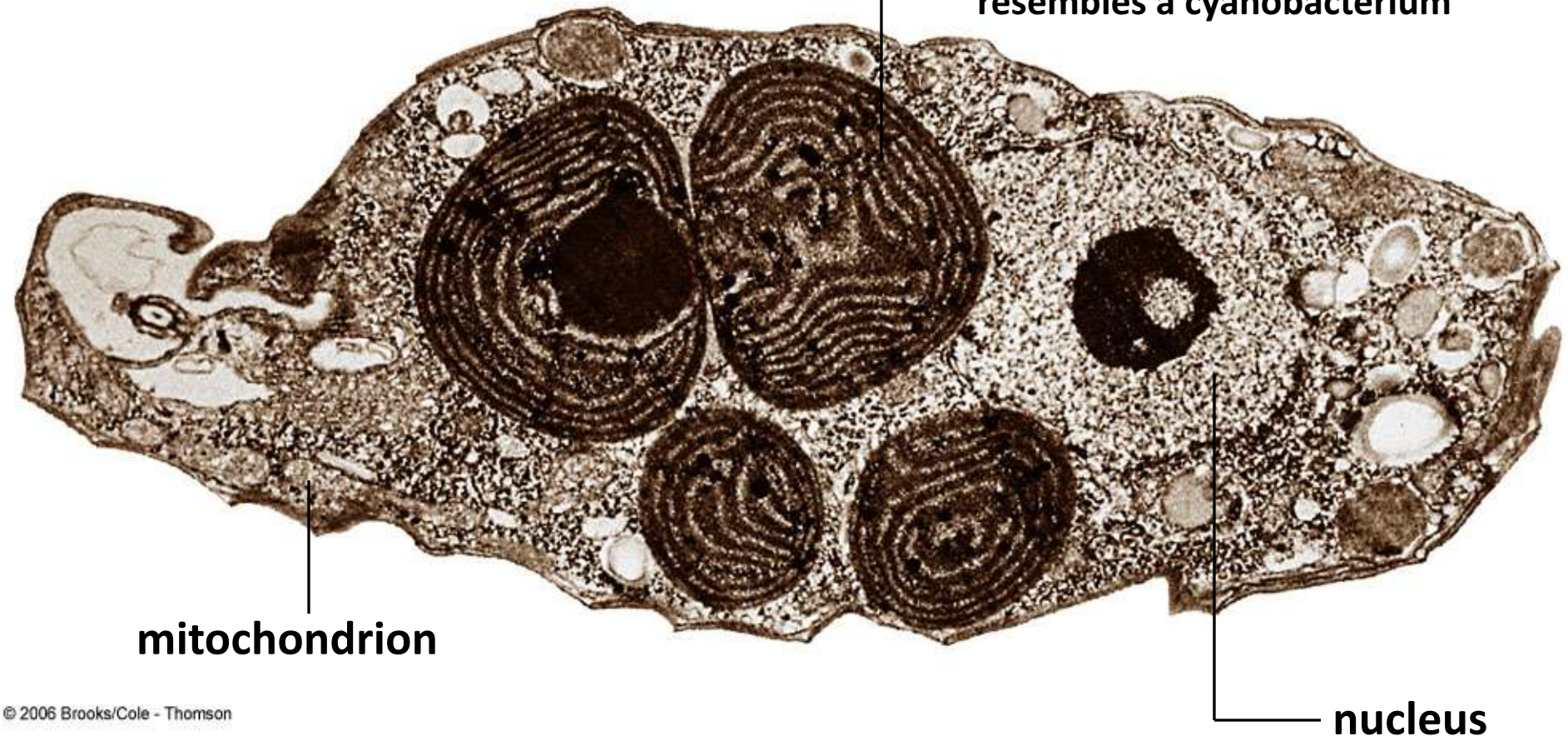


Fig. 20-11b, p.327

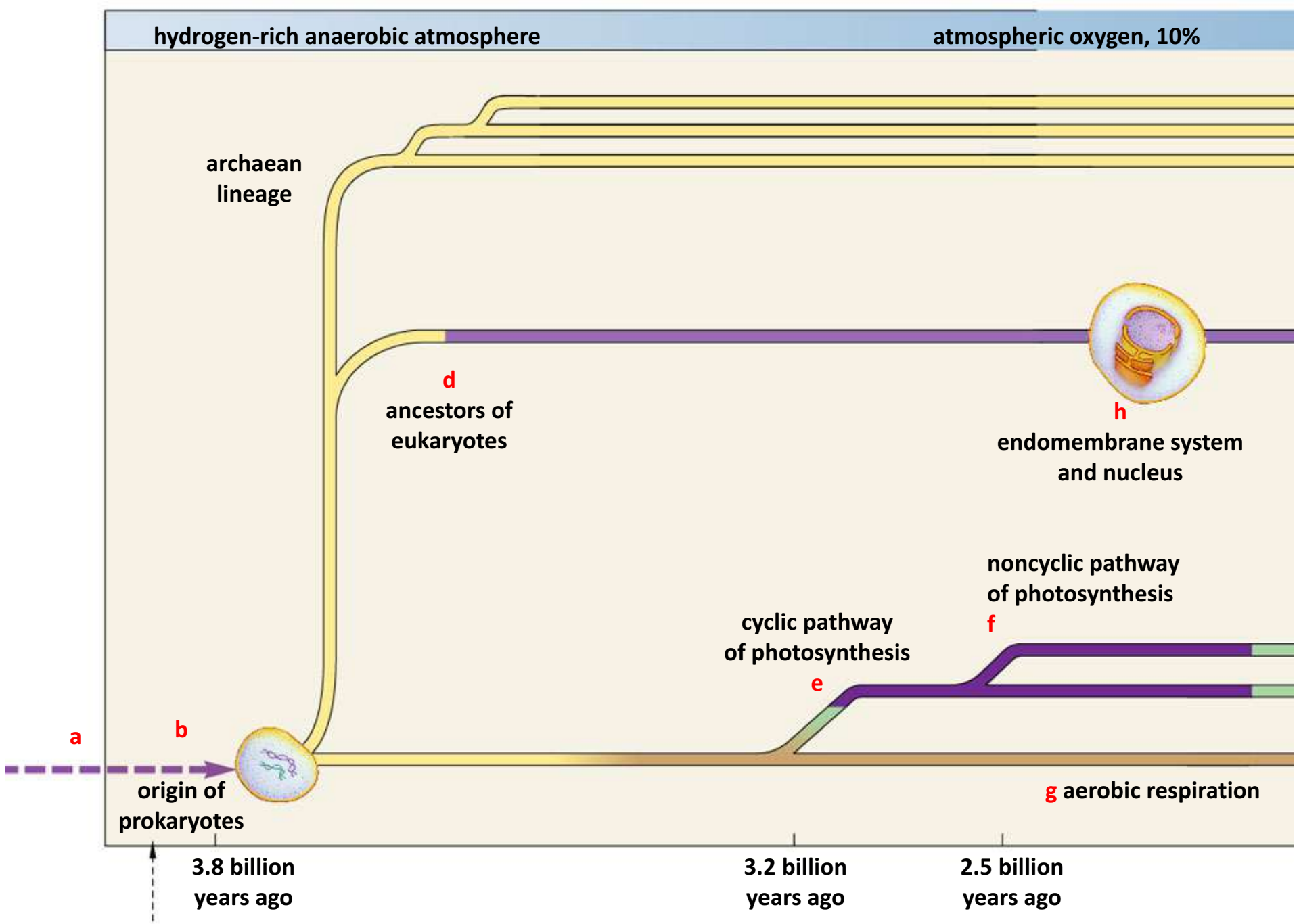


Fig. 20-12a, p.328

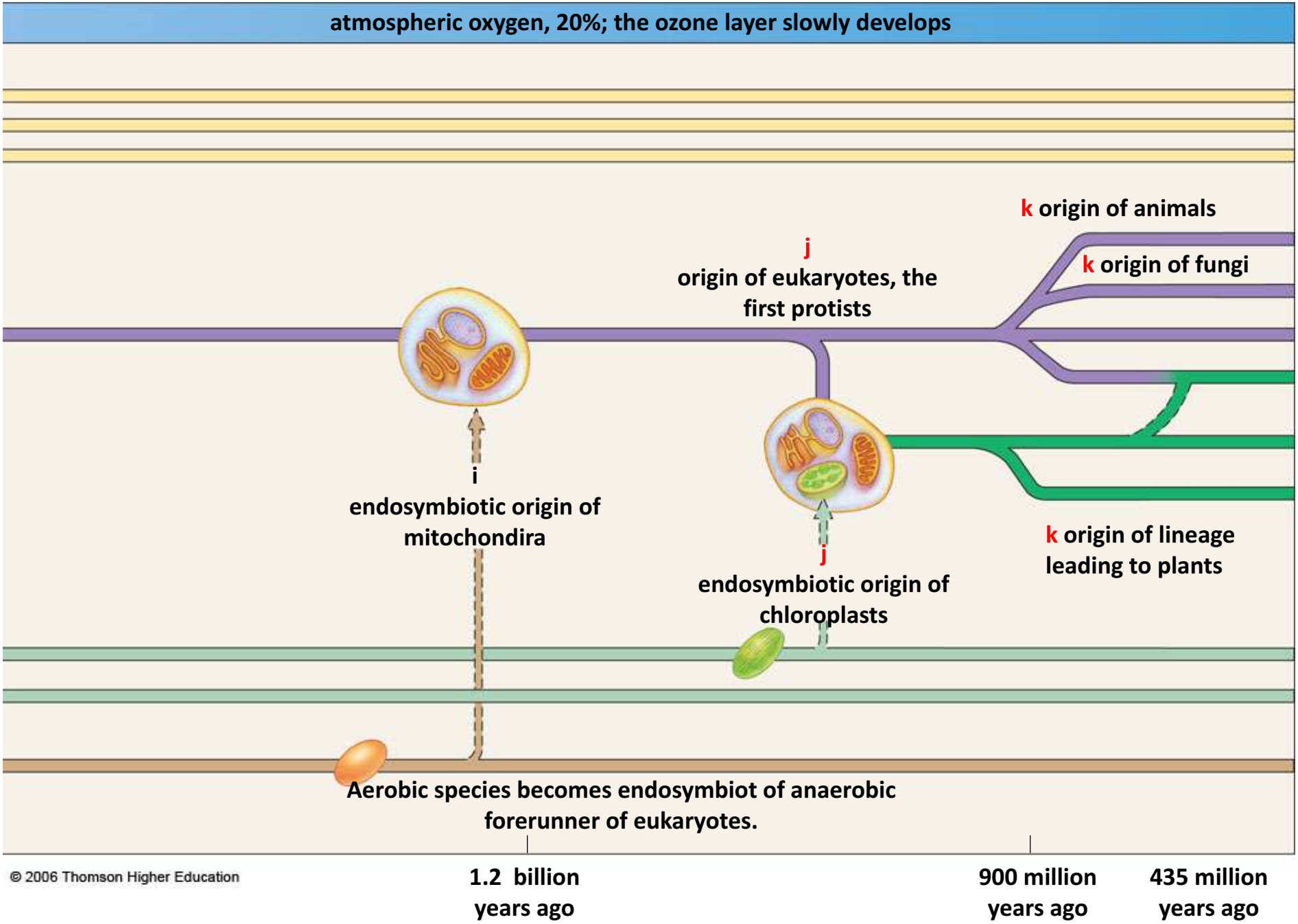


Fig. 20-12b, p.328