**Maine Science Standards and Immune Defense**

**Federation of American Scientists**

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*The notes following each of the relevant standards have been written by Melanie Stegman at the Federation of American Scientists.  Please direct any questions, comments or suggestions to her* [*mstegman@fas.org*](mailto:mstegman@fas.org)*. Thank you, and I look forward to hear from you!*

**A. Unifying Themes: Students apply the principles of *systems*, *models*, constancy and change, and scale in science and technology.**

**A1. Systems**: **Students apply an understanding of *systems* to explain and analyze man-made and natural phenomena.**

a. Analyze a system using the principles of boundaries, subsystems, inputs, outputs, feedback, or the system’s relation to other *systems* and design solutions to a *system* problem.

b. Explain and provide examples that illustrate how it may not always be possible to predict the impact of changing some part of a man- made or natural *system*.

*Note: There are many ways to use Immune Defense as a model of a system.  The Immune Defense video game is a model of the immune system.  The game is limited to a stylized local infection.  In our model there are 4 types of cells, each with abilities, requirements and dependencies on other cell types, thus forming a simplified immune system.  Players must make predictions about cell and pathogen behaviors to succeed in the game.  The cells and pathogens all exist in real life, but in reality, the combinations become impossible to predict.*

**A2. Models: Students evaluate the effectiveness of a *model* by comparing its predictions to actual observations from the physical setting, the living environment, and the technological world.**

*Note: The immune system is usually in steady-state, but when an infection occurs, signals cause cells to become activated, differentiate, move, and attack pathogens.  An active immune system returns to the steady-state, but some things are permanently changed.  The player loses points due to damage to tissues caused by activation of Macrophages; Neutrophils die after eating a certain number of Pathogens; and skin cells infected with chicken pox are killed off.*

**A3. Constancy and Change: Students identify and analyze examples of constancy and change that result from varying types and rates of change in physical, biological, and technological systems with and without *counterbalances*.**

*Note: On the molecular level, signal molecules drift randomly until player uses points to move them; the system functions on its own and player can manipulate it somewhat to see consequences.*

**A4. Scale**: **Students apply understanding of scale to explain phenomena in physical, biological, and technological *systems*.**

a. Describe how large changes of scale may change how physical and biological *systems* work and provide examples.

b. Mathematically represent large magnitudes of scale.

*Note: In Immune Defense, cells and bacteria are drawn to scale, but molecules and receptors are not.  Bacteria are 10x smaller than the white blood cells and we show them all drawn as they are in real life.  But molecules are 1000 fold smaller than the cells in real life, and each cell has millions of receptors. So everything smaller than 100 Nanometers is drawn as a cartoon, using “Nano-Radar.”*

**B. The Skills and Traits of Scientific Inquiry and Technological Design: Students plan, conduct, analyze data from and communicate results of in-depth scientific investigations; and they use a systematic process, tools, equipment, and a variety of materials to create a technological design and produce a solution or product to meet a specified need.**

**B1. Skills and Traits of Scientific Inquiry: Students methodically plan, conduct, analyze data from, and communicate results of in-depth scientific investigations, including experiments guided by a testable hypothesis.**

a. Identify questions, concepts, and testable hypotheses that guide scientific investigations.

b. Design and safely conduct methodical scientific investigations, including experiments with controls.

c. Use statistics to summarize, describe, analyze, and interpret results.

d. Formulate and revise scientific investigations and *models* using logic and evidence.

e. Use a variety of tools and technologies to improve investigations and communications.

f. Recognize and analyze alternative explanations and *models* using scientific criteria.

g. Communicate and defend scientific ideas.

*Note:  By participating in either Beta or Controlled Evaluation Testing, students will participating in an experiment.  After the experiment is complete, teachers will be able to discuss our hypothesis and some of our real data with students.*

**B2. Skills and Traits of Technological Design**: **Students use a systematic process, tools and techniques, and a variety of materials to design and produce a solution or product that meets new needs or improves existing designs.**

a. Identify new problems or a current design in need of improvement.

b. Generate alternative design solutions.

c. Select the design that best meets established criteria.

d. Use *models* and simulations as prototypes in the design planning process.

e. Implement the proposed design solution.

f. Evaluate the solution to a design problem and the consequences of that solution.

g. Present the problem, design process, and solution to a design problem including models, diagrams, and demonstrations.

*Note: Students will be participating in the development of a new technological product.*

**C. The Scientific and Technological Enterprise: Students understand the history and nature of scientific knowledge and technology, the processes of inquiry and technological design, and the impacts science and technology have on society and the environment.**

**C1. Understandings of Inquiry: Students describe key aspects of scientific investigations: that they are guided by *scientific principles* and knowledge, that they are performed to test ideas, and that they are communicated and defended publicly.**

**C2. Understandings About Science and Technology: Students explain how the relationship between scientific inquiry and technological design influences the advancement of ideas, products, and systems.**

a. Provide an example that shows how science advances with the introduction of new technologies and how solving technological problems often impacts new scientific knowledge.

b. Provide examples of how creativity, imagination, and a good knowledge base are required to advance scientific ideas and technological design.

c. Provide examples that illustrate how technological solutions to problems sometimes lead to new problems or new fields of inquiry.

*Note:  Students can discuss the similarities and differences between a video game about cells, a video about cells, and a textbook about cells. Textbooks are being digitalized right now, and games and books are downloadable…which makes them cheaper, easier to update, and easier to carry home. However, this also makes them easier to pirate.  Such unforeseen consequences are at the heart of the technology debate, as well as the aims of this standard!*

**C3. Science, Technology, and Society: Students describe the role of science and technology in creating and solving contemporary issues and challenges.**

*Note:  Students can discuss the role of games, simulations and the Internet in providing people around the world with more scientifically detailed and specialized information than ever before.  Perhaps the planet will sustain more people due to global efforts that are only possible through the Internet and sharable software?  See* www.gamesforchange.org *for example.*

**D. The Physical Setting: Students understand the universal nature of matter, energy, force, and motion and identify how these relationships are exhibited in Earth Systems, in the solar system, and throughout the universe.**

**D2. Earth: Students describe and analyze the biological, physical, energy, and human influences that shape and alter Earth Systems**.

*Note:  Many of the effects than humans have on the Earth occur at the molecular level, and their full impact is difficult to understand.  After playing Immune Defense, students should have a feel for what a change in concentration of a natural chemical or how the appearance of a chemical contaminant might change a cell or organism's behavior.*

**D3. Matter and Energy: Students describe the structure, behavior, and interactions of matter at the atomic level and the relationship between matter and energy**

*Note:  Our main learning objective for Immune Defense is to introduce atoms and molecules and let students use them for various tasks.  Armed with functional definition of a few molecules, students are prepared to imagine functions of more molecules.  Additionally, after learning to take advantage of the random motion of the signaling molecules in the game, students are prepared to more deeply understand, for example, how heating or cooling the molecules may have an effect on their functions.*