LESSON TEMPLATE

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Lesson Code:

Lesson Title: *Critical Analysis of Evolution*

Ohio Standards Connection:

Standard(s): Life Sciences

Benchmark(s): H
Describe a foundation of biological evolution as the change in gene frequency of a population over time. Explain the historical and current scientific developments, mechanisms and processes of biological evolution. Describe how scientists continue to investigate and critically analyze aspects of evolutionary theory. (The intent of this benchmark does not mandate the teaching or testing of intelligent design.)

Indicator(s): 23
Describe how scientists continue to investigate and critically analyze aspects of evolutionary theory. (The intent of this indicator does not mandate the teaching or testing of intelligent design.)

Related Science Benchmark
Standard(s): Scientific Ways of Knowing

Benchmark A
Explain that scientific knowledge must be based on evidence; be predictive, logical, subject to modification and limited to the natural world.

Grade 10 Indicator 2
Describe that scientists may disagree about explanations of phenomena, about interpretation of data or about the value of rival theories, but they do agree that questioning, response to criticism and open communication are integral to the process of science.

Grade 10 Indicator 3
Recognize that science is a systematic method of continuing investigation, based on observation, hypothesis testing, measurement, experimentation, and theory building, which leads to more adequate explanations of natural phenomena.

Lesson Summary:

The purpose of this lesson is to allow students to critically analyze nine different aspects of evolutionary theory. As new scientific data emerge, scientists' understanding of the natural world may become enhanced, modified, or even changed all together. Specifically, the same can hold true for our understanding of evolution. Using library and Internet sources, groups of students will conduct background research for one of the aspects of evolution in preparation for a classroom debate.

Estimated Duration:

240-330 minutes

Pre-Assessment:

I The following questions can be used to stimulate dialogue with the students.

II Instruct students to copy questions from the chalkboard in their science lab notebook (or paper to be place in their science notebook).

A. Describe what constitutes an *anomaly*.
B. Why do scientific anomalies exist in science?
C. Are there any benefits to exploring scientific anomalies?
D. How do scientists critically analyze conflicting data?
E. Define the following terms in your own words:
(Compare students' definitions with the actual definitions given by the teacher).
    1. Biological evolution
    2. Critical analysis
    3. Natural selection
    4. Macroevolution
    5. Microevolution
    6. Theory

III. Direct students to respond to the questions in their science notebook in as much detail as possible leaving space to record information from the ensuing dialogue to add to their notes.

Scoring Criteria

Collect and evaluate for indication of prior knowledge and/or misconception.

Post-Assessment

A. Describe why scientific critical analysis of macroevolution is important.

B. Describe three major pieces of evidence used to support and challenge macroevolution and explain why these pieces are important.

C. Compare and contrast the supporting and challenging information regarding the aspect of macroevolution you studied.

D. Evaluate the scientific data supporting and challenging areas of macroevolution in light of the scientific method. In other words, is the data that is used to support macroevolution consistent or inconsistent with the scientific method? Are there any limitations?
(NOTE: steps of scientific method, observation, hypothesis, test, retest, and conclusion)

Instructional Procedures:

This lesson consists of two major parts. Students first research the evidence supporting and challenging one particular aspect of evolutionary theory. They will then use that information to participate in a debate about the aspect they studied. Students will also listen to their classmate's debate additional aspects of evolutionary theory.

A. Student Engagement

1. Write the following statement on the chalkboard or overhead.
"Anomalies are ideas in science that depart from the general consensus of the time. Many anomalies occur in science. In an effort to determine the cause of this deviation, scientists conduct research to collect data that will explain the phenomena. As the evidence mounts by careful analysis of the data, original ideas may change from one scientific understanding to another."

2. Ask students to think through the following science topics and discuss where anomalies lead to the collection of data that further explained the phenomena and contributed to changing scientific understandings.

1. Spontaneous generation v. biogenesis
(Several pieces of data could be used. One example is Francesco Redi's observation and that maggots appeared on meat a few days after flies were seen on the meat which lead to his investigations.)
2. Geocentric v. Heliocentric
(Several pieces of data could be used. One example is the observed phases of Venus.)
3. Global warming v. non global warming

(Several pieces of data could be used. One example is the observed increasing size of the ozone hole.)

3. Ask students to cite additional areas where critical analysis is needed by the scientific community.

Teacher Note: The terms macroevolution and microevolution, originally used in 1927, continues to be more commonly used in the scientific community. These words are defined in the following ways:

- "Microevolution refers to any evolutionary change below the level of species, and refers to changes in the frequency within a population or a species."

- "Macroevolution is used to refer to any evolutionary change at or above the level of species."

These terms have appeared in OhioLink research databases, numerous Internet sites, biology and evolution textbooks. Though "micro" and "macro" are prefixes, it is quite clear that the scientific community recognizes and acknowledges the distinction of the words. There is more research on microevolution than there is on macroevolution. In order to help ensure academic clarity, the focus of this lesson is on macroevolution. More information about macroevolution and microevolution can be found at the website used to obtain the about definitions: www.talkorigins.org/faqs/macroevolution.html

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B. Researching Aspects of Evolutionary Theory

1. Form groups of students consisting of 2, 3, but no more than 4 students each. Assign each group a number.

2. Allow the groups to pick (or assign) one of the nine aspects of evolutionary theory. Assign two groups to research one of the nine aspects used to support and challenge macroevolution. Two groups researching the same, single aspect will ultimately allow one group to debate the supporting and the other to debate the challenging side. The nine aspects that can be researched are:

a) Anaerobic early atmosphere
b) Darwin's tree of life
c) DNA/RNA (Molecular genetics)
d) Embryology
e) Endosymbotic theory
f) Fossil formation through gradualism

g) Miller and Urey's experiment
h) Natural selection of antibiotic resistant bacteria
i) Natural selection of Peppered moths

Teacher Note: For the teacher's convenience, brief sample statements and references for the nine aspects can be located at the end of the Instructional procedure section. The teacher can simply use this information as background knowledge that may be helpful in guiding students if questions arise. Alternative strategies for beginning this lesson could be to engage students in a Socratic discussion or a mini-lecture.

3. Allow the two groups assigned the same aspect, time to research and investigate their aspect by answering questions on the *Investigative worksheet* (Attachment #1). Have the two groups use the worksheet as a guide, to help them research both the supporting and challenging data on their particular aspect of macroevolution. The worksheet will also help increase student knowledge and ability to critically analyze macroevolutionary data and help students prepare for the student-lead debate.

Teacher Note: The *Investigative worksheet* (Attachment #1) consists of questions that can be applied to all nine aspects. The questions on the worksheet are designed for students to examine the aspects used to support and challenge macroevolution. This will help students become familiar with the data, and therefore be able to debate for either the supporting side or the challenging side. As they complete the worksheet, the group members may all work together on each question, or divide the questions among themselves, answer the questions and then come back together as a group to share their research findings.

4. After the groups have completed their research, collect the *Investigative worksheet* and review it to make sure students are "on track." Return the worksheet to them prior to their debate.

C. <u>Conducting the Macroevolution Debate.</u>

5. Allow the students to spend quality time researching and preparing to debate on both the supporting and challenging information. Prior to the debate, randomly determine which of the two groups will take the "supporting" side and which will take the "challenging" side. One option would be to have groups draw cards to decide their position.

6. Encourage all students to participate in the debate because the experience itself will be a learning opportunity. However there may be a few students who may not feel comfortable talking in front of their peers. Determine if you have any

students that fit this description and design an alternative assignment. One option might be a written assignment.

7. Each pair of groups will address the same aspect, with one group taking the "supporting" side and the other group taking the "challenging" side. Flip a coin to decide which group begins the debate. Have students use the following format for their debate:

Group 1: Three to four minutes for an opening statement.

Group 2: Three to four minutes for an opening statement.

Group 1: One or two minute response to Group 2's opening statement.

Group 2: One or two minute response to Group 1's opening statement.

Group 1: One or two minutes for closing remarks.

Group 2: One or two minutes for closing remarks.

The teacher will serve as moderator to assure that the groups remain on task and on time.

8. Prior to the debate, ask each group to write out their opening statement and closing remarks (Attachment #1), and practice them to be sure that timing is appropriate. Their materials should:
   a) Be limited to scientific data;
   b) Include visual aids (e.g. graphs, tables, etc. displayed on posters, transparencies, chalkboard, or presentation software);
   c) Provide an opportunity for all group members to speak;
   d) Follow the norms of courtesy (e.g., no insults or interrupting; avoid debating about personal beliefs).

   There are no winners or losers in this debate. This debate is a sharing of the results of their research concerning macroevolution. Share the debate rubric with students before beginning.

9. Students will be active participants as they debate their assigned aspect. To ensure that they remain engaged as they watch other groups debate other aspects, have them take notes on the debate worksheet (Attachment #2). At the conclusion of the lesson, this worksheet will be turned in for a grade.

10. Evaluate each group following their debate. Use the rubric previously shared with students.

D. Supporting Information

"NINE ASPECTS USED TO SUPPORT/CHALLENGE MACROEVOLUTION"
(Some of the resources upon which this information is based from can be found in the "Resource" section).

1. Anaerobic early atmosphere

Brief supporting sample answer:
The early atmosphere of planet Earth was an anaerobic (no oxygen) environment. Later on, as autotrophic organisms evolved, the atmosphere became aerobic (oxygen). This paved the way for the evolution of aerobic organisms.

Brief challenging sample answer:
If the Earth's atmosphere were anaerobic, then the ozone layer, which is composed of oxygen, would not exist. As a result, UV light from the sun would have mutated and potentially destroyed living organisms.

2. Darwin's Tree of life

Brief supporting sample answer:
Darwin's tree of life and what is known as the phylogenetic tree in the basic context are synonymous. The tree displays the evolutionary history of organisms over time. Ancestral life is represented at the base of the tree trunk. As a result of the evolutionary process that includes adaptations, natural selection, genetic variability, and many years, organisms slowly evolved into more complex organisms. The earth now hosts a variety of different organisms representing the tips of the branches.

Brief challenging sample answer:
The Cambrian explosion conflicts with Darwin's tree of life because there was a sudden appearance or an "explosion" of major and complex phyla fossils at the Cambrian level with virtually no fossils (with the exception of some sponge embryos) in the pre Cambrian level. With the Cambrian explosion at the base, Darwin's tree would be shaped differently.

3. DNA/RNA (Molecular genetics)

Brief supporting sample answer:
DNA sequences resulted from a random assortment of nitrogen containing bases. All organisms on Earth are the ultimate products of this assortment that has taken place over long periods of time through billions of years of nature's trial and error.

Brief challenging sample answer:
Nitrogen bases randomly coming together to form coherent genetic language is similar to cutting all the letters out of an encyclopedia, tossing them up in the air and all those letters falling back down exactly in the same sequence as before. Not only is it highly improbable statistically speaking, but it is also difficult to test in laboratory settings.

4. Embryology

Brief supporting sample answer:
The characteristics seen in embryonic stages of an animal's development reflect its evolutionary history. Similarities seen in homologous structures provide clues to evolutionary relationships. Ernst Haekel popularized the study of embryology, although his original drawings have since been modified by scientists.

Brief challenging sample answer:
Embryos of animals do not go through all of the developmental stages of their ancestors. Therefore, embryonic characteristics are not reliable indicators of evolutionary relationships. Ernst Haekel's work inaccurately portrayed a variety of animal embryos passing through the same developmental changes.

5. Endosymbiotic theory:

Brief supporting sample answer:
Many years ago, smaller bacteria were engulfed by larger bacterial cells. They co-existed in a symbiotic relationship. As a result, the smaller bacteria eventually changed into chloroplasts and mitochondria. It was by this process that these two organelles evolved.

Brief challenging sample answer:
Laboratory tests have not demonstrated that small bacteria prokaryotes can change into eukaryotic cellular organelles within larger bacterial cells. Although, some smaller bacterial cells can live in eukaryotes, but there is no evidence that cells change into organelles.

6. Fossil formation through gradualism

Brief supporting sample answer:
Evolution is a slow process with gradual transformation of one population into another. The slow transformations are reflected in the fossil record. The evidence of these transitional organisms are known as transitional fossils which "bridge" the gap from one species into another**.**

Brief challenging sample answer:

Evolution occurs suddenly over brief periods of time, followed by longer periods of stasis during which genetic change has no effect on the outward appearance of organisms. Therefore, no transitional organisms are recorded in the fossil record. This is known as punctuated equilibrium.

7. Miller and Urey's experiment

Brief supporting sample answer:
Miller and Urey reconstructed the early atmosphere of Earth by adding **e**lements and molecules such as methane, ammonia, and hydrogen to an elaborate apparatus. As a result of a random mixing of these chemicals, and with the aid of an electric shock, they demonstrated that some amino acids can be formed, just like it did on Earth.

Brief challenging sample answer:
Some scientists, believe that the chemicals used in Miller and Urey's experiment were not present during the early atmosphere. Moreover, the chemicals used in their experiment already had the vital elements which are a part of the structure of amino acids**.**

8. Natural selection of antibiotic resistant bacteria.

Brief supporting sample answer:
Antibiotic resistant bacteria, such as *Staphylococcus aureus,* have significantly increased in number over time. The antibiotics used by patients to eliminate the bacteria, serves as the natural selection agent. As a result, it kills those cells that "less fit" but, those cells that has a specific mutation survives and reproduce more resistant mutants in the presence of the antibiotic. This serves as a model demonstrating small evolutionary changes of bacteria from non resistant *S. aureus* to resistant *S. aureus* (microevolution), the precursor to the ultimate large-scale changes which over time could result in new species (macroevolution).

Brief challenging sample answer:
Antibiotic resistant *Staphylococcus aureus* have increased in frequency, due to selection against non-resistant strains (resistant *S. aureus* has always been among the population of non resistant *S. aureus)*. Antibiotics do not create resistant microbes, but rather it only amplifies the number of resistant microbes that were already present. Although new strains of prokaryotic *S. aureus* have evolved, none have evolved into eukaryotic species.

9. Natural selection of Peppered moths

Brief supporting sample answer:
A darker population of Peppered moths (scientifically known as *Biston betularia*) began to emerge as the environment changed over time. The lighter colored moths were more camouflaged while resting against the light tree trunk than the darker moths who were susceptible to predators. As a result of pollution from the industrial revolution in England, the trees grew darker and darker over time from the factory's soot. The lighter colored moths now became more visible to its predators while resting on dark tree trunks. This study demonstrated how natural selection changes the frequencies of a body type (color) in a species over time.

Brief challenging sample answer:
The Peppered moths (scientifically known as *Biston betularia*) do not rest on tree trunks, therefore bringing the legitimacy of this study into question. Using this example to support an evolutionary event may be inappropriate. However, if the experiment was factual, it demonstrated that the moths with the darker pigmentation increased in frequency (microevolution) as a result of the environmental change. However, the experiment does not demonstrate that the moths evolved into a different species (macroevolution).

Scoring Guideline:

DEBATE RUBRIC

3=excellent
2=acceptable
1=needs work
0=unacceptable/none existent

1. Group was able to articulate and demonstrate knowledge of the aspect of macroevolution they presented.

3 2 1 0

2. Students were courteous and respected the opinions of their fellow students.

3 2 1 0

3. Students were able to effectively use research to support their position.

3 2 1 0

4. Students were logical in presenting their position.

3 2 1 0

5. Students used support material (poster, graphic, etc.) effectively.

3 2 1 0

15 – 11 = Excellent (mastery)
11 – 8 = Good (acceptable)
7 – 4 = Not acceptable, material needs to be reviewed
3 – 0 = Poor, material needs to be thoroughly reviewed

Differentiated Instructional Support: Instruction is differentiated according to learner needs, to help all learners either meet the intent of the specified indicator(s) or, if the indicator is already met, to advance beyond the specified indicator(s).

- For this activity, a copy of the post assessment ought to be made available for all students. This will allow students to clearly understand what is expected from them. Additionally, students can submit an outline of their opening statement and closing remark, therefore assisting in their organizational skills. This allows the teacher to give feedback to the students in order to help them be prepared for the debate.

Extension:

OTHER ASPECTS THAT ARE USED TO SUPPORT/CHALLENGE MACROEVOLTUION

- Homology
- Archaeopteryx
- Fruit flies
- Darwin's finches

Homework Options and Home Connections:

Continue to complete Investigative Question Worksheet and prepare for debate.

Interdisciplinary Connections:

Social Studies Skills and Methods Standard
"Students collect, organize, evaluate and synthesize information form multiple sources to draw logical conclusions. Students communicate this information using appropriate social studies terminology in oral, written or multimedia form and apply what they have learned to societal issues in stimulated or real world settings."

"Evaluate the reliability and credibility of sources." (Social Studies Benchmark A, p. 41)

Research Standard
"Students define and investigate self-selected or assigned issues, topics and problems. They locate, select and make use of relevant information from a variety of media, reference and technological sources. Students use an appropriate form to communicate their findings."

"Formulate open-ended research questions suitable for investigation and adjust questions as necessary while research is conducted." (English Language Arts Benchmark A, p.171)

"Evaluate the usefulness and credibility of data and sources." (English Language Arts Benchmark B, p.171)

Materials and Resources:
Investigative Worksheet – Attachment #1
Debate Worksheet – Attachment #2

Vocabulary:

1. Biological evolution
2. Critical Analysis
3. Evolutionary theory
4. Macroevolution
5. Microevolution
6. Natural selection
7. Theory

Technology Connections:

Internet

Research Connections:

Bliss, Richard B. (1979). A comparison of two approaches to the teaching of origins of living things to high school biology students in Raccine, Wisconsin. Doctorial dissertation. University of Sarasota.

Brickhouse, Nancy (2000). Diversity of students' views about evidence, theory. *Journal of Research in Science Teaching*. 37:4.

Carrol, Robert (2002). Confirmation bias. Retrieved March 27, 2002 from the World Wide Web: http//skepdic.com/confirmbias.html.

Chinn, Clark (1993). The role of anomalous data in knowledge acquisition: a theoretical framework and implications for science instruction. *Review of Educational Research*. 63:1. 1-49.

Chinn, Clark (1998). An empirical test of a taxonomy of responses to anomalous data in science. *Journal of Research in Science Teaching*. 35:6.

Chinn, Clark A., William Brewer. *Knowledge change in response to data in science, religion, and magic*, Ch. 12. 9 (p. 334).

Evans, Margaret E. (2000). The Emergence of Beliefs About the Origins of Species in School-Age Children. *Merrill-Palmer Quarterly*. 46:2. p. 221-253.

Faust, David. The limits of scientific reasoning. University of Minnesota Press. Minneapolis, Minnesota. 1984.

Gilber, S, J. Optiz, and R. Raff. (1996). Resynthesize evolution and developmental biology. J. of Developmental Biology. Vol. 173. P. 361.

Lewin, Roger (1980). Evolutionary Theory Under Fire. Science. Vol. 210 p. 883.

Mynatt, Clifford (1977). Confirmation bias in a simulated research environment: an experimental study of scientific inference. *Quarterly Journal of Experimental Psychology*. 29: 85-95.

Mahoney, Michael. (1977). Publication prejudices: an experimental study of confirmatory bias in the peer review system. *Cognitive Therapy and Research*. 1:2 161-175.

National Science Education Standards (1996). Washington, D.C. National Academy Press.

Plous, Scott. (1993). The psychology of judgment and decision making. McGraw-Hill, Inc. New York, New York.

Samarapungavan, Ala. (1992). Children's judgment in theory choice tasks: Scientific rationality in childhood. *Cognition.* 45 1 - 32.

Scott F. Gilbert, John M. Opitz, and Rudolf A. Raff, "Resynthesizing Evolutionary and Developmental Biology," *Developmental Biology* 173 (1996): 357-372.

Smith, Mike U. (1994). Counterpoint: Belief, Understanding, and Teaching of Evolution. *Journal of Research in Science Teaching*. 31: 5 591-597. p. 591.

Thagard, Paul. (1994). Mind, society, and the growth of knowledge. *Philosophy of Science*. 61.

Tomson, Keith S. (1982)..*"*The meanings of evolution.*"* *American Scientist*. Vol. 70. 529-531.

Wiggins, Grant and Jay McTighe. (1998). *Understanding By Design.* Association for Supervision and Curriculum Development. Alexandria, Virginia. p. 159.

Resources Cataloged by the Nine Aspects

1. Anaerobic early atmosphere

Supports

National Academy of Science (1998*). Teaching About Evolution and the nature of science*. p. 4. National Academy Press.

Challenges

Towe, Kenneth M. (1996). "Environmental Oxygen conditions during the origin and early evolution of life" *Advances in space research* 18 pp. 7-15.

2. Darwin's tree of life

Supports

National Academy of Science (1998*). Teaching About Evolution and the nature of science*. pp. 32 & 39. National Academy Press.

Hickman, Cleevland P. (1986). Biology of animals 4th edition. Times Mirro/Mosby College Publishing. St. Louis, MO.

Mader, Sylvia S. (1993). *Biology* 4th edition. p. 340-343. Wm. C. Brown Publishers. Dubuque, Iowa.
Essenfeld, Bernice, Carol Gontang, and Randy Moore. (1996). *Biology* 2nd edition. p. 284-287. Addison-Wesley Publishing Company. Menlo Park, California.

Freeman, Scott and Jon Herron (2001). Evolutionary analysis. 2nd edition. p 437-464. Prentice Hall, Inc. Upper Saddle River, New Jersey.

Challenges

Herve Philippe and Patrick Forterre, (1999) "The rooting of the universal tree of life is not reliable" Journal of Molecular Evolution 49 pp. 509-523.

W. Ford Doolittle, "Uprooting the tree of life," Scientific American, February 2000, pp. 90-95.

Wells, Jonathan. (2000). *Icons of evolution*. p. 29. Regency Publishing, Inc., Washington, D.C.

2b. Cambrian Explosion

Douglas H. Erwin (1994). "Early introduction of major morphological innovations," *Acta Palaeontologica Polonica* 38 pp. 281-294.

Jeffrey S. Levinton, ("The big bang of animal evolution," *Scientific American* 267 (November 1992), pp. 84-91.

3. DNA/RNA (Molecular genetics)

Supports

Making Copies in the RNA world. *Science*. May 18, 2001 vol. 292. P. 1278

Challenges

Wells, Jonathan. (2000). *Icons of evolution*. p. 22-24. Regency Publishing, Inc., Washington, D.C.

4. Embryology

Supports

Krogh, David. (2002). *Biology, a guide to the natural world* 2nd edition. p. 328. Prentice Hall. UpperSaddle River, New Jersey.

Starr, Cecie (1994). Biology, concepts and applications 2nd edition. p. 213. Wadsworth Publishing Company. Belmont, California.

Challenges

Gould, Stephen Jay. March 2000. Abscheulich (Atrocious), Haeckel's distortions did not help Darwin. *Natural History*.

Micheal K. Richardson (1997). "There is no highly conserved stage in the vertebrates: implications for current theories of evolution and development," *Anatomy and Embryology* vol. 196: 91-106.

5. Endosymbiotic theory

None listed at this time.

6. Fossils formation through gradualism

Supports

Hickman, Cleevland P. (1986). Biology of animals 4th edition. Times Mirro/Mosby College Publishing. St. Louis, MO.

John Maynard Smith & Eörs Szathmáry. *The Major Transitions in Evolution.* Oxford University Press 1995

Challenges

Neil H. Shubin and Charles R. Marshall, (2000). "Fossils, genes, and the origin of novelty," Deep Time (Paleontological Society) pp. 324-340.

Robert Carroll (1997/98). "Limits to knowledge of the fossil record" *Zoology*. 100 pp. 221-231.

7. Miller and Urey

Supports

Mader, Sylvia S. (1993). *Biology* 4th edition. p. 355-357. Wm. C. Brown Publishers. Dubuque, Iowa.

Essenfeld, Bernice, Carol Gontang, and Randy Moore. (1996). *Biology* 2nd edition. p. 226-228. Addison-Wesley Publishing Company. Menlo Park, California.

Challenges

Monastersky, Richard. *National Geographic*, March 1998. P. 58-81.

Wells, Jonathan. (December2000/January2001). Survival of the fakest (Appeared *in The American Spectator* magazine) p. 20.

8. Natural Selection of antibiotic resistant bacteria

Supports

Freeman, Scott and Jon Herron (2001). *Evolutionary analysis*. 2nd edition. p 647-651. Prentice Hall, Inc. Upper Saddle River, New Jersey.

Challenges

Talaro, Kathleen and Arthur Talaro. (2002). Foundations in microbiology 4th edition. p. 357-358. McGraw-Hill. Boston, MA.

9. Natural Selection of Peppered moths

Supports

Essenfeld, Bernice, Carol Gontang, and Randy Moore. (1996). *Biology* 2nd edition. p. 251. Addison-Wesley Publishing Company. Menlo Park, California.

Mader, Sylvia S. (2001). *Biology* 7th edition. p. 355-357. Wm. C. Brown Publishers. Dubuque, Iowa.

Starr, Cecie (1994). *Biology, concepts and applications* 2nd edition. p. 202. Wadsworth Publishing Company. Belmont, California.

Challenges

The Wall Street Journal Online Books (August 20, 2002)

Kenney, Michael (8/20/02). Evolution takes wings in Moths. The Boston Globe www.boston.com/dailyglobe2/232/living/evolution_takes_wings_in_moths+.shtml

Wade, Nicholas (6/18/02). Staple of Evolutionary Teaching May Not Be textbook case. The New York Times. www.nytimes.com/2002/06/18/science/life/18moth.html

Macroevolution

Supports

Freeman, Scott and Jon Herron (2001). *Evolutionary analysis*. 2nd edition. p 521. Prentice Hall, Inc. Upper Saddle River, New Jersey.

Krogh, David. (2002). *Biology, a guide to the natural world* 2nd edition. p. 356. Prentice Hall. UpperSaddle River, New Jersey.

Raven, Peter, Ray F. Evert, and Susan E. Eichhorn (1986). *Biology of Plants*. P. 581. Worth Publishing Company. New York, New York.

Challenges

Robert L. Carroll, "Towards a new evolutionary synthesis," *Trends in Ecology and Evolution* 15 (2000):27-32.

Douglas Erwin, "Macroevolution is more than repeated rounds of microevolution," *Evolution & Development* 2 (2000):78-84.

Keith Stewart Thomson, "Macroevolution: The Morphological Problem," *American Zoologist* 32 (1992): 106-112.

Sample Web Sites that support macroevolution

http://www.talkorigins.org

http://www.micro.utexas.edu/courses/levin/bio304/evolution/speciation.html

http://www.stephenjaygould.org

www.pbs.org/wgbh/evolution

www.ucmp.berkeley.edu/history/evolution.html

http://www.bbc.co.uk/education/darwin

Sample Web Sites that challenge macroevolution

www.objectivityinscience.org

www.origins.org

http://www.ridgenet.net/~do_while/sage/v1i4f.htm

http://www.scienceagainstevolution.org

http://www.rae.org
(revolution against evolution)

http://www.arn.org
Access Research Network

Suggested key word(s) that may assist in your internet and/or library search for information. You may search by using either the bold face or non-bold face words.

General key words

Evolution
Biological Evolution
Macroevolution
Microevolution
Pro-evolution
Anti-evolution
Support evolution
Challenge evolution
Refute evolution

1. Anaerobic early atmosphere

2. Darwin's Tree of life

Phylogenetic tree
Cambrian explosion

3. Deoxyribonucleic Acid

DNA

4. Embryology (Ontogeny Recapitulates Phylogony)

Ontogeny
Ernst Haekel

5. Endosymbiosis

Endosymbiotic theory

L10H23

6. Fossils formation through gradualism

Fossils
Gradualism
Punctuated equilibrium

7. Miller and Urey's experiment

Early atmosphere

8. Natural selection of antibiotic bacteria

Antibiotic resistant bacteria

9. Natural selection of Peppered moths

Peppered moths
Biston betularia

ATTACHMENT #1

Name: _____

INVESTIGATIVE WORKSHEET

This activity will help you to prepare for the debate. Complete the following table by addressing the following points when you record supporting and challenging data for one aspect of evolution. Record your responses on the appropriate space on the chart.

- Write a brief summary of what you have read and discovered regarding your particular aspect that is used to support macroevolution.
- Write a brief summary of what you have read and discovered regarding your particular aspect that is used to challenge macroevolution.
- Were any scientific tools, instruments or other forms of technology used by scientists to support this aspect of macroevolution? Briefly explain your answer.
- Were any scientific tools, instruments or other forms of technology used by scientists to challenge this aspect of macroevolution? Briefly explain your answer.
- How do scientists critically analyze this aspect of macroevolution?
- Is the information you found supported by using the scientific method? Are there any limitations?
- Are there any other type(s) of research that scientists need to do, in order to critically analyze macroevolution? Briefly explain your answer.

Aspect of macroevolution	Supports	Challenges

What comparisons can be made between the supporting and challenging information you have found? Briefly explain.

A. In the space below write your opening statement for the debate.

B. In the space below, write your closing remarks.

ATTACHMENT #2

Teacher Note: Have the audience complete the following worksheet while listening to the other debates. Filling out this worksheet will help students to gain knowledge on the other aspects of macroevolution they did not focus on.

DEBATE WORKSHEET

Directions: Fill in the following worksheet with information you have learned from the debating groups.

Aspects of macroevolution	Supports	Challenges
1. Anaerobic early atmosphere	Debating group name/number	Debating group name/number
2. Darwin's Tree of life	Debating group name/number	Debating group name/number

Aspects of macroevolution	Supports	Challenges
3. DNA/RNA (Molecular genetics)	Debating group name/number	Debating group name/number
4. Embryology	Debating group name/number	Debating group name/number

Aspects of macroevolution	Supports	Challenges
5. Endosymbiotic Theory	Debating group name/number	Debating group name/number
6. Fossil formation through gradualism	Debating group name/number	Debating group name/number

Aspects of macroevolution	Supports	Challenges
7. Miller and Urey's experiment	Debating group name/number	Debating group name/number
8. Natural selection of antibiotic resistant bacteria	Debating group name/number	Debating group name/number

Aspects of macroevolution	Supports	Challenges
9. Natural selection of Peppered moths	Debating group name/number	Debating group name/number

Student Reflection:

1. Why is it important for scientists to critically analyze macroevolution?

2. Based on the information presented by the various groups, what is your opinion about macroevolution? Explain your position with evidence.