BIOTECHNOLOGY AND FORENSIC SCIENCE CURRICULUM

NEWTOWN SCHOOLS
NEWTOWN, CT.
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PHILOSOPHY

− The following belief statements represent the philosophy of the K-12 Science Curriculum.
− It is essential for all learners to apply and communicate scientific principles.
− The primary goal of science education is the understanding of scientific concepts through decision-making, problem solving, and critical thinking.
− The study of science empowers students to set goals, make plans, and assess achievement of their goals.
− Science is connected to everything in life.
− All sciences are interconnected.
− It is essential that students recognize that there are common themes and processes that are at the core of science.
− It is essential that students work together to become actively involved in discovering connections between science and other aspects of human experience.
− It is essential that students experience science as engagement, exploration, explanation, elaboration, and evaluation.
− It is essential that students understand scientific knowledge as constantly changing through discovery and investigation.
− It is essential that students through active engagement acquire and apply the knowledge and skills necessary to seek answers to their questions.
− It is essential that science education prepare students for a changing world and environment.
− It is essential that students should continuously recognize the interconnections between science, technology and society.
− It is essential that students use technology as a tool for understanding science.
− It is essential that students demonstrate their mastery of scientific knowledge and processes through a variety of assessments.
GOALS

Upon completion of the Newtown Science Curriculum, students will be able to:

- Make informed decisions about themselves and their environment through understanding science.
- Apply scientific reasoning and knowledge to address societal and technological problems.
- Explain the interconnectedness and interdependence among all areas of science.
- Extend their science problem solving skills to future education and life.
- Evaluate scientific inquiry and investigation through the process of solving relevant and challenging problems.
- Communicate scientific understandings through words, graphs, charts, and equations.
- Describe, explain, and make predictions based on previous knowledge and observations.
- Demonstrate mastery of scientific knowledge and processes through a variety of assessments.
**Content Standards:**
Students will understand that:

- DNA technology is based on the insights and experiments that led to the realization that DNA is the hereditary material. Its foundations are in genetics, the science of heredity.
- The practical applications of DNA technology are based on a knowledge of the structure and function of DNA.
- The manipulation of DNA offers great benefits to humans in many fields such as the production of pharmaceutical and agricultural products, the diagnosis and treatment of genetic diseases, and forensics. Therefore, DNA technology has major social and economic implications.
- The tools and techniques of biotechnology and forensic science require fundamental laboratory skills used in modern research laboratories.
- Forensic science applies all scientific disciplines and mathematics to the criminal and civil laws enforced by police agencies in the criminal justice system.
- Biotechnology and forensic investigation require mastery of technical reading and writing, oral communication, research, critical thinking, and deductive reasoning skills.

The Biotechnology and Forensic Science curriculum is for all levels. The expectation of the curriculum is that students will demonstrate understanding of the content standards through concrete application of major scientific concepts. Objectives serve as key learning components of each content standard. Students will be assessed according to the level at which they take the course. All students are expected to work to their fullest potential in achieving the content standards.

**Key features of this course:**

- **Creation of interdisciplinary opportunities.** The biotechnology and forensic science course combines skills and knowledge from all disciplines of science including physics, biology, anatomy and physiology, chemistry and earth science, and also integrates mathematics and language arts.
- **Integration of technology into the classroom.** Utilization of modern molecular biology and forensic science materials and equipment and computer programs and data bases will enhance learning and provide opportunities to develop technological skills.
- **Heterogeneous learning environment.** The relevance of biotechnology and forensics in today's society will have an appeal to a diversified group of students and promote a cooperative learning environment.
Overview of Course Content:

Unit 1: What Is Biotechnology
- History of molecular genetics
- Structure & function of DNA
- Universality and variations in the genetic code
- DNA extraction techniques and rationale

Unit 2: What Are The Methods Of Biotechnology
- Structure and Function of DNA
- Characteristics of prokaryotic and eukaryotic cells
- Characteristics of viruses
- Tools of recombinant DNA technology
  - The host organisms
  - The vectors: plasmids, viruses
  - Restriction enzymes
  - Ligases
- Methods of recombinant DNA technology
  - Gene cloning
  - Restriction analysis & DNA fingerprinting
  - Transformation
  - Collection of gene product-protein purification
- Advanced methods of recombinant DNA technology
  - PCR (polymerase chain reaction)
  - DNA sequencing
  - DNA probes
  - RFLP (restriction fragment length polymorphism) analysis

Unit 3: How Does Biotechnology Benefit People?
- Careers in biotechnology, biochemistry and molecular biology
- Biotechnology applications
  - Pharmaceutical products
  - Forensics investigations
  - Agricultural products
  - Health care-diagnostic and gene therapy
  - Environmental issues
  - Animal and plant cloning
  - Transgenic animals
  - The Human Genome Project
- Ethical issues
- Legal issues

Unit 4: What Laboratory Skills Are Required In A Modern Research Laboratory
- Safety
- Biohazard & toxic material disposal
- Preparation of solutions
- Use of laboratory equipment
- Microorganisms as host cells in biotechnology
- Sterile microbiology techniques
- Chromatography
- Metric Measurement
- Recognition, collection and preservation of physical evidence at a crime scene.
- Care and use of the microscope
- Technical writing
- Observation and recording data
- General laboratory set-up and procedures

Unit 5: How Are All Scientific Disciplines And Mathematics Used In Forensic Science Investigations?
- Careers in forensics fields
- History of forensic science
- Qualitative and quantitative chemical analysis
- Chemistry terminology
- Refractive index and glass identification
- Density determination
- Characteristics and identification of fibers
- Document analysis
- Chromatography
- Characteristics of a body after death
- Dichotomous keys
- DNA technology
- Body regions and planes terminology
- Body systems
- Characteristics and identification of sand and soil
- Blood spatter patterns
- Chromatography analysis-Rf(rate of flow) values
- Logic problem solving

Unit 6: How Are Communication, Research, Critical Thinking And Deductive Reasoning Skills Used In Biotechnology And Forensic Science
- Bioethics case studies-risk/benefit analysis
- Writing lab reports
- Research skills
- Technical reading and writing
- Lesson planning
- Oral presentations
- Interview techniques
Unit 1: What Is Biotechnology

Essential Question:

Students will understand that DNA technology is based on the insights and experiments that led to the realization that DNA is the hereditary material. Its foundations are in genetics, the science of heredity.

Objectives:

Students will
- Identify the process of science that occurs as investigators build upon the work of other investigators in the area of molecular genetics.
- Recognize how the experiments of Gregor Mendel focused attention on cellular factors as the basis for inheritance.
- Follow the reasoning that led scientists to a genetic code in DNA and helped them relate the code to the functions of DNA in reproduction and protein synthesis.
- Investigate evidence that DNA is the basis for the unity and diversity of all life.
- Experimentally verify that DNA can be extracted from a variety of prokaryotic and eukaryotic cells.

Topics Covered:
- History of molecular genetics
- What is Biotechnology?
- Structure & function of DNA
- Universality and variations in the genetic code
- DNA extraction techniques and rationale

Activities and Assessments:
- History of molecular genetics poster project and presentation
- Reading: DNA Technology: The Awesome Skill: chapters 1 - 3
- Articles on biotechnology companies and "What is Biotechnology?"
- DNA extraction labs
- Quantitation of DNA lab
- Serial dilutions of lambda DNA to use for standard comparisons

Performance Standards:

Students will
- Describe how the work of a scientist or team of scientists was built upon the work of other scientists in the area of molecular genetics.
- Successfully extract DNA from two organisms.
- Rationalize each procedural step in DNA extraction experiments.
- Successfully quantify the relative amounts of DNA obtained in the extractions by comparison to DNA standards prepared by serial dilutions of lambda DNA.
- Connect the structure and characteristics of DNA with how they are used to extract and manipulate DNA.
Unit 2: What Are The Methods Of Biotechnology?

**Essential Question:**
Students will understand that the practical applications of DNA technology are based on a knowledge of the structure and function of DNA.

**Objectives:**
Students will
- Identify the details of the structure of the DNA molecule.
- Relate the unique structure of the DNA molecule to its functions of replication and protein synthesis.
- Distinguish between the genetic structure and function of prokaryotic and eukaryotic cells.
- Use restriction enzymes, plasmids, chromosomal DNA and bacterial cells to manipulate and analyze DNA and to transfer genetic material between organisms.
- Use advanced biotechnology techniques such as PCR and DNA sequencing and relate these technologies to the structure and function of DNA.

**Topics Covered:**
- Structure of DNA
- Function of DNA
  - Replication
  - Protein synthesis
- Tools of recombinant DNA technology
  - The host organisms
  - The vectors: plasmids, viruses
  - Restriction enzymes
  - Ligases
- Methods of recombinant DNA technology
  - Gene cloning
  - Restriction analysis & DNA fingerprinting
  - Transformation
  - Collection of gene product-protein purification
- Advanced methods of recombinant DNA technology
  - PCR (polymerase chain reaction)
  - DNA sequencing
  - DNA probes
  - RFLP (restriction fragment length polymorphism) analysis

**Activities and Assessments:**
- Construction of DNA models.
- Drawing and labeling a diagram of the DNA molecule.
- Labeling and describing the steps and the cell structures involved in the process of protein synthesis.
- Drawing, labeling and describing the steps in the process of DNA replication.
- "DNA Scissors" simulation.
- Paper simulation of restriction digest and gel electrophoresis.
- Restriction mapping of lambda and plasmid DNA.
- DNA Fingerprinting Lab Activity (Biorad Kit)
- Bacterial Transformation (pBLU or pGLO-Biorad or Carolina Kits)
− Production of a Recombinant DNA Product lab Activity (Biorad "Secrets of the Rainforest Kit")
− PCR: ALU DNA Extraction and Amplification Kit
− DNA Sequencing Lab Activity (Carolina Kit)
− Protein Quantitation Lab Activity (Carolina Kit)

Performance Standards:

Students will
− Identify the molecular parts, charges, bonds and orientation in the structure of the DNA molecule.
− Relate the unique structure of the DNA molecule to its functions of replication and protein synthesis.
− Prepare electrophoresis buffer solutions and agarose gel with 100% accuracy.
− Correctly set up a gel electrophoresis chamber.
− Determine the volume of DNA, restriction buffer and enzyme in a DNA restriction digest based on given concentrations of these reagents.
− Prepare a DNA restriction digest with 100% accuracy.
− Run DNA samples in a gel, stain and obtain results 90 consistent with expected results.
− Transform bacteria with the pBLU or pGLO plasmid with moderate efficiency.
− Perform PCR (polymerase chain reaction) and DNA sequencing and achieve at least 75 of expected results.
− Describe specific reasons for variations from "ideal" results in restriction analysis and bacterial transformation lab activities.
− Troubleshoot and solve problems with laboratory protocols and equipment.
Unit 3: How Does Biotechnology Benefit People?

**Essential Question:**
Students will understand that the manipulation of DNA offers great benefits to humans in many fields such as the production of pharmaceutical and agricultural products, the diagnosis and treatment of genetic diseases, and forensics. Therefore DNA technology has major social and economic implications.

**Objectives:**
Students will
- Observe that biotechnology is cutting-edge and will impact the food we eat, our health care and our lifestyles.
- Investigate the applications of biotechnology in various biological fields.
- Discuss ethical issues raised by technology.
- Evaluate the legality of DNA as a courtroom tool.

**Topics Covered:**
- Careers in biotechnology, biochemistry and molecular biology
- Biotechnology applications
  - Pharmaceutical products
  - Forensics investigations
  - Agricultural products
  - Health care: diagnosis and gene therapy
  - Environmental issues
  - Animal and plant cloning
  - Transgenic animals
  - The Human Genome Project
  - Ethical issues
  - Legal issues

**Activities/Assessments:**
- Video: CURE: Careers in the Biosciences
- Current Articles: Written abstracts and class discussion of articles related to biotechnology, bioethical issues and genetics.
- Guest speakers from Boehringer-Ingelheim Pharmaceuticals
- Student research and presentation of a lesson on the agricultural, medical, forensics and environmental applications of biotechnology
- Student Research and presentation of a lesson on a genetically inherited disease, its diagnosis and treatment
- "Search for a Gene" simulation of the Human Genome Project
- Systematic analysis of ethical issues: Case studies in human genetic diagnosis and gene therapies

**Performance Standards:**
Students will
- Explore articles from reputable scientific magazines and professional journals.
- Describe the characteristics, means of diagnosis and treatment of a genetically inherited disease.
- Convey practical applications of biotechnology and analyze the risks and benefits of the technology.
- Use systematic analysis to evaluate several case studies in molecular genetics and biotechnology.
- Demonstrate critical thinking skills in well-informed, intelligent discussions of the ethical issues raised by biotechnology.
Unit 4: What Laboratory Skills Are Required In A Modern Research Laboratory?

**Essential Question:**
Students will understand that the tools and techniques of biotechnology and forensic science require mastery of fundamental laboratory skills used in modern research laboratories.

**Instructional Objectives:**
Students will
- Follow laboratory directions and protocols.
- Practice careful and correct use and disposal of biohazardous and toxic materials.
- Prepare various types of solutions and media.
- Use the biochemical tools of DNA technology in a variety of applications, including production of commercial products and forensics investigations.
- Recognize why microorganisms occupy an important place in the experiments of DNA technology.
- Practice using sterile microbiological techniques and rationalize their use.
- Use several types of Chromatography in a variety of applications.
- Use authentic laboratory equipment.
- Use appropriate metric measurement.
- Recognize the value of physical evidence and collect and preserve it.
- Use correct microscope technique.
- Accurately record and report data and observations using language, numbers, maps and diagrams.

**Topics Covered:**
- Safety
- Biohazard & toxic material disposal
- Preparation of solutions
  - Molar solutions
  - Percent by weight solutions
  - Percent by volume solutions
- Use of laboratory equipment
  - Clinical centrifuge
  - Microcentrifuge
  - Incubator
  - Water bath
  - Autoclave
  - UV/Visible Spectrophotometer
  - Microscope
  - Magnetic stirrer
  - Vortexer
  - Vertical gel electrophoresis apparatus
  - Horizontal gel electrophoresis apparatus
  - Thermal cycler
- Microorganisms as host cells in biotechnology
- Sterile microbiology techniques
  - Media preparation
  - Pouring plates
  - Growth and transfer of microorganisms
- Chromatography
  - Paper
  - TLC (Thin Layer Chromatography)
  - Column
  - HPLC (High Pressure Liquid Chromatography)
  - Gas Chromatography
- Metric Measurement
- Use of micropipettors
- Use of appropriate equipment to measure volume, mass and length
- Recognition, collection and preservation of physical evidence at a crime scene.
- Care and use of the microscope
- Technical writing
- Observation and recording data
  - Crime scene mapping
  - Arithmetic graphs
  - Semi-logarithmic graphs
  - Data tables
- Writing lab reports
- General laboratory set-up and procedures
  - Location of biohazard and toxic materials disposal
  - Location of supplies and equipment
  - Maintenance & care of equipment
  - Clean-up

Activities/Assessments:
- Safety lab
- Preparation of molar and percent solutions
- Micropipetting and centrifuging practice lab (colored solutions)
- Electrophoresis of dyes lab (practice electrophoresis lab)
- Pouring media plates for transformation lab and for biology disinfectant laboratory
- Streaking plates with bacteria to obtain single colonies
- Thin layer Chromatography and paper Chromatography in forensic analysis of dyes and inks
- Crime scene simulation: mapping and collection of evidence
- Column Chromatography (protein purification lab)
- Microscopic skills: identification of hair, fibers, blood, sand and trace evidence

Performance Standards:
Students will
- Prepare solutions for DNA extractions, electrophoresis labs, transformation and forensics labs for biotechnology and for biology classes with 100% accuracy.
- Measure using the electronic balance, micropipettors and graduated cylinders with 100% accuracy by the end of the first marking period.
- Record observations and results using complete labeled diagrams, data tables, arithmetic and logarithmic graphs.
- Set up and appropriately use clinical and microcentrifuges, incubator, water bath, vortexors, magnetic stirrers, Spectrophotometer and horizontal and vertical gel electrophoresis apparatus with 100% accuracy by the end of the first semester.
- Independently collect and label crime scene evidence and completely map a crime scene with 100% accuracy.
- Determine the appropriate analysis procedure and perform analysis on physical evidence including: hair, fibers, serological evidence, DNA evidence, fingerprints, ink and dyes, chemicals
- Independently recognize measuring and procedural errors and technical problems when they occur; Repeat measurements and procedures as needed without prompting from the teacher.
- Independently prepare solutions, set up restriction digest, set up gel electrophoresis chamber, perform electrophoresis, record and interpret results and validity with 90% accuracy.
- Explain the procedural steps and reasons for the steps of a given biotechnology research problem such as cloning a gene and producing a pharmaceutical product.
Unit 5: How Are All Scientific Disciplines And Mathematics Used In Forensic Science Investigations?

Essential Question:
Students will understand that forensic science applies all scientific disciplines and mathematics to the criminal and civil laws enforced by police agencies in the criminal justice system.

Instructional Objectives:
Students will
- Describe the various jobs performed in forensic investigation.
- Identify and quantify unknown compounds using quantitative and qualitative chemical techniques.
- Apply physical science principles to solve forensic problems.
- Use biological keys to identify unknown organisms.
- Apply their knowledge of and skills in DNA technology to solve forensics problems.
- Explore the basic anatomy and physiology of the human body systems and use correct anatomical terminology.
- Identify the parts of the body which are used for identification.
- Describe characteristics of earth materials and use them to identify unknowns.
- Use mathematics to analyze and interpret evidence.

Topics Covered:
- Careers in forensics
- History of forensic science
- Qualitative and quantitative chemical analysis
- Chemistry terminology
  - Organic
  - Inorganic
- Refractive index and glass identification
- Density determination
- Characteristics and identification of fibers
- Document analysis
  - Handwriting
  - Typewriting
  - Voice examination
- Chromatography
- Characteristics of a body after death
- Dichotomous keys
- DNA technology
  - DNA fingerprinting
  - RFLP (restriction fragment length polymorphism) analysis
  - PCR (polymerase chain reaction)
  - DNA data bases
- Body regions and planes terminology
- Circulatory system
  - Blood composition
  - Blood types and genetics
  - Animal blood identification
  - Blood circulation pathway
  - Skeletal system
- Human and animal bone identification
- Teeth and bite mark identification

- **Integumentary system**
  - Hair identification
  - Fingerprint identification
  - Lip prints
  - Palm prints

- **Nervous system**
  - Retinal prints

- **Excretory system**
  - Basic structure and function
  - Formation of urine
  - Elimination of alcohol and toxic compounds

- **Respiratory system**
  - Alveolar breath
  - Breathalyzer test

- Characteristics and identification of sand and soil
- Blood spatter patterns
- Chromatography analysis-Rf(rate of flow) values
- Logic problem solving

**Activities/Assessments:**
- Visit to the state of Connecticut Forensic Science lab to investigate the various careers involved in forensic science
- Construction of timeline of the history of forensic science
- Qualitative and quantitative chemistry lab
- Physical science labs-refractive index and density
- Identification of fibers and hairs lab
- Chromatography of inks lab
- Blood analysis and identification lab
- Document analysis lab
- Location of anatomical regions and use of terms of position activity
- Fingerprint lab
- Identification of sand and soil lab
- Urine analysis lab
- Simulation of human and animal skeletal remains identification
- Simulation of characteristics of a body after death
- Guest speaker from Newtown Police Department: alveolar breath and breathalyzer tests
- Case studies of crime scene investigation
- Research unsolved criminal cases and prepare research paper and oral presentation
- Student Hands-on lesson to a fifth grade class: How to solve a mystery.
- Logic problem solving

**Performance Standards:**
Students will
- Describe the history of forensic science.
- Correctly identify 10 unknown chemicals using chemical analysis or the PDR (Physicians Desk Reference).
- Perform refractive index and density tests to match suspect's samples with glass samples from the crime scene.
- Perform refractive index and density tests to match suspect's samples with glass samples from the crime scene.
- Correctly identify animal or human hair samples and match suspect's samples with samples from the crime scene.
- Correctly identify and match fiber samples.
- Use simulated blood typing analysis to include or exclude a suspect in a criminal investigation.
- Use a variety of forensic materials such as crime scene diagrams, fingerprints, anatomical positions, hair, fibers, footprints, documents, blood spatter patterns and chemical testing results to solve a murder mystery.
- Prepare, present and evaluate a lesson to a fifth grade class. Include forensic laboratory activities used to solve a mystery.
- Research and describe an unsolved criminal case or a case which was not definitively resolved and gather evidence to support a definitive conclusion to the case.
- Read and critique a book related to forensic investigation.
Unit 6: How Are Communication, Research, Critical Thinking and Deductive Reasoning Skills Used In Biotechnology and Forensic Science?

**Essential Question:**
Students will understand that biotechnology and forensic investigation requires mastery of technical reading and writing, oral communication, research, critical thinking, and deductive reasoning skills.

**Instructional Objectives:**
Students will
- Use logic to solve problems.
- Discuss the fourth and fifth amendments and their relationship to the study of forensics.
- Use a variety of sources to conduct in depth research, including internet, interviews, shadowing, original source articles and criminal and civil agency documents.
- Prepare oral presentations and lessons.
- Use appropriate interview techniques.
- Organize and use a variety of scientific evidence to communicate the results of biotechnology and forensics investigations.

**Topics Covered:**
- Solving logic problems
- Legal issues and forensic investigation
- Bioethics case studies-risk/benefit analysis
- Writing lab reports
- Technical reading
- Lesson planning
- Oral presentation
- Interview techniques

**Activities/Assessments:**
- Lab reports
- Data recording
- Crime scene diagrams
- Free response and essay questions
- Article abstracts
- Research papers
  - Biotechnology applications
  - Genetic disease
  - Unsolved criminal case
- Evaluation of case studies in human genetic diagnosis
- Presentation of lessons to the class and to fifth graders

**Performance Standards:**
Students will
- Complete all lab, research reports, essays and presentations using technical writing standards and critical thinking skills.
- Solve biotechnology and forensic problems using logic.