



Creating Excellence



Bioengineering

*Instructional Framework for
Technology Education*

Commonwealth of Virginia
Department of Education

Bioengineering

(DTE8467)

Instructional Framework for Technology Education

Produced by

Technology Education Department
Old Dominion University
and the
Virginia Bioengineering Writing Team

In cooperation with

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FOREWORD

To help students select appropriate courses of study to complete their occupational and educational objectives, Virginia program specialists have placed all courses in a structure composed of a career family, a career area, and one or more career roles according to the following definitions:

career family: A way of grouping occupations that have a core of common knowledge and skills

career area: A broad and flexible subdivision of a career family that is specific enough to provide real-life occupational context

career role: The most specific level in the family structure, identifying an occupational title

This instructional framework supports the course that prepares students for the following career roles. The course may be sequenced with a variety of career and technical courses to form a concentration or specialization to prepare students for careers and support additional education and training in the industry.

Career Family: Science, Technology, Engineering, and Mathematics

Career Areas:

Science and Technology

Engineering and Mathematics

Career Roles:

Biomedical engineer

Biotechnology engineer

Geneticist

Research technician

Course sequences are outlined in the CTE Administrative Planning Guide (APG), located at <http://www.pen.k12.va.us/VDOE/Instruction/CTE/apg/>. Bioengineering may be combined with other Technology Education courses to make a concentration or specialization, or with courses from other content areas to form a program mix.

The instructional framework presents a number of tasks/competencies considered essential for student learning in this 36-week course. Tasks not identified with a bullet are considered optional and may be taught at the discretion of the school division. Also, teachers may add tasks to the task/competency list to supplement instruction and meet local student needs.

Students completing certain CTE courses may be eligible for a certification by an industry, professional organization, or trade association, or for licensure from the Commonwealth of Virginia. Students may also earn the Virginia Board of Education's Advanced Mathematics and Technology Seal or its Career and Technical Education Seal and a student-selected verified credit. For information about the requirements for either of these Board of Education diploma seals or the requirements for earning a student-selected verified credit, see <http://www.pen.k12.va.us/VDOE/Instruction/CTE/apg/> and go to Section 5.

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INTRODUCTION/COURSE DESCRIPTION

Bioengineering deals with designing and manipulating organisms to create new products and processes for medical, agricultural, and engineering applications. Humans have been using and manipulating organisms for thousands of years, but advances of the last twenty years have significantly changed the field. In particular, biology, chemistry, materials science, and computing technology have all helped define the modern discipline of bioengineering.

Career opportunities in bioengineering require people that can be mentally flexible, willing to adopt and adapt techniques from other industries and to work with people from a wide range of disciplines. As an example, consider a kidney machine and the subsystems that make up this example of vital life support equipment:

- Water treatment and purification
- Heating and temperature control for pasteurization and patient comfort
- Measurement systems for flow and pressure, electrolytes
- Alarm systems for all vital parameters
- Data collection and processing
- Ergonomics
- Electrical safety.

Bioengineering is an exciting and rapidly expanding field. This course along with its prerequisite, Biotechnology Foundations, will provide students with an excellent understanding of the type of knowledge that is necessary to become a successful bioengineer.

This instructional framework supports the competency-based course in Bioengineering (8467) and is designed for use by teachers to help students achieve specific, validated tasks/competencies. The framework is available online at <http://www.cteresource.org/VERSO/>, enabling navigation among the framework's various elements. The online version also offers a convenient printing feature. Additionally, the course task/competency list and matching student competency record may be accessed by going to <http://www.cteresource.org/tasklists/>.

The instructional framework contains the course content, design briefs, and related information. The course content consists of each task/competency accompanied by a correlation of all the elements that reinforce its particular instructional objective. Design briefs are critical-thinking experiences for students and may serve as evaluation measures for the tasks/competencies in this course. The related information includes summaries of the elements in the course content, supplementary information showing ways in which these elements fit into the structure of the course, and the requirements for Virginia career and technical education.

Course Description

Bioengineering (8467) - 36 weeks

Grade Level: 11 or 12

Prerequisite Course: Biotechnology Foundations (8468)

Students enrolled in Bioengineering will develop an understanding of bioengineering systems, processes, tools, and materials. In addition, the ethical and environmental implications will be explored. Individual and group experiences are designed to enable students to understand, use, manage, and assess historical, current, and emerging bioengineering developments.

HOW TO USE THIS GUIDE

Each Concept Area section starts with a list of the Tasks/Competencies and Teacher Resources (print and electronic) that pertain to that particular area. Tasks/Competencies define what students should know and be able to do after studying the Concept Area. Task/Competency Definitions and Process/Skill Questions are provided to help guide instructional delivery and assessment. In addition, the Suggested Assessment Method section lists activities for analyzing student achievement. Design Briefs have been included and are the primary assessment activities in Bioengineering. However, problem solving, design portfolios, and technology assessment are all encouraged (see the Instructional Delivery section below).

Task/Competency correlations to the Virginia Standards of Learning (SOL) have been identified for English, Mathematics, Science, History and Social Science, and Computer/Technology. Additional correlations have been made for Technology Student Association (TSA) events, All Aspects of Industry competencies, and *Standards for Technological Literacy: Content for the Study of Technology*.

Further resources included in the framework are the full list of Virginia's Workplace Readiness Skills (a requirement for all Virginia CTE courses), the list of Virginia Leadership Expectations for High School, a complete list of the Standards for Technological Literacy, and a glossary of curriculum-related terms.

As a supplement to this framework, an introductory slide presentation to Bioengineering (Microsoft PowerPoint® format) has been created and is available from the Technology Education Service Web site at <http://www.pen.k12.va.us/VDOE/Instruction/CTE/te/bio/Bioengineering.ppt>.

RESOURCES

Bioengineering

NOTE: Each concept area section starts with a list of resources for that particular area. The resources contained below pertain to multiple concept areas.

PRINT RESOURCES

- Barnum, S.R. (1998). *Biotechnology: An Introduction*. Belmont, CA: Wadsworth Publishing Company.
- Kreuzer, H.K., and Massey, A. (1996). *Recombinant DNA and Biotechnology: A Guide for Students*. Washington, DC: ASM Press.
- Morris, B. (1995). *Science and Our Future: Biotechnology*. New York, NY: Cambridge University Press.
- Rainis, K.G., and Nassis, G. (1998). *Biotechnology Projects for Young Scientists*. New York, NY: Franklin Watts.

ELECTRONIC RESOURCES

- *Biotechnology: An Information Resource*. Web site of the National Agricultural Library. Beltsville, MD: U.S. Department of Agriculture. <http://www.nal.usda.gov/bic/>
- Carolina Biological Supply Company. Burlington, NC. <http://www.carolina.com/>
- Connecticut Valley Biological Supply Company. Southamton, MA. <http://www.ctvalleybio.com/>
- CTE Resource Center. Richmond, VA. *Featured Resources: Biotechnology for Educators*. <http://cteresource.org/publications/featured/biotechnology>
- EdVoTek Company. Bethesda, MD. <http://www.edvotek.com/index.html>
- Frey Scientific. Mansfield, OH. <http://www.freyscientific.com/index.jsp>
- “The Top 100 Sites.” *Genetic Engineering News*. Larchmont, NY. <http://www.genengnews.com/top100.asp>
- Science Instruments Company. Baltimore, MD. http://omgsic.com/science_instruments.htm
- Science Kit & Boreal Laboratories. Tonawanda, NY. <http://www.sciencekit.com/>
- The University of Arizona Biotech Project. Mobile Biotechnology for the Classroom. Tucson, AZ. <http://biotech.biology.arizona.edu/labs/labs.html>
- University of Wisconsin–River Falls. Biotechnology Classroom Activities. <http://www.uwrf.edu/biotech/workshop/activity.htm#group2>
- U.S. Department of Labor. Occupational Safety & Health Administration (OSHA). Washington, DC. <http://www.osha.gov/>
- Virginia's Center for Innovative Technology. <http://www.vabio.org/>
- Ward's Natural Science. Rochester, NY. <http://www.wardsci.com/category.asp?c=733>
- Wells, J. G. (2000). *Technology Education Biotechnology Curriculum*. Morgantown, WV: West Virginia University, Technology Education Program. <http://www.te-biotech.wvu.edu/default.htm>

Virginia Department of Education

The following documents and Web sites are designed to supplement career and technical education course instruction across all program areas:

Enhancing Workplace Readiness Skills. Order Catalog #8.01.02 from the CTE Resource Center at <http://www.cteresource.org/publications/ordering/>

Teaching Virginia's All Aspects of Industry. Order Catalog #8.01.05 from the CTE Resource Center at <http://www.cteresource.org/publications/ordering/>

Virginia Department of Education Leadership Development Initiative, located at <http://www.pen.k12.va.us/VDOE/Instruction/leadership/>

The Virginia Standards of Learning for Virginia Public Schools, located at

<http://www.pen.k12.va.us/VDOE/Superintendent/Sols/home.shtml>

The Virginia Department of Education, Office of Career and Technical Education Services, located at

<http://www.pen.k12.va.us/VDOE/Instruction/CTE/>

The CTE Resource Center, located at <http://www.cteresource.org/>

The Virginia Career Resource Network, located at <http://www.vacrn.net/>

Equipment lists, located at <http://www.pen.k12.va.us/VDOE/Instruction/CTE/regulations/equipment.html>

INSTRUCTIONAL DELIVERY

The technological method is central to the high school technology education curriculum. Using the technological method, students recognize technological problems and follow logical procedures to find solutions. The technological method enables students to create new opportunities, effectively communicate ideas and solutions, and analyze the technological benefits and consequences.

Teachers may use four instructional approaches to help students understand and use the technological method:

The Design Brief — Recognizing technological problems: A design brief helps students learn to recognize technological problems within a context or situation from the real world. Using critical thinking, students first clarify the problem and state it in written form before they follow the other steps in problem solving. Effective design briefs stimulate the application of math, science, and other disciplines to technological solutions. Teachers can use design briefs to focus learning on the specific content, materials, or processes that students need to study.

Problem Solving — Following logical procedures: Teachers who use this approach challenge students to find creative solutions to practical problems. The steps of problem solving are flexible; however, each step (analyze the problem, consider alternatives, make solutions, evaluate results) engages students in thinking, planning, and using various resources. Teams of students work cooperatively to solve problems and present solutions with models, products, displays, and/or graphic illustrations.

Design Portfolio — Communicating ideas and solutions: The portfolio documents the thinking process, serving as a graphic and written record of student work and accomplishment. Students benefit from presenting their ideas for others to consider. Portfolios allow students to record their progress, recycle ideas, and communicate with team members, teachers, and parents. In addition, a well-done portfolio is a resource for job and college interviews, bringing to light otherwise hidden skills.

Technology Assessment — Analyzing impacts: Technological knowledge and application are incomplete until the appropriateness of technology to society, the environment, and economic systems is determined. Using techniques of assessment, students learn to analyze the impacts of technology and make decisions based on their findings. Assessment ensures that new designs are appropriate solutions for today and tomorrow.

2004/2005 Competency-Based Task/Competency List
Bioengineering
8467 - 36 Weeks

Tasks/competencies designated by bullets in the left-hand column(s) are considered essential statewide and are required of all students. In some courses, all tasks/competencies have been identified as essential. Unbulleted tasks/competencies and/or locally added tasks/competencies should be included as local conditions permit.

8467 36 Weeks	Bioengineering TASKS/COMPETENCIES
	Understanding Foundations of Bioengineering
•	DTE8467.001 Define bioengineering.
•	DTE8467.002 Define terms related to bioengineering.
•	DTE8467.003 Describe bioengineering milestones.
•	DTE8467.004 Demonstrate safe laboratory procedures.
•	DTE8467.005 Describe social impacts of bioengineering.
•	DTE8467.006 Use course content to participate in Technology Student Association experiences as an individual member, leader, and committee member.
•	DTE8467.007 Use the technological method to solve bioengineering problems.
•	DTE8467.008 Apply mathematical and scientific principles in solving bioengineering challenges.
•	DTE8467.009 Analyze data generated from lab activities.
•	DTE8467.010 Describe technology transfer of bioengineering developments.
•	DTE8467.011 Identify careers related to bioengineering.
	Exploring Medical Technologies
•	DTE8467.012 Describe the engineering design process as related to vaccines and drugs.
•	DTE8467.013 Demonstrate the DNA modification process.
•	DTE8467.014 Analyze the design of medical, biomedical, and bioengineering instruments/tools.
•	DTE8467.015 Investigate the bioengineering processes related to tissue culture.
	Investigating Agricultural and Related Biotechnologies
•	DTE8467.016 Analyze the process for engineering food.
•	DTE8467.017 Investigate the engineering process as related to plants and animals.
•	DTE8467.018 Describe various outcomes of producing bio-based products.
	Investigating Energy and Power Technologies
•	DTE8467.019 Analyze the development of alternative fuel sources.
•	DTE8467.020 Describe biomolecular systems and the field of bioelectronics.
	Examining Information and Communication Technologies
•	DTE8467.021 Explore how bioengineering has affected and has been affected by imaging technologies.
•	DTE8467.022 Explore how database technologies have been affected by bioengineering.

8467 36 Weeks	Bioengineering TASKS/COMPETENCIES
•	DTE8467.023 Analyze equipment used in gathering biological information.
•	DTE8467.024 Investigate bioengineering communication systems.
•	DTE8467.025 Analyze the factors involved in the marketing of bioengineered products.
	Examining Transportation Technologies
•	DTE8467.026 Investigate the equipment and process for transporting biological materials.
•	DTE8467.027 Identify policies and regulations that affect the transfer of biological materials.
	Investigating Manufacturing Technologies
•	DTE8467.028 Explore the manufacturing process for biomaterials.
•	DTE8467.029 Demonstrate the engineering design process of prosthetics and implants.
•	DTE8467.030 Identify nanotechnologies that are used in bioengineering.
•	DTE8467.031 Investigate the field of biowarfare.
•	DTE8467.032 Demonstrate techniques of genetic engineering.
•	DTE8467.033 Describe the bioleaching processes.
•	DTE8467.034 Describe bioremediation processes.
	Exploring Construction Technologies
•	DTE8467.035 Analyze the impact of construction on natural ecosystems.
•	DTE8467.036 Explore systems used to manage biological waste.
•	DTE8467.037 Investigate the design and construction of artificial environments.
	Examining All Aspects of Industry
•	Planning
•	Management
•	Finance
•	Technical and Production Skills
•	Underlying Principles of Technology
•	Labor Issues
•	Community Issues
•	Health, Safety, and Environmental Issues

Concept Area: Understanding Foundations of Bioengineering

- DTE8467.001 Define bioengineering.
- DTE8467.002 Define terms related to bioengineering.
- DTE8467.003 Describe bioengineering milestones.
- DTE8467.004 Demonstrate safe laboratory procedures.
- DTE8467.005 Describe social impacts of bioengineering.
- DTE8467.006 Use course content to participate in Technology Student Association experiences as an individual member, leader, and committee member.
- DTE8467.007 Use the technological method to solve bioengineering problems.
- DTE8467.008 Apply mathematical and scientific principles in solving bioengineering challenges.
- DTE8467.009 Analyze data generated from lab activities.
- DTE8467.010 Describe technology transfer of bioengineering developments.
- DTE8467.011 Identify careers related to bioengineering.

Teacher Resources

PRINT

- Bains, W. (1998). *Biotechnology from A to Z*. New York, NY: Oxford University Press.
- Coombs, J. (1986). *Dictionary of Biotechnology*. New York, NY: Elsevier Science Publishing Co. Inc.
- Fleschar, M.H., and Nill, K.R. (1993). *Glossary of Biotechnology Terms*. Lancaster, PA: Technomic Publishing Company, Inc.

ELECTRONIC

CTE Resource Center. Richmond, VA. *Featured Resources: Biotechnology for Educators*.

<http://cteresource.org/publications/featured/biotechnology>

As a supplement to this framework, an introductory slide presentation to Bioengineering (Microsoft PowerPoint® format) has been created and is available from the Technology Education Service Web site at <http://www.pen.k12.va.us/VDOE/Instruction/CTE/te/bio/Bioengineering.ppt>.

Concept Area: Understanding Foundations of Bioengineering

Task/Competency

DTE8467.001 Define bioengineering. (essential)

Task Definition

Definition should include the concept that bioengineering is designing and manipulating organisms to create new products and processes for medical, agricultural, and engineering applications. Definition should mention the relationship of bioengineering to the technologies, the life sciences, and the manipulation of life processes. In addition, it should address the evolving nature of the field of bioengineering. The definition should reflect research in a variety of sources.

Process/Skill Questions

- What are some milestones in the history of bioengineering? How did each milestone further the field of bioengineering?
- What terms are used to describe bioengineering?
- What types of engineers work in bioengineering?

Related Academic Standards of Learning

For a complete listing of standards, see Related Information A.

- English: 11.4, 11.10, 12.1, 12.2, 12.4, 12.7, 12.8

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

- C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.
- C/T12.3 The student will develop skills in the use of telecommunications networks.
- C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

Related All Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Underlying Principles of Technology
- Community Issues

Related TSA Competitive Events

- Agriculture & Biotechnology Design
- Technology Bowl

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Concept Area: Understanding Foundations of Bioengineering

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- The Characteristics and Scope of Technology

Suggested Evaluation Measures

- Design Brief: Bioengineering Central

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Understanding Foundations of Bioengineering

Task/Competency

DTE8467.002 Define terms related to bioengineering. (essential)

Task Definition

Definitions should include the relationship of bioengineering to the fields of medicine, agriculture, energy and power, information and communication, transportation, manufacturing, and construction.

Process/Skill Questions

- What bioengineering terms are common to the fields of medicine, agriculture, energy and power, information and communication, transportation, manufacturing, and construction?
- Why do so many bioengineering concepts apply across these fields?
- What resources are useful for researching bioengineering terms?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

- English: 11.4, 12.4
- Science: BIO.2

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

- C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.
- C/T12.3 The student will develop skills in the use of telecommunications networks.
- C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

Related All Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Underlying Principles of Technology
- Community Issues
- Health, Safety, and Environmental Issues

Related TSA Competitive Events

- Agriculture & Biotechnology Design
- Technology Bowl

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Concept Area: Understanding Foundations of Bioengineering

Related ITEA Standards

For a complete listing of standards, see Related Information G and H.

- The Characteristics and Scope of Technology

Suggested Evaluation Measures

- Design Brief: Bioengineering Central

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Understanding Foundations of Bioengineering

Task/Competency

DTE8467.003 Describe bioengineering milestones. (essential)

Task Definition

Description should include examples representative of early cultures (e.g., China, Greece, and Egypt) as well as more recent milestones. They should include examples from various categories, such as humanitarian (e.g., vaccine development), inventions (e.g., artificial heart), discoveries (e.g., DNA or yeast), artifacts (e.g., medical instrumentation), and processes (e.g., distillation of alcohol).

Process/Skill Questions

- How have historical events influenced and been influenced by bioengineering?
- What discoveries have increased the pace of breakthroughs in bioengineering? How has each increased the pace?
- What are some environmental impacts of bioengineering developments?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

- English: 11.1, 11.4, 11.10, 12.1, 12.4
- Science: BIO.2
- History and Social Science: WHII.1, WHII.2, WHII.6, WHII.8, WHII.12

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

- C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.
- C/T12.3 The student will develop skills in the use of telecommunications networks.
- C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

Related All Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Underlying Principles of Technology
- Community Issues
- Health, Safety, and Environmental Issues

Related TSA Competitive Events

- Agriculture & Biotechnology Design

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Concept Area: Understanding Foundations of Bioengineering

Related ITEA Standards

For a complete listing of standards, see Related Information G and H.

- The Characteristics and Scope of Technology
- The Influence of Technology on History

Suggested Evaluation Measures

- Design Brief: Bioengineering Central

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Understanding Foundations of Bioengineering

Task/Competency

DTE8467.004 Demonstrate safe laboratory procedures. (essential)

Task Definition

Demonstration should reflect knowledge of general safety rules (including those related to fire, machine use, and tool use), aseptic technique, and industry-specified guidelines (including OSHA). It should also follow manufacturers' guidelines for equipment and material use. Demonstration should include safety procedures related to use and disposal of sharps, hazardous materials, and other potentially dangerous items.

Process/Skill Questions

- What are appropriate clean-up procedures for hazardous materials?
- Why are aseptic rules important?
- What are the specific rules and procedures involved in asepsis?
- What is a material safety data sheet (MSDS)? Why are these sheets important?
- Why is documentation important to safety?
- What is the chain of infection? Why is it important?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

- English: 11.4, 12.4
- History and Social Science: GOVT.1, GOVT.17
- Science: BIO.1, BIO.2, BIO.8, BIO.9

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

Related All Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Planning
- Health, Safety, and Environmental Issues

Related Code of the Virginia Board of Education, Regulations Governing Career and Technical Education
§ VAC 20-120-160 – Student safety

Related TSA Competitive Events

- Agriculture & Biotechnology Design

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Concept Area: Understanding Foundations of Bioengineering

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- The Core Concepts of Technology
- Use and Maintain Technological Products and Systems

Suggested Evaluation Measures

- Student demonstration of proficiency
- Design Brief: Safety First

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Understanding Foundations of Bioengineering

Task/Competency

DTE8467.005 Describe social impacts of bioengineering. (essential)

Task Definition

Description should include positive and negative, foreseen and unforeseen impacts. It should include the following and other types of impacts:

- Cultural (e.g., European process-based regulation versus North American product-based regulation)
- Medical (e.g., India's trade-off of using DDT, a known carcinogen, to prevent malaria, which is a greater threat than cancer)
- Financial (e.g., HIV medications in developing countries)
- Political (e.g., stem cell research)
- Ethical (e.g., cloning)
- Legal (e.g., food labeling)

Process/Skill Questions

- What is the origin of ELSI (Ethical, Legal, and Social Issues — a program of the Human Genome Project)?
- What are the bioengineering issues associated with ethics, legal, and social issues (ELSI)?
- How does the term *trade-off* apply to the social impacts of bioengineering?
- When making bioengineering decisions, why is it important to include cultural issues in the decision-making process? (For example, if a culture does not allow blood transfusions or gene therapy, there is no reason to pursue stem cell research within the culture.)
- For a given bioengineered device, what are the social impacts?
- What is the role of bioengineering in different countries?
- How is bioengineering research and development funded?
- Why is it important to understand statistical analysis in relation to the social impacts of bioengineering?
- What resources may be used to research social impacts of bioengineering?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

- English: 11.1, 11.4, 12.1, 12.4
- History and Social Science: WHII.1, WHII.6, WHII.12, WG.6, VUS.1, VUS.4
- Mathematics: PS.1, PS.2
- Science: BIO.1, BIO.2, BIO.8, BIO.9

Related Computer and Technology Standards of Learning

C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.

C/T12.3 The student will develop skills in the use of telecommunications networks.

C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

For a complete listing of standards, see Related Information B.

Concept Area: Understanding Foundations of Bioengineering

Related All Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Underlying Principles of Technology
- Community Issues
- Health, Safety, and Environmental Issues

Related TSA Competitive Events

- Agriculture & Biotechnology Design
- Technology Bowl
- Engineering Design
- Medical Technology

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsa.org>.

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- The Characteristics and Scope of Technology
- The Cultural, Social, Economic, and Political Effects of Technology

Suggested Evaluation Measures

- Design Brief: Presenting . . . Bioengineering!

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Understanding Foundations of Bioengineering

Task/Competency

DTE8467.006 Use course content to participate in Technology Student Association experiences as an individual member, leader, and committee member. (essential)

Task Definition

Knowledge of course content should be demonstrated by participation in the Technology Student Association and should reinforce research and presentation skills, leadership skills, organization skills, interpersonal skills, and problem-solving abilities.

Process/Skill Questions

- What student organizations provide opportunities to learn about bioengineering?
- What opportunities are available through these organizations?
- How are the skills reinforced in student organization participation used in industry and research?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

- English: 11.1, 11.4, 11.10, 12.1, 12.2, 12.4
- History and Social Science: VUS.1, VUS.14, GOVT.3, GOVT.6, GOVT.17
- Mathematics: COM.4, COM.5, COM.8, COM.16, PS.10
- Science: BIO.1, BIO.2, BIO.8, BIO.9

Related Computer and Technology Standards of Learning

C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.

Related All Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Planning
- Management
- Community Issues

Related TSA Competitive Events

- Agriculture & Biotechnology Design
- Technology Bowl
- Technology Problem Solving

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org/>.

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- The Core Concepts of Technology

Concept Area: Understanding Foundations of Bioengineering

Suggested Evaluation Measures

- Membership and participation in TSA

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Understanding Foundations of Bioengineering

Task/Competency

DTE8467.007 Use the technological method to solve bioengineering problems. (essential)

Task Definition

Demonstration should include examples of problem resolution using the technological method (i.e., define a problem, generate ideas, select a solution, test the solution, make the item, evaluate it, and present results).

Process/Skill Questions

- What are the steps in the scientific method? Of the technological method?
- What are the similarities and difference between the scientific method and the technological method?
- Under what conditions would each method be used?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

English: 11.4, 11.9, 11.10, 12.4, 12.7

History and Social Science: WG.1, WG.12, VUS.1, VUS.14

Mathematics: COM.4, COM.5, COM.14, COM.16, PS.19

Science: ES.1, BIO.1, BIO.9, PH.1

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.

C/T12.2 The student will use application software to accomplish a variety of learning tasks.

C/T12.3 The student will develop skills in the use of telecommunications networks.

C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

Related Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Planning
- Technical and Production Skills
- Underlying Principles of Technology

Related TSA Competitive Events

- Agriculture & Biotechnology Design
- Technology Problem Solving

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Concept Area: Understanding Foundations of Bioengineering

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving
- Apply Design Processes

Suggested Evaluation Measures

- Completion of at least two enclosed Design Briefs or instructor-created Design Briefs.

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Understanding Foundations of Bioengineering

Task/Competency

DTE8467.008 Apply mathematical and scientific principles in solving bioengineering challenges. (essential)

Task Definition

Demonstration should include examples of problem resolution using mathematical and scientific principles.

Process/Skill Questions

- What mathematical and scientific skills are needed by bioengineers? How might bioengineers apply these skills?
- How can mathematical and scientific solutions be graphically illustrated?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

- English: 11.4, 12.4
- History and Social Science: WG.1, WG.12 VUS.1 VUS.14
- Mathematics: COM.4, COM.5, COM.6, COM.14
- Science: ES.1, BIO.1, BIO.3, CH.1, PH.1, PH.3

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

- C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.
- C/T12.2 The student will use application software to accomplish a variety of learning tasks.
- C/T12.3 The student will develop skills in the use of telecommunications networks.
- C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

Related Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Underlying Principles of Technology

Related TSA Competitive Events

- Agriculture & Biotechnology Design
- Technical Research & Report Writing
- Computer-Aided Design, Animation

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Concept Area: Understanding Foundations of Bioengineering

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- Relationships among Technologies and the Connections between Technology and Other Fields
- Apply Design Processes

Suggested Evaluation Measures

- Completion of at least two Design Briefs from this framework, or instructor-created Design Briefs
- Completion of a problem solving activity, design portfolio, or technology assessment activity
- Design Brief: Database Dilemma
- Design Brief: Vaccine

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Understanding Foundations of Bioengineering

Task/Competency

DTE8467.009 Analyze data generated from lab activities. (essential)

Task Definition

Analysis should include comparative research, observations, documentation (e.g., lab journals and logs), application of formulas, conclusions, and quality control (e.g., identification of quality standard, data validation).

Process/Skill Questions

- How and why are data collected from lab activities? How may the data be documented?
- Why is it important to understand data analysis before collecting data?
- How are quality controls maintained? What would happen if quality controls were not maintained?
- How are data standards identified?

Related Standards of Learning

- English: 11.4, 11.9, 11.10, 12.4, 12.7
- History and Social Science: WHII.1
- Mathematics: A.18, AII.1, AII.2, COM.1, PS.8
- Science: BIO.1, CH.1, CH.3, PH.2

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

- C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.
- C/T12.2 The student will use application software to accomplish a variety of learning tasks.
- C/T12.3 The student will develop skills in the use of telecommunications networks.
- C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

Related Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Planning
- Technical and Production Skills

Related TSA Competitive Events

- Agriculture & Biotechnology Design

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Concept Area: Understanding Foundations of Bioengineering

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- Assess the Impact of Products and Systems

Suggested Evaluation Measures

- Design Brief: Tasty Technology

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Understanding Foundations of Bioengineering

Task/Competency

DTE8467.010 Describe technology transfer of bioengineering developments. (essential)

Task Definition

Description should include an explanation of technology transfer, along with examples of technology transfer from outside bioengineering into bioengineering (e.g., metal science from space industry crossing over into implants such as artificial joints) and vice versa (e.g., bioengineering crossing over into agriculture in the areas of no-rot food and pest-resistant crops), as well as within or among bioengineering fields (e.g., xenotransplantation, which is a crossover from bioagriculture).

Process/Skill Questions

- What technology transfer has occurred in bioengineering?
- Why is interdisciplinary collaboration important in technology transfer?
- What is an example of a spin-off technology in bioengineering?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

- English: 11.4, 12.4
- History and Social Science: WHII.15, WG.12, VUS.14
- Mathematics: COM.16, PS.17, PS.19
- Science: BIO.8, BIO.9

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

- C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.
- C/T12.2 The student will use application software to accomplish a variety of learning tasks.
- C/T12.3 The student will develop skills in the use of telecommunications networks.
- C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

Related All Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Underlying Principles of Technology
- Community Issues
- Health, Safety, and Environmental Issues

Related TSA Competitive Event

- Agriculture & Biotechnology Design

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Concept Area: Understanding Foundations of Bioengineering

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- The Characteristics and Scope of Technology
- Relationships among Technologies and the Connections between Technology and Other Fields
- The Cultural, Social, Economic, and Political Effects of Technology

Suggested Evaluation Measures

- Design Brief: Presenting... Bioengineering!
- Design Brief: Bioengineering Central

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Understanding Foundations of Bioengineering

Task/Competency

DTE8467.011 Identify careers related to bioengineering. (essential)

Task Definition

Identification should include research, design, product development, manufacturing/production, education/training, and other areas. It should include careers in medicine, agriculture, energy and power, information and communication, transportation, manufacturing, and construction. It should also include responsibilities, salaries, environment, education/training, and job outlook for each career.

Process/Skill Questions

- What employment opportunities in bioengineering are available to entry-level employees?
- What career paths in bioengineering might an employee pursue?
- What certifications, licensure, and other credentials are required for careers in bioengineering?
- What is the outlook for careers in bioengineering?
- What sources are useful for learning about careers in bioengineering?
- What bioengineering programs and fields are available in higher education?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

- English: 11.4, 11.10, 12.4
- Science: BIO.2

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

- C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.
- C/T12.2 The student will use application software to accomplish a variety of learning tasks.
- C/T12.3 The student will develop skills in the use of telecommunications networks.
- C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

Related Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Planning
- Management
- Labor Issues
- Community Issues

Related TSA Competitive Events

- Agriculture & Biotechnology Design

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Concept Area: Understanding Foundations of Bioengineering

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- The Cultural, Social, Economic, and Political Effects of Technology
- The Influence of Technology on History
- The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

Suggested Evaluation Measures

- Design Brief: Presenting... Bioengineering!
- Design Brief: Bioengineering Central

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Exploring Medical Technologies

- DTE8467.012 Describe the engineering design process as related to vaccines and drugs.
- DTE8467.013 Demonstrate the DNA modification process.
- DTE8467.014 Analyze the design of medical, biomedical, and bioengineering instruments/tools.
- DTE8467.015 Investigate the bioengineering processes related to tissue culture.

Teacher Resources

PRINT

Carr, J.J. (1992). *Biomedical Equipment: Use, Maintenance, and Management*. Englewood Cliffs, NJ: Prentice Hall, Inc.

Hill, W.E. (2000). *Genetic Engineering: A Primer*. Amsterdam, The Netherlands: Harwood Academic Publishers.

ELECTRONIC

NOVA Online. (2003). *Bioterror: Making Vaccines*. Public Broadcasting Service.

<http://www.pbs.org/wgbh/nova/bioterror/vaccines.html#>

Concept Area: Exploring Medical Technologies

Task/Competency

DTE8467.012 Describe the engineering design process as related to vaccines and drugs. (essential)

Task Definition

Description should include the engineering design process (i.e., define a problem, generate ideas, select a solution, test the solution, make the item, evaluate it, and present results). Description should also include the history, design, and production of specific vaccines and pharmaceuticals.

Process/Skill Questions

- What are the current methods of producing bioengineered vaccines?
- What is the difference between bioengineered vaccines and cultured vaccines?
- How is the production of bioengineered vaccines driven by current events?
- How was production driven by historical events?
- How has the production of bioengineered vaccines since World War II affected social health?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

- English: 11.4, 12.4
- Science: BIO.2, BIO.5, BIO.7

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

- C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.
- C/T12.3 The student will develop skills in the use of telecommunications networks.
- C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

Related Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Technical and Production Skills
- Underlying Principles of Technology Community Issues
- Health, Safety, and Environmental Issues

Related TSA Competitive Events

- Medical Technology

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- Medical Technologies

Concept Area: Exploring Medical Technologies

- Agricultural and Related Biotechnologies

Suggested Evaluation Measures

- Design Brief: Vaccine

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Exploring Medical Technologies

Task/Competency

DTE8467.013 Demonstrate the DNA modification process. (essential)

Task Definition

Demonstrations should include pre-modification processes (i.e., spinning, stranding, and extracting) as well as the materials and processes used to modify DNA for use in engineered materials.

Process/Skill Questions

- What is DNA? In what ways is it used in bioengineering?
- What equipment is used for spinning, stranding, and extracting DNA?
- What modifications are currently performed on DNA?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

- English: 11.4, 12.4
- Mathematics: COM.1, PS.1
- Science: BIO.6
- History and Social Science: WHII.1, WHII.2, WHII.6, WHII.8, WHII.12

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.

Related Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Technical and Production Skills
- Underlying Principles of Technology
- Health, Safety, and Environmental Issues

Related TSA Competitive Events

- Medical Technology

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- Use and Maintain Technological Products and Systems
- Medical Technologies

Concept Area: Exploring Medical Technologies

Suggested Evaluation Measures

- Design Brief: DNA Model

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Exploring Medical Technologies

Task/Competency

DTE8467.014 Analyze the design of medical, biomedical, and bioengineering instruments/tools. (essential)

Task Definition

Analysis should include the materials from which each instrument/tool is made. More advanced tools should be broken down according to mechanical, electronic, and fluid systems. Analysis should also include a research portfolio and presentation on a biotechnology-related (e.g., medical, biomedical, and bioengineering) instrument/tool created through the engineering design process.

Process/Skill Questions

- What materials are used in bioengineered instruments and tools?
- How does the design principle “form follows function” apply to medical, biomedical, and bioengineered instruments and tools?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

- English: 11.1, 11.2, 11.4, 12.1, 12.1, 12.4
- Mathematics: G.1, PS.12, PS.18
- Science: BIO.1, BIO.6, PH.1, PH.4
- History and Social Science: WG.2, WG.12, VUS.14

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

- C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.
- C/T12.2 The student will use application software to accomplish a variety of learning tasks.
- C/T12.3 The student will develop skills in the use of telecommunications networks.
- C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

Related Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Planning
- Technical and Production Skills
- Underlying Principles of Technology

Related TSA Competitive Events

- Medical Technology
- Engineering Design
- Technological Systems

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Concept Area: Exploring Medical Technologies

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- The Attributes of Design
- Engineering Design

Suggested Evaluation Measures

- Design Brief: Instruments to Manage Living Things

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Exploring Medical Technologies

Task/Competency

DTE8467.015 Investigate the bioengineering processes related to tissue culture. (essential)

Task Definition

Investigations should include techniques for collection, storage, multiplication, and transportation of tissue cultures. Documentation and data tracking to ensure proper identification are required.

Process/Skill Questions

- What procedures are used to track laboratory cultures?
- How are cultures collected and stored?
- How are engineered tissues (e.g., skin, cartilage, organs) created?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

- English: 11.4, 12.4
- Mathematics: COM.4, COM.14, PS.19
- Science: BIO.1, BIO.5, BIO.6, PH.1
- History and Social Science: WHII.1

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

- C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.
- C/T12.3 The student will develop skills in the use of telecommunications networks.
- C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

Related Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Underlying Principles of Technology
- Community Issues
- Health, Safety, and Environmental Issues

Related TSA Competitive Events

- Medical Technology

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- Medical Technologies

Concept Area: Exploring Medical Technologies

Suggested Evaluation Measures

- Design Brief: Presenting... Bioengineering!
- Design Brief: Bioengineering Central
- Design Brief: Vaccine

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Investigating Agricultural and Related Biotechnologies

DTE8467.016 Analyze the process for engineering food.

DTE8467.017 Investigate the engineering process as related to plants and animals.

DTE8467.018 Describe various outcomes of producing bio-based products.

Teacher Resources

PRINT

Morris, B. (1995). *Science and Our Future: Biotechnology*. New York, NY: Cambridge University Press.

ELECTRONIC

Biotechnology: An Information Resource. Web site of the National Agricultural Library. Beltsville, MD: U.S.

Department of Agriculture. <http://www.nal.usda.gov/bic/>

Concept Area: Investigating Agricultural and Related Biotechnologies

Task/Competency

DTE8467.016 Analyze the process for engineering food. (essential)

Task Definition

Analysis will include application of the engineering process to food production. Analysis will also incorporate advances in food science including the creation of engineered foods and techniques for processing (e.g., fermentation), preservation (e.g., freeze-drying), and storage (e.g., food additives and preservatives).

Process/Skill Questions

- What are the historical milestones for engineered foods? What are the current methods?
- What national and international policies exist regarding engineered foods?
- In the United States, who is responsible for overseeing the food supply?
- What genes are added or removed in engineered food?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

- English: 11.4, 11.10, 12.4
- Mathematics: COM.4, COM.14, PS.19
- Science: BIO.1, BIO.8, PH.1
- History and Social Science: WG.12, VUS.14

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

- C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.
- C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

Related Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Technical and Production Skills
- Community Issues
- Health, Safety, and Environmental Issues

Related TSA Competitive Events

- Agriculture & Biotechnology Design
- Engineering Design

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Concept Area: Investigating Agricultural and Related Biotechnologies

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- Assess the Impact of Products and Systems
- Medical Technologies
- Agricultural and Related Biotechnologies

Suggested Evaluation Measures

- Design Brief: Engineered Foods
- Design Brief: Tasty Technology

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Investigating Agricultural and Related Biotechnologies

Task/Competency

DTE8467.017 Investigate the engineering process as related to plants and animals. (essential)

Task Definition

Investigation should include historical, current, and emerging techniques. It should also include legal processes, tools, and equipment used in engineering plants and animals.

Process/Skill Questions

- What are the current and historical methods used to alter plants and animals?
- What are some of the national and international policies regarding the engineering of plants and animals?
- In the United States, who is responsible for overseeing engineered plants and animals?
- What are some current issues associated with the patenting of plants and animals?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

- English: 11.4, 12.4
- Mathematics: COM.4, COM.14, PS.19
- Science: BIO.5, BIO.6, BIO.8, PH.1
- History and Social Science: WHII.1, VUS.1, VUS.14

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

- C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.
- C/T12.3 The student will develop skills in the use of telecommunications networks.
- C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

Related Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Technical and Production Skills
- Underlying Principles of Technology
- Health, Safety, and Environmental Issues

Related TSA Competitive Events

- Agriculture & Biotechnology Design
- Engineering Design

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Concept Area: Investigating Agricultural and Related Biotechnologies

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- Medical Technologies
- Agricultural and Related Biotechnologies

Suggested Evaluation Measures

- Design Brief: Tasty Technology

For full text of design briefs, see Design Briefs section of this framework.

Concept Area: Investigating Agricultural and Related Biotechnologies

Task/Competency

DTE8467.018 Describe various outcomes of producing bio-based products. (essential)

Task Definition

Description should include positive and negative, foreseen and unforeseen outcomes. The description should focus on bioagriculture products. Examples may include bioremediation and biodegradation.

Process/Skill Questions

- Why will there always be unforeseen outcomes of bioengineered products?
- How much weight should be given to cultural, financial, political, ethical, and legal issues?

Related Academic Standards of Learning

For a complete listing of academic standards, see Related Information A.

- English: 11.4, 12.4
- Mathematics: PS.1, PS.12
- Science: ES.1, BIO.1, CH.1, PH.1
- History and Social Science: WG.1, VUS.14, GOVT.16

Related Computer and Technology Standards of Learning

For a complete listing of C/T standards, see Related Information B.

- C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.
- C/T12.2 The student will use application software to accomplish a variety of learning tasks.
- C/T12.3 The student will develop skills in the use of telecommunications networks.
- C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

Related Aspects of Industry

For a complete listing of aspects, see Related Information C.

- Finance
- Technical and Production Skills
- Underlying Principles of Technology
- Labor Issues
- Community Issues
- Health, Safety, and Environmental Issues

Related TSA Competitive Events

- Agriculture & Biotechnology Design

For a summary correlation of all tasks/competencies to TSA Competitive events, see Related Information F. For complete rules and additional information, visit the Virginia TSA Web site at <http://www.vatsa.org> and the National TSA Web site at <http://www.tsaweb.org>.

Concept Area: Investigating Agricultural and Related Biotechnologies

Related Standards for Technological Literacy

For a summary correlation and additional information on the standards, see Related Information G and H.

- Assess the Impact of Products and Systems
- Agricultural and Related Biotechnologies

Suggested Evaluation Measures

- Design Brief: Tasty Technology

For full text of design briefs, see Design Briefs section of this framework.

Artificial Environments

Context

The international space station is an engineering marvel. Dozens of countries have provided personnel, modules, financing, parts, training, and other resources. The station is constantly staffed and serves as a crucial research facility that is so large it can be seen from earth with the naked eye. Redundant systems were developed to insure the residents of the station would have clean air, water, and safe environments for eating, sleeping, and exercising.

Submarines have similar obstacles that must be overcome. Several systems are similar to space technologies, but some are unique. Fresh air on many large submarines, for example, is created by separating the oxygen and the hydrogen atoms from the water molecules outside the ship.

Challenge

Research and design a space station, submarine, or other artificial environment. You must model the systems for clean air and water and provide safe environments for eating, sleeping, and exercising.

Objectives

Upon completion of this design brief, students will be able to do the following:

- Identify the modules that make up the international space station.
- Explain the systems that provide oxygen and remove carbon dioxide in artificial environments.
- Describe the temperature control systems in artificial environments.
- Explain the systems that provide clean water and remove biological waste in artificial environments.
- Explain how food is stored and prepared in artificial environments.
- Describe the methods used to exercise and sleep in artificial environments.
- Create a model of an artificial environment.

Materials

- Computers with Internet connections for research
- Assorted modeling materials such as foam core, card stock, paper, tubing, glue, tape, and other found objects
- Assorted modeling tools such as measuring scales, hobby knives, and triangles

References

- National Aeronautics and Space Administration (NASA). International Space Station. <http://www.nasa.gov/topics/iss/index.html>
- *How Stuff Works*. "How are people able to breathe inside a submarine?" <http://www.howstuffworks.com/question83.htm>

Design Briefs: Artificial Environments

Evaluation

Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from student design portfolios containing brainstorming and documentation of source material.

	Excellent	Average	Unacceptable
Identify the modules that make up the international space station.	List includes an explanation of all the modules. Also, the primary functions of the module, country that manufactured the module, and date when it was launched are highlighted.	List includes an explanation of all the modules.	List does not include an explanation of all the modules.
Explain the systems that provide oxygen and remove carbon dioxide in artificial environments.	Explanations include a comprehensive list (>5) of systems with their advantages and disadvantages clearly explained.	Explanations include a good list (2-5) of systems with their advantages and disadvantages clearly explained.	Explanations include one system with its advantages and disadvantages clearly explained.
Describe the temperature control systems in artificial environments.	Descriptions include a comprehensive list (>5) of systems with their advantages and disadvantages clearly explained.	Descriptions include a good list (2-5) of systems with their advantages and disadvantages clearly explained.	Descriptions include one system with its advantages and disadvantages clearly explained.
Explain the systems that provide clean water and remove biological waste in artificial environments.	Explanations include a comprehensive list (>5) of systems with their advantages and disadvantages clearly explained.	Explanations include a good list (2-5) of systems with their advantages and disadvantages clearly explained.	Explanations include one system with its advantages and disadvantages clearly explained.
Explain how food is stored and prepared in artificial environments.	Explanations include a comprehensive list (>5) of different methods with their advantages and disadvantages clearly explained.	Explanations include a good list (2-5) of different methods with their advantages and disadvantages clearly explained.	Explanations include one method with its advantages and disadvantages clearly explained.
Describe the methods used to exercise and sleep in artificial environments.	Descriptions include a comprehensive list (>5) of methods with their advantages and disadvantages clearly explained.	Descriptions include a good list (2-5) of methods with their advantages and disadvantages clearly explained.	Descriptions include one method with its advantages and disadvantages clearly explained.
Create a model of an artificial environment.	The model accurately shows each of the systems described in the objectives above. The model shows excellent craftsmanship.	The model accurately shows each of the systems described in the objectives above. The model shows good craftsmanship.	The model does not show each of the systems described in the objectives above. The model shows poor craftsmanship.

Bioengineering Central

Context

The World Wide Web has greatly improved the exchange of information and ideas. One of its most powerful advantages over other media formats is its ability to help people quickly learn about new and emerging technologies. Text, graphics, animation, audio, and other methods of conveying information can promptly be developed, placed on the World Wide Web, and viewed from anywhere there is a computer with a connection to the Internet.

Challenge

Working as a class, create a “one-stop” Web site to educate people about bioengineering. You will work in small groups to develop individual Web pages that will be compiled into one site. Include the following Web pages:

- A glossary of bioengineering terms and concepts
- Milestones in the history of bioengineering
- Bioengineering careers
- Medical applications and instrumentation
- Bioengineered foods
- Organizations that regulate bioengineered medicines, foods, and products
- An online quiz to check people’s knowledge of bioengineering
- Other topics identified by the class and instructor

In addition to groups developing the Web pages above, one group will need to be in charge of design and navigation for the entire Web site. Work closely with the other teams and your instructor to insure uniformity of text, graphics, and colors. You will have four weeks to complete this project, but maintenance and updating of the site will last throughout the course. Be sure to give credit to any sources and to always use copyright-free artwork, video, and audio. You will need to keep a design portfolio that documents your work on this project and all of the sources you consulted for information.

Objectives

Upon completion of this design brief, students will be able to do the following:

- Define terms related to bioengineering.
- Describe bioengineering milestones.
- Identify careers related to bioengineering.
- Explain medical applications and instrumentation.
- List bioengineered foods.
- Identify organizations that regulate bioengineered medicines, foods, and products.
- Create a Web page for bioengineering resources.

Materials

- Computers with Internet connections
- Server to host Web site
- Web browser software
- HTML/Web authoring software
- Image editing software
- Optional materials: Scanners, digital cameras, audio software, and video software

References

- Barnum, S. R. (1998). *Biotechnology: An Introduction*. Belmont, CA: Wadsworth Publishing Company.

Design Briefs: Bioengineering Central

- *Biotechnology: An Information Resource*. Web site of the National Agricultural Library. Beltsville, MD: U.S. Department of Agriculture. <http://www.nal.usda.gov/bic/>
- “The Top 100 Sites.” *Genetic Engineering News*. Larchmont, NY
<http://www.genengnews.com/top100.asp>
- Morris, B. (1995). *Science and Our Future: Biotechnology*. New York, NY: Cambridge University Press.
- Virginia’s Center for Innovative Technology. <http://www.vabio.org/>

Evaluation

Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from student design portfolios containing brainstorming and documentation of source material.

	Excellent	Average	Unacceptable
Define terms related to bioengineering.	Clearly defines terms in understandable language and cites examples. Terms include a comprehensive list (>15) of historical, current, and emerging bioengineering materials, processes, and artifacts.	Defines terms in understandable language and cites examples. Terms (6-15) include some historical, current, and emerging bioengineering materials, processes, and artifacts.	Terms are not defined in understandable language (i.e., are taken directly from a technical dictionary). Very limited number (1-5) of terms and examples.
Describe bioengineering milestones.	Descriptions include a comprehensive list (>15) of milestones with their significances clearly explained.	Descriptions include a good list of milestones (6-15) with a few of their significances explained.	Descriptions include a short list (1-5) of milestones with none of their significances explained.
Identify careers related to bioengineering.	Identifications include a comprehensive list (>15) of historical, current, and emerging careers that are clearly explained.	Identifications include a good list of careers (6-15) with a few of them explained.	Identifications include a short list (1-5) of careers with few or none of them explained.
Explain medical applications and instrumentation.	Explanations include a significant number (>15) of medical applications and instruments with a clear description of each one.	Explanations include a good number (6-15) of medical applications and instruments with a clear description of each one.	Explanations include a limited number (1-5) of medical applications and instruments with a poor description of each one.
List bioengineered foods.	Lists include a significant number (>15) of foods and a clear description of how each one is engineered.	Lists include a good number (6-15) of foods and a clear description of how each one is engineered.	Lists include a limited number (1-5) of foods and a poor description of how each one is engineered.

Design Briefs: Bioengineering Central

Identify organizations that regulate bioengineered medicines, foods, and products.	Identifications include a significant number (>15) of international, national, state, and local organizations. The regulatory authority is clearly explained for each organization.	Identifications include a good number (6-15) of international, national, state, and local organizations. The regulatory authority is clearly explained for each organization.	Identifications include a limited number (1-5) of international, national, state, and local organizations. The regulatory authority is not clearly explained for each organization.
Create a Web page for bioengineering resources.	The Web page contains the six sections listed above, is easy to navigate (i.e., all links work), and follows good design principles.	The Web page contains the six sections listed above, but has some navigational problems or does not follow good design principles.	The Web page is missing one or more of the six sections listed above and has some navigation problems or does not follow good design principles.

Bio-Fuel Vehicles

Context

Environmentalists have long pressed for alternative fuel vehicles to help reduce the airborne pollutants produced from burning fossil fuels. Several automakers are now producing alternative fuel vehicles to help meet new Environmental Protection Agency (EPA) emissions guidelines. Some of these vehicles are powered by propane, natural gas, fuel cells, and even plants. Bio-fuels are a promising option because the plant materials they are distilled from are plentiful and renewable. Ethanol is the main type of bio-fuel. In the United States, cornstarch is the primary plant material used to create gasohol (90% unleaded gas & 10% ethanol). In Brazil, the government has pushed heavily for the production and implementation of bio-fuels produced from sugar cane. Methanol, the second type of bio-fuel, comes in several different grades. M100 is straight methanol that can be used as a gasoline or diesel substitute. M85 is a blend that contains 15% gasoline. Methanol is also used for chemical production and as a solvent.

Challenge

Research bio-fuels and create a model and/or illustration of either (a) the process used to create a bio-fuel or (b) an engine that runs on a bio-fuel. If the fuel you select does not require a modified engine, then focus on the energy efficiency of the fuel, the cost, and engine wear as compared to fossil fuels and other alternative fuels. You will present your model and/or illustration to the class once completed.

Objectives

Upon completion of this design brief, students will be able to do the following:

- Identify types and uses of bio-fuels.
- Explain the process used to create a bio-fuel.
- Compare and contrast bio-fuels, fossil fuels, and alternative fuels.
- Create a model and/or illustration that accurately represents the process used to create a bio-fuel or a bio-fuel engine.

Materials

- For models: Assorted materials such as foam core, card stock, paper, tubing, glue, tape, and other found objects
- For illustrations: Mechanical drawing tools or a computer with computer aided drafting (CAD) or animation software
- Alternative fuel resources such as textbooks, magazines, and Internet sites

References

- “The Top 100 Sites.” *Genetic Engineering News*. Larchmont, NY.
<http://www.genengnews.com/top100.asp>

Design Briefs: Bio-Fuel Vehicles

Evaluation

Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from student design portfolio.

	Excellent	Average	Unacceptable
Identify types and uses of bio-fuels.	Lists include a significant number (>5) of bio-fuels and uses.	Lists include a good number (2-5) of bio-fuels and uses.	Lists include a limited number (1) of bio-fuels and uses.
Explain the process used to create a bio-fuel.	The student correctly explains, in writing, all of the steps involved to create two different bio-fuels.	The student correctly explains, in writing, all of the steps involved to create one bio-fuel.	The student does not correctly explain, in writing, all of the steps involved to create one bio-fuel.
Compare and contrast bio-fuels, fossil fuels, and alternative fuels.	Descriptions include a comprehensive list (>15) of advantages and disadvantages among bio-fuels, fossil fuels, and alternative fuels.	Descriptions include a good list (6-15) of advantages and disadvantages among bio-fuels, fossil fuels, and alternative fuels.	Descriptions include a short list (1-5) of advantages and disadvantages among bio-fuels, fossil fuels, and alternative fuels.
Create a model and/or illustration that accurately represents the process used to create a bio-fuel or a bio-fuel engine.	The model/illustration accurately shows the process used to create a bio-fuel or a bio-fuel engine. The model shows excellent craftsmanship.	The model/illustration accurately shows the process used to create a bio-fuel or a bio-fuel engine. The model shows good craftsmanship.	The model/illustration does not accurately show the process used to create a bio-fuel or a bio-fuel engine. The model shows poor craftsmanship.

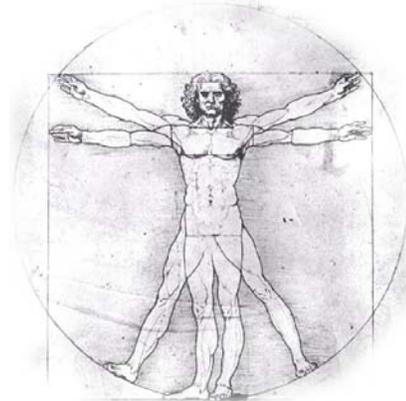
Building a Body Part

Context

Medical and bioengineering developments have had a major impact on individuals' abilities to adapt to physical birth or health related impairments and injuries. Have you ever met or known anyone who had a prosthetic limb or artificial joint? Prosthetics and implants give individuals in unfortunate circumstances a chance to use their bodies in ways that previously would have been impossible.

The technology used in developing these devices is diverse. Materials, electronics, medical knowledge, cosmetology, anthropometrics (use of body measurements and properties) and many other areas are used to create devices that attach to or are implanted in the human body. One of the greatest challenges designers encounter is being able to create a device that functions identically to the actual part for which it is designed to substitute. Several issues they may consider are flexibility, intended use (passive or active lifestyle), durability, and cost. In some cases the device does not function at all; rather, it is in place solely for aesthetic reasons.

Unfortunately implants and prosthetics do not last forever and are therefore not the final solution for achieving total rehabilitation. Components may wear, break, or be rejected by the body. In these situations, additional surgery, rehabilitation, and costs may burden the individual for a long time.



Leonardo da Vinci's Vitruvian Man shows the science of measuring the human body, anthropometrics.

Challenge

Each student will demonstrate the engineering process of prosthetics or implants by creating an artificial limb or joint. Depending on your class or laboratory setting, use modeling materials or machining techniques. Research and design of the joint or limb will need to be conducted. In these stages sketches, working drawings, and a summary report of the artificial joint or limb will be assembled. The end product should be created to scale so that it is proportional to the mannequin or doll to which it will be mounted.

Objectives

Upon completion of this design brief, students will be able to do the following:

- Create to scale an artificial joint or limb that may be fitted to a mannequin or doll.
- Explain the processes for creating a prosthetic or implant.
- Use word processing skills to write a product report.

Materials

- Photographs, pictures, drawings, or actual examples of various artificial joints and limbs
- Any material appropriate to construct the artificial joint or limb model
- Mannequin or doll
- Appropriate tools to shape the chosen material(s)
- Computer with appropriate word processing capabilities

References

- American Academy of Orthotists and Prosthetists. *The Orthotics and Prosthetics Profession*. http://www.oandp.org/jpo/library/1990_03_175.asp
- *Arthroscopy.com*. <http://www.arthroscopy.com/sports.htm>

Design Briefs: Building a Body Part

Evaluation

Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from student design portfolios containing brainstorming and documentation of source material.

	Excellent	Average	Unacceptable
Create to scale an artificial joint or limb that may be fitted to a mannequin or doll.	Creations include a joint or limb that is built to scale and fitted to the mannequin or doll. The model shows excellent craftsmanship.	Creations include a joint or limb that is built to scale and fitted to the mannequin or doll. The model shows good craftsmanship.	Creations include a joint or limb that is built to scale and fitted to the mannequin or doll. The model shows poor craftsmanship.
Explain the processes for creating a prosthetic or implant.	Demonstrations include a list of steps used to produce/manufacture a prosthetic or implant. Note that these will vary depending on the tools and materials available in your laboratory or classroom. Your teacher will specify the performance elements for this objective.		
Use word processing skills to write a product report.	Demonstrations include a clearly written report that lists and explains the research, design, manufacture, testing, fitting, and maintenance of a prosthetic or implant. Very good grammar and word processing skills are demonstrated.	Demonstrations include a written plan that lists and explains the research, design, manufacture, testing, fitting, and maintenance of a prosthetic or implant. Good grammar and word processing skills are demonstrated.	Demonstrations include a written plan that lists and explains the research, design, manufacture, testing, fitting, and maintenance of a prosthetic or implant. Good grammar and word processing skills are not adequately demonstrated.

Contaminate and Clean Up

Context

Have you ever thought what happens to the gas or oil spilled in the yard when filling a lawn mower? What about the incident involving the Exxon Valdez? In both instances oil or gas has been dispersed into the natural environment. Spills similar to these and other environmental incidents occur daily. If unattended, the results could be harmful, if not fatal to nature and mankind. When materials are spilled or released accidentally from storage facilities into their surroundings the soil, flora, fauna, water, and other aspects of the environment are affected. In many instances concerned parties try to recover the contaminated environments by cleaning or removing the water and soil (remediation). Some instances involve the use of organisms to clean the environment (bioremediation). Putting harmful materials into the environment is easy; getting them out and returning the area to its pre-incident condition is not. Absorbents, excavation, emulsifiers, bacteria, and the natural cleansing ability of nature all represent methods used in remediation activities.

In the United States there are laws that govern the release and clean up of spills. Unfortunately this is not the case throughout the world and particularly in developing nations. In areas such as these, run-off of chemicals into the soil and waterways poses a real threat to the people, plants and animals that rely on the soil and waterways.

Challenge

Each student will create a working diorama/model that illustrates a contaminated area and a remediation process. The diorama/model can illustrate these processes in land or marine environments. Record the remediation process tried and resultant outcomes. Teams of students will present their observations at the conclusion of the exercise.

Objectives

Upon completion of this design brief, students will be able to do the following:

- Create an artificially contaminated environment.
- Recommend alternative methods of clean-up as opposed to excavation.
- Present observations associated with a controlled experiment.

Materials

- Water tight containment area that will avert the spread of fluids from diorama/model (e.g., buckets, fish tanks, boxes lined with plastic)
- Water, sand, soil, or other environmental materials
- Simulated contaminant such as cooking oil
- Various materials for remediation to be determined by students (e.g., absorbent materials, detergents, filtration materials)
- Tools and materials to construct the diorama/model

References

- International Centre for Science and High Technology. *Technological and Economic Aspects of Soil Bio/Phyto Remediation*. <http://www.ics.trieste.it/Documents/Downloads/df972.pdf>
- U.S. Environmental Protection Agency. *About Superfund*. <http://www.epa.gov/superfund/about.htm>
- U.S. Environmental Protection Agency. *Exxon Valdez*. <http://www.epa.gov/oilspill/exxon.htm>

Design Briefs: Contaminate and Clean Up

Evaluation

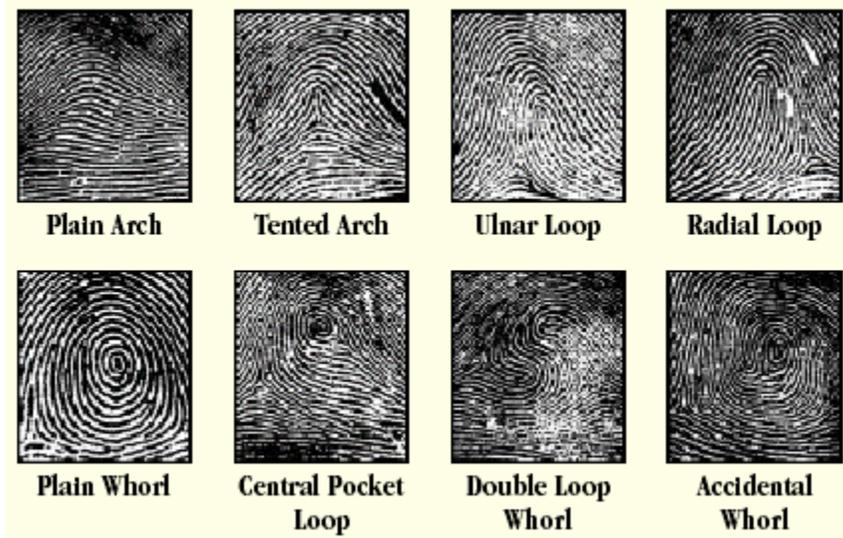
Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from student design portfolios containing brainstorming and documentation of source material.

	Excellent	Average	Unacceptable
Create an artificially contaminated environment.	Creations emulate a natural or man-made environment and are watertight. The model shows excellent craftsmanship.	Creations emulate a natural or man-made environment and are watertight. The model shows good craftsmanship.	Creations emulate a natural or man-made environment and are watertight. Poor craftsmanship.
Recommend alternative methods of clean-up as opposed to excavation.	Recommendations include a comprehensive list (>5) of alternative remediation methods with their advantages and disadvantages clearly explained.	Recommendations include a good list (2-4) of alternative remediation methods with their advantages and disadvantages clearly explained.	Recommendations include an alternative (1) remediation methods, but its advantages and disadvantages are not clearly explained.
Present observations associated with a controlled experiment.	Presentations include a clearly written report that lists and explains the research questions, hypothesis, experiment design, results, and recommendations. Very good grammar and word processing skills are demonstrated.	Presentations include a clearly written report that lists and explains the research questions, hypothesis, experiment design, results, and recommendations. Good grammar and word processing skills are demonstrated.	Presentations include a clearly written report that lists and explains the research questions, hypothesis, experiment design, results, and recommendations. Good grammar and word processing skills are not adequately demonstrated.

Database Dilemma

Context

Biometrics is the field that studies the unique characteristics of the human body. Facial recognition and eye/retinal scans are gaining acceptance, but fingerprinting is still the most accepted biometric technique. Used for over one hundred years, fingerprinting is based on the fact that each person has distinctive prints, even identical twins. The three main fingerprint characteristics (patterns) are loops, whorls, and arches:



Source: Federal Bureau of Investigation

In addition to the main patterns above, minutiae points are also used for identification. Minutiae points are unique characteristics such as the point made when two ridges come together. These points are identified and several are used when comparing fingerprints. The Federal Bureau of Investigation (FBI) and other law enforcement agencies share fingerprint information to help solve crimes. Surprisingly, varying requirements exist from one agency to another with regard to the number of unique characteristics (minutiae) that must be used to match a fingerprint. However, the task of matching a print is becoming more reliable with the use of electronic databases. The Integrated Automated Fingerprint Identification System (IAFIS) is the system used by the FBI.

Challenge

As a class, build a database of fingerprints. Since you do not have a fingerprint scanner, you must first print your fingerprint on paper and then scan it into the computer. Develop a numbering system, and include the characteristics of each print (i.e., loop, whorl, or arch) as well as several minutiae points for each print.

Consider other types of data that you might want to include in your database. Also, if you have image manipulation software (e.g., Photoshop[®], Paint Shop Pro[®]), try comparing two fingerprints by layering one print on top of another.

Objectives

Upon completion of this design brief, students will be able to do the following:

- Identify the three characteristics found in human fingerprints.
- Label minutiae points on a fingerprint.
- Print a fingerprint and scan the image into a computer.
- Create a database.

Design Briefs: Database Dilemma

Materials

- Computer with a scanner
- Scanning software
- Spreadsheet or database software
- Water-based inking pad for fingerprinting
- White paper
- Optional: Image manipulation software

References

- Biometrics at Michigan State University. <http://biometrics.cse.msu.edu/fingerprint.html>
- Federal Bureau of Investigation. <http://www.fbi.gov/>

Design Briefs: Database Dilemma

Evaluation

Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from student design portfolios containing brainstorming and documentation of source material.

	Excellent	Average	Unacceptable
Identify the three characteristics found in human fingerprints.	Identification would include correctly identifying the specific characteristics of a randomly presented fingerprint: ulnar loop, central pocket loop, radial loop, plain whorl, double loop whorl, accidental whorl, plain arch, or tented arch.	Identification would include correctly identifying the basic characteristics of a randomly presented fingerprint: loop, whorl, or arch.	Student could not correctly identify the basic characteristics of a randomly presented fingerprint: loop, whorl, or arch.
Label minutiae points on a fingerprint.	Student could label at least 5 minutiae points on a randomly presented fingerprint.	Student could label 2-4 minutiae points on a randomly presented fingerprint.	Student could label only 1 minutiae point on a randomly presented fingerprint.
Print a fingerprint and scan the image into a computer.	The student printed the fingerprint without smudges. The dried print was scanned and saved as a TIFF file. The student used software to enhance the clarity of the image and to reduce file size.	The student printed the fingerprint without smudges. The dried print was scanned and saved as a TIFF file.	The student printed the fingerprint but the image was not clear. The dried print was not successfully scanned and saved as a TIFF file.
Create a database.	Variables are correctly established and entered for each image. Data are accurately keyed into the software. The student demonstrates the ability to successfully query and print reports from the data.	Variables are correctly established and entered for each image. Data are accurately keyed into the software. The student has difficulty demonstrating the ability to query and print reports from the data.	Variables are not correctly established and entered for each image. Data are not accurately keyed into software. The student has difficulty demonstrating the ability to query and print reports from the data.

Debate

Context

One of the greatest rights of living in a democratic country is the right to free speech. In order for others to feel your opinions are worth listening to, however, you need to be well-educated on your topic. Engaging in debates, for example, is one way that politicians express their views on controversial topics. Politicians must look at all viewpoints when they prepare for a debate so they can clearly present the benefits of their position.

Debates are not what you see on the sensationalized television talk shows in the afternoon. Rather, they are very orderly exchanges with a moderator that allows each participant equal time to address the issue and to contest (rebut) the opponent's views. Winners are often selected during academic debates, but political debates are typically just for informational purposes.

Challenge

You will work in small groups (2-3 students) to research a certain position on a controversial bioengineering topic. Due to the nature of this activity, you may be defending positions you do not hold personally. Teams are expected to present factual evidence in a professional manner. The four debate topics are as follows:

1. Countries should/should not produce biowarfare weapons.
2. Genetic engineering should/should not be allowed on human cells and tissue.
3. Bioleaching is/is not safer than traditional mining techniques.
4. Bioremediation is/is not safe for cleaning up environmental pollutants.

Each team will be required to submit a typed annotated reference sheet containing at least five references. Sheets are due prior to each team's debate.

The following debate format will be strictly followed:

1. Each side will have five minutes to present its position.
2. Each side will have five minutes to prepare its rebuttal and two minutes to present its rebuttal.
3. No member of the audience or from the opposing team can make comments during the presentation or rebuttal periods. Interruptions from the audience will result in the loss of points from their team.
4. After the presentation and rebuttal periods, audience members may ask for points of clarification. Questions and comments concerning opinion should be held for the post-debate discussion.
5. After the debate, members from the audience will choose the winning team based on factual presentation.
6. A short class discussion will follow each debate.

Objectives

Upon completion of this design brief, students will be able to do the following:

- Demonstrate the ability to research and present a controversial topic in a professional manner.
- Explain the procedures used in an academic debate.

Materials

- Timer to monitor the length of each presentation and rebuttal
- Library and Internet resources for research
- Computers with word processing software

Design Briefs: Debate

References

- Bains, W. (1998). *Biotechnology from A to Z*. New York, NY: Oxford University Press.
- NOVA Online. (2003). *Bioterror: History of Biowarfare*. Public Broadcasting Service. <http://www.pbs.org/wgbh/nova/bioterror/history.html>
- Organisation for Economic Co-operation and Development. (2001). *The Application of Biotechnology to Industrial Sustainability*. Paris, France: OECD Publications.

Evaluation

Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from an instructor-prepared quiz or test.

	Excellent	Average	Unacceptable
Demonstrate the ability to research and present a controversial topic in a professional manner.	Demonstrations include an annotated list of references and a debate presented on evidence, not opinion. The team is organized and each member participates equally.	Demonstrations include an annotated list of references and a debate presented on evidence, not opinion. The team is somewhat organized and most members participate equally.	Demonstrations do not include an annotated list of references and a debate presented on opinion. The team is not organized and most members do not participate.
Explain the procedures used in an academic debate.	Explanations include a clearly written report that lists and explains (1) presentation of position, (2) rebuttal, (3) clarification, (4) selecting a winner, and (5) reflection. Very good grammar and word processing skills are demonstrated.	Explanations include a clearly written report that lists and explains (1) presentation of position, (2) rebuttal, (3) clarification, (4) selecting a winner, and (5) reflection. Good grammar and word processing skills are demonstrated.	Explanations include a written report that inadequately lists and explains (1) presentation of position, (2) rebuttal, (3) clarification, (4) selecting a winner, and (5) reflection. Good grammar and word processing skills are not adequately demonstrated.

DNA Model

Context

Perhaps the biggest area in bioengineering involves the manipulation of the deoxyribonucleic acid (DNA) in organisms. DNA is found in the simplest bacterial cells and all plants and animals. Bioengineers that manipulate DNA create food crops and animals that are resistant to certain diseases and pests. To fully understand this process, you need to understand the make-up of DNA and how it is manipulated.

The illustration below shows that DNA looks like a twisted ladder. The sides of the ladder are made up of sugar (deoxyribose) and phosphate units. The rungs are made up of pairs of nucleic acids (bases) that connect to the sugar units on the sides. There are four bases: Guanine (G), Cytosine (C), Adenine (A), and Thymine (T). Adenine pairs with Thymine and Guanine pairs with Cytosine. The patterns of the rungs make up the unique code of the organism.

Challenge

Create a model of DNA, using the materials provided. Be sure to color code the various materials (e.g., phosphates, sugars, G, C, A, and T) and provide a key so observers can easily identify the phosphates, sugars, and bases.

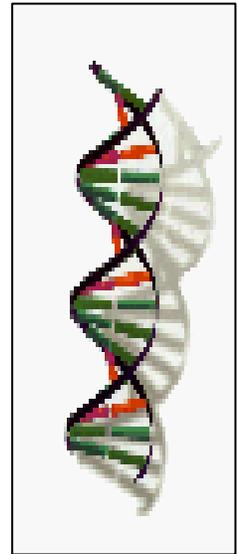
Objectives

Upon completion of this design brief, students will be able to do the following:

- Explain the configuration of phosphates, sugars, G, C, A, and T that make a strand of DNA.
- Accurately create a model of a DNA strand.

Materials

- Assorted modeling materials such as paper, wire, beads, and other found objects
- Assorted modeling tools such as measuring scales, hobby knives, and wire cutters



References

- Kreuzer, H.K. and Massey, A. (1996). *Recombinant DNA and Biotechnology: A Guide for Students*. Washington, DC: ASM Press.
- Morris, B. (1995). *Science and Our Future: Biotechnology*. New York, NY: Cambridge University Press.

Design Briefs: DNA Model

Evaluation

Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from an instructor-prepared quiz or test.

	Excellent	Average	Unacceptable
Explain the configuration of phosphates, sugars, and bases that make a strand of DNA.	The model key accurately explains the relationship of phosphates, sugars, and bases. The key is organized and easy to understand.	The model key accurately explains the relationship of phosphates, sugars, and bases. The key is not organized and is difficult to understand.	The model key does not accurately explain the relationship of phosphates, sugars, and bases.
Accurately create a model of a DNA strand.	The model accurately shows the relationship of phosphates, sugars, and bases. The model shows excellent craftsmanship.	The model accurately shows the relationship of phosphates, sugars, and bases. The model shows good craftsmanship.	The model does not accurately show the relationship of phosphates, sugars, and bases. The model shows poor craftsmanship.

Engineered Foods

Context

The issue of engineered foods has created very diverse opinions throughout the world. In Europe, for example, many people are opposed to all bioengineered foods so governments have required manufacturers to label modified foods. In the United States, the public has been more accepting of bioengineered foods. Nevertheless, the Food and Drug Administration (FDA) is researching different ideas for labeling the packaging of modified foods.

Challenge

The icon at the right is the international symbol for a biohazard. Your challenge is to design an icon for the FDA that will be used on the packaging of bioengineered foods. The symbol should be easily understood but must not resemble the biohazard icon. Start by creating some thumbnail sketches of various ideas. Once you select a design, create a color copy and then a final camera-ready copy. Be sure to demonstrate good design principles by effectively using text, color, and white space.



Objectives

Upon completion of this design brief, students will be able to do the following:

- Create a symbol that appropriately represents a given concept.
- Create thumbnail sketches, color copies, and camera-ready copies of artwork.
- Demonstrate good design principles.

Materials

- Samples of internationally recognized icons
- Paper
- Computers with computer aided design (CAD) software or mechanical drawing tools

References

- Morris, B. (1995). *Science and Our Future: Biotechnology*. New York, NY: Cambridge University Press.
- *Biotechnology: An Information Resource Site*. Web site of the National Agricultural Library. Beltsville, MD: U.S. Department of Agriculture. <http://www.nal.usda.gov/bic/>

Design Briefs: Engineered Foods

Evaluation

Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from student design portfolios containing brainstorming and documentation of source material.

	Excellent	Average	Unacceptable
Create a symbol that appropriately represents a given concept.	The intended purpose of the design is clear. No further explanation or context is needed.	The intended purpose of the design is somewhat clear. Further explanation or context may be needed.	The intended purpose of the design is not clear. Further explanation or context is needed.
Create thumbnail sketches, color copies, and camera-ready copies of artwork.	Thumbnail sketches for four different designs were presented. Color copies for two designs were presented. The final camera-ready copy was clean.	Thumbnail sketches for four different designs were presented. Color copies for one or two designs were presented. The final camera-ready copy was not clean.	Thumbnail sketches for four different designs were not presented. Color copies for one or two designs were presented. The final camera-ready copy was not clean.
Demonstrate good design principles.	Appropriate graphic design includes a balance among text, color, artwork, and white space.	Appropriate graphic design includes a balance among at least three of the four: text, color, artwork, and white space.	The graphic design does not include a balance among text, color, artwork, or white space.

Design Briefs: How Do You Move It?

How Do You Move It?

Context

Medical and biological waste is being created and disposed of every day. It is not acceptable to merely throw all of this waste in a trashcan for disposal in the general municipal landfill. Federal, state, and local laws establish minimum guidelines that must be followed when disposing of such materials. In addition to these laws, community citizens have a “right-to-know” what is being transported through their localities and the risks involved in doing so. Many companies have implemented “Route Risk Assessments” to determine how and where such waste is transported, impacts of the transport, and emergency protocols when transporting medical and biological waste products.

Challenge

In groups, plan the collection, transportation, and disposal of biomaterials collected from specific sources (e.g., medical, sanitation, industrial, or research). In the plan, key items to consider should include labeling, route risk assessments, end of life cycle, and regulations involved (e.g., DOT, EPA, OSHA, Virginia Department of Environmental Quality). At the conclusion of the exercise, each group will present their plan to the class for additional discussion.

Objectives

Upon completion of this design brief, students will be able to do the following:

- Identify the most appropriate route(s) to transport biotype materials.
- Research key items required by the federal, state, or local law for transporting biotype materials.
- Use word processing skills to write up an appropriate plan that addresses the collection, transportation, and disposal of biomaterials.

Materials

- Computer with appropriate word processing and Internet access capabilities
- Overhead projector or projection unit
- Maps (national, state, local)

References

- U.S. Department of Labor. Occupational Safety & Health Administration. <http://www.osha.gov/>
- U.S. Department of Transportation. <http://www.dot.gov/>
- U.S. Environmental Protection Agency. *Transportation and Air Quality Planning*. <http://www.epa.gov/otaq/traq/>
- University of California Los Angeles. *Department of Transportation Regulations for Medical Waste*. <http://www.biosafety.ucla.edu/docs/New Department of Transportation Regulations for Medical Waste.pdf>
- University of Washington. Environmental Health and Safety. *Biosafety Manual*. <http://www.ehs.washington.edu/Manuals/Bsmanual/index.htm>
- Virginia Department of Environmental Quality. Office of Pollution Prevention. <http://www.deq.state.va.us/tanks/transprt.html>

Design Briefs: How Do You Move It?

Evaluation

Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from student design portfolios containing brainstorming and documentation of source material.

	Excellent	Average	Unacceptable
Identify the most appropriate route(s) to transport biotype materials.	Descriptions include a comprehensive list (>5) of proposed routes with a route risk assessment of each. The student can explain why one route was selected above the others.	Descriptions include a good list (2-4) of proposed routes with a route risk assessment of each. The student can explain why one route was selected above the others.	Descriptions include only one route with a route risk assessment.
Research key items required by the federal, state, or local law for transporting biotype materials.	Descriptions include a comprehensive list (>15) of federal, state, or local laws. The student can explain each of these laws.	Descriptions include a good list (6-15) of federal, state, or local laws. The student can explain each of these laws.	Descriptions include a short list (1-5) of federal, state, or local laws. The student can explain each of these laws.
Use word processing skills to write-up an appropriate plan that addresses the collection, transportation, and disposal of biomaterials.	Demonstrations include a clearly written plan that lists and explains the collection, transportation, and disposal of biomaterials. Very good grammar and word processing skills are demonstrated.	Demonstrations include a written plan that lists and explains the collection, transportation, and disposal of biomaterials. Good grammar and word processing skills are demonstrated.	Demonstrations include a written plan that lists and explains the collection, transportation, and disposal of biomaterials. Good grammar and word processing skills are not adequately demonstrated.

Instruments to Manage Living Things

Context

Instruments and tools have been used in the medical field throughout recorded history. As with any medical field, the more advanced the field becomes, the more advanced its tools and instruments become. Medical tools and instruments can be categorized into various groups. Two of these groups, diagnostic (used to help determine the patient's status) and surgical (used when performing surgical procedures), are commonly known to nonmedical practitioners. Diagnostic instruments and tools may be as simple as a thermometer, stethoscope, or sphygmomanometer (blood pressure cuff) or as complex as EKG/ECG (electrocardiograph) or pulse oximeter. This same range of complexity applies to surgical equipment when one looks at the examples of scalpels, forceps, and syringes as opposed to laser cutting/cauterizing.

So where and how do ideas for these tools and instruments originate? Curiosity, necessity and product improvement are three major avenues for getting new products. Industry calls this method of creating new products *research and development*.

What tools or instruments might the future bring for the medical, biomedical, and bioengineering fields?

Challenge

Each student will research and develop a new medical, biomedical, or bioengineering instrument/tool based on the analysis of existing instruments/tools. Students will conduct research and design of the chosen instrument/tool. In these stages, students will accumulate sketches, working drawings, intended use, and safety precautions and will assemble a product report of the instrument/tool. The student's end product should be a mock-up or prototype model.

Objectives

Upon completion of this design brief, students will be able to do the following:

- Explain the uses of different bioengineered tools and instruments.
- Create a mock-up or prototype tool/instrument that may be used in the field of bioengineering.
- Demonstrate technical writing and word processing skills.

Materials

- Photographs, pictures, drawings or actual examples of various instruments/tools used in bioengineering
- Any material appropriate to construct the mock-up or prototype model
- Appropriate tools to shape the chosen material(s)
- Computer with appropriate word processing capabilities

References

- Carr, J. J. (1992). *Biomedical Equipment: Use, Maintenance, and Management*. Englewood Cliffs, NJ: Prentice Hall, Inc.
- Hill, W.E. (2000). *Genetic Engineering: A Primer*. Amsterdam, The Netherlands: Harwood Academic Publishers.

Design Briefs: Instruments to Manage Living Things

Evaluation

Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from student design portfolios containing brainstorming and documentation of source material.

	Excellent	Average	Unacceptable
Explain the uses of different bioengineered tools and instruments.	Explanations include a significant number (>15) of bioengineered tools and instruments with a clear description of each one.	Explanations include a good number (6-15) of bioengineered tools and instruments with a clear description of each one.	Explanations include a limited number (1-5) of bioengineered tools and instruments with a poor description of each one.
Create a mock-up or prototype tool/instrument that may be used in the field of bioengineering.	The model is based on research into current bioengineered tools/instruments. The model shows excellent craftsmanship.	The model is based on research into current bioengineered tools/instruments. The model shows good craftsmanship.	The model is based on research into current bioengineered tools/instruments. The model shows poor craftsmanship.
Demonstrate technical writing and word processing skills.	Demonstrations include a clearly written explanation of the student-designed tool/instrument. Very good grammar and word processing skills are demonstrated.	Demonstrations include a written explanation of the student-designed tool/instrument. Good grammar and word processing skills are demonstrated.	Demonstrations include a written explanation of the student-designed tool/instrument. Good grammar and word processing skills are not adequately demonstrated.

Internal Imaging

Context

Imaging techniques have greatly increased the knowledge and ability of medical professionals to help their patients. Most people are aware of X-rays, sonograms, CAT Scans, and MRI (magnetic resonance imaging) that are non-invasive techniques to assist in determining what ailment or medical issue may be present. An invasive technique used to see blockages in the circulatory, pulmonary, and digestive systems involves the use of a camera. These cameras can also assist physicians when performing arthroscopic surgery. Instead of making large incisions, a physician can make a small one and use a fiber optic camera to see and record the damage. The fiber optic camera uses a fiber that can be inserted into the passageway. As it approaches the area of concern the operator can actually see the blockage or injury. The use of real-time video or single frame pictures has also allowed for the recording of this information for future use and documentation. Not surprisingly, the fiber optic camera, X-rays, sonogram, and MRI technologies can be transferred to other occupations (e.g., plumbing, law enforcement/military, environmental, mining) that benefit from its size, flexibility, and ability to leave the object intact.

Challenge

As a group, students will use a fiber optic camera or equivalent to determine if blockages are present in various passageways (these will be artificial mock-ups of human passageways, e.g., esophagus, arteries, or gastrointestinal tract). The students will collectively determine what and where the blockage(s) is and the most appropriate means to remove it if necessary. Have the team record its observations, challenges and corrective actions and prepare a laboratory report detailing the experience.

Objectives

Upon completion of this design brief, students will be able to do the following:

- Explain how the fiber optic camera works.
- Use a camera to locate and identify foreign objects that may be blocking a passageway.
- Demonstrate teamwork skills used to complete the task.
- Use word processing skills to write-up an appropriate laboratory report.

Materials

- Fiber optic camera or equivalent
- Piping of any type with multiple bends
- Material(s) used to create blockages (e.g., clay, soil, string)
- Computer with appropriate word processing capabilities

References

- Fiber Optic Scope Source. <http://www.professionalequipment.com/>
- Huntsville Gastroenterology Associates, P.C. Upper GI Endoscopy. http://www.huntsville-gastroenterology.com/upper_gi_endoscopy.shtml
- National Digestive Diseases Information Clearinghouse. *Colonoscopy*. <http://digestive.niddk.nih.gov/ddiseases/pubs/colonoscopy/index.htm>
- Visualization Laboratory. *3D Virtual Colonoscopy*. <http://www.cs.sunysb.edu/~vislab/projects/colonoscopy/colonoscopy.html>

Design Briefs: Internal Imaging

Evaluation

Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from student design portfolios containing brainstorming and documentation of source material.

	Excellent	Average	Unacceptable
Explain how the fiber optic camera works.	The student correctly explains in writing how a fiber optic camera collects and stores images. Also, the student explains, in writing, how a fiber optic camera is maneuvered. Explanations also include other applications such as surgical, military, and public safety.	The student correctly explains in writing how a fiber optic camera collects and stores images. Also, the student explains, in writing, how a fiber optic camera is maneuvered.	The student cannot correctly explain in writing how a fiber optic camera collects and stores images. The student cannot explain, in writing, how a fiber optic camera is maneuvered.
Use a camera to locate and identify foreign objects that may be blocking a passageway.	The student can write down and follow the steps used to locate a foreign object. The student can accurately identify the object without disturbing it.	The student can write down and follow the steps used to locate a foreign object. The student can accurately identify the object but may disturb it when doing so.	The student cannot write down and follow the steps used to locate a foreign object. The student cannot accurately identify the object without disturbing it.
Demonstrate teamwork skills used to complete the task.	Demonstrations include (1) respectfully sharing and listening to ideas, (2) agreeing to a unified course of action, (3) taking part to implement the solution, (4) reflecting on the process, and (5) demonstrating leadership.	Demonstrations include (1) respectfully sharing and listening to ideas, (2) agreeing to a unified course of action, (3) taking part to implement the solution, and (4) reflecting on the process.	Demonstrations are missing one or more of the following: (1) respectfully sharing and listening to ideas, (2) agreeing to a unified course of action, (3) taking part to implement the solution, and (4) reflecting on the process.
Use word processing skills to write-up an appropriate laboratory report.	Demonstrations include a clearly written explanation of the entire internal imaging activity. Very good grammar and word processing skills are demonstrated.	Demonstrations include a written explanation of the internal imaging activity. Good grammar and word processing skills are demonstrated.	Demonstrations include a written explanation of the internal imaging activity. Good grammar and word processing skills are not adequately demonstrated.

Marketing Bioengineered Products

Context

The controversy of bioengineered products has caused governments from around the world to react differently. In Europe, for example, bioengineering is generally regulated from a *process* approach. This means that governments tell researchers which processes are acceptable and which ones are not. In the United States bioengineering is regulated from a *product* approach. This means the government regulates what can and cannot be produced. The ban on human cloning is a good example. This approach allows regulation of the bioengineering industry mostly through existing laws and regulations. Despite the regulation of bioengineered products, people all over the world are still worried about safety. To help educate the public and sell more products, companies spend a lot of time and money on advertising. Probably the most apparent example is the modified seeds that are advertised and sold to farmers.

Challenge

Select a bioengineered product and create a comprehensive marketing campaign. The campaign must explain the target audience, the methods you will use to reach this audience, and how you will determine the effectiveness of your campaign. Be sure to include the advertising mediums you will use (e.g., radio, television, Internet, newspaper) and sample ads for each medium.

Objectives

Upon completion of this design brief, students will be able to do the following:

- Identify a target audience for a given product.
- Identify the ethical, legal, and social issues associated with a bioengineered product.
- Select appropriate advertising mediums for a specific audience.
- Use creativity in the production of an advertisement.
- Analyze the impact of an advertisement.

Materials

- Sample advertisements from radio, television, Internet, newspaper, magazines, and other sources
- Computers with word processing and Internet software
- Computer printers and paper
- Optional: Scanner, digital camera, and audio and video equipment

References

- Sanders, M.E. (1997). *Communication Technology: Today and Tomorrow* (2nd ed.). Peoria, IL: Glencoe/McGraw-Hill.

Design Briefs: Marketing Bioengineered Products

Evaluation

Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from student design portfolios containing brainstorming and documentation of source material.

	Excellent	Average	Unacceptable
Identify a target audience for a given product.	The student explains in writing the age, gender, and interests of the target audience. Explanations also include this information for similar products and sales data on these similar products.	The student explains in writing the age, gender, and interests of the target audience.	The student cannot explain in writing the age, gender, and interests of the target audience.
Identify the ethical, legal, and social issues associated with a bioengineered product.	Descriptions include a comprehensive list (>15) of ethical, legal, and social issues. The student can explain each of these issues.	Descriptions include a good list of milestones (6-15) of ethical, legal, and social issues. The student can explain each of these issues.	Descriptions include a short list (1-5) of ethical, legal, and social issues. The student can explain each of these issues.
Select appropriate advertising mediums for a specific audience.	Students select the best radio station, television station, newspaper, and magazine for the demographic they identified in the first objective. Students are also able to write down 5 or more strategies for marketing on the Internet and other nontraditional avenues.	Students select the best radio station, television station, newspaper, and magazine for the demographic they identified in the first objective. Students are also able to write down 1-4 strategies for marketing on the Internet and other nontraditional avenues.	Students cannot select the best radio station, television station, newspaper, and magazine for the demographic they identified in the first objective. Students are not able to write down strategies for marketing on the Internet and other nontraditional avenues.
Analyze the impact of an advertisement.	The student researches advertising campaigns for similar products and can list 5 or more positive and 5 or more negative strategies. The student correctly explains in writing all of the findings.	The student researches advertising campaigns for similar products and can list 1-4 positive and 1-4 negative strategies. The student correctly explains in writing all of the findings.	The student researches advertising campaigns for similar products but cannot list positive or negative strategies.

Presenting... Bioengineering!

Context

Bioengineering is starting to gain more coverage in newspapers, magazines, television, and other sources. Popular news sources, however, often do not cover these technologies in much depth. To become technologically literate, you must learn to assess technology by using a variety of sources and by comparing and contrasting new and existing technologies.

As you have learned in your technology class and from surfing the Internet, not all research is boring or tedious! Learning about new and emerging technologies is often fun since technology plays such a significant part in our everyday lives.

Challenge

You will work individually to create a presentation on a topic related to bioengineering. You will have five days to research and assemble an electronic presentation. Each student will then present his/her topic to the class. Here are some possible presentation topics:

- Technology transfer of bioengineering developments
- Terms and concepts
- Materials used in prosthetics and implants
- Milestones
- DNA modification process
- Careers
- Bioelectronics and biomolecular systems
- Medical applications and instrumentation
- Tissue culture
- Foods, medicines, and products
- How mathematics and science are used in bioengineering
- Artificial organs and xenotransplantation
- Nanotechnology
- Other topics identified by you or your instructor.

Use the library, popular media sources, and the Internet for researching your topic. Be sure to give credit to any sources and to always use copyright-free artwork, video, and audio.

Objectives

Upon completion of this design brief, students will be able to do the following:

- Research new and emerging bioengineering technologies.
- Use a variety of sources for researching a bioengineering topic.
- Illustrate the positive and negative issues related to a bioengineering topic.
- Create a presentation using presentation software.
- Demonstrate professional presentation skills.

Materials

- Computers with Internet connections
- Storyboard sheets for planning
- Presentation software
- Presentation computer with a projector
- Optional materials: Scanners, clip art, digital cameras, audio software, and video software

Design Briefs: Presenting... Bioengineering!

References

- Bains, W. (1998). *Biotechnology from A to Z*. New York, NY: Oxford University Press.
- Fleschar, M.H., and Nill, K.R. (1993). *Glossary of Biotechnology Terms*. Lancaster, PA: Technomic Publishing Company, Inc.
- Coombs, J. (1986). *Dictionary of Biotechnology*. New York, NY: Elsevier Science Publishing, Co., Inc.
- “The Top 100 Sites.” *Genetic Engineering News*. Larchmont, NY.
<http://www.genengnews.com/top100.asp>
- Virginia’s Center for Innovative Technology. <http://www.vabio.org/>

Evaluation

- Presentation should be approximately 10 minutes long with time for questions and discussion at the end.
- Design must include 12-15 electronic slides.
- Design must include at least three images, tables, and/or illustrations.

Use the evaluation sheet on the next page to evaluate student presentations. Additional assessment could come from student lesson outlines and documentation of source material.

Design Briefs: Presenting... Bioengineering!

Student Presentation Evaluation

Student: _____ **Date:** _____

Lesson Title: _____

Instructions: Circle the number most closely representing the quality you observed.

Rating Scale: 4 = Excellent; 3 = Good; 2 = Average; 1 = Poor/Unsatisfactory; NA= Did Not Observe

I. Preparation

Did the presenter:

- | | | | | | |
|--|----|---|---|---|---|
| A. relate the material to the students' past knowledge or experience? | NA | 1 | 2 | 3 | 4 |
| B. state specifically <i>what</i> the presentation objectives were and <i>why</i> the objectives were important to the students? | NA | 1 | 2 | 3 | 4 |
| C. demonstrate a thorough understanding of the content? | NA | 1 | 2 | 3 | 4 |

Comments about preparation:

II. Presentation

Did the presenter:

- | | | | | | |
|--|----|---|---|---|---|
| A. talk to the students and not to the instructional materials? | NA | 1 | 2 | 3 | 4 |
| B. present each idea or step in a logical sequence? | NA | 1 | 2 | 3 | 4 |
| C. present only one idea or method at a time? | NA | 1 | 2 | 3 | 4 |
| D. present the information or skill with ease? | NA | 1 | 2 | 3 | 4 |
| E. use instructional materials that enhance the lesson? | NA | 1 | 2 | 3 | 4 |
| F. provide an opportunity for students' response and/or participation? | NA | 1 | 2 | 3 | 4 |
| G. vary the pace and methods of conducting the presentation? | NA | 1 | 2 | 3 | 4 |
| H. react favorably to students' questions, answers, and comments? | NA | 1 | 2 | 3 | 4 |
| I. use instructional materials and equipment correctly? | NA | 1 | 2 | 3 | 4 |

Comments about presentation:

Safety First

Context

Anyone working in a technological or scientific area will tell you that safety is always a primary concern. In technological fields, safety focuses on procedures as well as tool and equipment use. Procedures and tool and equipment use are also very important in scientific fields, but so are sterilization and material handling. Bioengineering poses unique safety challenges because it is so diverse and draws upon procedures used in science and technology.

Challenge

Your teacher has explained what you will study during this course and the types of activities you will be doing throughout the year. Many of the class activities involve the use of equipment and materials. Your challenge is to review the activities, equipment, rules, and safety procedures discussed by your teacher and create a brochure or poster on safety. You must include all of the necessary information in a clear, easy to understand manner. Be sure to use good design principles, such as the efficient use of white space, and clearly written text.

Objectives

Upon completion of this design brief, students will be able to do the following:

- Identify laboratory rules and procedures.
- Identify correct laboratory safety procedures.
- Create a printed communication on correct laboratory safety.
- Use appropriate graphic design to convey a message.

Materials

- Sample brochures and posters
- A printed copy of the classroom/laboratory safety rules and procedures
- Computers with desktop publishing software and royalty-free clip art
- Computer printer and paper
- Optional: digital camera and scanner

References

- Kreuzer, H.K., and Massey, A. (1996). *Recombinant DNA and Biotechnology: A Guide for Students*. Washington, DC: ASM Press.
- Wells, J.G. (2000). *Technology Education Biotechnology Curriculum*. Morgantown, WV: West Virginia University. Technology Education Program. <http://www.te-biotech.wvu.edu/default.htm>

Design Briefs: Safety First

Evaluation

Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from student design portfolios containing brainstorming and documentation of source material.

	Excellent	Average	Unacceptable
Identify laboratory rules and procedures.	Clearly lists all rules and procedures explained by the teacher.	Clearly lists at least 80% of the rules and procedures explained by the teacher.	Clearly lists less than 80% of the rules and procedures explained by the teacher.
Identify correct laboratory safety procedures.	Clearly lists all safety procedures explained by the teacher.	Clearly lists at least 80% of the safety procedures explained by the teacher.	Clearly lists less than 80% of the safety procedures explained by the teacher.
Create a printed communication on correct laboratory safety.	Brochure or poster includes all laboratory rules, procedures, and safety procedures. Explanations and graphics complement the rules and procedures.	Brochure or poster includes all laboratory rules, procedures, and safety procedures. Explanations and graphics do not complement the rules and procedures.	Brochure or poster is missing laboratory rules, procedures, or safety procedures. Explanations and graphics do not complement the rules and procedures.
Use appropriate graphic design to convey a message.	Appropriate graphic design includes a balance among text, graphics, and white space. No more than three fonts are used and the intended purpose of the message is clear.	Appropriate graphic design includes a balance among text, graphics, and white space. No more than three fonts are used but the intended purpose of the message is not clear.	The graphic design does not include a balance among text, graphics, and white space. More than three fonts are used, and the intended purpose of the message is not clear.

Tasty Technology

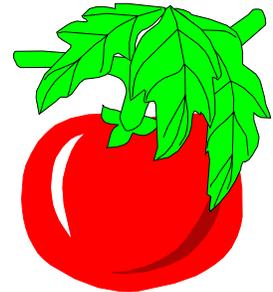
Context

Humans have altered their food supply for centuries through the use of seed selection and animal husbandry practices. New technologies allow for modifications that probably would never happen in the natural world. Many tomatoes, for example, have been designed to have thicker skins so they can be picked by automated equipment without bruising. Most people do not understand how these foods are modified, but the majority of processes simply alter undesired traits. The Food and Drug Administration (FDA) and other organizations closely monitor the modification of foods.

Challenge

Develop a taste-test for modified and unmodified foods. Foods might include organic and modified tomatoes and watermelons with seeds and those modified without seeds.

Develop a survey that asks participants their impression of modified and unmodified foods during the taste-test. Enter the results into a spreadsheet program so you can create tables and charts to represent your results. You will need to present your results to the class once your analysis is complete.



Objectives

Upon completion of this design brief, students will be able to do the following:

- Develop a survey instrument and collect data.
- Enter data into a spreadsheet for analysis.
- Analyze research data.
- Produce a graphic based on spreadsheet data.
- Report research findings.

Materials

- Several fruits and vegetables that have been modified and several that have not been modified
- Plates, napkins, and assorted utensils
- Computer with word processing and spreadsheet software
- Paper for survey and research findings

References

- Morris, B. (1995). *Science and Our Future: Biotechnology*. New York, NY: Cambridge University Press.
- *Biotechnology: An Information Resource*. Web site of the National Agricultural Library. Beltsville, MD: U.S. Department of Agriculture. <http://www.nal.usda.gov/bic/>

Design Briefs: Tasty Technology

Evaluation

Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from an instructor-prepared quiz or test on research methods.

	Excellent	Average	Unacceptable
Develop a survey instrument and collect data.	Survey questions are ethical, clear, and easy to understand. Respondents will be anonymous or, if their identity is known, their responses will be kept confidential. Data collection is non-invasive and uses a paper and pencil instrument or interview procedures.	Survey questions are ethical but are not clear and easy to understand. Respondents will be anonymous or, if their identity is known, their responses will be kept confidential. Data collection is non-invasive and uses a paper and pencil instrument or interview procedures.	Survey questions are not ethical, clear, and easy to understand. Respondents will not be anonymous or, if their identity is known, their responses will not be kept confidential. Data collection does not use standard survey procedures.
Enter data into a spreadsheet for analysis.	Variables are correctly established before data entry. Data are accurately keyed into spreadsheet software. The student writes formulas or utilizes existing formulas to summarize the data.	Variables are correctly established before data entry. Data are accurately keyed into spreadsheet software.	Variables are not correctly established before data entry. Data are not accurately keyed into spreadsheet software.
Analyze research data.	The student correctly explains in writing all of the findings.	The student correctly explains in writing at least 80% of the findings.	The student correctly explains in writing less than 80% of the findings.
Produce a graphic based on spreadsheet data.	Graphic was created directly from the data. The type of graphic makes the data easy to understand.	Graphic was created directly from the data. The type of graphic makes the data difficult to understand.	Graphic does not represent the data. The type of graphic makes the data difficult to understand.

Report research findings. To evaluate this objective, use the evaluation sheet on the next page.

Design Briefs: Tasty Technology

Student Presentation Evaluation

Student: _____ **Date:** _____

Lesson Title: _____

Instructions: Circle the number most closely representing the quality you observed.

Rating Scale: 4 = Excellent; 3 = Good; 2 = Average; 1 = Poor/Unsatisfactory; NA= Did Not Observe

I. Preparation

Did the presenter:

- | | | | | | |
|--|----|---|---|---|---|
| A. relate the material to the students' past knowledge or experience? | NA | 1 | 2 | 3 | 4 |
| B. state specifically <i>what</i> the presentation objectives were and <i>why</i> the objectives were important to the students? | NA | 1 | 2 | 3 | 4 |
| C. demonstrate a thorough understanding of the content? | NA | 1 | 2 | 3 | 4 |

Comments about preparation:

II. Presentation

Did the presenter:

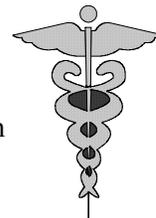
- | | | | | | |
|--|----|---|---|---|---|
| A. talk to the students and not to the instructional materials? | NA | 1 | 2 | 3 | 4 |
| B. present each idea or step in a logical sequence? | NA | 1 | 2 | 3 | 4 |
| C. present only one idea or method at a time? | NA | 1 | 2 | 3 | 4 |
| D. present the information or skill with ease? | NA | 1 | 2 | 3 | 4 |
| E. use instructional materials that enhance the lesson? | NA | 1 | 2 | 3 | 4 |
| F. provide an opportunity for students' response and/or participation? | NA | 1 | 2 | 3 | 4 |
| G. vary the pace and methods of conducting the presentation? | NA | 1 | 2 | 3 | 4 |
| H. react favorably to students' questions, answers, and comments? | NA | 1 | 2 | 3 | 4 |
| I. use instructional materials and equipment correctly? | NA | 1 | 2 | 3 | 4 |

Comments about presentation:

Vaccine

Context

The widespread manufacture of vaccines is a significant reason for the increased lifespan of humans during the past century. Vaccines for a variety of diseases are now required for babies born in the United States. The theory behind many vaccines is to expose the person with a weak version of the virus so his/her immune system can build antibodies to protect against the virus in the future.



Challenge

Working with cultures that are utilized in many vaccines is not feasible in a classroom for several reasons. Fortunately, you can learn about vaccine production through the use of interactive software. The public television program *NOVA* has developed a series of animations to help you learn about vaccine production. The diseases included are as follows:

- Small pox
- Measles
- Polio
- Tetanus
- Hepatitis B
- HIV.

Your challenge is to log into the *NOVA* vaccine Web site and go through the animations for each of the above diseases. The Web site is listed below in the *Materials* section.

Objectives

Upon completion of this design brief, students will be able to do the following:

- Use interactive, Web-based instructional materials.
- Describe the common methods used to produce vaccines.

Materials

- Computers with Internet connections
- *NOVA* Online. *Making Vaccines*. <http://www.pbs.org/wgbh/nova/bioterror/vaccines.html>

References

- Hill, W.E. (2000). *Genetic Engineering: A Primer*. Amsterdam, The Netherlands: Harwood Academic Publishers.
- *NOVA* Online. (2003). *Bioterror: Making Vaccines*. Public Broadcasting Service. <http://www.pbs.org/wgbh/nova/bioterror/vaccines.html>

Design Briefs: Vaccine

Evaluation

Use the rubric below to evaluate student work. The left column lists the performance elements that correspond to the objectives above. Additional assessment could come from an instructor prepared quiz or test.

	Excellent	Average	Unacceptable
Use interactive, Web-based instructional materials.	The student completed all six tutorials.	The student completed four of the six tutorials.	The student completed three or fewer of the six tutorials.
Describe the common methods used to produce vaccines.	The student can accurately describe how all six vaccines are produced.	The student can accurately describe how four of the six vaccines are produced.	The student can accurately describe how three or fewer vaccines are produced.

Related Information: Virginia's Academic Standards of Learning

A. Virginia's Academic Standards of Learning Correlated with Bioengineering

A list of Virginia Standards of Learning reinforced in Bioengineering is presented below. Additional standards may be reinforced, depending on local course requirements. For specific connections between the Standards of Learning and course tasks/competencies for Bioengineering, see individual task competency pages in this instructional framework.

English

- 11.1 The student will make informative and persuasive presentations.
- Gather and organize evidence to support a position.
 - Present evidence clearly and convincingly.
 - Support and defend ideas in public forums.
 - Use grammatically correct language, including vocabulary appropriate to the topic, audience, and purpose.
- 11.2 The student will analyze and evaluate informative and persuasive presentations.
- Critique the accuracy, relevance, and organization of evidence.
 - Critique the clarity and effectiveness of delivery.
- 11.4 The student will read and analyze a variety of informational materials.
- Use information from texts to clarify or refine understanding of academic concepts.
 - Read and follow directions to complete an application for college admission, for a scholarship, or for employment.
 - Apply concepts and use vocabulary in informational and technical materials to complete a task.
 - Generalize ideas from selections to make predictions about other texts.
 - Analyze information from a text to draw conclusions.
- 11.7 The student will write in a variety of forms, with an emphasis on persuasion.
- Generate, gather, plan, and organize ideas for writing.
 - Develop a focus for writing
 - Evaluate and cite applicable information.
 - Organize ideas in a logical manner.
 - Elaborate ideas clearly and accurately.
 - Adapt content, vocabulary, voice, and tone to audience, purpose, and situation.
 - Revise writing for accuracy and depth of information.
 - Proofread final copy and prepare document for intended audience or purpose.
- 11.9 The student will write, revise, and edit personal, professional, and informational correspondence to a standard acceptable in the workplace and higher education.
- Apply a variety of planning strategies to generate and organize ideas.
 - Organize information to support purpose and form of writing.
 - Present information in a logical manner.
 - Revise writing for clarity.
 - Use technology to access information, organize ideas, and develop writing.
- 11.10 The student will analyze, evaluate, synthesize, and organize information from a variety of sources to produce a research product.
- Narrow a topic.
 - Develop a plan for research.
 - Collect information to support a thesis.
 - Evaluate quality and accuracy of information.

Related Information: Virginia's Academic Standards of Learning

- e. Synthesize information in a logical sequence.
 - f. Document sources of information, using a style sheet, such as that of the Modern Language Association (MLA) or American Psychological Association (APA).
 - g. Edit writing for clarity of content and effect.
 - h. Edit copy for grammatically correct use of language, spelling, punctuation, and capitalization.
 - i. Proofread final copy and prepare for publication or submission.
 - j. Use technology to access information, organize ideas, and develop writing.
- 12.1 The student will make a 5 to 10 minute formal oral presentation.
- a. Choose the purpose of the presentation: to defend a position, to entertain an audience, or to explain information.
 - b. Use a well-structured narrative or logical argument.
 - c. Use details, illustrations, statistics, comparisons, and analogies to support purposes.
 - d. Use visual aids or technology to support presentation.
 - e. Use grammatically correct language, including vocabulary appropriate to the topic, audience, and purpose.
- 12.2 The student will evaluate formal presentations.
- a. Critique relationships among purpose, audience, and content of presentations.
 - b. Critique effectiveness of presentations.
- 12.4 The student will read and analyze a variety of informational materials, including electronic resources.
- a. Identify formats common to new publications and information resources.
 - b. Recognize and apply specialized informational vocabulary.
 - c. Evaluate a product based on analysis of the accompanying warranty and instruction manual.
 - d. Evaluate the quality of informational and technical materials.
- 12.7 The student will develop expository and informational writings.
- a. Generate, gather, and organize ideas for writing.
 - b. Consider audience and purpose when planning for writing.
 - c. Write analytically about literary, informational, and visual materials.
 - d. Elaborate ideas clearly and accurately.
 - e. Revise writing for depth of information and technique of presentation.
 - f. Apply grammatical conventions to edit writing for correct use of language, spelling, punctuation, and capitalization.
 - g. Proofread final copy and prepare document for publication or submission.
- 12.8 The student will write documented research papers.
- a. Identify and understand the ethical issues of research and documentation.
 - b. Evaluate the accuracy and usefulness of information.
 - c. Synthesize information to support the thesis.
 - d. Present information in a logical manner.
 - e. Cite sources of information, using a standard method of documentation, such as that of the Modern Language Association (MLA) or American Psychological Association (APA).
 - f. Edit copies for correct use of language, spelling, punctuation, and capitalization.
 - g. Proofread final copy and prepare document for publication or submission.

Related Information: Virginia's Academic Standards of Learning

History and Social Science

- WHII.1 The student will improve skills in historical research and geographical analysis by
- identifying, analyzing, and interpreting primary and secondary sources to make generalizations about events and life in world history since 1500 A.D.;
 - using maps, globes, artifacts, and pictures to analyze the physical and cultural landscapes of the world and to interpret the past since 1500 A.D.;
 - identifying geographic features important to the study of world history since 1500 A.D.;
 - identifying and comparing political boundaries with the location of civilizations, empires, and kingdoms from 1500 A.D. to the present;
 - analyzing trends in human migration and cultural interaction from 1500 A.D. to the present.
- WHII.2 The student will demonstrate an understanding of the political, cultural, and economic conditions in the world about 1500 A.D. by
- locating major states and empires;
 - describing artistic, literary, and intellectual ideas of the Renaissance;
 - describing the distribution of major religions;
 - analyzing major trade patterns;
 - citing major technological and scientific exchanges in the Eastern Hemisphere.
- WHII.6 The student will demonstrate knowledge of scientific, political, economic, and religious changes during the sixteenth, seventeenth, and eighteenth centuries by
- describing the Scientific Revolution and its effects;
 - describing the Age of Absolutism, including the monarchies of Louis XIV, Frederick the Great, and Peter the Great;
 - assessing the impacts of the English Civil War and the Glorious Revolution on democracy;
 - explaining the political, religious, and social ideas of the Enlightenment and the ways in which they influenced the founders of the United States;
 - describing the French Revolution;
 - identifying the impact of the American and French Revolutions on Latin America;
 - describing the expansion of the arts, philosophy, literature, and new technology.
- WHII.8 The student will demonstrate knowledge of the effects of the Industrial Revolution during the nineteenth century by
- citing scientific, technological, and industrial developments and explaining how they brought about urbanization and social and environmental changes;
 - explaining the emergence of capitalism as a dominant economic pattern, and subsequent development of socialism and communism;
 - describing the evolution of the nature of work and the labor force, including its effects on families, the status of women and children, the slave trade, and the labor union movement;
 - explaining the rise of industrial economies and their link to imperialism and nationalism;
 - assessing the impact of European economic and military power on Asia and Africa, with emphasis on the competition for resources and the responses of colonized peoples.
- WHII.11 The student will demonstrate knowledge of the worldwide impact of World War II by
- explaining economic and political causes, major events, and identifying leaders of the war, with emphasis on Franklin D. Roosevelt, Harry Truman, Dwight D. Eisenhower, Douglas MacArthur, George Marshall, Winston Churchill, Joseph Stalin, Adolf Hitler, Hideki Tojo, and Hirohito;
 - examining the Holocaust and other examples of genocide in the twentieth century;
 - explaining the terms of the peace, the war crimes trials, the division of Europe, plans to rebuild Germany and Japan, and the creation of international cooperative organizations.

Related Information: Virginia's Academic Standards of Learning

- WHII.12 The student will demonstrate knowledge of major events and outcomes of the Cold War by
- explaining key events of the Cold War, including the competition between the American and Soviet economic and political systems and the causes of the collapse of communism in the Soviet Union and Eastern Europe;
 - assessing the impact of nuclear weaponry on patterns of conflict and cooperation since 1945;
 - describing conflicts and revolutionary movements in eastern Asia, including those in China and Vietnam, and their major leaders, i.e., Mao Tse-tung (Zedong), Chiang Kai-shek, and Ho Chi Minh.
- WHII.15 The student will demonstrate knowledge of cultural, economic, and social conditions in developed and developing nations of the contemporary world by
- identifying contemporary political issues, with emphasis on migrations of refugees and others, ethnic/religious conflicts, and the impact of technology, including chemical and biological technologies;
 - assessing the impact of economic development and global population growth on the environment and society, including an understanding of the links between economic and political freedom;
 - describing economic interdependence, including the rise of multinational corporations, international organizations, and trade agreements.
- WG.1 The student will use maps, globes, photographs, and pictures in order to
- obtain geographical information and apply the concepts of location, scale, and orientation;
 - develop and refine his or her mental maps of world regions;
 - create and compare political, physical, and thematic maps;
 - analyze and explain how different cultures develop different perspectives on the world and its problems;
 - recognize different map projections and explain the concept of distortion.
- WG.2 The student will analyze how selected physical and ecological processes shape the Earth's surface by
- identifying regional climatic patterns and weather phenomena and their effects on people and places;
 - describing how humans influence the environment and are influenced by it;
 - explaining how technology affects one's ability to modify the environment and adapt to it.
- WG.6 The student will analyze past and present trends in human migration and cultural interaction as they are influenced by social, economic, political, and environmental factors.
- WG.7 The student will identify natural, human, and capital resources and explain their significance by
- showing patterns of economic activity and land use;
 - evaluating perspectives and consequences regarding the use of resources.
- WG.9 The student will analyze the global patterns and networks of economic interdependence by
- identifying criteria that influence economic activities;
 - explaining comparative advantage and its relationship to international trade;
 - describing ways that economic and social interactions have changed over time;
 - describing and evaluating the formation of economic unions.
- WG.11 The student will analyze the patterns of urban development by
- applying the concepts of site and situation to major cities in each region;
 - explaining how the functions of towns and cities have changed over time;
 - describing the unique influence of urban areas and some challenges they face.

Related Information: Virginia's Academic Standards of Learning

- WG.12 The student will apply geography to interpret the past, understand the present, and plan for the future by
- using geographic knowledge, skills, and perspectives to analyze problems and make decisions;
 - relating current events to the physical and human characteristics of places and regions.
- VUS.1 The student will demonstrate skills for historical and geographical analysis, including the ability to
- identify, analyze, and interpret primary and secondary source documents, records, and data, including artifacts, diaries, letters, photographs, journals, newspapers, historical accounts, and art to increase understanding of events and life in the United States;
 - evaluate the authenticity, authority, and credibility of sources;
 - formulate historical questions and defend findings based on inquiry and interpretation;
 - develop perspectives of time and place, including the construction of maps and various time lines of events, periods, and personalities in American history;
 - communicate findings orally and in analytical essays and/or comprehensive papers;
 - develop skills in discussion, debate, and persuasive writing with respect to enduring issues and determine how divergent viewpoints have been addressed and reconciled;
 - apply geographic skills and reference sources to understand how relationships between humans and their environment have changed over time;
 - interpret the significance of excerpts from famous speeches and other documents.
- VUS.4 The student will demonstrate knowledge of events and issues of the Revolutionary Period by
- analyzing how the political ideas of John Locke and those expressed in Common Sense helped shape the Declaration of Independence;
 - describing the political differences among the colonists concerning separation from Britain;
 - analyzing reasons for colonial victory in the Revolutionary War.
- VUS.5 The student will demonstrate knowledge of the issues involved in the creation and ratification of the United States Constitution and how the principles of limited government, consent of the governed, and the social contract are embodied in it by
- explaining the origins of the Constitution, including the Articles of Confederation;
 - identifying the major compromises necessary to produce the Constitution, and the roles of James Madison and George Washington;
 - describing the conflict over ratification, including the Bill of Rights and the arguments of the Federalists and Anti-Federalists;
 - examining the significance of the Virginia Declaration of Rights and the Virginia Statute for Religious Freedom in the framing of the Bill of Rights.
- VUS.14 The student will demonstrate knowledge of economic, social, cultural, and political developments in the contemporary United States by
- analyzing the effects of increased participation of women in the labor force;
 - analyzing how changing patterns of immigration affect the diversity of the United States population, the reasons new immigrants choose to come to this country, and their contributions to contemporary America;
 - explaining the media influence on contemporary American culture and how scientific and technological advances affect the workplace, health care, and education.

Related Information: Virginia's Academic Standards of Learning

- GOVT.1 The student will demonstrate mastery of the social studies skills citizenship requires, including the ability to
- analyze primary and secondary source documents;
 - create and interpret maps, diagrams, tables, charts, graphs, and spreadsheets;
 - analyze political cartoons, political advertisements, pictures, and other graphic media;
 - distinguish between relevant and irrelevant information;
 - evaluate information for accuracy, separating fact from opinion;
 - identify a problem and prioritize solutions;
 - select and defend positions in writing, discussion, and debate.
- GOVT.3 The student will demonstrate knowledge of the concepts of democracy by
- recognizing the fundamental worth and dignity of the individual;
 - recognizing the equality of all citizens under the law;
 - recognizing majority rule and minority rights;
 - recognizing the necessity of compromise;
 - recognizing the freedom of the individual.
- GOVT.6 The student will demonstrate knowledge of local, state, and national elections by
- describing the organization, role, and constituencies of political parties;
 - describing the nomination and election process;
 - examining campaign funding and spending;
 - analyzing the influence of media coverage, campaign advertising, and public opinion polls;
 - examining the impact of reapportionment and redistricting;
 - identifying how amendments extend the right to vote;
 - analyzing voter turnout.
- GOVT.9 The student will demonstrate knowledge of the process by which public policy is made by
- examining different perspectives on the role of government;
 - explaining how local, state, and national governments formulate public policy;
 - describing the process by which policy is implemented by the bureaucracy at each level;
 - analyzing how individuals, interest groups, and the media influence public policy.
- GOVT.14 The student will demonstrate knowledge of economic systems by
- identifying the basic economic questions encountered by all economic systems;
 - comparing the characteristics of free market, command, and mixed economies, as described by Adam Smith and Karl Marx;
 - evaluating the impact of the government's role in the economy on individual economic freedoms;
 - explaining the relationship between economic freedom and political freedom;
 - examining productivity and the standard of living as measured by key economic indicators.
- GOVT.15 The student will demonstrate knowledge of the United States market economy by
- assessing the importance of entrepreneurship, the profit motive, and economic independence to the promotion of economic growth;
 - comparing types of business organizations;
 - describing the factors of production;
 - explaining the interaction of supply and demand;
 - illustrating the circular flow of economic activity;
 - analyzing global economic trends, with emphasis on the impact of technological innovations.

Related Information: Virginia's Academic Standards of Learning

- GOVT.16 The student will demonstrate knowledge of the role of government in the Virginia and United States economies by
- analyzing the impact of fiscal and monetary policies on the economy;
 - describing the creation of public goods and services;
 - examining environmental issues, property rights, contracts, consumer rights, labor-management relations, and competition in the marketplace.
- GOVT.17 The student will demonstrate knowledge of personal character traits that facilitate thoughtful and effective participation in civic life by
- practicing trustworthiness and honesty;
 - practicing courtesy and respect for the rights of others;
 - practicing responsibility, accountability, and self-reliance;
 - practicing respect for the law;
 - practicing patriotism.

Mathematics

- A.4 The student will use matrices to organize and manipulate data, including matrix addition, subtraction, and scalar multiplication. Data will arise from business, industrial, and consumer situations.
- A.16 The student will, given a set of data points, write an equation for a line of best fit and use the equation to make predictions.
- A.18 The student will analyze a relation to determine whether a direct variation exists and represent it algebraically and graphically, if possible.
- G.2 The student will use pictorial representations, including computer software, constructions, and coordinate methods, to solve problems involving symmetry and transformation. This will include
- investigating and using formulas for finding distance, midpoint, and slope;
 - investigating symmetry and determining whether a figure is symmetric with respect to a line or a point; and
 - determining whether a figure has been translated, reflected, or rotated.
- G.10 The student will investigate and solve practical problems involving circles, using properties of angles, arcs, chords, tangents, and secants. Problems will include finding arc length and the area of a sector, and may be drawn from applications of architecture, art, and construction.
- G.12 The student will make a model of a three-dimensional figure from a two-dimensional drawing and make a two-dimensional representation of a three-dimensional object. Models and representations will include scale drawings, perspective drawings, blueprints, or computer simulations.
- G.13 The student will use formulas for surface area and volume of three-dimensional objects to solve practical problems. Calculators will be used to find decimal approximations for results.
- AII.1 The student will identify field properties, axioms of equality and inequality, and properties of order that are valid for the set of real numbers and its subsets, complex numbers, and matrices.
- AII.2 The student will add, subtract, multiply, divide, and simplify rational expressions, including complex fractions.

Related Information: Virginia's Academic Standards of Learning

- T.1 The student will use the definitions of the six trigonometric functions to find the sine, cosine, tangent, cotangent, secant, and cosecant of an angle in standard position, given a point, other than the origin, on the terminal side of the angle. Circular function definitions will be connected with trigonometric function definitions.
- T.2 The student, given the value of one trigonometric function, will find the values of the other trigonometric functions. Properties of the unit circle and definitions of circular functions will be applied.
- COM.1 The student will apply programming techniques and skills to solve practical problems in mathematics arising from consumer, business, other applications in mathematics. Problems will include opportunities for students to analyze data in charts, graphs, and tables and to use their knowledge of equations, formulas, and functions to solve these problems.
- COM.4 The student will design a step-by-step plan (algorithm) to solve a given problem. The plan will be in the form of a program flowchart, pseudo code, hierarchy chart, and/or data-flow diagram.
- COM.5 The student will divide a given problem into manageable sections (modules) by task and implement the solution. The modules will include an appropriate user-defined function, subroutines, and procedures. Enrichment topics might include user-defined libraries (units) and object-oriented programming.
- COM.6 The student will design and implement the input phase of a program, which will include designing screen layout and getting information into the program by way of user interaction, data statements, and/or file input. The input phase also will include methods of filtering out invalid data (error trapping).
- COM.8 The student will design and implement computer graphics, which will include topics appropriate for the available programming environment as well as student background. Students will use graphics as an end in itself, as an enhancement to other output, and as a vehicle for reinforcing programming techniques.
- COM.11 The student will describe the way the computer stores, accesses, and processes variables, including the following topics: the use of variables versus constants, variables addresses, pointers, parameter passing, scope of variables, and local versus global variables.
- COM.14 The student will implement conditional statements that include "if/then" statements, "if/then/else" statements, case statements, and Boolean logic.
- COM.16 The student will select and implement appropriate data structures, including arrays (one-dimensional and/or multidimensional), files, and records. Implementation will include creating the data structure, putting information into the structure, and retrieving information from the structure.
- PS.1 The student will analyze graphical displays of data, including dotplots, stemplots, and histograms, to identify and describe patterns and departures from patterns, using central tendency, spread, clusters, gaps, and outliers. Appropriate technology will be used to create graphical displays.
- PS.2 The student will analyze numerical characteristics of univariate data sets to describe patterns and departure from patterns, using mean, median, mode, variance, standard deviation, interquartile range, range, and outliers. Appropriate technology will be used to calculate statistics.

Related Information: Virginia's Academic Standards of Learning

- PS.3 The student will compare distributions of two or more univariate data sets, analyzing center and spread (within group and between group variations), clusters and gaps, shapes, outliers, or other unusual features. Appropriate technology will be used to generate graphical displays.
- PS.7 The student, using two-way tables, will analyze categorical data to describe patterns and departure from patterns and to find marginal frequency and relative frequencies, including conditional frequencies.
- PS.8 The student will describe the methods of data collection in a census, sample survey, experiment, and observational study and identify an appropriate method of solution for a given problem setting.
- PS.10 The student will plan and conduct an experiment. The plan will address control, randomization, and measurement of experimental error.
- PS.12 The student will identify and describe two or more events as complementary, dependent, independent, and/or mutually exclusive.
- PS.13 The student will find probabilities (relative frequency and theoretical), including conditional probabilities for events that are either dependent or independent, by applying the "law of large numbers" concept, the addition rule, and the multiplication rule.
- PS.17 The student will identify properties of a normal distribution and apply the normal distribution to determine probabilities, using a table or graphing calculator.
- PS.18 The student, given data from a large sample, will find and interpret point estimates and confidence intervals for parameters. The parameters will include proportion and mean, difference between two proportions, and difference between two means (independent and paired).
- PS.19 The student will apply and interpret the logic of a hypothesis-testing procedure. Tests will include large sample test for proportion, mean, difference between two proportions, and difference between two means (independent and paired) and Chi-squared test for goodness of fit, homogeneity of proportions, and independence.

Science

- ES.1 The student will plan and conduct investigations in which
- volume, area, mass, elapsed time, direction, temperature, pressure, distance, density, and changes in elevation/depth are calculated utilizing the most appropriate tools;
 - technologies including computers, probeware, and global positioning systems (GPS), are used to collect, analyze, and report data and to demonstrate concepts and simulate experimental conditions;
 - scales, diagrams, maps, charts, graphs, tables, and profiles are constructed and interpreted;
 - variables are manipulated with repeated trials; and
 - a scientific viewpoint is constructed and defended (the nature of science).
- ES.2 The student will demonstrate scientific reasoning and logic by
- analyzing how science explains and predicts the interactions and dynamics of complex Earth systems;
 - recognizing that evidence is required to evaluate hypotheses and explanations;
 - comparing different scientific explanations for a set of observations about the Earth;
 - explaining that observation and logic are essential for reaching a conclusion; and
 - evaluating evidence for scientific theories.

Related Information: Virginia's Academic Standards of Learning

- ES.7 The student will investigate and understand the differences between renewable and nonrenewable resources. Key concepts include
- fossil fuels, minerals, rocks, water, and vegetation;
 - advantages and disadvantages of various energy sources;
 - resources found in Virginia;
 - making informed judgments related to resource use and its effects on Earth systems; and
 - environmental costs and benefits.
- ES.9 The student will investigate and understand how freshwater resources are influenced by geologic processes and the activities of humans. Key concepts include
- processes of soil development;
 - development of karst topography;
 - identification of groundwater zones including water table, zone of saturation, and zone of aeration;
 - identification of other sources of fresh water including rivers, springs, and aquifers with reference to the hydrologic cycle;
 - dependence on freshwater resources and the effects of human usage on water quality; and
 - identification of the major watershed systems in Virginia including the Chesapeake Bay and its tributaries.
- ES.11 The student will investigate and understand that oceans are complex, interactive physical, chemical, and biological systems and are subject to long- and short-term variations. Key concepts include
- physical and chemical changes (tides, waves, currents, sea level and ice cap variations, upwelling, and salinity variations);
 - importance of environmental and geologic implications;
 - systems interactions (density differences, energy transfer, weather, and climate);
 - features of the sea floor (continental margins, trenches, mid-ocean ridges, and abyssal plains) as reflections of tectonic processes; and
 - economic and public policy issues concerning the oceans and the coastal zone, including the Chesapeake Bay.
- ES.12 The student will investigate and understand the origin and evolution of the atmosphere and the interrelationship of geologic processes, biologic processes, and human activities on its composition and dynamics. Key concepts include
- scientific evidence for atmospheric changes over geologic time;
 - current theories related to the effects of early life on the chemical makeup of the atmosphere;
 - comparison of the Earth's atmosphere to that of other planets;
 - atmospheric regulation mechanisms including the effects of density differences and energy transfer; and
 - potential atmospheric compositional changes due to human, biologic, and geologic activity.
- BIO.1 The student will plan and conduct investigations in which
- observations of living organisms are recorded in the lab and in the field;
 - hypotheses are formulated based on direct observations and information from the scientific literature;
 - variables are defined and investigations are designed to test hypotheses;
 - graphing and arithmetic calculations are used as tools in data analysis;
 - conclusions are formed based on recorded quantitative and qualitative data;

Related Information: Virginia's Academic Standards of Learning

- f. sources of error inherent in experimental design are identified and discussed;
- g. validity of data is determined;
- h. chemicals and equipment are used in a safe manner;
- i. appropriate technology, including computers, graphing calculators, and probeware, is used for gathering and analyzing data and communicating results;
- j. research utilizes scientific literature;
- k. differentiation is made between a scientific hypothesis and theory;
- l. alternative scientific explanations and models are recognized and analyzed; and
- m. a scientific viewpoint is constructed and defended (the nature of science).

- BIO.2 The student will investigate and understand the history of biological concepts. Key concepts include
- a. evidence supporting the cell theory;
 - b. scientific explanations of the development of organisms through time (biological evolution);
 - c. evidence supporting the germ theory of infectious disease;
 - d. development of the structural model of DNA ; and
 - e. the collaborative efforts of scientists, past and present.
- BIO.3 The student will investigate and understand the chemical and biochemical principles essential for life. Key concepts include
- a. water chemistry and its impact on life processes;
 - b. the structure and function of macromolecules;
 - c. the nature of enzymes; and
 - d. the capture, storage, transformation, and flow of energy through the processes of photosynthesis and respiration.
- BIO.4 The student will investigate and understand relationships between cell structure and function. Key concepts include
- a. characteristics of prokaryotic and eukaryotic cells;
 - b. exploring the diversity and variation of eukaryotes;
 - c. similarities between the activities of a single cell and a whole organism; and
 - d. the cell membrane model (diffusion, osmosis, and active transport).
- BIO.5 The student will investigate and understand life functions of archaeobacteria, monerans (eubacteria), protists, fungi, plants, and animals, including humans. Key concepts include
- a. how their structures and functions vary between and within the kingdoms;
 - b. comparison of their metabolic activities;
 - c. analyses of their responses to the environment;
 - d. maintenance of homeostasis;
 - e. human health issues, human anatomy, body systems, and life functions; and
 - f. how viruses compare with organisms.
- BIO.6 The student will investigate and understand common mechanisms of inheritance and protein synthesis. Key concepts include
- a. cell growth and division;
 - b. gamete formation;
 - c. cell specialization;
 - d. prediction of inheritance of traits based on the Mendelian laws of heredity;
 - e. genetic variation (mutation, recombination, deletions, additions to DNA) ;

Related Information: Virginia's Academic Standards of Learning

- f. the structure, function, and replication of nucleic acids (DNA and RNA);
 - g. events involved in the construction of proteins;
 - h. use, limitations, and misuse of genetic information; and
 - i. exploration of the impact of DNA technologies.
- BIO.7 The student will investigate and understand bases for modern classification systems. Key concepts include
- a. structural similarities among organisms;
 - b. fossil record interpretation;
 - c. comparison of developmental stages in different organisms;
 - d. examination of biochemical similarities and differences among organisms; and
 - e. systems of classification that are adaptable to new scientific discoveries.
- BIO.8 The student will investigate and understand how populations change through time. Key concepts include
- a. evidence found in fossil records;
 - b. how genetic variation, reproductive strategies, and environmental pressures impact the survival of populations;
 - c. how natural selection leads to adaptations;
 - d. emergence of new species; and
 - e. scientific explanations for biological evolution.
- BIO.9 The student will investigate and understand dynamic equilibria within populations, communities, and ecosystems. Key concepts include
- a. interactions within and among populations including carrying capacities, limiting factors, and growth curves;
 - b. nutrient cycling with energy flow through ecosystems;
 - c. succession patterns in ecosystems;
 - d. the effects of natural events and human activities on ecosystems; and
 - e. analysis of the flora, fauna, and microorganisms of Virginia ecosystems, including the Chesapeake Bay and its tributaries.
- CH.1 The student will investigate and understand that experiments in which variables are measured, analyzed, and evaluated produce observations and verifiable data. Key concepts include
- a. designated laboratory techniques;
 - b. safe use of chemicals and equipment;
 - c. proper response to emergency situations;
 - d. manipulation of multiple variables using repeated trials;
 - e. accurate recording, organization, and analysis of data through repeated trials;
 - f. mathematical and procedural error analysis;
 - g. mathematical manipulations (SI units, scientific notation, linear equations, graphing, ratio and proportion, significant digits, dimensional analysis);
 - h. use of appropriate technology including computers, graphing calculators, and probeware, for gathering data and communicating results; and
 - i. construction and defense of a scientific viewpoint (the nature of science).
- CH.3 The student will investigate and understand how conservation of energy and matter is expressed in chemical formulas and balanced equations. Key concepts include
- a. nomenclature;
 - b. balancing chemical equations;

Related Information: Virginia's Academic Standards of Learning

- c. writing chemical formulas (molecular, structural, and empirical; and Lewis diagrams);
- d. bonding types (ionic and covalent);
- e. reaction types (synthesis, decomposition, single and double replacement, oxidation-reduction, neutralization, exothermic, and endothermic); and
- f. reaction rates and kinetics (activation energy, catalysis, degree of randomness).

- CH.4 The student will investigate and understand that quantities in a chemical reaction are based on molar relationships. Key concepts include
- a. Avogadro's principle and molar volume;
 - b. stoichiometric relationships;
 - c. partial pressure;
 - d. gas laws;
 - e. solution concentrations;
 - f. chemical equilibrium; and
 - g. acid/base theory: strong electrolytes, weak electrolytes, and nonelectrolytes; dissociation and ionization; pH and pOH; and the titration process.
- PH.1 The student will plan and conduct investigations in which
- a. the components of a system are defined;
 - b. instruments are selected and used to extend observations and measurements of mass, volume, temperature, heat exchange, energy transformations, motion, fields, and electric charge;
 - c. information is recorded and presented in an organized format;
 - d. metric units are used in all measurements and calculations;
 - e. the limitations of the experimental apparatus and design are recognized;
 - f. the limitations of measured quantities are recognized through the appropriate use of significant figures or error ranges;
 - g. data gathered from non-SI instruments are incorporated through appropriate conversions; and
 - h. appropriate technology including computers, graphing calculators, and probeware, is used for gathering and analyzing data and communicating results.
- PH.2 The student will investigate and understand how to analyze and interpret data. Key concepts include
- a. a description of a physical problem is translated into a mathematical statement in order to find a solution;
 - b. relationships between physical quantities are determined using the shape of a curve passing through experimentally obtained data;
 - c. the slope of a linear relationship is calculated and includes appropriate units;
 - d. interpolated, extrapolated, and analyzed trends are used to make predictions; and
 - e. analysis of systems employs vector quantities utilizing trigonometric and graphical methods.
- PH.3 The student will investigate and understand how to demonstrate scientific reasoning and logic. Key concepts include
- a. analysis of scientific sources to develop and refine research hypotheses;
 - b. analysis of how science explains and predicts relationships;
 - c. evaluation of evidence for scientific theories;
 - d. examination of how new discoveries result in modification of existing theories or establishment of new paradigms; and
 - e. construction and defense of a scientific viewpoint (the nature of science).

Related Information: Virginia's Academic Standards of Learning

- PH.4 The student will investigate and understand how applications of physics affect the world. Key concepts include
- examples from the real world; and
 - exploration of the roles and contributions of science and technology.
- PH.7 The student will investigate and understand properties of fluids. Key concepts include
- density and pressure;
 - variation of pressure with depth;
 - Archimedes' principle of buoyancy;
 - Pascal's principle;
 - fluids in motion; and
 - Bernoulli's principle.
- PH.10 The student will investigate and understand that different frequencies and wavelengths in the electromagnetic spectrum are phenomena ranging from radio waves through visible light to gamma radiation. Key concepts include
- the properties and behaviors of radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays; and
 - current applications based on the wave properties of each band.
- PH.11 The student will investigate and understand, in describing optical systems, how light behaves in the fundamental processes of reflection, refraction, and image formation. Key concepts include
- application of the laws of reflection and refraction;
 - construction and interpretation of ray diagrams;
 - development and use of mirror and lens equations; and
 - predictions of type, size, and position of real and virtual images.
- PH.13 The student will investigate and understand how to diagram and construct basic electrical circuits and explain the function of various circuit components. Key concepts include
- Ohm's law;
 - series, parallel, and combined circuits; and
 - circuit components including resistors, batteries, generators, fuses, switches, and capacitors.

Related Information B: Computer/Technology Standards of Learning

B. Correlation to Virginia Computer/Technology Standards of Learning: Complete List

The Computer/Technology Standards by the End of Grades Five and Eight identify technology skills for improving student learning through the integration of technology across the curriculum. Mastery of these skills results in students who are both computer literate and competent in the application of technology tools to support their learning needs.

In grades nine through twelve, technology continues to be integrated across the curriculum. The goal is that students in these grades achieve a higher level of mastery in the application of technology in their learning. The following standards identify essential skills for the student's appropriate use of existing and emerging technology tools for communication, productivity, management, research, problem-solving, and decision making. Additional Computer/Technology Standards may be reinforced, depending on local course requirements.

C/T12.1 The student will demonstrate a basic understanding of fundamental computer operations and concepts.

- Successfully operate a multimedia computer system with related peripheral devices.
- Demonstrate touch-typing skills in computer use.
- Use terminology related to computers and technology appropriately in written and oral communications.
- Describe how imaging devices may be used with computer systems.
- Describe how computers may be connected to form a telecommunication network.
- Analyze and solve simple hardware and software problems.
- Identify new and emerging technologies.

C/T12.2 The student will use application software to accomplish a variety of learning tasks.

- Use advanced features of word processing, desktop publishing, graphics programs, and utilities in learning activities.
- Use spreadsheets for analyzing, organizing, and displaying numeric data graphically.
- Design and manipulate databases and generate customized reports.
- Use features of applications that integrate word processing, database, spreadsheet, telecommunication, and graphics.
- Identify, select, and integrate video and digital images in varying formats for creating multimedia presentations, publications and/or other products.
- Select, evaluate, and use appropriate technology for research and data collection.
- Apply specific-purpose electronic devices (such as a graphing calculator, scientific probeware, or multifunction keyboards) in appropriate content areas.

CT12.3 The student will develop skills in the use of telecommunications networks.

- Use local, wide area, and worldwide network communication systems to access, analyze, interpret, and synthesize information.
- Compare and contrast the use of local area networks, wide area networks, and worldwide networks.
- Access and use telecommunications tools and resources for information sharing, remote information access and retrieval, and multimedia/hypermedia publishing.
- Demonstrate an understanding of the concepts of broadcast instruction, audio/video conferencing, and other distance learning applications.
- Explain legal, personal safety, network etiquette, and ethical behaviors regarding the use of technology and information.

Related Information B: Computer/Technology Standards of Learning

C/T12.4 The student will demonstrate skill in the selection and use of appropriate technologies to gather, process and analyze data and to report information related to an investigation.

- Design and use a wide range of effective search strategies to acquire information.
- Use a wide variety of electronic media and databases to search for and retrieve information.
- Evaluate the usefulness, appropriateness, currency, and reliability of acquired information.
- Select appropriate technology for communicating information for an intended purpose and audience.
- Utilize a variety of media and resources in collaboration with peers, experts, and others to design a learning activity and/or presentation.
Appropriately cite electronic resources in gathering information.
- Apply Copyright and Fair Use Guidelines in reporting information.

Related Information C: Virginia's All Aspects of Industry

C. Virginia's All Aspects of Industry: Complete List

The All Aspects of Industry requirement of federal legislation is designed to provide students with a complete and clear picture of an industry they may plan to enter. So that students may compare potential careers, they should study the same elements of different industries. These elements are planning, management, finance, technical and production skills, underlying principles of technology, labor and community issues, health and safety, and environmental issues related to that industry.

1. Planning is examined at the level of both an individual business and the overall industry. Planning elements might include:

- Developing strategic plans---mission, vision, goals, objectives, and/or a plan of action
- Working with planning tools such as surveys, market research, and competitive analysis
- Anticipating needs for staffing and major purchases of equipment and supplies
- Developing plans for training and upgrading of staff
- Forecasting market trends
- Developing business plans for entrepreneurial ventures.

2. Management addresses methods typically used to manage enterprises over time within the industry, as well as methods for expanding and diversifying workers' tasks and broadening worker involvement in decisions. Key elements of management might include:

- Using an organization chart to explain how a corporate chain of command works
- Providing input for strategic plans and communicating the company's vision and mission statements
- Leading employees in carrying out strategic plans and action plans
- Evaluating employee performance
- Anticipating technology and other major purchasing needs
- Ensuring equity and access for employees
- Resolving conflicts
- Developing job descriptions and written policies/procedures
- Identifying recruitment procedures, training opportunities, methods of evaluation, and retention strategies
- Working with professional associations and community outreach efforts.

3. Finance examines ongoing accounting and financial decisions and different methods for raising capital to start or expand enterprises. Finance functions might include:

- Developing budgets
- Preparing financial statements
- Analyzing and managing financial transactions and records
- Implementing payroll procedures
- Determining and paying taxes
- Identifying indirect wage costs (benefits, FICA, insurance, worker's compensation)
- Making loans and granting credit to customers
- Developing graphs and charts related to company finances
- Identifying and implementing methods of sustaining profitability of a business
- Managing 401K plans
- Identifying sources of capital.

Related Information C: Virginia's All Aspects of Industry

- 4. Technical and Production Skills cover specific production techniques and alternative methods for organizing the production work, including methods that diversify and rotate workers' jobs. Technical and production skills that an employee should have to succeed in a business or industry might include:**
 - Developing and upgrading job-specific skills
 - Using troubleshooting and problem-solving techniques
 - Analyzing information to make decisions
 - Identifying and implementing quality assurance techniques
 - Employing communication skills such as writing, listening, speaking, and reading
 - Participating in team efforts
 - Implementing projects and new techniques
 - Demonstrating basic computer skills; employing time management techniques in completing projects and assigned tasks
 - Demonstrating ethical behavior and work ethic.

- 5. Underlying Principles of Technology provide an integrated study across the curriculum of the mathematical, scientific, social, and economic principles that underlie the industry's technology. Principles of technology that an employee should know might be demonstrated by:**
 - Exhibiting proficiency in mathematical and scientific functions related to new and emerging technologies
 - Continuously upgrading job skills needed to implement new technologies
 - Participating in industry certification programs
 - Cross-training to enhance one's value to the organization and to enhance job promotion opportunities
 - Understanding and adhering to ethical issues related to technologies.

- 6. Labor Issues examine worker rights and responsibilities, labor unions and labor history, and methods for expanding workers' roles. Labor issues might include:**
 - Understanding and implementing worker rights and responsibilities
 - Working with labor unions
 - Keeping abreast of local, state, and federal legislation affecting employee and employer rights and responsibilities
 - Negotiating and settling worker disputes
 - Identifying certification requirements for specific jobs
 - Analyzing the impact of labor agreements on business operations.

- 7. Community Issues explore the impact of the industry on the community and the community's impact on and involvement with the industry. Concepts of business and community relations might include:**
 - Developing and working with community outreach projects
 - Participating on advisory committees and community organizations
 - Working with professional associations
 - Developing and implementing public relations plans
 - Participating in community service projects.

Related Information C: Virginia's All Aspects of Industry

- 8. Health, Safety, and Environmental Issues** examine these concepts in relation to both the workers and the larger community. Concepts related to health, safety, and the environment might include:
- Identifying and implementing federal, state, and local regulations related to the health and safety of employees
 - Understanding and strictly adhering to federal, state, and local environmental regulations related to the business
 - Identifying job-specific health hazards and safety issues
 - Identifying and implementing basic safety and first aid training techniques for emergencies such as personal illness or injury, tornadoes, fires, nuclear accidents, floods, and incidences of employee rage or violent behavior
 - Communicating safety regulations and plans to employees
 - Working with selected community groups to implement safety programs.

Instructional activities to enhance the teaching of All Aspects of Industry are available in Teaching Virginia's All Aspects of Industry (CTE Resource Center, <http://www.CTEresource.org>, Catalog # 8.01.05).

Related Information D: Virginia's Workplace Readiness Skills

D. Virginia's Workplace Readiness Skills: Complete List

- 1. Demonstrate reading skills on a level required for employment in a chosen career field.**
Standard: Demonstration of reading skills includes
 - interpreting technical and general interest materials commonly used in this field
 - applying understanding of the material to job operations.

- 2. Demonstrate math skills on a level required for employment in a chosen career field.**
Standard: Demonstration of math skills includes
 - performing math operations using whole numbers, fractions, percentages
 - using statistics (percentages, averages, medians, and standard deviations) to monitor processes and quality of performance
 - using mathematical reasoning to solve word problems
 - using algebra-based formulas
 - performing job-specific math operations.

- 3. Demonstrate writing skills on a level required for employment in a chosen career field.**
Standard: Demonstration of writing skills involves composing and editing work-related documents of varying complexity, a process that includes
 - defining the purpose
 - determining the audience
 - gathering information
 - planning the format/layout
 - writing a first draft
 - editing and revising as necessary to ensure that the document is complete, clear, concise, correct, and considerate of the reader.

- 5. Demonstrate speaking and listening skills on a level required for employment in a chosen career field.**
Standard: Speaking and listening skills involve the ability to express ideas clearly and to understand the ideas expressed by others in both formal and informal contexts, demonstrated by
 - giving and taking direction or instruction
 - giving and responding to oral reports or presentations
 - participating in group or team discussions
 - engaging in conversation with co-workers, supervisors, and clients
 - conducting business in person and via electronic means.

- 5. Demonstrate computer literacy on a level required for employment in a chosen career field.**
Standard: Demonstration of computer literacy includes
 - using common software to accomplish word processing, construction of simple spreadsheets, and keying in and retrieving information from databases
 - transferring the operating principles of one application to another similar application
 - using knowledge of computer logic, operating systems, and basic troubleshooting techniques to identify problems
 - using special job-specific computer equipment, software, and other technology.

Related Information D: Virginia's Workplace Readiness Skills

6. Demonstrate reasoning, problem-solving, and decision-making skills.

Standard: Demonstration of reasoning, problem-solving, and decision-making skills includes

- differentiating among types of problems (e.g., technical, human relations, ethical)
- using established methods of problem solving and decision making in both individual and group settings
- applying previous learning to situations where problems must be solved or decisions made quickly
- predicting short- and long-term effects of proposed solutions or decisions
- testing solutions or decisions to determine effects or to identify related problems.

7. Demonstrate understanding of the "big picture."

Standard: Demonstration includes

- identifying the company's mission and the individual employee's contribution to that mission
- how the company functions within the broad world of business, industry, and service
- explaining the rationale behind organizational policies and procedures
- explaining the necessity and benefits/disadvantages of organizational change
- explaining basic economic concepts.

8. Demonstrate a strong work ethic.

Standard: Demonstration includes

- exhibiting responsibility: coming to work as assigned, contributing work required to meet organizational goals, adhering to policies and procedures, managing time to accomplish assigned tasks
- exhibiting flexibility and adaptability: working longer hours than normal to accomplish a goal, substituting for an absent coworker, taking a temporary assignment, accepting changes in the work environment as a challenge and an opportunity.

9. Demonstrate a positive attitude.

Standard: Demonstration includes

- cooperating with coworkers and supervisors
- taking direction willingly
- exhibiting eagerness to learn
- acting in a pleasant and polite manner with customers, coworkers, and supervisors.

10. Demonstrate independence and initiative.

Standard: Demonstration includes

- working without constant supervision
- finding tasks to perform on one's own
- making suggestions for improvement
- exhibiting interest in making the organization more effective and productive
- maintaining work standards in the midst of change.

11. Demonstrate self-presentation skills.

Standard: Demonstration includes

- identifying ways in which the individual employee represents the organization
- exhibiting a neat appearance
- using effective communication skills
- exhibiting elements of etiquette required in professional settings.

Related Information D: Virginia's Workplace Readiness Skills

12. Maintain satisfactory attendance.

Standard: Satisfactory attendance involves

- being on time for work and all appointments
- limiting tardiness, early departures, and absences to legitimate and essential occasions
- explaining the importance of satisfactory attendance to the overall operation of the business
- negotiating anticipated absences according to company policy
- calling in to notify the supervisor of unanticipated absences.
-

13. Participate as a team member to accomplish goals.

Standard: Participation includes

- attending team (group) meetings, focusing on the topic and purpose of the meeting, offering facts and ideas,
- and helping others contribute facts and ideas
- passing on good ideas to others
- looking for ways to help others
- recognizing others for their contributions
- letting others know what is needed to get the job done
- explaining the importance of teamwork to the overall operation of the business.

Instructional activities to support the teaching of workplace readiness skills are available in *Enhancing Workplace Readiness Skills* (CTE Resource Center, <http://www.cteresource.org/>, Catalog # 8.01.02).

Related Information E: Leadership Development Expectations

E. Leadership Development Expectations: High School

The Virginia Board of Education has approved student expectations for leadership development that, while not mandated for all students, are available for integration into curriculum from kindergarten through grade 12. The middle and high school expectations are reinforced in a variety of career and technical courses. For more information about the leadership initiative, see <http://www.pen.k12.va.us/VDOE/Instruction/leadership/>.

The expectations reinforced by the instruction in all Technology Education courses are as follows:

- HS.1 The student will evaluate his or her own self-image.**
- A. Compare one's own interests, values, and skills with those of selected effective leaders.
 - B. Evaluate one's own desire for leadership roles in the local, state, national, and world communities.
 - C. Define ways to capitalize on individual strengths and improve areas of personal weakness.
- HS.2 The student will evaluate his or her own behaviors.**
- A. Recognize the ongoing benefits of self-analysis.
 - B. Evaluate one's own decisions and actions in terms of short- and long-term consequences.
 - C. Evaluate one's own behaviors in terms of their positive or negative effects on others.
- HS.3 The student will use knowledge of others to improve one's leadership skills.**
- A. Create strategies to utilize the strengths and diminish the limitations of group members.
 - B. Demonstrate ways to organize and delegate responsibilities.
 - C. Encourage ideas, perspectives, and contributions of all group members.
 - D. Use leadership skills to encourage cooperation and collaboration among groups with different needs and concerns.
- HS.4 The student will analyze the characteristics of leaders.**
- A. Identify and discuss effective leadership qualities, such as integrity and wisdom (in addition to setting of limits, tolerance, self-reliance, initiative, charisma, competence, honesty, care for others, civility, fairness, responsibility, courage, and reliability).
 - B. Explain how leadership traits apply to many aspects of life, such as economic and political systems, scientific discoveries, mathematical reasoning, and artistic endeavors.
 - C. Examine leadership theories that explore different styles/types of leadership.
 - D. Explore philosophical concepts associated with leadership, such as virtue and justice.
- HS.5 The student will analyze the complex relationship between the leader and the follower.**
- A. Critically analyze situations in which followers become leaders.
 - B. Analyze and understand the dynamic relationship between the leader and the follower.
 - C. Evaluate the risks and consequences of civil disobedience.
- HS.6 The student will evaluate the role of context in the process of leadership.**
- A. Analyze the influence of different contexts on leadership, such as gender, ethnicity, political affiliation, religion, and socio-economics.
 - B. Understand that as contexts change, leaders may become followers, and followers may become leaders.
 - C. Evaluate the effects of changing situations upon leadership roles in the family, classroom, school, community, state, nation, and world.

Related Information E: Leadership Development Expectations

- HS.7 The student will communicate effectively in pairs, small groups, teams, and large groups.**
- A. Suspend judgment until all ideas are expressed.
 - B. Refine interpretation and synthesis of ideas.
 - C. Present personal ideas as well as those of others in a clear, concise, and effective manner.
 - D. Balance personal expression with others' contributions.
 - E. Distinguish between fact and opinion.
 - F. Work toward consensus in heterogeneous groups.
 - G. Facilitate the mediation of conflict.
 - H. Motivate team members individually and collectively to collaborate to achieve a common purpose.
- HS.8 The student will analyze and refine decision-making skills.**
- A. Take the lead in implementing, monitoring progress toward, and evaluating solutions.
 - B. Support group decisions.
 - C. Adjust group decisions according to changes within or outside the group.
 - D. Refine skills in parliamentary procedure to facilitate meetings or discussions.
- HS.9 The student will evaluate the relationship between personal vision and the group vision.**
- A. Present one's personal vision to a group, using persuasive techniques.
 - B. Compare one's personal vision with that of a group.
 - C. Recognize the necessity for compromise in various leadership situations.
 - D. Motivate others to act according to the group's vision.
- HS.10 The student will appraise communities and community needs.**
- A. Evaluate the needs of communities within the school, locality, state, nation, and world.
 - B. Demonstrate that good citizens strengthen a community through tolerance of ideas and respect for the freedoms and civil rights of others.
 - C. Justify the priorities by which needs are addressed in a community.
- HS.11 The student will evaluate the roles and responsibilities of citizenship.**
- A. Demonstrate that citizenship requires gathering information, making informed choices, and acting responsibly.
 - B. Devise ways to assume active roles in the class, school, locality, state, nation, and world, such as volunteering for additional duties, participating on a committee, and leading a group.
- HS.12 The student will evaluate the concept of stewardship.**
- A. Debate methods that leaders may use to take care of and preserve their school, local, state, national, and world communities.
 - B. Explain ways in which one becomes vested in the community and its resources.
- HS.13 The student will practice leadership through service in a variety of communities.**
- A. Justify decisions in situations where community needs are more important than individual benefits.
 - B. Demonstrate altruistic behavior.
 - C. Encourage others to volunteer for community service.

Related Information F: TSA Competitive Events Correlation

F. Technology Student Association Information and Competitive Events Summary

The Technology Student Association (TSA) is the co-curricular student organization for Technology Education. TSA provides many opportunities through its leadership and competitive events program for students to apply the knowledge, skills, and processes learned in each Technology Education course. The following is a summary of all TSA competitions correlated by task/competency for Bioengineering.

For complete rules and additional information, visit the Virginia TSA Web site (<http://www.vatsa.org>) and the National TSA Web site (<http://www.tsaweb.org>).

- DTE8467.001 Define bioengineering.
- Agriculture & Biotechnology Design
 - Technology Bowl
- DTE8467.002 Define terms related to bioengineering.
- Agriculture & Biotechnology Design
 - Technology Bowl
- DTE8467.003 Describe bioengineering milestones.
- Agriculture & Biotechnology Design
- DTE8467.004 Demonstrate safe laboratory procedures.
- Agriculture & Biotechnology Design
- DTE8467.005 Describe social impacts of bioengineering.
- Agriculture & Biotechnology Design
 - Technology Bowl
 - Engineering Design
 - Medical Technology
- DTE8467.006 Use course content to participate in Technology Student Association experiences as an individual member, leader, and committee member.
- Agriculture & Biotechnology Design
 - Technology Bowl
 - Technology Problem Solving
- DTE8467.007 Use the technological method to solve bioengineering problems.
- Agriculture & Biotechnology Design
 - Technology Problem Solving
- DTE8467.008 Apply mathematical and scientific principles in solving bioengineering challenges.
- Agriculture & Biotechnology Design
 - Technical Research & Report Writing
- DTE8467.009 Analyze data generated from lab activities.
- Agriculture & Biotechnology Design
- DTE8467.010 Describe technology transfer of bioengineering developments.
- Agriculture & Biotechnology Design

Related Information F: TSA Competitive Events Correlation

- DTE8467.011 Identify careers related to bioengineering.
- Agriculture & Biotechnology Design
- DTE8467.012 Describe the engineering design process as related to vaccines and drugs.
- Medical Technology
- DTE8467.013 Demonstrate the DNA modification process.
- Medical Technology
- DTE8467.014 Analyze the design of medical, biomedical, and bioengineering instruments/tools.
- Medical Technology
 - Engineering Design
 - Technological Systems
- DTE8467.015 Investigate the bioengineering processes related to tissue culture.
- Medical Technology
- DTE8467.016 Assess the process for engineering food.
- Agriculture & Biotechnology Design
 - Engineering Design
- DTE8467.017 Investigate the engineering process as related to plants and animals.
- Agriculture & Biotechnology Design
 - Engineering Design
- DTE8467.018 Describe various outcomes of producing bio-based products.
- Agriculture & Biotechnology Design
- DTE8467.019 Analyze the development of alternative fuel sources.
- Technological Systems
- DTE8467.020 Describe biomolecular systems and the field of bioelectronics.
- Technological Systems
 - Engineering Design
 - Electronics Research & Experimentation
- DTE8467.021 Explore how bioengineering has affected and has been affected by imaging technologies.
- SciVis
 - Engineering Design
- DTE8467.022 Explore how database technologies have been affected by bioengineering.
- Engineering Design
- DTE8467.023 Analyze equipment used in gathering biological information.
- Manufacturing Prototype
- DTE8467.024 Investigate bioengineering communication systems.
- SciVis
 - Engineering Design

Related Information F: TSA Competitive Events Correlation

- DTE8467.025 Explain the factors involved in the marketing of bioengineered products.
- Promotional Graphics
- DTE8467.026 Investigate the equipment and process for transporting biological materials.
- Manufacturing Prototype
 - Engineering Design
- DTE8467.027 Identify policies and regulations that affect the transfer of biological materials.
None identified for this task/competency
- DTE8467.028 Explore the manufacture of biomaterials.
- Manufacturing Prototype
- DTE8467.029 Demonstrate the engineering process of prosthetics and implants.
- Medical Technology
 - Engineering Design
- DTE8467.030 Identify nanotechnologies that are used in bioengineering.
None identified for this task/competency
- DTE8467.031 Investigate the field of biowarfare.
None identified for this task/competency
- DTE8467.032 Demonstrate techniques of genetic engineering.
- Medical Technology
 - Technical Research & Report Writing
- DTE8467.033 Describe the bioleaching processes.
None identified for this task/competency
- DTE8467.034 Describe bioremediation processes.
None identified for this task/competency
- DTE8467.035 Analyze the impact of construction on natural ecosystems.
- Technological Systems
- DTE8467.036 Explore systems used to manage biological waste.
- Technological Systems
- DTE8467.037 Investigate the design and construction of artificial environments.
- Engineering Design

Related Information G: Standards for Technological Literacy — Correlation

Following is a summary of the Bioengineering course tasks/competencies correlated with the *Standards for Technological Literacy*. For further details about the standards, see Related Information H.

- DTE8467.001 Define bioengineering.
- The Characteristics and Scope of Technology
- DTE8467.002 Define terms related to bioengineering.
- The Characteristics and Scope of Technology
- DTE8467.003 Describe bioengineering milestones.
- The Characteristics and Scope of Technology
 - The Influence of Technology on History
- DTE8467.004 Demonstrate safe laboratory procedures.
- The Core Concepts of Technology
 - Use and Maintain Technological Products and Systems
- DTE8467.005 Describe social impacts of bioengineering.
- The Characteristics and Scope of Technology
 - The Cultural, Social, Economic, and Political Effects of Technology
- DTE8467.006 Use course content to participate in Technology Student Association experiences as an individual member, leader, and committee member.
- The Core Concepts of Technology
- DTE8467.007 Use the technological method to solve bioengineering problems.
- The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving
 - Apply Design Processes
- DTE8467.008 Apply mathematical and scientific principles in solving bioengineering challenges.
- Relationships among Technologies and the Connections between Technology and Other Fields
 - Apply Design Processes
- DTE8467.009 Analyze data generated from lab activities.
- Assess the Impact of Products and Systems
- DTE8467.010 Describe technology transfer of bioengineering developments.
- The Characteristics and Scope of Technology
 - Relationships among Technologies and the Connections between Technology and Other Fields
 - The Cultural, Social, Economic, and Political Effects of Technology
- DTE8467.011 Identify careers related to bioengineering.
- The Cultural, Social, Economic, and Political Effects of Technology
 - The Influence of Technology on History
 - The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving
- DTE8467.012 Describe the engineering process as related to vaccines and drugs.
- Medical Technologies
 - Agricultural and Related Biotechnologies

Related Information G: Standards for Technological Literacy — Correlation

- DTE8467.013 Demonstrate the DNA modification process.
- Use and Maintain Technological Products and Systems
 - Medical Technologies
- DTE8467.014 Analyze the design of medical, biomedical, and bioengineering instruments/tools.
- The Attributes of Design
 - Engineering Design
- DTE8467.015 Investigate the bioengineering processes related to tissue culture.
- Medical Technologies
- DTE8467.016 Assess the process for engineering food.
- Assess the Impact of Products and Systems
 - Medical Technologies
 - Agricultural and Related Biotechnologies
- DTE8467.017 Investigate the engineering process as related to plants and animals.
- Medical Technologies
 - Agricultural and Related Biotechnologies
- DTE8467.018 Describe various outcomes of producing bio-based products.
- Assess the Impact of Products and Systems
 - Agricultural and Related Biotechnologies
- DTE8467.019 Analyze the development of alternative fuel sources.
- The Characteristics and Scope of Technology
 - The Effects of Technology on the Environment
 - Energy and Power Technologies
- DTE8467.020 Describe biomolecular systems and the field of bioelectronics.
- Energy and Power Technologies
- DTE8467.021 Explore how bioengineering has affected and has been affected by imaging technologies.
- Relationships among Technologies and the Connections between Technology and Other Fields
 - Information and Communication
- DTE8467.022 Explore how database technologies have been affected by bioengineering.
- Relationships among Technologies and the Connections between Technology and Other Fields
 - The Influence of Technology on History
 - Information and Communication
- DTE8467.023 Analyze equipment used in gathering biological information.
- The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving
 - Use and Maintain Technological Products and Systems
 - Information and Communication
- DTE8467.024 Investigate bioengineering communication systems.
- Information and Communication
 - The Characteristics and Scope of Technology

Related Information G: Standards for Technological Literacy — Correlation

- DTE8467.025 Analyze the factors involved in the marketing of bioengineered products.
- The Cultural, Social, Economic, and Political Effects of Technology
 - Manufacturing Technologies
- DTE8467.026 Investigate the equipment and process for transporting biological materials.
- The Characteristics and Scope of Technology
 - Transportation Technologies
- DTE8467.027 Identify policies and regulations that affect the transfer of biological materials.
- The Core Concepts of Technology
 - The Role of Society in the Development and Use of Technology
- DTE8467.028 Explore the manufacturing process for biomaterials.
- The Core Concepts of Technology
 - The Attributes of Design
 - Apply Design Processes
 - Manufacturing Technologies
- DTE8467.029 Demonstrate the engineering process of prosthetics and implants.
- Engineering Design
 - Manufacturing Technologies
- DTE8467.030 Identify nanotechnologies that are used in bioengineering.
- Use and Maintain Technological Products and Systems
- DTE8467.031 Investigate the field of biowarfare.
- The Cultural, Social, Economic, and Political Effects of Technology
 - The Role of Society in the Development and Use of Technology
 - The Attributes of Design
- DTE8467.032 Demonstrate techniques of genetic engineering.
- The Core Concepts of Technology
 - Assess the Impact of Products and Systems
- DTE8467.033 Describe the bioleaching processes.
- The Effects of Technology on the Environment
- DTE8467.034 Describe bioremediation processes.
- The Effects of Technology on the Environment
 - Agricultural and Related Biotechnologies
- DTE8467.035 Analyze the impact of construction on natural ecosystems.
- The Effects of Technology on the Environment
 - Agricultural and Related Biotechnologies
- DTE8467.036 Explore systems used to manage biological waste.
- The Core Concepts of Technology
 - Agricultural and Related Biotechnologies
 - Construction Technologies
- DTE8467.037 Investigate the design and construction of artificial environments.
- Construction Technologies

Related Information H: Standards for Technological Literacy — Content

The twenty standards below are organized according to the chapters in *Standards for Technological Literacy: Content* for the study of technology. To review all of the benchmarks, order a copy of the *Standards* from the International Technology Education Association ([ITEA] <http://www.iteawww.org/>).

The Nature of Technology

Standard 1: Students will develop an understanding of the characteristics and scope of technology.

Standard 2: Students will develop an understanding of the core concepts of technology.

Standard 3: Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

Standard 4: Students will develop an understanding of the cultural, social, economic, and political effects of technology.

Standard 5: Students will develop an understanding of the effects of technology on the environment.

Standard 6: Students will develop an understanding of the role of society in the development and use of technology.

Standard 7: Students will develop an understanding of the influence of technology on history.

Design

Standard 8: Students will develop an understanding of the attributes of design.

Standard 9: Students will develop an understanding of engineering design.

Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

Abilities of a Technological World

Standard 11: Students will develop abilities to apply the design process.

Standard 12: Students will develop abilities to use and maintain technological products and systems.

Standard 13: Students will develop abilities to assess the impact of products and systems.

The Designed World

Standard 14: Students will develop an understanding of and be able to select and use medical technologies.

Standard 15: Students will develop an understanding of and be able to select and use agricultural and related biotechnologies.

Standard 16: Students will develop an understanding of and be able to select and use energy and power technologies.

Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies.

Standard 18: Students will develop an understanding of and be able to select and use transportation technologies.

Standard 19: Students will develop an understanding of and be able to select and use manufacturing technologies.

Standard 20: Students will develop an understanding of and be able to select and use construction technologies.

Related Information I: Glossary

I. Glossary of Curriculum-Related Terms

- **All Aspects of Industry:** The industry components of planning; management; finance; technical and production skills; underlying principles of technology; labor issues; community issues; and health, safety, and environmental issues with respect to a particular career for which a student is preparing
- **Concept Area:** A broad descriptor under which similar tasks are organized
- **Essential Task/Competency:** A task/competency identified by experts in an industry and/or profession as critical for content mastery and/or industry standards certification
- **Leadership Expectations:** Skills, processes, and opportunities that enable students to develop leadership skills appropriate to their age group
- **Process/Skill Questions:** Questions designed to encourage higher-order skills in thinking, reasoning, and problem solving
- **Related Standards of Learning:** Academic and technological knowledge and skills that are reinforced when a task/competency is performed successfully
- **Task/Competency:** A unit of work with a definite beginning and ending, which is measurable and observable and consists of two or more definite steps
- **Task Definition:** A statement that identifies the elements to be included in instruction and evaluation of the task performance
- **Workplace Readiness Skills:** The generic skills related to seeking, obtaining, and keeping a job and advancing in a career