Lesson 4 – Early earth and origin of life

1. Which statement does not support the hypothesis that RNA functioned as the first genetic material of early protobionts?
   a. Short RNA sequences can self-assemble when combined with nucleotide monomers.
   b. Catalytic activity has been demonstrated for RNA in modern cells.
   c. Variations in base sequences produce molecules with variable stabilities in different environments.
   d. Modern cells use an RNA template when synthesizing proteins.
   e. In modern cells, RNA provides the template on which DNA nucleotides are assembled.

2. Fossilized mats called stromatolites
   a. date from 3.5 billion years ago and contain fossils that resemble modern filamentous prokaryotes.
   b. formed around deep-sea vents and provide the first evidence of life on Earth.
   c. contain layers of iron oxide that provide evidence for the oxygenic photosynthesis of cyanobacteria around 2.7 billion years ago.
   d. provide evidence that plants moved onto land in the company of fungi around 500 million years ago.
   e. contain the first undisputed fossil of eukaryotes and date from 2.1 billion years ago.

3. The oxygen revolution changed Earth's environment dramatically. Which of the following adaptations took advantage of this change?
   a. the evolution of chloroplasts when early protists engulfed photosynthetic cyanobacteria.
   b. the persistence of some animal groups in anaerobic habitats.
   c. the evolution of photosynthetic pigments that protected early algae from the corrosive effects of oxygen.
   d. the evolution of cellular respiration, which used oxygen to help harvest energy from fuel molecules.
   e. the evolution of multicellular eukaryotic colonies from symbiotic communities of prokaryotes.

4. The oldest known fossils of multicellular eukaryotes
   a. are dated by molecular clocks to be 1.5 billion years old.
   b. are corkscrew-shaped algae and date from 2.2 billion years ago.
   c. are filamentous algae that date from 1.2 billion years ago.
   d. are fossilized embryos that have been found in Chinese sediments 570 million years old.
   e. first appear in the fossil record in the late Precambrian after the thawing of snowball Earth.

5. Competition among various protobionts may have led to evolutionary improvement only when
   a. they were first able to catalyze chemical reactions.
   b. some kind of heredity mechanism developed.
   c. they were able to grow and split in two.
   d. photosynthesis evolved.
   e. DNA first appeared.

6. Which of the following represents a probable order in the biological history of Earth?
   a. metabolism before mitosis.
   b. an oxidizing atmosphere followed by a reducing atmosphere.
   c. eukaryotes before prokaryotes.
   d. DNA genes before RNA genes.
   e. animals before algae.
7. One current debate raises the issue that, rather than beginning in shallow pools, life could have begun
   a. on dry land.
   b. near deep-sea vents.
   c. from viruses.
   d. in northern Africa.
   e. when chunks that broke off from the moon bombarded Earth.

8. Which of the following steps has not yet been accomplished by scientists studying the origin of life?
   a. abiotic synthesis of small RNA polymers.
   b. abiotic synthesis of polypeptides.
   c. formation of molecular aggregates with selectively permeable membranes.
   d. formation of protobionts that use DNA to direct the polymerization of amino acids.
   e. abiotic synthesis of organic monomers.

9. What was the hypothesis that Stanley Miller and Harold Urey were testing with their experiments?

10. What is a ribozyme?

11. Why was the origin of membranes enclosing protein-nucleic acid cooperatives a key step in the onset of Darwinian evolution (natural selection)?

12. Put the following events in order, from the earliest to the most recent: diversification of animals (Cambrian explosion), evolution of eukaryotic cells, first humans, colonization of land by plants and fungi, origin of prokaryotes, evolution of land animals, evolution of multicellular eukaryotes.

13. Some RNA molecules have been discovered that can:
   a. degrade proteins
   b. duplicate lipid molecules
   c. act as enzymes
   d. form primitive cells
   e. take inorganically made organic molecules and assemble them into protocells

14. The theory that life began from non-living molecules that became able to reproduce themselves at one time in the distant past is:
   a. Prebiotic evolution
   b. Prehistoric evolution
   c. Prokaryotic
   d. Spontaneous generation
   e. a and d

15. As the rock from space joined together and began to cool forming the planet earth over four billion years ago, the early atmosphere probably had these gases:
   a. Carbon dioxide, methane, ammonia, nitrogen
   b. Nitrogen, oxygen, methane, ammonia
   c. Nitrogen, oxygen, carbon dioxide, methane
   d. Water vapor, oxygen, nitrogen, methane
   e. Carbon dioxide, oxygen, water, nitrogen

16. It has been proposed that the first atmosphere of Earth had all the following gasses except:
   a. H₂
   b. H₂O
   c. O₂
   d. NH₂
   e. CH₄
17. Oxygen has a _____ influence on the formation of complex organic molecules because ___________.
   a. positive; it acts as a coenzyme
   b. positive; it causes formation of hydrogen bonds
   c. positive; it increases metabolism
   d. negative; it prevents photosynthesis
   e. negative; it disrupts chemical bonds

18. What compounds were used in the experiment by Stanley Miller to demonstrate that organic molecules, and perhaps the first organisms, developed from molecules known to be present in the early atmosphere of earth?
   a. Oxygen, ammonia, hydrogen, and methane
   b. Ammonia, hydrogen, and carbon dioxide
   c. Water, oxygen, hydrogen, and methane
   d. Water, ammonia, hydrogen, and methane
   e. Water, oxygen, ammonia, and methane

19. What chemicals were produced by Stanley Miller in experiments investigating the origin of life in his laboratory? These molecules resulted from repetitive heating and cooling cycles and electric discharges in an atmosphere simulating the early atmosphere of Earth.
   a. Amino acids, ATP
   b. Short proteins, nucleotides
   c. Cells similar to bacteria
   d. Only choices a and b are correct
   e. Choices a, b, and c are correct

20. Laboratory research has shown that if a solution containing lipids and proteins is agitated for a long time, some structures characteristic of organisms are produced. They are called:
   a. Amino acids and enzymes
   b. Adenosine triphosphate
   c. Cell-like microspheres
   d. Mitochondria
   e. Amino acids, enzymes and adenosine triphosphate

21. Microspheres are nonliving structures that are most similar to:
   a. Complete cells
   b. RNA
   c. Bacteria
   d. Amino acids
   e. Cell membranes

22. Louis Pasteur's experiment illustrated that:
   a. Microbes will grow spontaneously in a nutrient broth that has been sterilized and sealed.
   b. Only some organisms can form spontaneously in nutrient broth.
   c. Life may have begun by chemical evolution.
   d. Some complex molecules associated with living organisms can be synthesized by heating and cooling a solution of simple molecules and providing an electric spark.
   e. Microbes will not grow in a nutrient broth that has been sterilized unless they are allowed to enter by opening the vessel to the air.

23. The first self-replicating molecules were ______.
   a. DNA
   b. RNA
   c. Ribozymes
   d. enzymes
   e. cells
24. The scientist usually given credit for disproving the theory of spontaneous generation of bacteria was:
   a. Redi
   b. Oparin
   c. Miller
   d. Pasteur
   e. Urey

25. If you open a can of chicken noodle soup and immediately examine it microscopically you will find no microorganisms. If you let the open can sit on the shelf for a few weeks and then examine it you will find lots of microorganisms. The origin of these microorganisms is most likely
   a. spontaneous generation
   b. improper sterilization of the soup prior to canning
   c. prebiotic evolution
   d. endosymbiotic microspheres
   e. airborne microorganisms

26. All experiments that stimulate conditions in the early earth's atmosphere assume that the early atmosphere did NOT contain which gas?
   a. water vapor
   b. methane
   c. oxygen
   d. hydrogen
   e. carbon dioxide

27. Before the development of photosynthesis, as ancient cells became crowded a major competition was probably for:
   a. organic molecules
   b. sunlight
   c. oxygen gas
   d. water
   e. enzymes

28. The oldest fossil organisms presently known have been dated at approximately how many years old?
   a. 4.5 billion
   b. 3.5 billion
   c. 1.7 billion
   d. less than 1.7 billion
   e. greater than 4.5 billion

29. If the early earth's atmosphere contained little or no free O₂ then where did most of the 21% O₂ in our modern atmosphere come from?
   a. oxidation of metals
   b. photosynthesis
   c. respiration
   d. the breakdown of carbon dioxide
   e. the splitting of water vapor by sunlight

30. The fossil record indicates that the earliest cells lived about:
   a. 1.5 million years ago
   b. 2.5 billion years ago
   c. 3.5 million years ago
   d. 3.5 billion years ago
   e. 6 billion years ago
31. Eukaryotic cells evolved about ________ years ago.
   a. 4.5 billion
   b. 3.5 billion
   c. 1.4 billion
   d. 600 thousand
   e. 10 thousand

32. ________ may have evolved from aerobic bacteria and ________ may have evolved from
   photosynthetic cyanobacteria engulfed by predatory cells and then kept alive within the predatory host
   cell.
   a. Chloroplasts; mitochondria
   b. Mitochondria; nuclei
   c. Mitochondria; chloroplasts
   d. Cell membranes; chloroplasts
   e. Prokaryotes; eukaryotes

33. Which is the correct series of events?
   a. heterotrophic cells → O₂ → photosynthesis → aerobic metabolism
   b. heterotrophic cells → aerobic metabolism → photosynthesis → O₂
   c. O₂ → heterotrophic cells → photosynthesis → aerobic metabolism
   d. photosynthesis → O₂ → heterotrophic cells → aerobic metabolism
   e. heterotrophic cells → photosynthesis → O₂ → aerobic metabolism

34. Which is NOT an attribute of the eukaryotic cell's precursor?
   a. predatory
   b. aerobic respiration
   c. no cell wall
   d. prokaryotic
   e. bacterium

35. The organisms originally responsible for putting oxygen in our atmosphere were ________.
   a. green plants
   b. fungi
   c. mosses
   d. cyanobacteria
   e. algae

36. Most of the organelles in eukaryotic cells are believed to have evolved from...
   a. invaginations in the plasma membrane
   b. products of the cell's DNA
   c. endosymbiotic bacteria
   d. parasites
   e. the mitochondrion and chloroplasts

37. The endosymbiotic hypothesis accounts for the origin of which cell structure?
   a. chloroplast
   b. cell wall
   c. chromosome
   d. plasma membrane
   e. ribosome
38. The first multicellular eukaryotic fossils were:
   a. algae
   b. fungi
   c. mosses
   d. chordates
   e. archaea

39. The fossil record indicates that in the oceans about 600 million years ago a wide variety of ________ animals had evolved.
   a. unicellular
   b. vertebrate
   c. fish-like
   d. whale-like
   e. invertebrate

40. By examination of fossil evidence, paleontologists believe that mammals evolved from ancestors of modern:
   a. sharks
   b. arthropods
   c. amphibians
   d. reptiles
   e. lobe finned fish

41. The fossil evidence indicates that amphibians evolved from ancestors of a group of ___________, some of whom survive today.
   a. fish
   b. frogs
   c. reptiles
   d. porifera
   e. starfish

42. Flowering plants first rose to great prominence in the
   a. Cambrian
   b. Precambrian
   c. Cretaceous
   d. Eocene
   e. Paleozoic

43. The explosion of early marine arthropods can be considered a preadaptation for life on land because that shell can:
   a. protect against predators
   b. resist drying
   c. absorb light
   d. reflect ultraviolet radiation
   e. allow a diversity of body types

44. Which group of vertebrates were the first to evolve a waterproof egg allowing the group to move away from bodies of water deeper into dry land?
   a. lobe finned fish
   b. mammals
   c. birds
   d. primates
   e. reptiles
45. Which are adaptations that allow reptiles to inhabit much drier environments than amphibians?
   a. Internal fertilization
   b. Waterproof eggs
   c. Better lungs
   d. Only choices a and b are correct
   e. Choices a, b, and c are correct

46. Which are major adaptations that allow birds and mammals to have a more active lifestyle than reptiles?
   a. Internal fertilization
   b. High, constant body temperature
   c. Insulation over body surface
   d. Internal fertilization and high, constant body temperature
   e. High, constant body temperature and insulation over body surface

47. All of these are potential problems for organisms that dwell on land rather than water EXCEPT:
   a. dessication
   b. light availability
   c. union of sex cells
   d. body support
   e. movement

48. Cuticles and vascular tissue are both plant adaptations to ...
   a. increase nutrient absorption
   b. help support the plant
   c. decrease water loss
   d. increase photosynthesis
   e. aid reproduction

49. The first land plants were restricted to moist, marshy environments because of...
   a. need for stem support
   b. lack of cuticle
   c. reproduction
   d. need for nutrients
   e. mutualists

50. _______ eliminated the need for water for reproduction.
   a. Pollen
   b. Pollinators
   c. Flowers
   d. Sperm
   e. Cones

51. The first multicellular terrestrial organisms were:
   a. Plants
   b. Insects
   c. Fungi
   d. Amphibians
   e. Reptiles

52. The first terrestrial animals probably were:
   a. Arthropods
   b. Amphibians
   c. Reptiles
   d. Mycorrhizae
   e. Mammals
53. These primitive fish, called ________, were probably the ancestors of both modern bony fish and _________.
   a. lobefins; reptiles
   b. lobefins; amphibians
   c. sharks; amphibians
   d. trilobites; Salmonella
   e. trilobites; reptiles

54. An extremely important preadaptation of early arthropods, which allowed them to evolve into terrestrial forms, was:
   a. Lungs
   b. Vertebral columns
   c. Kidneys
   d. Exoskeletons
   e. Egg-laying

55. Which arthropod characteristic "pre-adapted" them to life on land?
   a. multiple legs
   b. compound eyes
   c. exoskeleton
   d. open circulatory system
   e. antennae

56. The modern-day vertebrate taxon that bridges the gap between land-dwelling and water-dwelling organisms is _________.
   a. fish
   b. amphibians
   c. reptiles
   d. cetaceans (whales and dolphins)
   e. shore birds

57. Which is NOT an adaptation of reptiles to life on land?
   a. scaly skin
   b. internal fertilization
   c. leathery egg shells
   d. efficient lungs
   e. aerobic respiration

58. The reptiles evolved body coverings as a means for...
   a. insulation
   b. courtship rituals
   c. heat production
   d. flight
   e. protection from dessiccation

59. Which is the way that environmental change might occur and cause species to become extinct?
   a. continental drift
   b. meteorite impact
   c. climate change
   d. global warming
   e. all of these
60. Most scientists attribute the mass extinction of the dinosaurs to:
   a. sunspots
   b. gradual climate change
   c. meteor impact
   d. predation by mammals
   e. sea level change

61. The boundaries between the major periods of geologic time are marked by:
   a. unusually high rates of continental drift
   b. genetic equilibrium
   c. balanced polymorphism
   d. extreme specialization of a few species
   e. episodes of mass extinction

62. Some of the sudden mass extinctions in geologic history have probably been caused by:
   a. meteorites hitting earth
   b. random natural selection events
   c. competition with predators
   d. continental drift
   e. generalized species in a changing environment

**Essay**
63. Discuss why RNA is considered by many scientists to have been the basis for early forms of life.

**Essay**
64. Describe how the mitochondrion evolved as an organelle according to the endosymbiont hypothesis.