**BID Georgia Performance Standards (9-12)**

<https://www.georgiastandards.org/Standards/Pages/BrowseStandards/ScienceStandards9-12.aspx>

**Habits of Mind (common among all)**

SCSh1. Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science.

Relevance to BID: Students will learn the value of curiosity by seeing how people have solved challenges by asking how animals do things, as well as learning that the way human technology works may not be the best way. They can examine how experiments are used to understand functions performed by animals

1. Exhibit the above traits in their own scientific activities.
2. Recognize that different explanations often can be given for the same evidence.
3. Explain that further understanding of scientific problems relies on the design and execution of new experiments which may reinforce or weaken opposing explanations.

SCSh2. Students will use standard safety practices for all classroom laboratory and field investigations.

1. Follow correct procedures for use of scientific apparatus.
2. Demonstrate appropriate technique in all laboratory situations.
3. Follow correct protocol for identifying and reporting safety problems and violations.

SCSh3. Students will identify and investigate problems scientifically.

Relevance to BID: “Design” is really a form of hypothesis testing. The BID process relies on students making a hypothesis that a particular animal provides a mechanism can be used to solve a particular problem (i.e. perform a given function), acquire information pertaining to this (understand the animal “solution” and the technical problem), revise their hypothesis (proposed design) and evaluate whether they were correct.

1. Suggest reasonable hypotheses for identified problems.
2. Develop procedures for solving scientific problems.
3. Collect, organize and record appropriate data.
4. Graphically compare and analyze data points and/or summary statistics.
5. Develop reasonable conclusions based on data collected.
6. Evaluate whether conclusions are reasonable by reviewing the process and checking against other available information.

SCSh4. Students use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.

Relevance to BID: Depending on the nature of the BID project, students may have to use a variety of methods and tools to analyze their system and examine the proposed design. Sometimes this can be done computationally, other times this may require testing a prototype or mock up. Students can also do simple experiments on natural objects to understand their functions and properties better.

1. Develop and use systematic procedures for recording and organizing information.
2. Use technology to produce tables and graphs.
3. Use technology to develop, test, and revise experimental or mathematical models.
4. SCSh5. Students will demonstrate the computation and estimation skills necessary for analyzing data and developing reasonable scientific explanations.
5. Trace the source on any large disparity between estimated and calculated answers to problems.
6. Consider possible effects of measurement errors on calculations.
7. Recognize the relationship between accuracy and precision.
8. Express appropriate numbers of significant figures for calculated data, using scientific notation where appropriate.
9. Solve scientific problems by substituting quantitative values, using dimensional analysis and/or simple algebraic formulas as appropriate.

SCSh6. Students will communicate scientific investigations and information clearly.

Relevance to BID: Using oral or written design reports that summarize the process of problem formulation, research, and the resulting design (and it’s strengths and weaknesses) practices these skills

1. Write clear, coherent laboratory reports related to scientific investigations.
2. Write clear, coherent accounts of current scientific issues, including possible alternative interpretations of the data.
3. Use data as evidence to support scientific arguments and claims in written or oral presentations.
4. Participate in group discussions of scientific investigation and current scientific issues.

**The Nature of Science (common among all)**

SCSh7. Students analyze how scientific knowledge is developed. Students recognize that:

Relevance to BID: Students will learn that the same principles that govern how technology works also govern how biology works, and will see the value of experimentation in understanding animal properties, and determining if they can be used in technology that solves a human problem

1. The universe is a vast single system in which the basic principles are the same everywhere.
2. Universal principles are discovered through observation and experimental verification.
3. 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. Major shifts in scientific views typically occur after the observation of a new phenomenon or an insightful interpretation of existing data by an individual or research group.
4. Hypotheses often cause scientists to develop new experiments that produce additional data.
5. Testing, revising, and occasionally rejecting new and old theories never ends

**Human Anatomy and Physiology**

SAP1. Students will analyze anatomical structures in relationship to their physiological functions.

Relevance to BID: some problems humans have relate to physiological process (e.g. filtering-artificial kidneys; thermal regulation etc). Students will have understand the relevant structures and functions in order to suggest how these physiological mechanisms may be adapted for technology.

1. Apply correct terminology when explaining the orientation of body parts and regions.
2. Investigate the interdependence of the various body systems to each other and to the body as a whole.
3. Explain the role of homeostasis and its mechanisms as these relate to the body as a whole and predict the consequences of the failure to maintain homeostasis.
4. Relate cellular metabolism and transport to homeostasis and cellular reproduction.
5. Describe how structure and function are related in terms of cell and tissue types.

SAP2. Students will analyze the interdependence of the integumentary, skeletal, and muscular systems as these relate to the protection, support and movement of the human body.

Relevance to BID: Biorobotics requires understanding of the muscular-skeletal system. Buildings, or other human technology has to transport heat, chemicals, water etc from the inside to the outside, which all are functions of the integument, providing a framework to examine skins. Next Gen building technology talks explicitly about “building skins”.

1. Relate the structure of the integumentary system to its functional role in protecting the body and maintaining homeostasis.
2. Explain how the skeletal structures provide support and protection for tissues, and function together with the muscular system to make movements possible.

SAP3. Students will assess the integration and coordination of body functions and their dependence on the endocrine and nervous systems to regulate physiological activities.

Relevance to BID: Artificial sensing systems inspired by animals requires understanding of the areas below.

1. Interpret interactions among hormones, senses, and nerves which make possible the coordination of functions of the body.
2. Describe how the body perceives internal and external stimuli and responds to maintain a stable internal environment, as it relates to biofeedback.

**Biology**

SB1. Students will analyze the nature of the relationships between structures and functions in living cells.

Relevance to BID: some problems humans have relate to physiological processes (e.g. filtering-artificial kidneys; thermal regulation etc). Students will have to understand the relevant structures and functions in order to suggest how these physiological mechanisms may be adapted for technology.

1. Explain the role of cell organelles for both prokaryotic and eukaryotic cells, including the cell membrane, in maintaining homeostasis and cell reproduction.
2. Explain how enzymes function as catalysts.
3. Identify the function of the four major macromolecules (i.e., carbohydrates, proteins, lipids, nucleic acids).
4. Explain the impact of water on life processes (i.e., osmosis, diffusion)
5. SB4. Students will assess the dependence of all organisms on one another and the flow of energy and matter within their ecosystems.
6. Relate plant adaptations, including tropisms, to the ability to survive stressful environmental conditions.
7. Relate animal adaptations, including behaviors, to the ability to survive stressful environmental conditions.

**Botany**

SBO1. Students will use current plant phylogenetic principles and describe the structural changes used to delineate the plant divisions.

Relevance to BID: There are quite a few bio-inspired applications based on plants. BID incorporates principles from all organisms, not simply animals.

1. Describe the major structures and evolutionary changes of major organs, tissues, cells, and organelle types in nonvascular/seedless and vascular/seed plants.
2. Identify and evaluate plant structures in relation to their functions.
3. Use, compare, and contrast the methods and purposes of plant classification

SBO3. Students will explore the structures and processes necessary for the mutual survival of plants and animals.

Relevance to BID: There are quite a few bio-inspired applications based on plants, some of which involve understanding dispersal, signaling or other processes involved in plant-animal interactions.

Describe and relate plant structures (organs, tissues, cells, organelles) to plant processes (photosynthesis, respiration, transport, growth, reproduction, dispersal).

1. Explore how flowering plants and animals have co-evolved in pollination, which confers genetic and evolutionary advantages.
2. Explore how fruit and seed adaptations help promote dispersal, which prevents competition between plants and helps in colonization.

**Environmental Science**

SEV2. Students will demonstrate an understanding that the Earth is one interconnected system.

Relevance to BID: Understanding animal properties as potential solutions requires understanding how animals perform functions important for their survival (elements e,h). Linking functions and properties of ecosystems to functions and properties of human systems (e.g. cities) requires understanding of many of the issues in these standards.

1. Describe how the abiotic components (water, air, and energy) affect the biosphere.
2. Recognize and give examples of the hierarchy of the biological entities of the biosphere (organisms, populations, communities, ecosystems, and biosphere).
3. Characterize the components that define a Biome.
4. Abiotic Factors – to include precipitation, temperature and soils.
5. Biotic Factors – plant and animal adaptations that create success in that biome.
6. Characterize the components that define fresh-water and marine systems.
7. Abiotic Factors – to include light, dissolved oxygen, phosphorus, nitrogen, pH and substrate.
8. Biotic Factors – plant and animal adaptations characteristic to that system.

SMI1. Students will analyze different types of microorganisms and their defining characteristics.

Relevance to BID: Skeletal features of plankton have been used to inspire human technology.

1. Distinguish between different kinds of microorganisms based on cellular structure, molecular biology and biochemical composition.
2. Describe how viruses differ from other parasitic microorganisms.
3. Compare relative sizes of microorganisms, different types of cell shapes, and various methods used to visualize microorganisms.

**Physics**

Relevance to BID: because animals must obey the same physical laws, understanding how to apply biomechanics (to robotics) requires understanding of many of the elements below. Understanding the properties of biological materials to examine how principles and properties relevant to human technical materials requires the same. This also covers SP3.

SP1. Students will analyze the relationships between force, mass, gravity, and the motion of objects.

1. Calculate average velocity, instantaneous velocity, and acceleration in a given frame of reference.
2. Compare and contrast scalar and vector quantities.
3. Compare graphically and algebraically the relationships among position, velocity, acceleration, and time.
4. Measure and calculate the magnitude of frictional forces and Newton’s three Laws of Motion.
5. Measure and calculate the magnitude of gravitational forces.
6. Measure and calculate two-dimensional motion (projectile and circular) by using component vectors.
7. Measure and calculate centripetal force.
8. Determine the conditions required to maintain a body in a state of static equilibrium

SP3. Students will evaluate the forms and transformations of energy.

1. Analyze, evaluate, and apply the principle of conservation of energy and measure the components of work-energy theorem by • describing total energy in a closed system. • identifying different types of potential energy.

**Oceanography**

Relevance to BID: The concept that we may learn important principles from animals that can help us solve our challenges creates an environmental ethic by causing students to revalue nature. Many of the challenges faced by humans involve technology that has deleterious consequences for oceans (and the terrestrial environment). Students will gain an appreciation for many issues related to conservation, management and sustainability by using BID as a framework to explore problems with current human technology that may be addressed by using principles derived from animals, which solve the problem in different, and sometimes better ways.

SO6. Students will identify how humans use the oceans for food, commerce, and energy and will evaluate the potential for abuse in the absence of responsible stewardship.

1. Describe how physical, geological, and biological resources are extracted from the oceans, and assess the consequences for marine ecosystems.
2. Identify how the oceans are used as sources of alternative energy.
3. Explain how the oceans are used for recreation and transportation, and evaluate their impacts on marine ecosystems.
4. Analyze issues, policies, and laws that promote responsible stewardship of the oceans, including trade, fisheries, transportation, and resources.