HIV, AIDS, AND TRNA

NEW YORK STATE

THE LIVING ENVIRONMENT CORE CURRICULUM

Standard 1:

Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions.

Key Idea 1:

The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing and creative process.

Performance Indicator 1.3

Work toward reconciling completing explanations; clarify points of agreement and disagreement.

Major Understandings

1.3a Scientific explanations are accepted when they are consistent with experimental and observational evidence and when they lead to accurate predictions.

Scientific papers are accepted by the scientific community through a review process. This review process involves other scientists who read the paper, analyze the data that is shown in the paper and concur with the authors' conclusions. The experiments performed in this paper were done multiple times with similar results.

1.3b All scientific explanations are tentative and subject to change or improvement. Each new bit of evidence can create more questions than it answers. This leads to increasingly better understanding of how things work in the living world.

The results illustrated in this interactive paper suggest that the tRNA-Lys that has a U instead of an A as its 58th nucleotide can block the ability of HIV to convert its single stranded RNA into double stranded DNA. However, the results of this experiment do not address whether this harms the cells in any way, and thus this question now needs to be answered in order to know whether or not it is an effective therapy.

Key Idea 2:
Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

Performance Indicator 2.1
Devise ways of making observations to test proposed explanations.

The scientists who did the work described in this interactive paper designed their experiments with the appropriate variables and controls in order to test their hypothesis

Performance Indicator 2.2
Refine research ideas through library investigations, including electronic information retrieval and reviews of the literature, and through peer feedback obtained from review and discussion.

Major Understandings

2.2a Development of a research plan involves researching background information and understanding the major concepts in the area being investigated. Recommendations for methodologies, use of technologies, proper equipment, and safety precautions should also be included.

The experiments described in this interactive paper were done using existing methodologies (Flow cytometry) and techniques (HIV-Thy1). Without these methodologies, the experiments may not have been possible

Performance Indicator 2.3
Develop and present proposals including formal hypotheses to test explanations; i.e., predict what should be observed under specific conditions if the explanation is true.

Major Understandings

2.3a Hypotheses are predictions based upon both research and observation.
2.3b Hypotheses are widely used in science for determining what data to collect and as a guide for interpreting the data.
2.3c Development of a research plan for testing a hypothesis requires planning to avoid bias (e.g., repeated trials, large sample size, and objective data-collection techniques).

The study described in this interactive paper is an illustration of all these steps of scientific inquiry

Key Idea 3:
The observations made while testing proposed explanations, when analyzed using conventional and invented methods, provide new insights into natural phenomena.

Performance Indicator 3.1
Use various methods of representing and organizing observations (e.g., diagrams, tables, charts, graphs, equations, matrices) and insightfully interpret the organized data.

Major Understandings

3.1a Interpretation of data leads to development of additional hypotheses, the formulation of generalizations, or explanations of natural phenomena.

The results illustrated in this interactive paper suggest that the tRNA-Lys that has a U instead of an A as its 58th nucleotide can block the ability of HIV to convert its single stranded RNA into double stranded DNA. However, the results of this experiment do not address whether this harms the cells in any way, and thus this question now needs to be answered in order to know whether or not it is an effective therapy.

Performance Indicator 3.2
Apply statistical analysis techniques when appropriate to test if chance alone explains the results.

Performance Indicator 3.3
Assess correspondence between the predicted result contained in the hypothesis and actual results, and reach a conclusion as to whether the explanation on which the prediction was based is supported.

Performance Indicator 3.5
Develop a written report for public scrutiny that describes the proposed explanation, including a literature review, the research carried out, its result, and suggestions for further research.

Major Understandings

3.5a One assumption of science is that other individuals could arrive at the same explanation if they had access to similar evidence. Scientists make the results of their investigations public; they should describe the investigations in ways that enable others to repeat the investigations.

3.5b Scientists use peer review to evaluate the results of scientific investigations and the explanations proposed by other scientists. They analyze the experimental procedures, examine the evidence, identify faulty reasoning, point out statements that go beyond the evidence, and suggest alternative explanations for the same observations.

This interactive paper describes work that has undergone peer review

Standard 4:

Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science.

Key Idea 1:
Living things are both similar to and different from each other and from nonliving things.

Performance Indicator 1.2
Describe and explain the structures and functions of the human body at different organizational levels (e.g., systems, tissues, cells, organelles).

Major Understandings

1.2b Humans are complex organisms. They require multiple systems for digestions, respiration, reproduction, circulation, excretion, movement, coordination, and immunity. The systems interact to perform the life functions.

This paper touches on the function of cells of the immune system (T-Cells, macrophages, and B-Cells)

1.2d If there is a disruption in any human system, there may be a corresponding imbalance in homeostasis.

The destruction of a single type of cell (T-Cells) can severely affect the ability of a human organism to fight infections

1.2j Receptor molecules play an important role in the interactions between cells. Two primary agents of cellular communication are hormones and chemicals produced by nerve cells. If nerve or hormone signals are blocked, cellular communication is disrupted and the organism's stability is affected.

In the background research section (How does HIV cause disease?) there is an illustration of how T-Cells "see"other cells through a membrane receptor.

Key Idea 2
Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

Performance Indicator 2.1
Explain how the structure and replication of genetic material result in offspring that resemble their parents.

Major Understandings

2.1b Every organism requires a set of coded instructions for specifying its traits. For offspring to resemble their parents, there must be a reliable way to transfer information from one generation to the next. Heredity is the passage of these instructions from one generation to another.

HIV is an organism that needs to pass its genetic material on to its progeny. It does this by utilizing a host cell's resources.

2.1d In asexually reproducing organisms, all the genes come from a single parent. Asexually produced offspring are normally genetically identical to the parent.

HIV is an asexually reproducing organism. All of its offspring are genetically identical (barring random mutations)

2.1f In all organisms, the coded instructions for specifying the characteristics of the organism are carried in DNA, a large molecule formed from subunits arranged in a sequence with bases of four kinds (represented by A, G, C, and T). the chemical and structural properties of DNA are the basis for how the genetic information that underlies heredity is both encoded in genes (as a string of molecular "bases") and replicated by means of a template.

The interactive paper illustrates the replication of DNA at a level that allows students to see that complementary bases pair with each other, and one strand is used as a template.

2.1g Cells store and use coded information. The genetic information stored in DNA is used to direct the synthesis of the thousands of proteins that each cell requires.

The proteins that are required to make the HIV virus are coded in the HIV genetic material

Performance Indicator 2.2
Explain how the technology of genetic engineering allows humans to alter genetic makeup of organisms.
Major Understandings

2.2d Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every cell that develops from it.

HIV-Thy1 is an example of a genetically engineered virus. It contains a gene that normal HIV does not have. Every time HIV-Thy1 replicates, its progeny contain that gene.

2.2e Knowledge of genetics is making possible new fields of health care; for example, finding genes which may have mutations that can cause disease will aid in the development of preventive measures to fight disease. Substances, such as hormones and enzymes, from genetically engineered organisms may reduce the cost and side effects of replacing missing body chemicals.

Gene therapy can not only replace missing body chemicals, but may supply molecules that can fight disease, as the research in this paper describes. Supplying cells with tRNA-58U may render those cells "resistant" to HIV infection.

Key Idea 3:
Individual organisms and species change over time.

3.1d Mutations occur as random change events. Gene mutations can also be caused by such agents as radiation and chemicals. When they occur in sex cells, the mutations can be passed on to offspring; if they occur in other cells, they can be passed on to other body cells only.

3.1f Species evolve over time. Evolution is the consequence of the interactions of (1) the potential for a species to increase its numbers, (2) the genetic variability of offspring due to mutation and recombination of genes, (3) a finite supply of the resources required for life, and (4) the ensuing selection by the environment of those offspring better able to survive and leave offspring.

3.1g Some characteristics give 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.

3.1h The variation of organisms within a species increases the likelihood that at least some members of the species will survive under changed environmental conditions.

Viruses in general are exemplars of organisms that mutate in order to evade human measures to eliminate them. One of the difficulties in developing treatments and vaccines for HIV or any virus is that the virus's genetic material can mutate to accommodate or avoid the therapy. It is thought that the requirement for tRNA-Lys was fairly stable – it would be less likely that HIV could mutate to not use tRNA-Lys (and use another tRNA instead) or mutate to avoid utilizing tRNA-58U

Key Idea 5:
Organisms maintain a dynamic equilibrium that sustains life.

Performance Indicator 5.1
Explain the basic biochemical processes in living organisms and their importance in maintaining dynamic equilibrium.
Major Understandings

5.1g Enzymes and other molecules, such as hormones, receptor molecules, and antibodies, have specific shapes that influence both how they function and how they interact with other molecules.

The interactive paper illustrates how the cells of the immune system interact with each other. This involves cell-surface receptors that "see" other cells, and thus trigger cells to perform certain functions.

Performance Indicator 5.2
Explain disease as failure of homeostasis.
Major Understandings

5.2b Viruses, bacteria, fungi, and other parasites may infect plants and animals and interfere with normal life functions.

HIV is an example of a virus that infects human immune cells.

5.2c The immune system protects against antigens associated with pathogenic organisms or foreign substances and some cancer cells.

The interactive paper illustrates how immune cells protect against a bacterial infection

5.2d Some white blood cells engulf invaders. Others produce antibodies that attach them or mark them for killing. Some specialized white blood cells will remain, able to fight off subsequent invaders of the same kind.

The interactive paper illustrates how macrophages engulf cells, how plasma cells produce antibodies, and how B-Cells and T-Cells interact to mount an immune response.

5.2e Vaccinations use weakened microbes (or parts of them) to stimulate the immune system to react. This reaction prepares the body to fight subsequent invasions by the same microbes.

If the bacteria in the interactive paper (in "Background Research: How HIV causes disease) was replaced with a weakened microbe or a piece of a microbe, students may be able to visualize how those could be used to stimulate the immune system.

5.2f Some viral diseases, such as AIDS, damage the immune system, leaving the body unable to deal with multiple infectious agents and cancerous cells.

The interactive paper contains a "Background research: How HIV causes disease" section

5.2j Biological research generates knowledge used to design ways of diagnosing, preventing, treating, controlling, or curing diseases of plants and animals.

The interactive paper describes a study that was undertaken to prevent HIV from replicating in a human host. The tRNA described here was patented, in anticipation of its potential therapeutic use.