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Chapter 25: The History of Life on Earth

Overview

1. In the last chapter, you were asked about *macroevolution*. To begin this chapter, give some examples of *macroevolution*. Include at least one novel example not in your text.
Emergence of terrestrial vertebrates, flight in birds, or hair in mammals

Concept 25.1 Conditions on early Earth made the origin of life possible

2. How old is the planet? 4.6 bil. years How old is the earliest evidence of life on Earth? 3.5 billion years

3. The current theory of the origin of life suggests a sequence of four main stages. Summarize them here.

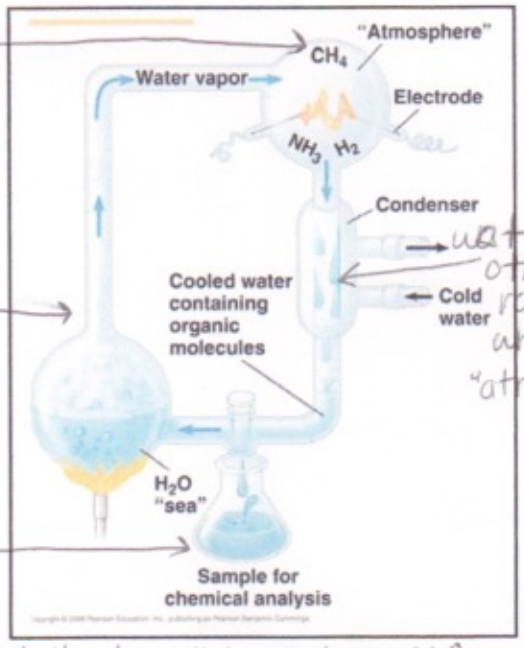
1.	Synthesis of small organic molecules
2.	Small organic molecules combine and make macromolecules
3.	Macromolecules packaged into protocells (droplets w/membrane)
4.	Origin of self-replicating molecules (inheritance possible!)

4. In your chart above, the first stage is the synthesis of organic molecules. Consider the early planet, probably thick with water vapor and stinky with methane, ammonia, and hydrogen sulfide. What gas was missing from this early mix? Why?
There was not a lot of oxygen present in the early atmosphere and also few (more like none) of the cells that could produce and/or metabolize O_2.

5. *A. I. Oparin and J. B. S. Haldane* hypothesized that the early atmosphere was a *reducing environment*. What did they suggest was the source of energy for the early organic synthesis?
Lightning ⚡ and intense radiation

6. In 1953 at the University of Chicago, *Stanly Miller* and *Harold Urey* tested the *Oparin-Haldane hypothesis* with this apparatus. (It is shown in Chapter 4, Figure 4.2, so you have seen it before.) Explain the elements of this experiment, using arrows to indicate what occurs in various parts of the apparatus.

sparks mimic lightning and are added to the various gases in the "atmosphere"



water and other molecules rain down when the "atmosphere" cools

"sea" allows for H_2O vapor to escape into atmosphere when heated

samples of the mixture were collected and a variety of commonly known molecules were present that could produce life

7. What was collected in the sample for chemical analysis? What was concluded from the results of this experiment?

simple compounds and complex molecules like amino acids and hydrocarbons were found. M and U concluded that organic molecules could have been formed abiotically on early Earth.

8. What are *protobionts*? What properties of life do they demonstrate?

A protobiont is a precursor to the fully functional cell (prokaryotic). They have a permeable membrane that surrounds a solution chemically different from the environment.

9. What did *Thomas Cech* propose was the first genetic material, DNA or RNA? RNA

They may also reproduce, metabolize, and interact w/environment :)

10. What are *ribozymes*?

RNA molecules that can carry out enzyme-like catalytic functions

11. Explain the evidence for an early "RNA world."

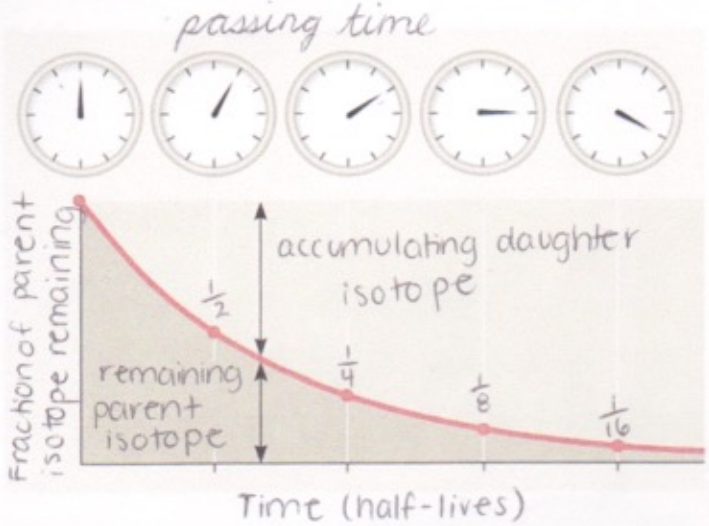
Single-stranded RNA can form into many different shapes and was/is more stable than other sequences. RNA replicates fast and leaves many descendant molecules, which would have been beneficial for the production of more cells in early Earth. A simple and efficient molecule storing genetic info and performing catalytic functions would probably have been instrumental in the life of an early cell.

Concept 25.2 The fossil record documents the history of life

12. In what type of rock are fossils found? Sedimentary rock
(strata: layers of rock)

13. What do we *not* know from analyzing rock strata?
The extent of species that existed at a certain time in history

14. Rocks and fossils are dated in several ways. *Relative dating* uses the order of rock strata to determine the relative age of fossils. *Radiometric dating* uses the decay of radioactive isotopes to determine the age of the rocks or fossils. It is based on the rate of decay, or **half-life** of the isotope. To determine the *absolute* age of a fossil, *radiometric dating* is used. Use this figure to explain the concept of radiometric dating. Label key elements.



time for 50% of parent isotope to decay

now the age of a fossil can be dated!

15. What is the age range for which carbon-14 dating may be used?
75 000 years
(not so long for the history of life)

16. To date fossils outside the rage of carbon-14 dating, researchers use indirect methods of establishing absolute fossil age. Explain two of these methods, *potassium-40* and *magnetism shifts*.
Potassium-40 is a radioactive isotope that could be used to infer the relative age of a fossil sandwiched between two layers of rock (the rocks would need to contain K, which would be dated).
Magnetism shifts is a process of interpreting fossil age by using shifts in the Earth's magnetic field that can be inferred by analysis of fossilized lava.

17. What are three groups of *tetrapods*?

Amphibians, reptiles, mammals

18. Cite three ways of distinguishing mammal fossils from the other two groups of tetrapods.

- Unique set of three bones to transmit hearing
- differentiated teeth (canines, incisors, molars)
- lower jaw is composed of only one bone

Concept 25.3 Key events in life's history include the origins of single-celled and multicelled organisms and the colonization of land

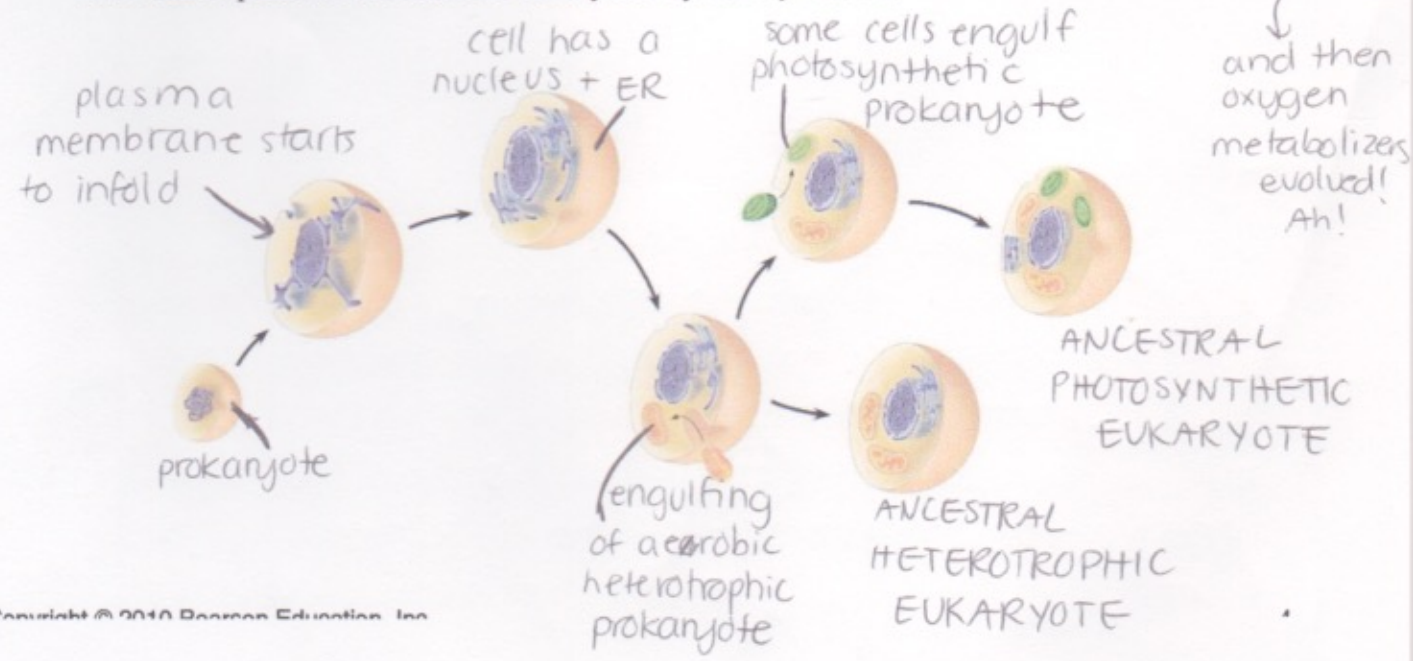
19. What was the earliest form of life on the planet? How long ago did this life-form first occur?

The earliest forms of life were prokaryotes that bound sediment together into stromatolites up to 3.5 billion years ago

20. What unique ability was originated with *cyanobacteria*? How did this alter life on Earth and lead to a wave of mass extinctions?

Cyanobacteria was/is photosynthetic and could produce oxygen. Oxygen accumulated gradually and eventually got into the atmosphere. Many groups of prokaryotes were ~~probably~~ anaerobic and went through mass extinction due to so much oxygen.

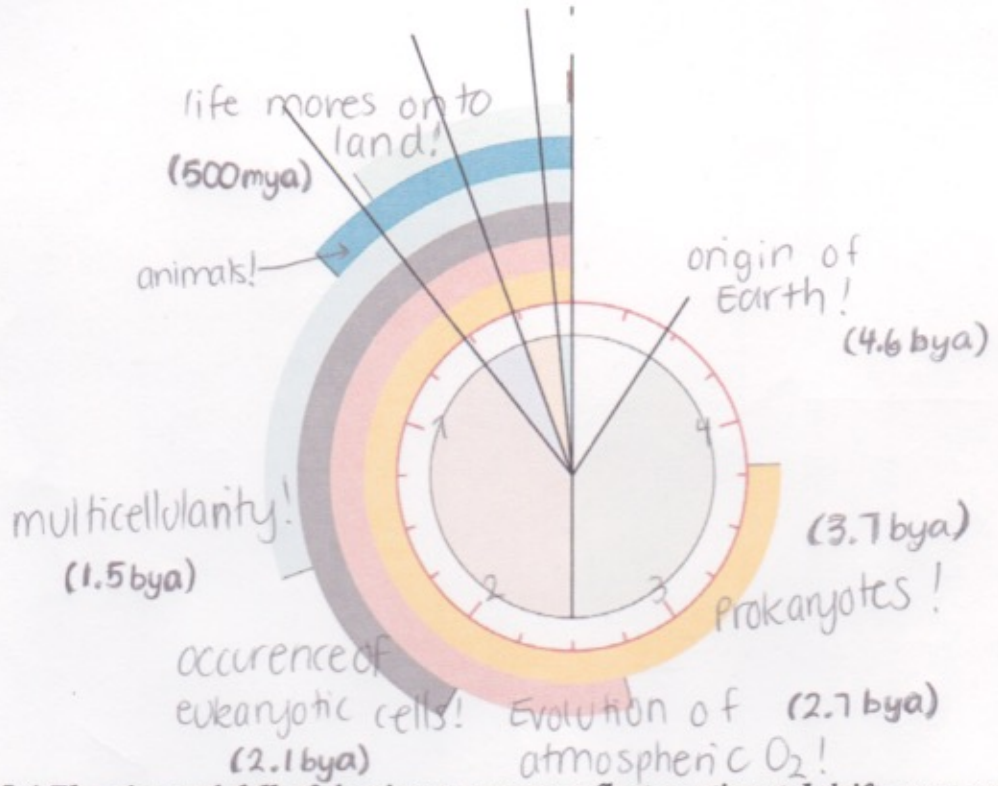
21. The first *eukaryotes* did not appear until approximately 2.1 billion years ago. Using the figure, label and explain the evolution of eukaryotes by *endosymbiosis*.



22. Summarize three lines of evidence that support the model of endosymbiosis.

→ mitochondria/plastids have their own DNA
→ they replicate in a way similar to prokaryotes
→ they have ribosomes that can read/translate their DNA

23. Use the clock model to note the following events in the life of the planet: ~~*origin of the Earth*~~, ~~*appearance of prokaryotes*~~, ~~*evolution of atmospheric oxygen*~~, ~~*occurrence of eukaryotic cells*~~, ~~*multicellularity*~~, and *life moves onto land*. For each event, also label the number of years ago it occurred.

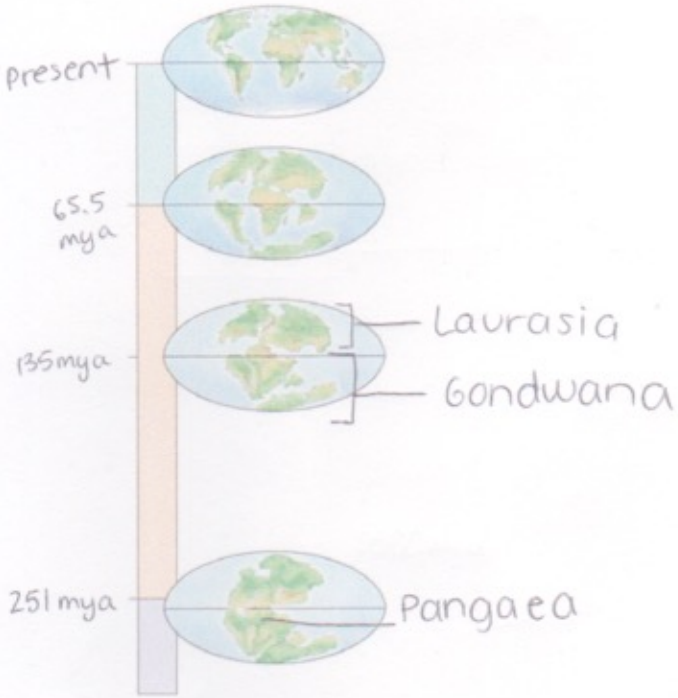


Concept 25.4 The rise and fall of dominant groups reflect continental drift, mass extinctions, and adaptive radiations

24. If you have not studied geology, you will find this concept introduces a fascinating look at the changes in our planet as explained by *continental drift*. Define *continental drift*. How can continents move?

Continental drift is when the plates that make up the Earth's crust move around on the Earth's mantle and cause the continents to move around as well.

25. On the figure below, label Pangaea, Gondwana, and Laurasia.



26. See if you can answer each of these short questions:

a. What is the *San Andreas* Fault?
It is a place where two plates slide past each other in CA.

b. What caused the uplift of the Himalayas?
Two terrestrial plates crashed into each other

c. How can a fossil freshwater reptile be found in both Brazil and west Africa, areas separated today by a wide expanse of ocean?
They used to live close together (probably on Gondwana)

d. Why are no *eutherians* (placental) mammals indigenous to Australia?
When the continents broke apart, eutherians did not diversify as well as marsupials did and consequently went extinct.

27. A *mass extinction* is the loss of large numbers of species in a short period, caused by global environmental changes. What caused the *Permian mass extinction* 250 million years ago (mya)? Summarize the species that were lost.
There was an extreme amount of volcanic eruptions at that time that produced lava, ash, increase in global climate warmth, less oxygen in the air, and the extinction of masses of organisms.
(96% of marine life died, 8 out of 27 known insect groups wiped out)

28. A second important mass extinction is the *Cretaceous mass extinction* that happened about 65 mya. Everyone's favorite group, the dinosaurs, was lost, along with more than half of all marine species. What caused it?

The best explanation for the Cretaceous mass extinction is that a large meteorite or asteroid crashed into Earth, blocking sunlight and disturbing the climate for many months. (Iridium in clay...)

29. What are *adaptive radiations*?

Adaptive radiations are periods of evolutionary change that allow organisms to fill vacant lots in their ecological community.

30. Why did a large-scale adaptive radiation occur after each mass extinction?

Large adaptive radiation may occur after mass extinctions because the more prevalent species may be wiped out, leaving room for new organisms to adapt and flourish.

Concept 25.5 Major changes in body form can result from changes in the sequences and regulation of developmental genes

31. What two areas of biology are merged in the field of study commonly called evo-devo?

study of evolution and study of development (relationship between genes and morphology)

32. What is an evolutionary change in the rate or timing of developmental events?

Heterochrony (organism shape depends on rate of development)

33. *Homeotic genes* are master regulatory genes that determine the location and organization of body parts. Mutations in a *homeotic gene* can have a profound effect on morphology. Homeotic gene mutations can contribute to the potential for evolutionary change. The *Hox* genes are one class of homeotic genes. What do they control?

Hox genes control where what body part goes in an animal embryo (positional information)

Concept 25.6 Evolution is not goal oriented

34. When a structure that has evolved in one context becomes co-opted for another purpose, this event is called exaptation.

Testing Your Knowledge: Self-Quiz Answers
Now you should be ready to test your knowledge. Place your answers here:

1. _____ 2. _____ 3. _____ 4. _____ 5. _____ 6. _____ 7. _____