BIOLOGY: Course Learning Outcomes

Develop critical thinking skills

Sample skill set includes:

- Developing one's perspective: creating or exploring beliefs, arguments or theories
- Evaluating the credibility of sources of information
- Making interdisciplinary connections

Increase appreciation for the natural world

- Students discover the relevance of biology in their everyday lives.
- The role and influence of humans in our biosphere is examined.
- Students develop an appreciation for the beauty of the natural world.

Understand the role of science & technology in local, national, and global challenges

- Progress in science and technology can be affected by social issues and challenges.
- Individuals and societies must decide on proposals involving new research and the introduction of new technologies into society.
- Decisions involve assessment of alternatives, risks, costs and benefits and who benefits and who suffers, who pays and who gains and what the risks are and who bears them.

Build interpersonal and communication skills

- Students will learn to work in groups; every group member understands the role of, and is capable of providing, leadership.
- Students are given opportunities to learn to make decisions as a team.
- Proficiency in communication skills will be developed through regular writing assignments, as well as frequent oral and verbal presentations.

Form a base for higher level science classes

- Students learn that science is a never ending search for the truth. Truth is based on our understanding of facts. If our understanding changes or the known facts change, then our truth will also change.
- Students gain confidence that they can solve problems on their own.
- Students stop looking for the "right answer" and learn to look for the "best answer".

Gain experience in self-evaluation

- Students learn that each step in their thinking process is subject to self-assessment.
- Students question their own thinking to make sure they are staying on track

Become a life-long learner

- Knowledge is expanding at an increasing rate and we can no longer be successful in life by memorizing a set of facts to be used the rest of our lives.
- Students gain confidence in their ability to research information and evaluate resources to find the most current information.
- Students understand the power of the Internet to provide access to information on any topic.
- Students learn how to effectively evaluate the reliability of electronic and print resources.

Sources:

Strategy List: 35 Dimensions for Critical Thought. Foundation for Critical Thinking. June 10, 2002 <http://www.criticalthinking.org/k12/k12class/stratall.html>

Askew, Jim. Science Class Goals. The Science Room, Howe High School (Howe, OK) http://www.howe.k12.ok.us/%7Ejimaskew/index.htm

National Science Education Standards. National Committee on Science Education Standards and Assessment, National Research Council. July 01, 2005 < http://www.nap.edu/readingroom/books/nses/>

American Association for the Advancement of Science. *Benchmarks for Science Literacy.* 1993. New York: Oxford University Press.

Sample Essential Questions:

Posted around the classroom on colorful posters created by both students/teachers (some stay throughout the year, others change as we move into a new unit)

- "I don't plan to study dinosaurs. Why do I need to understand evolution? "
- In nature, do only the strong survive?
- Can humans overcome natural selection?
- Will humans ever go extinct?
- How can natural selection produce complex, useful structures by chance?
- Are all mutations bad?
- Are we victims of the genes that we inherit?
- Who should have access to your genetic information?
- Do you want to "design" your family?
- Who will feed the world?
- How do cells "talk"?
- How does my immune system know how to protect me from disease?
- Is cancer caused by genes or the environment?
- Why sex?
- Are males necessary?
- How do I know if I have an STD?
- How do I protect myself from getting an STD?
- Do you have to go "all the way" to contract an STD?
- What is the connection between STDs and cancer?
- Is sex more important than life itself?
- What are the costs of sex?
- What happens when science is closely related to profit?
- What are the characteristics of a great scientist?

Critical Thinking (from the center for critical thinking)

- What is the purpose?
- What is the question at issue?
- What is/are the key conclusions?
- What key information (data, observations) was used to arrive at the key conclusions?
- Clarity: Could you elaborate further? Could you give me an example?
- Accuracy: How could we check on that? How could we verify or test that?
- Precision: Could you be more specific? Could you give me more details?
- Relevance: How does that relate to the problem? How does that help us with the issue?
- Logic: Does all this make sense together? Does what you say follow from the evidence?

Outcomes for Experimental Design/Scientific Inquiry Mini-Unit

Many of the following outcomes are introduced in the Experimental design mini-unit, and are further developed in other units throughout the year.

(FC)= Fundamental concepts (Ω)=Student skills set from Benchmarks, Project 2061

Evidence and reasoning in inquiry

(K-2)

- Ask "How do you know?" in appropriate situations and attempt reasonable answers when others ask them the same question.(Ω)
- Raise questions about the world around them and be willing to seek answers by making careful observations and trying things out.(Ω)

(3-5)

- Seek better reasons for believing than "everybody knows that…" or "I just know" and discount such reasons when given by others.(Ω)
- Support statements with facts found in books, articles, and databases, and identify the sources used. Expect others to do the same.(Ω)
- Scientists do not pay much attention to claims about how something they know about works unless they are backed up with evidence that can be confirmed and with a logical argument. (FC)
- Sometimes scientists have different explanations for the same set of observations, which usually leads to their making more observations to resolve the differences. (FC)

(6-8)

- Notice and criticize the reasoning in arguments in which fact and opinion are intermingled or the conclusions do not follow logically from the evidence given.(Ω)
- Scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence. (FC)
- Hypotheses are valuable, even if they turn out not to be true, or if they lead to fruitful investigations. (FC)

(9-12)

- There are different traditions in science about what is investigated and how, but they all have in common certain basic beliefs about the value of evidence, logic and good arguments.(FC)
- Sometimes, scientists can control conditions in order to focus on the effect of a single variable. When that is not possible for practical or ethical reasons, they try to observe as wide a range of natural occurrences as possible to be able to discern patterns. (FC)
- Hypotheses are widely used in science for choosing what data to pay attention to and what additional data to seek, and for guiding the interpretation of the data (both new and previously available). (FC)

Scientific Investigations

(3-5)

- Clear communication is an essential part of doing science. It enables scientists to inform others about their work, expose their ideas to criticism by other scientists, and stay informed about scientific discoveries around the world. (FC)

(6-8)

- If more than one variable changes at the same time in an experiment the outcome of the experiment may not be clearly attributable to any one of the variables. It may not always be possible to prevent outside variables from influencing the outcome of an investigation (or even to identify all of the variables). (FC)
- Even with similar results, scientists may wait until an investigation has been repeated many times before accepting the results as correct. (FC)

(9-12)

- Investigations are conducted for different reasons, including to explore new phenomena, to check on previous results, to test how well a theory predicts, and to compare theories. (FC)

Scientific theories (FC)

(6-8)

- Scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way.
- Some scientific knowledge is very old and yet is still applicable.

(9-12)

- In the long run, theories are judged by how they fit with other theories, the range of observations they explain, how well they explain observations, and how effective they are in predicting new findings.
- No matter how well one theory fits observations, a new theory might fit them better, or might fit a wider range of observations.
- In science, the testing, revising, and occasional discarding of theories, new and old, never ends. This ongoing process leads to an increasingly better understanding of how things work in the world but not to absolute truth.
- New ideas in science are limited by the context in which they are conceived, and are often rejected by the scientific establishment.
- In the short run, new ideas that do not mesh well with mainstream ideas in science often encounter vigorous criticism.
- From time to time, major shifts occur in the scientific view of how the world works. More often, however, the changes that take place in the body of scientific knowledge are small modifications of prior knowledge. Change and continuity are persistent features of science.

Habits of Mind: Critical Response (Ω)

(9-12)

- Insist the critical assumptions behind any line or reasoning be made explicit so that the validity of the position being taken whether one's own or that of others- can be judged.
- Suggest alternative was of explaining data and criticize arguments in which data, explanations or conclusions are represented as the only ones worth consideration, with no mention of other possibilities. Similarly, suggest alternative trade-offs in decisions and designs and criticize those in which major trade-offs are not acknowledged.

Avoiding Bias in Science (FC)

(9-12)

- The direction of scientific research is affected by informal influences within the culture of science itself, such as prevailing opinion on what questions are most interesting or what methods of investigation are most likely to be fruitful.
- Where their own personal, institutional, or community interests are at stake, scientists as a group can be expected to be no less biased than other groups are about their perceived interests.
- Bias attributable to the investigator, the sample, the method or the instrument may not be completely avoidable in every instance, but scientists want to know the possible sources of bias and how bias is likely to influence evidence.
- Scientists in any one research group tend to see things alike, so even groups of scientists may have trouble being entirely objective about their methods and findings. For that reason, scientific teams are expected to seek out the possible sources of bias in the design of their investigations and in their data analysis. Checking each other's results and explanations helps, but there is no guarantee against bias.
- The expectations, moods, and prior experiences of human beings can affect how they interpret new perceptions or ideas. People tend to ignore evidence that challenges their beliefs and to accept evidence that supports them.

(6-8)

- Scientists know about the danger of prior expectations to objectivity and take steps to try to avoid it when designing investigations and examining data. One safeguard is to have different investigators conduct independent studies of the same questions.

Critical thought (from Center for critical thinking www.criticalthinking.org) (Ω)

- Develop intellectual independence
- Develop intellectual good faith or integrity
- Develop intellectual perseverance
- Comparing analogous situations: transferring insights to new contexts
- Clarifying issues, conclusions, or beliefs
- Evaluating the credibility of sources of information
- Reading critically: clarifying and critiquing texts
- Listening critically: the art of silent dialogue
- Noting significant similarities and differences
- Distinguishing relevant from irrelevant facts
- Making plausible inferences, predictions or interpretations
- Giving reasons and evaluating evidence and alleged facts
- Exploring implications and consequences
- Recognizing contradictions

Outcomes for Evolution Unit

Evolution Subunits:

A. **Biological Evolution**
B. **Natural Selection**

(FC): Fundamental concepts (from Benchmarks, Project 2061) **(MC): Making connections**
(Ω): Student skills set **(**) Science and Society**

Evolution of Life: Biological Evolution and Natural Selection (FC)

(K-2)

- Different plants and animals have external features that help them thrive in different kinds of places.
- There is variation among individuals within a population

(3-5)

- Individuals of the same kind differ in their characteristics, and sometimes the differences give individuals an advantage in surviving and reproducing.

(6-8)

- Changes in environmental conditions can affect the survival of individual organisms and entire species.
- Individuals organisms with certain traits are more likely than others to survive and have offspring
- Small differences between parents and offspring can accumulate (through selective breeding) in successive generations so that descendants are very different from their ancestors.
- In all environments…organisms with similar needs may compete with one another for resources, including food, space, water, air, and shelter. In any particular environment, the growth and survival of organisms depend on physical conditions.

(9-12)

- Heritable characteristics can be observed at molecular and whole-organism levels—in structure, chemistry, or behavior. These characteristics strongly influence what capabilities an organism will have and how it will react, and therefore influence how likely it is to survive and reproduce.

- Natural selection provides the following mechanism for evolution: Some variation, in heritable characteristics, gives individuals an advantage over others in surviving and reproducing, and the advantaged offspring, in turn, are more likely than others to survive and reproduce. The proportion of individuals that have advantageous characteristics will increase.
- Natural selection leads to organisms well suited for survival in particular environments.
- When an environment changes the survival value of some inherited characteristics may change.
- Chance alone can result in the persistence of some heritable characteristics having no survival or reproductive advantage or disadvantage for the organism.
- The continuing operation of natural selection on new characteristics and in changing environments, over and over again for millions of years, has produced a succession of diverse new species.
- The basic idea of biological evolution is that the earth's present-day species developed from earlier, distinctly different species.
- Evolution builds on what already exists, so the more variety there is, the more there can be in the future. But evolution does not necessitate long-term progress in some set direction. Evolutionary changes appear to be like the growth of a bush: Some branches survive from the beginning with little or no change, many die out all together, and other branch repeatedly, sometimes giving rise to more complex organisms.
- The theory of NS provides a scientific explanation for the history of life on earth as depicted in the fossil record and in the similarities evident within the diversity of existing organisms.

Historical Perspectives: Explaining the diversity of life (FC)
(9-12)

- The scientific problem that led to the theory of natural selection was how to explain the similarities and differences within the great diversity of existing fossil organisms.
- Prior to Darwin, the most widespread belief was that all known species were created at the same time and remained unchanged throughout history.
- Some scientists at the time believed that features an individual acquired during its lifetime could be passed on to its offspring, and the species could thereby gradually change to fit its environment better.
- Darwin argued that only biologically inherited characteristics could be passed on to offspring. Some of these characteristics were advantageous in surviving and reproducing. The offspring would also inherit and pass on those advantages, and over generations the aggregation of these inherited advantages would lead to a new species.
- The success of Darwin's book the *Origin of Species* came from the clear and understandable argument it made, including the comparison of natural selection to the selective breeding of animals in wide use at the time, and from the massive array of biological and fossil evidence it assembled to support the argument.
- By the end of the 20th century, most scientists had accepted Darwin's basic idea. People usually do not reject evolution for scientific reasons but because they dislike its implications, such as the relation of human beings to other animals, or because they prefer a biblical account of creation.

Nature of Science: Scientific Inquiry (FC)
(9-12)

- New ideas that do not mesh well with mainstream ides in science often encounter vigorous criticism. In the long run, theories are judged by how they fit with other theories, the range of observations they explain, how well they explain observations, and how effective they are in predicting new findings.
- New ideas in science are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many investigators.

Habits of Mind: Communication skills (Ω)
(9-12)

- Participation in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration and expressing alternative positions.
- Use and correctly interpret relational terms such as *if… then*, *and, or, sufficient, necessary, some, every, not, correlates with,* and *causes.*

Habits of Mind: Values and attitudes (**)
(9-12)

- View science and technology thoughtfully, being neither categorically antagonistic nor uncritically positive.

Habits of Mind: Critical Response (Ω)
(9-12)

- Insist the critical assumptions behind any line or reasoning be made explicit so that the validity of the position being taken whether one's own or that of others- can be judged.
- Suggest alternative was of explaining data and criticize arguments in which data, explanations or conclusions are represented as the only ones worth consideration, with no mention of other possibilities. Similarly, suggest alternative trade-offs in decisions and designs and criticize those in which major trade-offs are not acknowledged.

Human Society: Social Change (**)
(9-12)

- To various degrees, governments try to bring about social change or to impede it through policies, laws, incentives, or direct coercion. Sometimes such efforts achieve their intended results and sometimes they do not.

Human Society: Social Trade-offs (**)
(6-8)

- One common aspect of all social trade-offs pits personal benefit and the rights of the individual, on one side, against the social good and the rights of the society, on the other.
- Trade-offs are not always desirable possibilities. Sometimes social and personal trade-offs require accepting an unwanted outcome to avoid some other unwanted one.
- There are trade-offs that each person must consider in making choices-about personal popularity, health, family relations, and education, for example- that often have life-long consequences.

(9-12)

- In deciding among alternatives, a major question is who will receive the benefits and who will bear the costs.

Critical thought (from Center for critical thinking www.criticalthinking.org) (Ω)

- Develop intellectual independence
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- Recognizing contradictions

Outcomes for Genetics Unit

(FC): Fundamental concepts (from Benchmarks, Project 2061) **(MC): Making connections**
(Ω): Student skills set **(**) Science and Society**

The Living Environment: Heredity (FC)
(6-8)

- In some kinds of organisms, all the genes come from a single parent.
- In organisms that have 2 sexes, typically half of the genes come from each parent.
- In sexual reproduction, a single specialized cell from a female merges with a specialized cell from a male.
- The fertilized egg cell, carrying genetic information from each parent, multiplies to form the complete organism.
- Cells repeatedly divide to make more cells for growth and repair.
- Following fertilization, cell division produces a small cluster of cells that then differentiate by appearance and function to form the basic tissues of the embryo.
- The same genetic information is copied in each cell of the new organism.

(9-12)

- The information passed from parents to offspring is coded in DNA molecules.
- The DNA code is virtually the same for all life forms.
- DNA molecules are long chains linking just 4 kinds of smaller molecules, whose precise sequence encodes genetic information.
- As successive generations of an embryo's cells form by division, small differences in their immediate environments cause them to develop slightly differently, by activating or inactivating different parts of the DNA information.
- Heritable characteristics can include details of biochemistry…and anatomical features that are ultimately produced in the development of the organism…by biochemical or anatomical means, heritable characteristics may also influence behavior.
- Heritable characteristics can be observed at molecular and whole-organism levels—in structure, chemistry, and behavior.
- Genes are segments of DNA molecules. Inserting, deleting, or substituting segments of DNA molecules can alter genes. An altered gene may be passed on to every cell that develops from it. The resulting features may help, harm, or have little or no effect on the offspring's success in its environment.
- The sorting and recombination of genes in sexual reproduction results in a great variety of possible gene combinations in the offspring of any 2 parents.
- Gene mutations can be caused by such things as radiation and chemicals. When they occur in sex cell, they can be passed on to offspring; if they occur in other cells they can be passed on to descendent cells only. The experiences an organism has during its lifetime can affect its offspring only if its own sex cells are changed by the experience.
- New heritable characteristics can result from new combinations of existing genes or from mutations of genes in reproductive cells.
- The degree of kinship between organisms or species can be estimated from the similarity of their DNA sequences, which often closely matches their classification based on anatomical similarities.

Human Organism: Physical health (FC)
(9-12)

- Faulty genes can cause body parts or systems to work poorly. Some genetic diseases appear only when an individual has inherited a certain faulty gene from both parents.

Human Organism: Basic functions (**)
(9-12)

- The development and use of technologies to maintain, prolong, sustain, or terminate life raises social, moral, ethical and legal issues.

Human Society: Social Change (**)
(9-12)

- To various degrees, governments try to bring about social change or to impede it through policies, laws, incentives, or direct coercion. Sometimes such efforts achieve their intended results and sometimes they do not.

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(9-12)

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The Designed World: Agriculture (**)
(6-8)

- People control the characteristics of plants and animals they raise by selective breeding and by preserving varieties of seeds (old and new) to use if growing conditions change.

(9-12)

- New varieties of farm plants and animals have been engineered by manipulating their genetic instructions to produce new characteristics.
- Agricultural technology requires trade-offs between increased production and environmental harm and between efficient production and social values. In the past century, agricultural technology led to huge shift of population from farms to cities and a great change in how people live and work.

The Designed World: Health and Technology (**)
(9-12)

- Biotechnology has contributed to health improvement in many ways, but its cost and application have led to a variety of controversial social and ethical issues.
- Knowledge of genetics is opening whole new fields of health care. In diagnosis, mapping of genetic instructions in cells makes it possible to detect defective genes that may lead to poor health. In treatment, substances from genetically engineered organisms may reduce the cost and side effects of replacing missing body chemicals.

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(9-12)

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(9-12)

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- Recognizing contradictions

Outcomes: Cells and the Origin of Life on Earth AND Cancer

Subunits:

A. Setting up the evolutionary context:
  a. Characteristics of living things
  b. Evolution of multicellularity
B. Cell Structure and Function
C. Cell Specialization: Stem Cells
D. Cell Specialization: the Immune Response as a model system
E. Embryonic Development
F. Cancer

(FC): Fundamental concepts (from Benchmarks, Project 2061) (MC): Making connections
(Ω): Student skills set (**) Science and Society

Setting up the evolutionary context:

I. Characteristics of living things
II. Evolution of multicellularity

Cells: Cell Functions (FC)
(6-8)

- All living things are composed of cells, from just one to many millions, whose details usually are visible only through a microscope. Different body tissues and organs are made up of different kinds of cells. The cells in similar tissues and organs in other animals are similar to those in human beings but differ somewhat from cells found in plants.
- Cells repeatedly divide to make more cells for growth and repair. Various organs and tissues function to serve the needs of cells for food, air, and waste removal.

- Within cells, many of the basic functions of organisms—such as extracting energy from food and getting rid of waste—are carried out. The way in which cells function is similar in all living organisms.

Evolution of Life: Biological evolution (FC)
(9-12)

- Life on earth is thought to have begun as simple, one-celled organisms, about 4 billion years ago… Once cells with nuclei developed about a billion years ago, increasingly complex multicellular organisms evolved.
- The basic idea of biological evolution is that the earth's present-day species developed for earlier, distinctively different species.

Cell Structure and Function

Cells: Cell Functions (FC)
(9-12)

- The work of the cell is carried out by the many different types of molecules it assembles, mostly proteins. Protein molecules are long, usually folded chains made from 20 different kinds of amino-acid molecules. The function of each protein molecule depends on its specific sequence of amino acids and the shape the chain takes is a consequence of attractions between the chain's parts.
- The genetic information encoded in DNA molecules provides instructions for assembling protein molecules. The code used is virtually the same for all life forms. Before a cell divides, the instructions are duplicated so that each of the two new cells gets all the necessary information for carrying on.
- Complex interactions among the different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Cell behavior can also be affected by molecules from other parts of the organism or even other organisms.
- Most cells function best within a narrow range of temperature and acidity. At very low temperatures, reaction rates are too slow. High temperatures and/or extremes of acidity can irreversibly change the structure of most protein molecules.
- The configuration of atoms in a molecule determines the molecule's properties. Shapes are particularly important in how large molecules interact with others.
- Some protein molecules assist in replicating genetic information, repairing cell structures, helping other molecules get in or out of the cell, and generally catalyzing and regulating molecular interactions.
- Every cell is covered by a membrane that controls what can enter and leave the cell. In all but quite primitive cells, a complex network of proteins provides organization and shape and, for animal cells, movement.
- Within every cell are specialized parts for the transport of materials, energy transfer, protein building, waste disposal, information feedback, and even movement. In addition, most cells in multi-cellular organisms perform some special functions that others do not.

Cell Specialization: Stem Cells

Cells: Cells and Organs (FC)
(6-8)

- Different body tissues and organs are made up of different kinds of cells.

(9-12)

- In addition to the basic cellular functions common to all cells, most cells in multicellular organisms perform some special functions that others do not.
- Different parts of the instructions are used in different types of cells, influenced by the cell's environment and past history.

    - Additional benchmarks associated with science and society and critical thinking components are included in the cancer subunit

Specialization of Function using the Immune Response as model system:

Human Organism: Basic Functions (FC)
(9-12)

- The immune system is designed to protect against microscopic organisms and foreign substances that enter from outside the body and against some cancer cells that arise within.

Human Organism: Physical Health (FC)
(6-8)

- Viruses, bacteria, fungi, and parasites may infect the human body and interfere with normal body functions. A person can catch a cold many times because there are many varieties of cold viruses that cause similar symptoms.
- White blood cells engulf invaders or produce antibodies that attack them or mark them for killing by other white cells. The antibodies produced will remain and can fight off subsequent invaders of the same kind.

(9-12)

- Some allergic reactions are caused by the body's immune responses to usually harmless environmental substances. Sometimes the immune system may attack some of the body's own cells.
- Some viral diseases, such as AIDS, destroy critical cells of the immune system, leaving the body unable to deal with multiple infection agents and cancerous cells.

Historical Perspectives: Discovering germs (FC)
(6-8)

- Vaccines induce the body to build immunity to a disease without actually causing the disease itself

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Embryonic Development

Cells: Cells and Organs (FC)
(9-12)

- Communication between cells is required to coordinate their diverse activities. Some cells secrete substances that spread only to nearby cells.
- Complex interactions among different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Cell behavior can also be affected by molecules from other parts of the organism or even other organisms.

Human Organism (FC)
(6-8)

- Following fertilization, cell division produces a small cluster of cells that then differentiate by appearance and function to form the basic tissues of an embryo. Patterns of human development are similar to those of other vertebrates.

(9-12)

- As successive generations of an embryo's cells form by division, small differences in their immediate environments cause them to develop slightly differently, by activating or inactivating different parts of the DNA information.

Heredity: Variation in inherited characteristics (FC)
(6-8)

- In sexual reproduction, a single specialized cell from a female merges with a specialized cell from a male. As the fertilized egg, carrying genetic information from each parent, multiplies to form the complete organism with about a trillion cells, the same genetic information is copied in each cell.

Cancer and the *Cancer Warrior*

Cells: Cells and Organs (FC)

(9-12)

- Communication between cells is required to coordinate their diverse activities. Some cells secrete substances that spread only to nearby cells.
- Complex interactions among different kinds of molecules in the cell cause distinct cycles of activities, such as growth and division. Cell behavior can also be affected by molecules from other parts of the organism or even other organisms.

Heredity: Variation in inherited characteristics (FC)

(9-12)

- Gene mutation in a cell can result in uncontrolled cell division, called cancer. Exposure of cells to certain chemicals and radiation increases mutations and thus increases the chance of cancer.

Human Organism: Physical Health-Maintaining good health (FC)

(6-8)

- Toxic substances, some dietary habits, and some personal behavior may be bad for one's health. Some effects show up right away, others years later. Avoiding toxic substances, such as tobacco, and changing dietary habits increases the chance of living longer.
- The length and quality of human life are influenced by many factors, including sanitation, diet, medical care, sex, genes, environmental conditions, and personal health behaviors.

Historical Perspectives: Discovering Germs (FC)

(6-8)

- In medicine, as in other fields of science, discoveries are sometimes made unexpectedly, even by accident. But knowledge and creative insight are usually required to recognize the meaning of the unexpected.

Nature of Science: Scientific Inquiry (FC)

(9-12)

- New ideas that do not mesh well with mainstream ides in science often encounter vigorous criticism. In the long run, theories are judged by how they fit with other theories, the range of observations they explain, how well they explain observations, and how effective they are in predicting new findings.
- New ideas in science are limited by the context in which they are conceived; are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many investigators.

Human Society: Social Change (**)

(9-12)

- To various degrees, governments try to bring about social change or to impede it through policies, laws, incentives, or direct coercion. Sometimes such efforts achieve their intended results and sometimes they do not.

Human Society: Social Trade-offs (**)

(6-8)

- One common aspect of all social trade-offs pits personal benefit and the rights of the individual, on one side, against the social good and the rights of the society, on the other.
- Trade-offs are not always desirable possibilities. Sometimes social and personal trade-offs require accepting an unwanted outcome to avoid some other unwanted one.
- There are trade-offs that each person must consider in making choices-about personal popularity, health, family relations, and education, for example- that often have life-long consequences.

(9-12)

- In deciding among alternatives, a major question is who will receive the benefits and who will bear the costs.

Habits of Mind: Communication skills (Ω)
(9-12)

- Participation in group discussions on scientific topics by restating or summarizing accurately what others have said, asking for clarification or elaboration and expressing alternative positions.
- Use and correctly interpret relational terms such as *if… then*, *and, or, sufficient, necessary, some, every, not, correlates with,* and *causes.*

Habits of Mind: Values and attitudes (**)
(9-12)

- View science and technology thoughtfully, being neither categorically antagonistic nor uncritically positive.

Habits of Mind: Critical Response (Ω)
(9-12)

- Insist the critical assumptions behind any line or reasoning be made explicit so that the validity of the position being taken whether one's own or that of others- can be judged.
- Suggest alternative ways of explaining data and criticize arguments in which data, explanations or conclusions are represented as the only ones worth consideration, with no mention of other possibilities. Similarly, suggest alternative trade-offs in decisions and designs and criticize those in which major trade-offs are not acknowledged.

Critical thought (from Center for critical thinking www.criticalthinking.org) (Ω)

- Develop intellectual independence
- Develop intellectual good faith or integrity
- Develop intellectual perseverance
- Comparing analogous situations: transferring insights to new contexts
- Clarifying issues, conclusions, or beliefs
- Evaluating the credibility of sources of information
- Reading critically: clarifying and critiquing texts
- Listening critically: the art of silent dialogue
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- Giving reasons and evaluating evidence and alleged facts
- Exploring implications and consequences
- Recognizing contradictions

Outcomes for Ecology Unit

(FC)= Fundamental concepts (Ω)=Student skills set from Benchmarks, Project 2061

Interdependence of Life (FC)
(6-8)

- Two types of organisms may interact with one another in several ways. They may be in a producer/consumer, predator/prey, or parasite/host relationship. Or, one organism may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other.
- All organisms, including the human species, are part of and depend on two major interconnected food webs. One includes microscopic ocean plants, the animals that feed on them and finally the animals that feed on those animals. The other web includes land plants, the animals that feed on them and so forth.
- Changes in environmental conditions can affect he survival of individual organisms and entire species.

- Human activities such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming have changed the earth's land, oceans and atmosphere. Some of these changes have decreased the capacity of the environment to support some life forms.
- In all environments (freshwater, marine forest, desert, grassland, mountain, and others) organisms with similar needs may compete with one another for resources, including food, space, water, air and shelter. In any particular environment, the growth and survival of organisms depend on the physical conditions.

(9-12)

- The elaborate interdependencies among species serve to stabilize food webs. Minor disruptions in a particular location tend to lead to changes that eventually restore the system. But large disturbances of living populations or their environments may result in irreversible changes in the food webs.
- Understanding any one part of an ecosystem well requires knowledge of how the parts interact.
- Ecosystems can be reasonably stable over hundreds or thousands of years. As any population of organism grows, it is held in check by one or more environmental factors: depletion of food or nesting sites, increased loss to increased numbers of predators, or parasites. If a disaster such as flood or fire occurs, the damaged ecosystem is likely to recover in stages that eventually result in a system similar to the original one.
- Plants alter the earth's atmosphere by removing carbon dioxide from it, using the carbon to make sugars and releasing oxygen. This process is responsible for the oxygen content of the air.
- The amount of life any environment can support is limited by the available energy, water, oxygen, and minerals and by the ability of ecosystems to recycle the residue of dead organic materials.
- In the long run, however, ecosystems always change when climate changes or when one or more new species appear as a result of migration or local evolution. Like may complex systems, ecosystems tend to have cyclic fluctuations around a state of rough equilibrium.
- A system in equilibrium may return to the same state of equilibrium if the disturbances are small, but large disturbances may cause it to escapes that equilibrium and eventually settle into some other state of equilibrium.
- Human beings are part of earth's ecosystems. Human activities can deliberately or inadvertently alter the equilibrium in ecosystems.

Flow of Matter in Ecosystems (FC)

(6-8)

- Over a long time, matter is transferred from one organism to another repeatedly and between organisms and their physical environment. As in all material systems, the total amount of matter remains constant, even though its form and location change.
- Organisms that eat plants break down the plant structures to produce the materials and energy they need to survive; then, other organisms consume them.
- Plants can use the food they make immediately or store it for later use.
- One of the most general distinctions among organisms is between plants, which use sunlight to make their own food, and animals, which consume energy-rich foods.
- Plants use the energy from light to make sugars from carbon dioxide and water.
- Carbon and hydrogen are common elements of living matter.
- No matter how substances within a closed system interact the total mass of the system remains the same.
- The idea of atoms explains the conservation of matter. If the number of atoms stays the same no matter how the same atoms are rearranged, then their total mass stays the same.
- Atoms may stick together in well-defined molecules, or may be packed together in large arrays. Different arrangements of atoms into groups compose all substances.

(9-12)

- The chemical elements that make up the molecules of living things pass through food webs and are combined and recombined in different ways. At each link in a food web, some energy is stored in newly made structures but much is dissipated into the environment as heat. Continual input of energy from sunlight keeps the process going.

- At times, environmental conditions are such that plants and marine organisms grow faster than decomposers can recycle them back to the environment. Layers of energy rich organic materials have been gradually turned into great coal beds and oil pools.

Flow of Energy in Ecosystems (FC)
(6-8)
- Most of what goes on in the universe involves some form of energy being transformed into another. Energy in the form of heat is almost always one of the products of energy transformations.
- An important kind of reaction between substances involves the combination of oxygen with something else-as in burning or rusting.
- Organisms get energy from oxidizing their food and release some of its energy as heat.
- Almost all food energy comes originally from sunlight.

(9-12)
- Different energy levels are associated with different configurations of atoms in molecules. Some changes of configuration require a net input of energy, others cause a net release.

Systems
(6-8)
- Thinking about things as systems means looking for how every part relates to others.

(9-12)
- Even in some very simple systems, it may not always be possible to predict accurately the result of changing some part or connection.

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(9-12)
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