Student Study Guide

to accompany

Biology

BURTON S. GUTTMAN

Prepared by
Iain Campbell
with contributions from Donald Ruch

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The Evergreen State College

Prepared by
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Multiple Choice/True False Questions
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A NOTE ABOUT QUIZSHEETS

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For those of you looking eventually towards studying for national exams such as the GRE, MCAT, DAT, OATS, etc. QuizSheets can be of value to you in two additional ways. Firstly, they represent a quick way of reviewing large volumes of material that you may not have looked at in several years. Don't spend hours reading and re-reading a textbook; rather, on your own—or better in a small group, start on the questions in order. If you get stuck for an answer on any one question go back and read just that section in the textbook chapter that is associated with the topic [remember, the relevant page number(s) are to be found at the end of each question]. If you have trouble with a whole set of questions in a given QuizSheet, it is likely time to read through the whole of the relevant chapter.

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CHAPTER 1: INTRODUCTION

CHAPTER OVERVIEW/INTRODUCTION

This chapter places biology in an evolutionary framework. All organisms are the result of biological evolution and biological evolution is one phase in the evolution of the universe. This chapter also emphasizes the genetic nature of organisms and the fact that they are controlled by molecular interactions.

EXTENDED CHAPTER/LECTURE OUTLINE

1.1 Scientific exploration and story-telling satisfy our curiosity about the natural world.
   a. *Aesthetic* wonder is the joy of encountering remarkable and beautiful things (**Figure 1.2**).
   b. *Scientific* wonder moves people to ask questions in an effort to understand observed phenomena.

1.2 Organisms have evolved as one stage in the continuing evolution of the universe.
   a. According to the best physical evidence, the universe originated at least 13 billion years ago (**Figure 1.3**).
   b. The universe has been evolving from the beginning of time, and evolution does not imply progress, only persistent change (**Figure 1.4**).
   c. Our existence depends on the accident that, as our own sun formed, much of the heavy matter was left outside the sun and condensed into planets, some with metal cores of iron and nickel and rocky surfaces with substantial amounts of water (**Figure 1.5**).
   d. Only large, complex carbon-based molecules can make the highly ordered structures of organisms.
      1. *Organic* molecules—called organic because they are typical of organisms—are made of carbon and hydrogen atoms, often with oxygen, nitrogen, and a few other elements (**Figure 1.6**).
      2. **Biological evolution** (also called organic evolution) began once the simplest carbon-based molecules formed.
   e. The first small carbon-based molecules combined into larger molecules, which eventually associated to make the first simple **cells** (**Figure 1.7**).
   f. Our knowledge of life, climate, and geological events in the past comes from rocks containing **fossils**, the mineralized remnants of organisms or their traces, such as footprints and impressions (**Figure 1.8**).
   g. Some of the most ancient rocks show remnants of small, simple, single-celled organisms quite similar to certain bacteria living today (**Figure 1.9**).

1.3 Natural sciences develop a systematic understanding of the world based on observation and experimentation.
   a. Science in general may be best defined by listing some of its principal features.
      1. Science is **empirical**; its information comes from observation and experiment, not just from thinking and imagining.
      2. Scientific explanations must be **intersubjectively testable**; different people must be able to observe the same thing and confirm or challenge one another's stories.
      3. Scientific explanations can only postulate physical objects or forces whose existence can be tested empirically; they cannot involve spirits or other nonphysical forces. This rule is called **naturalism**.
   b. A *hypothesis* is an educated guess, a conjecture offered to explain some phenomenon.
   c. In science, a *theory* is a logical structure of ideas that not only explains a few observations but also makes sense of a large body of knowledge and explains how some part of the world operates (**Figure 1.10**).

1.4 It is important to distinguish science from pseudoscience and nonscience.
   a. A story is considered *pseudoscience* if people continue to believe it in the absence of any sound evidence or in the face of strong counter evidence.
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c. *Unscientific* beliefs imitate science, but do it badly with too strong a will to believe and too little objective testing and skepticism.
d. Nonscientific work is human activity that has little or nothing to do with science and is done for different reasons (e.g. fine arts, sports).

1.5 Our study of biology will emphasize four major themes.
a. Organisms are genetic systems.
b. Organisms live in ecosystems.
c. Biological evolution, operating primarily through natural selection, is responsible for the variety of organisms we observe.
d. Organisms function through molecular interactions.

1.6 Biologists may use more types of explanations than those used in other sciences.
a. There are at least three good kinds of biological explanations:
1. causation,
2. function or survival value,
3. evolutionary history.
b. **Teleological** explanations try to explain events in terms of the purposes they serve.
c. **Teleonomic** explanations address the function served and use evolutionary history to explain how a process serving that function could appear.

1.7 Complex structures are understood by referring to both their components and their emergent properties.
a. **Reductionism** maintains that the more complex explanations of chemistry and biology can be reduced to physical explanations, and that every chemical statement could be translated into the sum of several physical statements.
b. **Emergent properties** are properties of a whole structure that go beyond those of its parts.

1.8 What is life?
a. **Metabolism** is a complicated series of chemical processes in living organisms that take in raw materials from the environment and shape them into structured molecules (**Figure 1.11**).
b. If "life" means anything at all, it is the sum of all the processes and ways of behaving.

1.9 Why should anyone study biology?
a. By picking up any newspaper, a casual observer can see that biology is a very busy area of modern science (**Figure 1.12**).
b. Some would argue that the best reason to study biology is simply to satisfy the human sense of curiosity and wonder about the world.
c. In addition to satisfying curiosity, the study of biology can lead to interesting, productive careers in areas such as:
1. molecular biology,
2. genetics,
3. immunology,
4. differentiation and development,
5. neuroscience,
6. ecology,
7. health sciences.

MULTIPLE CHOICE/TRUE-FALSE QUESTIONS

1. Attributing human characteristics to nonhuman organisms is known as:
a. expansionism.
b. anthropomorphism.
c. the Principle of Parsimony.
d. emergent properties.
e. evolution.

2. After watching a toad catch and eat a grasshopper and a beetle, you make the statement, "Toads are carnivores." Your statement is an example of:
a. a field experiment.
b. a hypothesis.
c. naturalism.
d. pseudoscience.
e. a theory.

3. Which statement is unfalsifiable?
    a. All cats have retractable claws.
    b. Red roses are more beautiful than yellow roses.
    c. Goldenrod flowers only in late summer.
    d. Wolves and dogs have similar metabolisms.
    e. Sugar is found on the surface of the moon.
4. The evolutionarily successful organism is:
    a. the one that is perfectly adapted to its environment.
    b. the largest and most aggressive one.
    c. the one that passes its genes to the next generation.
    d. the smartest one.
    e. all of the above.
5. Which of the following statements is false?
    a. Metabolism is the sum of all chemical reactions taking place in an organism.
    b. Reductionistic explanations in biology explain the operation of a system by referring to the structure and operation of its parts.
    c. The history of evolution is recorded by fossils.
    d. Organic evolution means that living organisms are composed of chemical elements not found in nonliving things.
    e. Science is characterized as empirical, systematic, open and progressive, and logical.
6. Pseudoscience is generally characterized by hasty generalizations, poorly confirmed hypotheses, and irrational beliefs that continue even in the face of contrary evidence.
    a. True
    b. False
7. Astrology is a pseudoscience.
    a. True
    b. False
8. Complex structures are understood by referring to both their components and their emergent properties.
    a. True
    b. False
9. Since many people report seeing UFOs, the existence of UFOs can be classified as an empirical fact.
    a. True
    b. False
10. A good scientific hypothesis is unfalsifiable.
    a. True
    b. False

QUIZSHEET

1. Is there any evidence presented in the first paragraphs that apes can use tools [p. 1-2]?
2. Are chimpanzees predominantly omnivores, carnivores or herbivores [p. 1-2]?
3. In what ways, if any, does a troop of chimpanzees impact the ecosystem in which they live [p. 2-3]?
4. Check to see if, in the next 24 hours, you take on the role of being a story-teller; what "pure aesthetic pleasure" have you experienced in the last 24 hours; what, if anything, needs to be added to aesthetic pleasure to give it scientific impact [p. 2-3].
5. Provide a definition of the subject of biology [p. 3].
6. In your own words, explain why it is technically correct to say that "Planet Earth and all that it contains, is made of star dust" [p. 3-4].
7. List any three critical requirements for life as we know it, to develop [p. 4].
8. What is an "organic" molecule; what elements do organic molecules contain in abundance; can such molecules ever be made in the absence of living cells [p. 4-5]?
9. What do you understand by the term "biological/organic evolution" [p. 5]?
10. Approximately how old is Planet Earth; approximately how old is life on Planet Earth [p. 5]?
11. Why is the cell so central to biology [p. 5]?
12. What is a "fossil"; are fossils always the mineralised remains of an organism — if not, what else might they be; what type of organism do the earliest fossils represent; were they multicellular organisms [p. 5-6]?
13. What role is played in science by observation; are organisms the only objects to be observed in science; could primitive peoples have a "science" [p. 6]?
14. What does it mean to say that "the universe is causal"; in your own words suggest why science must make this a basic presumption [p. 6]?
15. List any four principal features of the operation of scientific investigation [p. 7].
16. What does each of the following words mean in regards a definition of science: empirical, systematic, progressive, logical, and testable [p. 7]?
17. What, if anything, has science to do with "naturalism" [p. 7]?
18. Distinguish between a "scientific hypothesis" and a "scientific theory" [p. 7-8].
19. Can you tease apart the basic difference between the first and second logical sequence on page 7? — why is the first correct and the second wrong?
20. Is it ever possible to prove that a scientific hypothesis is (a) false), (b) true [p. 7]?

21. Why is science more like law than mathematics; why is this a boon to the tobacco industry and companies that may be liberating toxic waste into the environment [p. 7]?
22. In what way(s) is a theory like a road map; can you think of any additional benefits that a road map may provide over the simple estimates of intertown distances; can maps and theories ever be made "better" [p. 7-8]?
23. Is "evolution" a set of facts, an hypothesis, or a theory; explain your answer [p. 8]?
24. What is "pseudoscience"; which of the following would you consider a pseudo-science: astrology, astronomy, astrophysics, metaphysics, oriental medicine, para-psychology, psychology, acupuncture, mega-dose vitamin therapy, superstition; what test might you apply to find out [p. 8-9]?
25. Why could it be wise always to seek the simplest explanation of a phenomenon; (fun) what might be the simplest explanation for flunking a biology course [p. 9]?
26. Distinguish between the "unscientific" and "nonscientific"; (harder and for discussion) is the term "social science" an oxymoron [p. 9]?
27. What four organizational principles do the authors of the textbook suggest you use as foundations of your study of biology [p. 9, 11]?
28. Define the term "genome"; what, if anything has it to do with genes and inheritance; of what are genes made [p. 11]?
29. What is an organism's "ecological niche" [p. 11]?
30. Can organisms be moved from an ecosystem at will without perturbing that ecosystem [p. 11]?
31. In your own words and briefly, what does it mean to say that "an organism is adapted to its ecosystem" [p. 11]?
32. Are all members of a population of the same species of organism genetically identical to each other; what implication(s) has your answer on the operation of natural selection [p. 11]?
33. Is inheritance an important aspect of the operation of natural selection [p. 11]?
34. Who first conceived of the idea of natural selection [p. 11]?
35. To what extent, if any, is life a set of chemical reactions [p. 11]?
36. Why can one not make a gelatin salad with fresh pineapple [p. 11]?
37. To what extent, if any, is molecular shape important in the chemistry of biology [p. 11]?
38. In your own words explain why different kinds of questions are asked by different types of biologists [p. 10]?
39. Distinguish as best you can between "teleological" and "anthropomorphic" thinking; how do each relate to "teleonomy" [p. 10]?
40. Is evolution goal-oriented — if not, why not; if so, why so; is evolution teleological or teleonomic [p. 10, 12]?
41. What do you understand by the terms "reductionism", "emergent properties"; how do you reconcile them in your own mind [p. 12]?
42. What do you understand by the term "life"; is "life" a "substance" or a "state" or a "process"; list some characteristics that are shared by all living organisms; can you always distinguish between a living and a non-living system [p. 12-13]?
43. In what biological context, if any, would you use the term "viable" [p. 13]?
44. Why do the textbook authors think one should study biology; why are you studying biology — do any of the key fields of biology as seen by *Science* magazine, interest you or are there other areas that intrigue you more [p. 13-14]?
45. What special problems face the aspiring ecologist [p. 14]?
46. What applied fields of biology exist [p. 14-15]?

CHAPTER 2: ORGANISMS AND THE DIVERSITY OF LIFE

CHAPTER OVERVIEW/INTRODUCTION

Much of the human interest in biology stems from the observation that we are surrounded by a great diversity of other organisms, and each culture has made up stories to explain where these creatures came from and how they are related. The genetic *continuity* of organisms and the evolutionary *changes* that occur in organisms over time are the fundamental themes throughout biology and this textbook. This textbook is constructed based on a spiral approach to learning, where general topics are presented first, and the author and the reader will "spiral back" to these topics, and build on the level of detail, at each turn.

EXTENDED CHAPTER/LECTURE OUTLINE

2.1 The biological world is extraordinarily diverse.
- a. Biological diversity is defined as the number of different *species* of organisms we have observed (**Figures 2.1, 2.2, 2.3**).
- b. The field of **systematics** or **taxonomy** focuses on the naming and categorizing of organisms into species and other groups.
- c. The modern theory of evolution addresses questions of diversity, and the study of evolution begins by identifying and systematizing the world of organisms.

2.2 Species are shaped through selection.
- a. *Artificial selection* can occur either intentionally or accidentally.
- b. Artificial selection preserves desirable features or rejects undesirable ones.
- c. *Natural selection* is the molding of organisms by nature, without foresight or purpose.

2.3 The concept of evolution developed slowly with the growth of modern science.
- a. *Essentialism* is the long-held view that every member of a species has the same underlying or basic features, and that each species is unique.
- b. This *typological* view of species de-emphasized the importance of variation (**Figure 2.7**), and hindered the development of the evolutionary concept.
- c. Misconceptions concerning the age of the earth and postulates such as catastrophism both served to further hinder the advancement of the idea of evolution (**Figure 2.8**).
- d. Charles Lyell's *Principles of Geology* shaped the modern view that both living and nonliving elements of the earth have changed constantly and uniformly over time.

2.4 Evidence from the fossil record and the study of comparative anatomy indicates that organisms are related by evolution.
- a. The fossil record continues to supply the main evidence for evolution (**Figure 2.9**):
  1. it shows minor differences among closely related organisms,
  2. it shows drastic differences over long periods of time.
- b. Comparative anatomy, the analysis of anatomical features in various organisms, has produced strong evidence to support the evolutionary concept of continuity with modification (**Figures 2.10** and **2.11**).
- c. Additional support for evolution comes from observing **homologous** features among various groups of organisms.
- d. Homologous features have similar functions or occupy similar positions and result from common ancestry.
- e. **Analogous** features have similar functions but different origins.

2.5 Darwin and Wallace outlined the general process of natural selection.
- a. In 1834, Robert Chambers proposed that evolution occurred, but he could not account for its mechanism.
- b. Charles Darwin and Alfred Wallace focused on *populations* of organisms and noted the following:
  1. Populations are highly variable.
  2. Populations are stable in size.
  3. Not all individuals mature to reproductive age.
  4. The individuals which do survive to reproduce must be the most fit.
- c. The principle of natural selection can be summarized by four points:
  1. Every organism has the potential to produce more offspring than can survive.
  2. There is always variation among individuals in a population.
  3. Specific variations may make an individual either more or less likely to survive.
  4. Those variant traits that enhance survival and reproduction are most likely to be passed on.
- d. Lamarck's failed theory relies on the postulate that organisms can pass on acquired modifications (**Figure 2.12**).

2.6 An organism is a structure that functions on the basis of information carried in its genome.
   a. Evolution and natural selection are only possible because organisms can reproduce. The hereditary mechanism must be very stable but must also allow for change.
   b. A **model** will be used in this text to represent the main features of genetic **systems**.
   c. Organisms are genetic systems because of reproduction and inheritance (**Figure 2.13**).
   d. An organism's **genome** is defined as its encoded **genetic information**.
   e. There is an important connection between structures and functions of biological molecules, including DNA (**Figure 2.14**).
      1. DNA is an informational molecule.
      2. DNA has the ability to *replicate* or make copies of itself.

2.7 An organism is like a self-reproducing automaton.
   a. Each organism contains a genetic program that determines its structure and function.
   b. The concept of the genome might be illustrated by a comparison to a computer's program (**Figure 2.15**).
   c. A **virus** is not an organism, but contains a genome which can redirect the functions of other organisms.

2.8 Evolution occurs through natural selection operating on populations in ecosystems.
   a. An **ecosystem** is a **community** of organisms together with its physical environment.
   b. A community is a group of different organisms that live in the same area and interact in various ways (**Figure 2.16**).
   c. **Ecology** is the study of relationships within ecosystems, including those among the members of the community and those between the community and the physical environment.
   d. Members of a community exchange energy and are thus interdependent (**Figure 2.17**).
   e. Human beings are an integral part of their ecosystems and should realize their intimate connection therewith.
   f. Evolution can be best understood by viewing it in an ecological context.
   g. As a result of **adaptation**, each organism is shaped for its **ecological niche** in a community.
   h. An organism's niche includes not only where it lives, but how it lives, or its role in the ecosystem.

2.9 Organisms measure out their lives in cycles of growth and reproduction.
   a. All organisms have life *cycles* by which they produce new generations (**Figure 2.18**).
   b. **Asexual reproduction** involves the simple division of cells without combination.
   c. **Sexual reproduction** involves fertilization, whereby different cells (or their equivalents) are combined.
   d. A species can have organisms at different stages of their life cycle that present very different **morphologies**.
   e. A species can be defined as a group of organisms that both reproduce only with one another and are isolated (reproductively) from all other similar groups.

2.10 Populations of organisms tend to grow but are held in check by environmental factors.
   a. *Exponential growth* is typical of organisms growing in good surroundings without any limitations, with no lack of food or space, and with no predators to eat them.
   b. Environmental limitations restrict the growth of populations when **resources** such as living space, nutrients, and energy are limited.
   c. The growth of a population will level off at the point where the environment can no longer support unhindered growth. This maximum point on the growth curve is called the **carrying capacity**.
   d. Reverend Thomas Malthus (1766–1834) put forth the *Malthusian principle*, which states that the number of individuals in a population will increase faster than the food supply.
   e. Darwin was greatly influenced by this principle and the concept that, in a competition for space and food, only the fittest survive.

2.11 The genetic variability of populations is the basis for natural selection.
   a. Evolution is a change in a population of organisms from generation to generation, not a change in an individual. The product of evolution is defined by individuals that are different from their ancestors.
   b. **Mutations** are small changes in the structure of the DNA molecules that constitute the genome (**Figure 2.19**).
      1. Mutation is the first source of variation in organisms.
      2. Sexual reproduction is the second major source of variation in organisms.
   c. Genetic variation is the raw material upon which natural selection operates.
   d. **Fitness** measures an individual's ability to produce viable offspring.
   e. The English peppered moth, *Biston betularia,* is a classic illustration of natural selection operating over a very short period of time (fifty years), and also illustrates the concepts of *differential survival* and *differential reproduction* (**Figure 2.20**).

f. Natural selection can be thought of as a kind of *editing* process, in which the best features of each organism are developed, while the less suitable features are discarded (**Figure 2.21**).

2.12 Organisms are opportunists that meander into certain strategies of survival.
- a. All organisms are *opportunists* that are said to develop *strategies* for survival.
- b. These strategies are not the result of any grand scheme, but are driven by random evolutionary forces.
- c. The French biologist Jacques Monod characterized this process as one of *chance* and *necessity*.
  1. Genetic variation through recombination is largely a matter of chance.
  2. Environmental conditions for a given species are also a matter of chance.
  3. As opportunists, organisms operate by necessity under the laws of nature.

2.13 Phylogenies describe the apparent course of evolution.
- a. A central question in evolution is "Why do some organisms resemble one another more closely than they do others?".
- b. **Phylogeny** provides the answer to this question by proposing how similar organisms could have evolved from common ancestors (**Figure 2.22**).
- c. *Phylogenetic trees* illustrate relationships among various groups of organisms.
  1. Branch points in the tree show where groups have diverged.
  2. A single branch represents a *line* of evolution.
  3. Every tree has a direction, and shows a trend.

2.14 Biologists divide the world of organisms into kingdoms.
- a. The classification of species into a hierarchy of groups is a work in progress (**Figure 2.23**).
- b. The hierarchy of categories from most to least inclusive are: kingdom, phylum, class, order, family, genus, and species.
- c. This textbook follows a taxonomy of five kingdoms:
  1. Monera—bacteria whose cells are smaller (usually) and less organized than those of other organisms
  2. Protista—algae, protozoans, and some molds
  3. Fungi—mushrooms and most other molds
  4. Plantae—plants
  5. Animalia—animals
- d. The *domain* concept, which separates the Archaebacteria from the Eubacteria and from the eucaryotes, will be explored in Chapters 6 and 29.

MULTIPLE CHOICE/TRUE-FALSE QUESTIONS

Questions 1 to 4 refer to the following key list. For each numbered question, select the best term from the key list that most closely relates to it.

KEY LIST

a. adaptation

b. carrying capacity

c. community

d. ecological niche

e. fitness

1. A collection of different organisms that inhabits a particular area.
2. A species role in nature.
3. Evolutionary process that makes an organism better able to survive and reproduce.
4. Maximum population size that can be supported by available resources.

5. Which of the following is not a main idea proposed by Darwin and Wallace?
   a. The role of genetic variation in the evolution of a species is minor when compared to the role of the environment.
   b. Species change over time.
   c. Living species evolved from earlier life forms.
   d. Better adapted members of a species will survive and reproduce more successfully.
   e. The earth is relatively old.
6. Homologous structures argue for evolution, while analogous structures argue for independent creation.
   a. True
   b. False
7. The wings of insects and birds are homologous because they serve the same function but are not made of the same structures.
   a. True
   b. False
8. Vestigial organs are considered evidence of evolution
   a. True
   b. False

9. Natural selection means that individuals with the highest fitness are more likely to pass their features on.
   a. True
   b. False
10. Essentialism and typology are necessary to envision evolution, since once a "type" species is produced, it is easy for a naturalist to imagine variations within that species, and how one species could easily integrate into another species.
   a. True
   b. False

QUIZSHEET

1. What specialised hunting behaviour is exhibited by the archerfish; is this exclusively a learned skill; is it likely that ancestors of the modern archerfish possessed this skill; in what part of the world might you find an archerfish [p. 18-19]?
2. Explain briefly in your own words why the process of evolution can be termed "continuity with change" [p. 19].
3. How many species of humans are presently living on the Planet; do more than a single species of bird and insect inhabit the Planet [p. 19]?
4. Distinguish, if you can, between "systematics" and "taxonomy"; what do experts in these fields do with their time [p. 20]?
5. Very approximately, how many species of living organisms presently live on Planet Earth; have all the species that live on the Planet been catalogued to date; have any species that used to live on the Planet, died out [p. 20]?
6. Does our current understanding of the process of evolution explain (a) species diversity, (b) species origin [p. 20]?
7. In your own words, explain how human intervention could transform a population of indistinctly marked crabs into the current Heike crab population; do any examples of such human intervention in such "evolution" exist [p. 20].
8. Is there one or more species of domestic dog presently on the Planet; is it likely that our current range of dog species arose from a single ancestor [p. 20-21]?
9. Distinguish between "artificial" and "natural" selection; what agent plays the manipulative role in the latter [p. 20, 22]?
10. Prior to the Renaissance, how was the Cosmos thought to be structured; how old was Planet Earth thought to be; how was life thought to have come into being; what individual(s) brought new insight into pre-Renaissance cosmological notions; did these new insights impact biology [p. 22]?
11. What is the principal tenet of the notion of "essentialism"; name the Greek philosopher who was a major exponent of this notion; how does essentialism relate to the more modern notion of "typology" [p. 22]?
12. What was John Ray's understanding of what constituted a species; (harder) how does it contrast with current understanding [p. 22]?
13. For what finding is George Leclerc, Comte de Buffon, remembered; what previous understanding did his finding replace [p. 23]?
14. What notion is embodied in the 19th century term "catastrophism"; what was that notion designed to explain [p. 23]?
15. What is "uniformitarianism"; against what background was uniformitarianism introduced; by whom was it introduced; how does this notion deal with earthquakes, volcanism and erosion; are such geological events likely to destroy all life on Planet Earth [p. 23]?
16. What is a "unicellular organism"; are there any around in the world today[p. 23]?
17. Distinguish between an "invertebrate" and a "vertebrate"; can you provide one example of each; which appear first in the fossil record [p. 25]?
18. What group of vertebrates first moved onto the land; approximately when did the reptiles first appear [p. 25]?
19. Approximately when did mammals (a) first appear, (b) first flourish on Planet Earth [p. 24-25]?
20. Approximately when did (a) vascular, (b) cone-bearing, (c) flower-bearing plants first appear on Planet Earth; are examples of all three still around [p. 24-25]?
21. Does the fossil succession support or call in question the basic notion of biological evolution [p. 25]?
22. In what way(s), if any, does skull construction support or call in question the notion of biological evolution [p. 25]?
23. Distinguish between "homologous" and "analogous" structures in organisms; give a specific example of each; do homologous structures always/ever discharge the same function [p. 25]?
24. What embryonic relationship, if any, links homologous structures [p. 25-26]?
25. Was Charles Darwin the first to write about the possibility of evolution; if not, who contributed to the early debate; what unique contribution did Darwin/Wallace make to the debate [p. 26]?
26. What contribution was made to the evolution debate by de Lamarck; was there any flaw in his argument; was his contribution significant [p. 26]?

27. In what way(s) did the experimental approaches to biology used by Wallace and Darwin, differ from the approach used by most of their contemporaries [p. 26-27]?
28. What is a "population" of organism; why are populations of organisms so critical in evolutionary theory; what are the characteristics of populations that make them open to natural selection'; are real populations stable or variable in size, uniform or diverse in composition [p. 27]?
29. What are the four "legs" on which the Darwin/Wallace principle of natural selection are based; did one of these "legs" depend on a detailed knowledge of the mech-anism of inheritance [p. 28]?
30. Would evolution be possible if offspring always inherited information from their parents totally unchanged; would evolution be possible if parents contributed nothing to the genetic make-up of their offspring [p. 28]?
31. In your own words explain what a scientist or engineer means when he/she talks of (a) a "model", (b) a "system"; which might be learning aid; why does one sometimes talk of the "planetary model" of behaviour of electrons in an atom [p. 28, 29]?
32. To what extent is "information" rightfully seen as a reduction in uncertainty; to what extent, if any, can the latter be quantified [p. 28]?
33. What is an organism's "genome"; what is the relationship between "genes" and a genome; of what material is a genome composed; to what extent, if any, is a genome involved in inheritance [p. 28]?
34. What is the meaning of the verb "replicate"; why is it so critical in biology that DNA can replicate [p. 28]?
35. Is the ability to reproduce a component part of a comprehensive definition of a living organism [p. 28]?
36. Using the knowledge base you already possess, project from the model of the "universal constructor" to a human being; what, for instance, is our "fuel" and our "instruction tape" [p. 29]?
37. Can you pick up from the discussion of the "universal constructor" model, the principal difference between an organism and a virus [p. 30]?
38. To what extent, if any, is a computer "goal-directed"; is it conscious of so being [p. 30]?
39. How do biologists define a "community"; to what extent, if any, do community members interact [p. 31]?
40. What meaning(s) do biologists attach to the term "ecology" [p. 31]?
41. Is energy of any ecological significance; what is the primary source of energy is most ecosystems; through which organism type(s) does solar energy first enter an ecosystem [p. 31]?
42. To what extent, if any, is it true to say that (a) organic molecules (b) an organism's body are/is "an energy source" [p. 32]?
43. Are human beings ever part of an ecosystem [p. 32]?
44. What do you understand by the terms; adaptation, (ecological) niche; what force adapts an organism to its ecological niche; why might two, initially similar, organisms develop differently in different parts of the world [p. 32]?
45. Distinguish generally between sexual and asexual reproduction; which tends to be the faster; which involves a "zygote"; from what is the latter formed; which is more likely to cycle through series of widely different structures [p. 32]?
46. What do you understand by the term "morphology"; in modern days, is a species defined in terms of morphology; if not, how is a species defined [p. 33]?
47. What is "exponential growth"; under what circumstances will such a phenomenon be observed; what eventually limits exponential growth; what type of growth curve results when exponential growth is no longer possible [p. 33]?
48. What "resources" does any organism typically need [p. 33-34]?
49. What is meant by the term "carrying capacity"; in what way(s) does it impact an organism's exponential growth [p. 34]?
50. What economic/biological principle was conceived by Thomas Malthus; does it apply to human beings; what, if anything has it to do with "the survival of the fittest" [p. 34]?
51. Does evolution operate on individuals; if not, on what does it operate; will the poet John Whittier ever see an onion evolve into a geranium [p. 34]?
52. What two phenomena cause variability in a population; what, if anything, has variation to do evolution [p. 34]?
53. What do you understand by the term "mutation"; in what are biological mutations produced [p. 34]?
54. What, if anything, have pesticides, antibiotics, pesticide-resistant and antibiotic-resistant organisms to do with evolution [p. 34]?
55. How does an evolutionary biologist define the term "fitness"; will genetic characteristics that contribute to fitness increase or decrease in abundance in a population over succeeding generations [p. 34]?

56. In your own words describe the observations made by Kettlewell on the light and dark forms of the English peppered moth; what role, if any, do birds play in this story; what estimate of a possible time-frame for evolutionary change in a population, do these observations suggest [p. 35]?
57. What do understand by the terms: differential survival and differential reproduction; how are they interrelated [p. 35]?
58. In your own words explain how an organism can "become designed for their ways of life" [p. 35]?
59. To what extent, if any, can an ancestral species "strive" to acquire a specific capability through evolution [p. 36]?
60. What is an organism's "strategy for survival"; is such a strategy consciously chosen by the organism; if not, how does it arise; to what extent, if any, is the "choice" opportunistic [p. 36]?
61. What is a "phylogeny" and a "phylogenetic tree"; what do such structures contain and what meaning to they attempt to convey [p. 37]?
62. What biological classification(s) was/were used by the ancient Greeks and Romans; what addition did Haeckel make to the classical scheme and approximately when did he make it [p. 37-38]?
63. How many kingdoms are found in the Whittaker classification system; what are they [p. 38-39]?
64. What are the "archaebacteria"; what classification system separates them from all other living organisms [p. 42]?