Domains Of Life CD-ROM Learning Guide - Teacher Section
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Domains of Life - Teacher Section - Introduction

Suggestions for Using the CD-ROM

• Individual study; pre- or post- video viewing.
• Provide students with printed study quizzes (questions and word match) to stimulate learning of ideas/vocabulary.
• Group study (Use quizzes or tests to stimulate discussion.)
• Classroom Projection - If you have a computer video output system, you can project the learning guide to a TV (or screen with video projector).
• Overheads - You can print some of the pages, especially the table provided in this section and other tables linked to both program guides, in order to make overhead projecton transparancies for discussion.
• Research Projects - The guide is an excellent starting point for research projects in evolution and DNA technology. The Activity " Research Projects" can be a starting point for determining research projects. This topic is at the leading edge of biological thinking, and there are very few textbook discussions. We suggest using the internet, or recent scientific journals such as Scientific American, American Scientist, Discovery, or Science News.

Internet Component

• These programs provide about 25 different web-site jumps, chosen on the criteria that they are general accessible to the beginning biology student, are visually-oriented, and they enhance the topic. If the user should encounter any problems reaching a 'web link' consult our 'web update page' at **http://www.ebiomedia.com/teach/Domlinks.html**
• If students do not have internet access during the use of this Guide, they will still find the CD-ROM a useful tool for study of the topic.
• This program does not track time on the internet, nor monitor when the browser applications are open and on-line. The user should have knowledge of internet use, and using two applications at one time. She/he should frequently check the web browser.

The Tests

• Questions are arranged more or less in order of information in the programs.
• **To change the selection or arrangement of questions, cut and paste items in a word processor. Use the "select text" feature available in the "Tools" menu.**
• Tests are printable as is; the coloured buttons do not show up on your printed copy.
• Answer Keys are provided in this Guide.

Revising the Five Kingdoms

Most modern biology text books use the 'five kingdoms' approach. **The Domains of Life Videos and CD-ROM Learning Guide** are the first educational programs to focus on the revolution in biological classification and evolutionary thought brought about by DNA/RNA sequencing technologies. In the following two pages we have provided a discussion and a comparison table, to give a perspective on how the current revolution is changing these fields of biology.

Classification, Evolution and the Molecular Biology Revolution

A Two-Kingdom Tradition

For centuries, living organisms were divided into two kingdoms: the Animalia and the Plantae. In the second half of the 19th century, following the work of Charles Darwin and Ernst Haeckel, biologists realized that the animal/plant scheme did not accurately express the diversity of life, nor did it clarify many questions about how life evolved. Various schemes were proposed with three or more kingdoms, and the group name of single-celled organisms, Protista, was born.

The Five Kingdom View Takes Hold

In the 1970s and 80s, a revolution changed biology teaching. A new classification scheme took hold, based on renewed efforts to show relationships among living organisms, and to understand how each group evolved. Biochemical evidence and transmission electron microscopy (ultrastructure) evidence provided strong support for a five-kingdom scheme of classification: Monera (bacteria), Protista, Fungi, Plantae, and Animalia. Biochemical and molecular biology studies revealed startling evidence that mitochondria and plastids were related to bacteria, and the endosymbiotic theory of organelle evolution became established. During the same period, biochemical studies revealed a fundamental division of life into two main groups: the Prokaryotae (bacteria, etc.) and the Eukaryotae (animals, plants, fungi, and protists).

The Molecular Biology Revolution

The Five Kingdoms approach was a good framework, but like all science, it is subject to revision. Techniques for sequencing RNA and DNA molecules developed through a series of remarkable discoveries in the late 1980s and early 90s have opened new questions about classification. By comparing nucleotide sequences for fundamental macromolecules such as ribosomal RNA, molecular biologists can now infer evolutionary relationships in ways not previously possible. Far more profoundly than any other biological technique before it, DNA/RNA sequencing has allowed biologists to‘look into the past’; to infer which groups of living organisms have ‘primitive’ characteristics in relation to other groups; to learn which groups have strong evolutionary affinities; and to even probe evolutionary events that took place billions of years ago. Combined with all of the knowledge developed before, and with new developments in other fields such as paleontology, DNA/RNA sequence technology is now revolutionizing the fields of classification and evolution.

Revising the Five Kingdoms

Most modern biology text books use the‘five kingdoms’ approach. It’s catchy, memorable, and not too controversial (although it certainly revised the biology teaching picture dominant in 1975!) But in the real world of biology research, this approach is now undergoing significant revisions. Two fundamental proposed changes coming out ot these new perspectives are:

- Recognition of the three domains (Archaea, Bacteria, Eucarya) as the fundamental divisions of life. Archaea and bacteria are as different from each other as they are from eucarya, and none of the domains is ancestral to another.
- Changes in the kingdom-level classification of the eukaryotes to better reflect evolutionary relationships. Especially the Kingdom Protista may be modified to reflect fundamental patterns of eukaryote diversity and evolutionary relationships missing from the five kingdom approach.

On the following page, we present a table outlining trends in classification for the Three Domains of Life approach, in comparison to the Five Kingdoms approach.

Five Kingdoms and Domains of Life Compared

	Five Kingdoms	Domains of Life
Basic System	Five Kingdoms (Overlain by Prokaryote/Eukaryote division). Kingdom Monera at base of tree of life.	Three fundamentally different domains, none ancestral to others. An unknown ancestor to all domains is at the base of the tree of life.
Prokaryote classification	Prokaryotes are distinct from eukaryotes, and they evolved first. Living prokaryotes fall in the Kingdom Monera.	Two fundamental forms of life are prokaryotes - Bacteria and Archaea. Neither gave rise directly to the other, nor to the third domain-Eucarya.
Subdivisions of the prokaryotes.	One Kingdom: Monera. (Some biologists recognize another kingdom of prokaryotes, Kingdom Archaebacteria, for a Six Kingdom system).	Domain Archaea consists of two major subgroups (kingdoms?). Domain Bacteria may consist of two or more kingdom-level subgroups.
Eukaryote classification	Four Kingdoms: Plantae, Animalia, Fungi, and Protista (or Protoctista). Protist (eukaryote) evolution included endosymbiotic incorporation of prokaryotes as certain organelles.	Domain Eucarya has its origins near the base of the tree of life. Endosymbiosis involved in development of some eukaryote organelles and also in the diversification of the Eucarya. Kingdom-level classification is now undergoing revisions and several major lines of evolution have been suggested as kingdoms: the **Green Line** (plants, green algae, and related single-cell groups); **fungi**; **animals**; **chromista** (includes brown algae, diatoms, coccolithophores, downy mildews, and others); **alvaeolates**; **basal protists**; and **flagellates** and possibly others.
# of Prokaryote Kingdoms	1 Kingdom	2 to 4 + Kingdoms in 2 Domains
# of Eukaryote Kingdoms	4 Kingdoms	5 to 9+ Kingdoms in 1 Domain
Total # of Kingdoms	5 Kingdoms	7 to 13+ Kingdoms in 3 Domains

Multiple Choice Test On Program 1, Domains of Life

(Circle the letter of the correct choice for each question.)

1) Three and one-half billion years ago, at the dawn of life, the earth's atmosphere probably contained the following gases:

a) oxygen and ammonia, but no carbon dioxide.
b) water and ammonia, but no carbon dioxide.
c) methane and ammonia, but no oxygen.
d) nitrogen, hydrogen, oxygen, and fluorine.
e) no nitrogen.

2) Stromatolites:

a) hang down from the upper surface of caves.
b) have only been found in Shark Bay, Australia.
c) have been found in rock formations older than 3 billion years.
d) are only produced by eukaryotes.
e) always contain fossil remains of both prokaryotes and eukaryotes.

3) The prebiotic soup probably contained:

a) lots of inorganic salts, but no amino acids.
b) bacteria and archaea.
c) lots of mushrooms and butter.
d) organic molecules that formed spontaneously.
e) less dissolved organic material than today's oceans.

4) Protocells:

a) competed with each other in the prebiotic soup.
b) were capable of self-replication.
c) were acted upon by natural selection.
d) consumed raw materials in the form of organic compounds present in the environment.
e) All of the above.

5) Which of the following is <u>not</u> a property of the DNA of bacteria:

a) it is bound inside a double-membrane organelle.
b) it is duplicated at the time of cell division.
c) it is present in the cell as a single long strand or loop.
d) it is much shorter than the DNA molecules found in eukaryotes.
e) it is the same type as much of the DNA found in chloroplasts and mitochondria.

6) Archaea and bacteria are biochemically different in their:

a) basic ribosome structure.
b) cell wall structure.
c) transfer RNA starting point for protein synthesis.
d) sensitivity to antibiotic drugs such as streptomyocin.
e) All of the above.

Multiple Choice Test On Program 1, Domains of Life – p. 2

7) Hotsprings:
a) never contain photosynthetic organisms.
b) are usually too hot for living organisms.
c) are useful models for conditions found 3 billion years ago on Earth.
d) always denature the proteins found in living organisms.
e) None of the above.

8) Aerobic metabolism:
a) is many times more efficient than anaerobic metabolism.
b) is isolated in the eukaryotic cell in mitochondria.
c) involves oxygen, a potentially poisonous chemical.
d) probably evolved after the beginnings of cyanobacteria photosynthesis.
e) All of the above.

9) The nucleus:
a) probably evolved in the first living cell.
b) probably evolved in a cell with rigid cell walls.
c) probably evolved to protect a cell from its own digestive enzymes.
d) probably evolved as a response to oxygen in the environment.
e) None of the above.

10) Mitochondria:
a) probably evolved many times in the domain Eucarya.
b) are more closely related to archaea than to any of the other domains.
c) are the site of anaerobic metabolism in the cell.
d) contain DNA with biochemical differences compared to the DNA found in the nucleus of the cell.
e) are found in all eukaryotic cells.

11) According to the endosymbiotic theory:
a) at some time in the past, the ancestors of mitochondria were free-living bacteria.
b) eukaryotic organisms evolved to their present level of complexity because one of their ancestors formed a partnership with bacteria.
c) the modern eukaryotic cell contains two basic forms of DNA.
d) under certain conditions in the past, a symbiont inside a host cell became an integrated part of the host cell.
e) All of the above.

12) The three domains of life:
a) are part of the kingdom Monera.
b) represent fundamental, early branches in the tree of life.
c) do not share the same DNA information coding system.
d) have the same cell wall biochemistry (where cell walls are present).
e) evolved sometime around a billion years ago.

Multiple Choice Test On Program 2, Domains of Life

(Circle the letter of the correct choice for each question.)

1) The outer covering of early eukaryotes:
   a) was probably a cell wall with a biochemistry similar to that of bacteria.
   b) was probably flexible.
   c) was made from peptidoglycan.
   d) was probably a double membrane.
   e) None of the above.

2) Actin and myosin:
   a) are found only in bacteria.
   b) enable amoeba cells to move about through cytoplasmic streaming.
   c) are part of the DNA information system.
   d) are energy carrier molecules in the cell.
   e) create the spindle fibers in mitosis.

3) Tubulin rods:
   a) are the structural portion of cilia and flagella.
   b) can lengthen and shorten as molecular subunits are added/removed.
   c) can function as molecular highways in the cell.
   d) create the spindle fibers in mitosis.
   e) All of the above.

4) Mitosis:
   a) is a process only important in sexual reproduction.
   b) occurs in all three domains.
   c) involves the condensation of chromosomes.
   d) causes variation in populations because genes are shuffled and new genes are formed.
   e) occurs only in onion cells.

5) During what phase of the cell cycle do the chromosomes line up in the central part of the spindle?
   a) interphase
   b) anaphase
   c) prophase
   d) telophase
   e) None of the above.

6) The sequence of mitosis is:
   a) telophase, anaphase, prophase, metaphase.
   b) prophase, anaphase, metaphase, telophase.
   c) prophase, metaphase, anaphase, telophase.
   d) metaphase, anaphase, prophase, telophase.
   e) prophase, telophase, anaphase, metaphase.

Multiple Choice Test On Program 2, Domains of Life – p. 2

7) Photosynthetic plastids:
   a) evolved from mitochondria.
   b) are much smaller than bacteria.
   c) cannot be related to cyanobacteria since they carry out a very different type of photosynthesis.
   d) may have evolved through endosymbiosis three different times.
   e) unlike mitochondria, contain no DNA.

8) According to the endosymbiotic theory:
   a) green-sulfur bacteria evolved into chloroplasts.
   b) chloroplasts are descended from ancestors of *Prochloron*, a photosynthetic bacterium with both chlorophyll A and chlorophyll B.
   c) the DNA inside plastids should be totally similar to the DNA of the eukaryote nucleus.
   d) photosynthesis using chlorophyll A first evolved in an ancient eukaryote cell.
   e) None of the above.

9) Endosymbiosis of photosynthetic organisms living inside modern cells:
   a) occurs in many different groups of eukaryotes.
   b) can involve either prokayrote or eukaryote endosymbionts.
   c) is a model for the most plausible scenario for the evolution of plastids.
   d) indicates that similar endosymbioses probably occurred frequently during much of the history of life on earth.
   e) All of the above.

10) Which group does not belong in the proposed kingdom Chromista?
   a) coccolithophores
   b) moss
   c) downy mildews
   d) brown algae
   e) diatoms

11) The cannibal model for the evolution of sexual reproduction suggests that:
   a) ancient cannibal eukaryotes evolved a haploid/diploid cycle.
   b) when same-species cells were eaten by a cannibal cell, the nucleus and genes might not be digested.
   c) large cells with two nucleii would have an advantage during periods of harsh environmental conditions.
   d) All of the above.
   e) None of the above.

12) Multicellular organisms:
   a) probably evolved from colonial organisms
   b) evolved in the domains bacteria and eukarya
   c) suddenly evolved from single-celled eukaryotes
   d) have no survival advantages over single-celled organisms
   e) All of the above.

True/False Test On Program 1, Domains of Life

Circle the correct answer [True (T) or False (F)]

T / F 1) Life evolved three different times from protocells, because there are three different domains of life.

T / F 2) Strong ultraviolet radiation and electrical storms were common features of the biosphere 3.5 billion years ago.

T / F 3) Life evolved from molecular systems that replicated themselves and competed for organic molecules in the environment.

T / F 4) The first living cell was not an ancestor to humans, because it was not a eukaryote with a nucleus.

T / F 5) Bacteria can have up to 4 chromosomes.

T / F 6) The organisms now called archaea were thought to be bacteria until recently.

T / F 7) Archaea differ from bacteria in the type of organelles contained within the cell.

T / F 8) Both archaea and bacteria are prokaryotes.

T / F 9) Hotsprings harbor both bacteria and archaea.

T / F 10) Chemical gradients develop around decomposing organisms.

T / F 11) Eukaryotes are the only organisms that exhibit behavior.

T / F 12) Bacteria are not necessary on planet earth because their roles in the ecosystem would be taken by archaea and eukaryotes.

T / F 13) Oxygen in the atmosphere built up as a result of outgassing from the earth's rocks about 3-2 billion years ago.

T / F 14) Members of the domain archaea are the only organisms that carry out methane-producing metabolism.

T / F 15) Flagella are found in both the domain eukarya and domain bacteria.

T / F 16) When cows eat grass, they are relying upon bacteria and archaea to digest it.

T / F 17) Oxygen is poisonous to many prokaryotes.

T / F 18) Anaerobic metabolism is many times more efficient than aerobic metabolism.

T / F 19) Humans belong to the domain eukarya.

T / F 20) Multicellular organisms evolved in each of the three domains of life.

T / F 21) The nucleus probably evolved in predator cells, as a response to the need to isolate the cell's DNA from digestive enzymes.

T / F 22) The nucleus is found only in the domain Eukarya.

T / F 23) According to the endosymbiotic theory, all of the organelles inside the eukaryotic cell were originally bacteria that became symbionts inside an engulfing cell.

T / F 24) By comparing the sequence of nucleic acids on DNA, biologists can make conclusions about evolutionary events that happened billions of years ago.

T / F 25) A single-celled eukaryote species living without mitochondria may represent an ancient line of evolution that branched before eukaryotes acquired mitochondria.

True/False Test On Program 2, Domains of Life

T / F 1) Early eukaryote ancestors probably lacked a cell wall. They engulfed other cells and solid organic matter.

T / F 2) Like eukaryotes, bacteria can engulf other cells.

T / F 3) Mitochondria evolved inside the eukaryotic cell when cell organelles started taking on the role of aerobic metabolism.

T / F 4) The domain eukarya includes all organisms except bacteria.

T / F 5) When particles move from one region of the cell to another, ATP energy is required.

T / F 6) Muscles contract because tubulin molecules are becoming disassociated.

T / F 7) Muscle movement requires ATP.

T / F 8) Flagella are made of bundles of tubulin, but cilia are not.

T / F 9) Cirri are organelles within the eukaryotic cell.

T / F 10) Mitosis allows complex cells with long strands of DNA to replicate all of the genome before the cell divides.

T / F 11) Some single-celled eukaryotes have many copies of each gene, which are distributed to offspring as a random selection when the cell divides asexually.

T / F 12) Some modern eukaryotes have photosynthetic symbionts living inside their cells.

T / F 13) Only prokaryotes live symbiotically inside eukaryotic cells.

T / F 14) Symbiosis of photosynthetic prokaryotes was of no advantage to ancient eukaryotes.

T / F 15) Plastids in red algae have the same chlorophylls as plastids in green algae - only the accessory pigments are different, leading to the different colors of the algae.

T / F 16) Chloroplasts of modern plants are probably descended directly from ancient cyanobacteria.

T / F 17) Most members of the group, Chromista, contain chlorophyll A and chlorophyll C.

T / F 18) Sexual reproduction is only found in multicellular organisms.

T / F 19) According to the cannibal model for the evolution of sexual reproduction, engulfing cells consumed individuals of the same species, keeping the new nucleus intact. This provided a survival advantage during harsh environmental conditions.

T / F 20) Sexual reproduction increased the pace of evolution because more offspring were born more frequently.

T / F 21) Animals are multicellular, but they must have evolved from a line of ancestors that included colonial forms and single-celled forms.

T / F 22) Because sponges are considered the most primitive form of animal, it makes sense to look for animal ancestors with similar characteristics to sponges.

T / F 23) Ancestors of modern choanoflagellates evolved directly into multicellular plants.

T / F 24) Multicellularity evolved only once in the domain eukarya.

T / F 25) DNA sequence evidence can be used to study evolutionary relationships since DNA carries information from all ancestors in the evolutionary lineage of an organism.

Short Answer Test On Domains of Life

1) What is the strongest piece of evidence suggesting that all life is descended from one ancestor, and why?

2) Explain why the first cells to evolve were probably not eukaryotes.

3) Why are ribosomes important in the study of evolutionary relationships.

4) Explain the importance of stromatolites in the early evolution of life on earth (up to 1 billion years ago).

5) Explain the origin of the oxygen in Earth's atmosphere.

6) Explain the following statement, and it's significance to the evolution of life: oxygen is poisonous to many living organisms.

7) Why do biologists believe that mitochondria evolved from bacteria?

8) What is the significance of the large amoeboid organism, Pelomyxa?

9) Describe the biochemical mechanisms that allow cells and organisms to move?

10) Describe the structure of a flagellum. What is the role of tubulin in the flagellum?

11) Describe three pieces of evidence indicating that chloroplasts evolved from endosymbiotic ancestors.

12) Explain how chlorophylls can be important for classifying photosynthetic eukaryotes.

13) Write a short description explaining the cannibal model for the evolution of sexual reproduction.

14) What are the advantages of mixing the combination of genes among different individuals in a population?

15) In asexual reproduction, the offspring end up with an identical sets of genes (and chromosomes) to the parent. In sexually reproducing organisms the offspring end up with gene combinations not found in either parent. How is this possible?

Answer Key - Multiple Choice Tests

Program 1 Test

1) c
2) c
3) d
4) e
5) a
6) e
7) c
8) e
9) c
10) d
11) e
12) b

Program 2 Test

1) b
2) b
3) e
4) c
5) e
6) c
7) d
8) b
9) e
10) b
11) d
12) a

Answer Key - True/False Tests

Program 1 Test

1) F
2) T
3) T
4) F
5) F
6) T
7) F
8) T
9) T
10) T
11) F
12) F
13) F
14) T
15) T
16) T
17) T
18) F
19) T
20) F
21) T
22) T
23) F
24) T
25) T

Program 2 Test

1) T
2) F
3) F
4) F
5) T
6) F
7) T
8) F
9) F
10) T
11) T
12) T
13) F
14) F
15) F
16) F
17) T
18) F
19) T
20) F
21) T
22) T
23) F
24) F
25) T

Educational Multimedia

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Video or DVD and CD-ROM Packages

The Domains of Life
- Program 1: Life's Three Great Branches: Archaea, Bacteria, Eucarya
- Program 2: The Eukaryotic Cell Evolves
- Domains of Life CD-ROM Learning Guide

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Videos

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The Biology of Bacteria (22 minutes)
The Biology of Protists (20 minutes)
The Light Microscope (15 minutes)
The Biology of Plants (20 minutes)
The Biology of Fungi (15 minutes)
The Biology of Sponges (15 minutes)
The Biology of Cnidarians (20 minutes)
The Biology of Nematodes, Rotifers, Bryozoans
and some "Minor Phyla" (20 minutes)
The Biology of Molluscs (20 minutes)
The Biology of Annelids (20 minutes)
The Biology of Arthropods (24 minutes)
The Biology of Echinoderms (20 minutes)
The Biology of Chordates (20 minutes)

The Biology of Lakes, Ponds and Wetlands (30 minutes)
The Biology of Seashores (30 minutes)

CD-ROMs

The Wetlands Explorer CD-ROM
Exploring Cell Processes CD-ROM

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