GEORGIA | PEACH STATE PATHWAYS

Career, Technical, & Agricultural Education

HEALTHCARE SCIENCE

PATHWAY: Biotechnology Research & Development

COURSE: Applications of Biotechnology

UNIT 7: DNA Cloning and Bioinformatics

## INTRODUCTION

**Annotation:** This unit reviews the subjects of DNA cloning and bioinformatics. Modern biotechnology began when cloning techniques were discovered in the early 1970s. As recombinant DNA techniques and genetic engineering gained popularity, they helped speed up scientific discovery faster than data can be collected and analyzed. Bioinformatics developed from this need to gather huge amounts of data and manipulate information so it can be used to solve many complex problems.

**Grade(s):**

| | |
|---|---|
| | 9th |
| | 10th |
| X | 11th |
| X | 12th |

**Time:** Twenty 50-minute class periods

**Author:** Mandy Latimer

**Students with Disabilities:**

For students with disabilities, the instructor should refer to the student's IEP to be sure that the accommodations specified are being provided. Instructors should also familiarize themselves with the provisions of Behavior Intervention Plans that may be part of a student's IEP. Frequent consultation with a student's special education instructor will be beneficial in providing appropriate differentiation.

# FOCUS STANDARDS

## GPS Focus Standards:

**HS-ABT-1** **Students will describe how characteristics of living organisms are integrated with advanced biotechnology techniques to lead to discovery or production.**

b) Demonstrate how DNA structure and function may be exploited in genetic engineering to produce specific genetic constructs.

- Engineer nucleic acids through selecting, excising, ligating and cloning of plasmid or viral vectors for development of molecular delivery systems.
- Simulate enzymatic replication of nucleic acids utilizing real-time or traditional PCR including primer design.
- Isolate and prepare DNA samples for sequencing.
- Manage and analyze DNA sequence data using bioinformatics tools (*e.g.* Genbank and BLAST).

## GPS Academic Standards:

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

**SB2** Students will analyze how biological traits are passed on to successive generations.

**SB3** Students will derive the relationship between single-celled and multi-celled organisms and the increasing complexity of systems.

**SB4** Students will assess the dependence of all organisms on one another and the flow of energy and matter within their ecosystems.

**SCSh3** Students will identify and investigate problems scientifically.

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

**SCSh5** Students will demonstrate the computation and estimation skills necessary for analyzing data and developing reasonable scientific explanations.

**SCSh6** Students will communicate scientific investigations and information clearly.

**SC7** Students will characterize the properties that describe solutions and the nature of acids and bases.

**SCSh8** Students will understand important features of the process of scientific inquiry.

**SPS10** Students will investigate the properties of electricity and magnetism.

**MM1A1** Students will explore and interpret the characteristics of functions, using graphs, tables, and simple algebraic techniques.

**MM1D3** Students will relate samples to a population.

**MM1P1** Students will solve problems (using appropriate technology).

**MM1P4** Students will make connections among mathematical ideas and to other disciplines.

**MM1P5** Students will represent mathematics in multiple ways.

**MM2D2** Students will determine an algebraic model to quantify the association between two quantitative variables.

# UNDERSTANDINGS & GOALS

## Enduring Understandings:

- The greatest advantage of PCR is its ability to amplify millions of copies of DNA from a very small amount of starting material in a short period of time.

- Bioinformatics merges biology with computer science. The huge amount of data about genes from different species has made bioinformatics a rapidly emerging area of science that is essential for genomics.

### Essential Questions:

- What can be done with a cloned gene?
- What is the Human Genome Project?
- What is PCR?
- Why do bacteria have plasmids?
- How do scientists determine what primer sequences and temperature conditions should be used for a PCR experiment?
- Why is DNA ligase important?
- How is DNA ligase different from a restriction enzyme?
- What is the most popular DNA polymerase?
- Why is the science of bioinformatics important?

### Knowledge from this Unit:

Students will be able to:

- Explain the effects of PCR and cloning
- Describe how to prepare a DNA sample for sequencing
- Explain how bioinformatics websites can be used to observe where enzymes cut DNA and find information on genes

### Skills from this Unit:

Students will be able to:

- Use computer techniques to handle data
- Pour agarose gels
- Run a PCR machine

## ASSESSMENTS

### Assessment Method Type:

X Pre-test
____ Objective assessment - multiple-choice, true- false, etc.
__ Quizzes/Tests
__ Unit test
X Group project
____ Individual project
X Self-assessment - May include practice quizzes, games, simulations, checklists, etc.
__ Self-check rubrics
__ Self-check during writing/planning process
_xx Journal reflections on concepts, personal experiences and impact on one's life
__ Reflect on evaluations of work from teachers, business partners, and competition judges
__ Academic prompts
__ Practice quizzes/tests
____ Subjective assessment/Informal observations
__ Essay tests
_x_ Observe students working with partners
__ Observe students role playing

_____ Peer-assessment
__ Peer editing & commentary of products/projects/presentations using rubrics
__ Peer editing and/or critiquing
_X_ Dialogue and Discussion
__ Student/teacher conferences
__ Partner and small group discussions
__ Whole group discussions
__ Interaction with/feedback from community members/speakers and business partners
_____ Constructed Responses
__ Chart good reading/writing/listening/speaking habits
_x_ Application of skills to real-life situations/scenarios
_____ Post-test

**Assessment Attachments and / or Directions:**

## LESSON PLANS

### • LESSON 1: DNA CLONING

1. Identify the standards. Post standards in the classroom.

**HS-ABT-1** **Students will describe how characteristics of living organisms are integrated with advanced biotechnology techniques to lead to discovery or production.**

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**MM1P5** Students will represent mathematics in multiple ways.
**MM2D2** Students will determine an algebraic model to quantify the association between two quantitative variables.

2. Review Essential Questions. Post Essential Questions in the classroom.
    - What can be done with a cloned gene?
    - What is the Human Genome Project?
    - What is PCR?
    - Why do bacteria have plasmids?
    - How do scientists determine what primer sequences and temperature conditions should be used for a PCR experiment?
    - Why is DNA ligase important?
    - How is DNA ligase different from a restriction enzyme?
    - What is the most popular DNA polymerase?
    - Why is the science of bioinformatics important?

3. Identify and review the unit vocabulary. Terms may be posted on word wall.

| | | |
|---|---|---|
| Agar | Introns | Reverse Transcriptase |
| Agarose Gel | Marker DNA | Selection |
| Autoradiography | Oligonucleotides | Taq Polymerase |
| Blunt Ends | Plasmid | Thermal Cycler |
| Clones | Primer | Transformation |
| DNA Ligase | Recombinant DNA | Ultraviolet Light |
| EcoRI | Restriction Digest | Vector |
| Electroporation | Restriction Enzyme | |
| Ethidium Bromide | Restriction Map | |
| Gel Electrophoresis | Restriction Site | |

4. The Cloning Process
    - Show students the **Cloning** PowerPoint presentation.
        - See attached supplementary files
        - Have students write down the cloning process in their lab notebooks.
    - Lead a brief discussion about the ethics of cloning.
        - Ask students, "Do you think there are any risks to cloning?"
        - Should cloning be regulated?
        - How can cloning become less expensive and more efficient?
        - What affects has cloning had on the field of biotechnology?

5. Cloning Specific DNA
    - Explain to students there are two different types of DNA libraries which can be used to find specific sequences to clone
        - Genomic DNA Libraries
        - Complimentary DNA (cDNA) Libraries
    - Tell students these libraries can be obtained for many different organisms.

6. The Human Genome Project

- Explain to students the Human Genome Project was a large undertaking in which scientists discovered the entire human genetic code.
- Split the class into small groups and assign each group one of the following human diseases to research.
    - Huntington Disease
    - Cystic Fibrosis
    - Thalassaemia
    - Phenylketonuria
    - Hemophilia
    - Turner Syndrome
    - Klinefelter Syndrome
- Instruct each group to create a three-column poster and title one column "Disease Facts," one "Treatment," and the third one "Impact of the Human Genome Project."
- Tell students to look up information to put on their poster for each column.
- Have students share their research with the class.

## • LESSON 2: POLYMERASE CHAIN REACTIONS

1. Review Essential Questions. Post Essential Questions in the classroom.

    - What is PCR?
    - Why do bacteria have plasmids?
    - How do scientists determine what primer sequences and temperature conditions should be used for a PCR experiment?
    - Why is DNA ligase important?
    - How is DNA ligase different from a restriction enzyme?
    - What is the most popular DNA polymerase?

2. PCR and its Importance in Biotechnology
    - Show students the **Polymerase Chain Reactions** PowerPoint presentation.
        - See attached supplementary files
    - Have students look up different primer sequences which can be used in PCR and record them in their lab notebooks.
    - Instruct students to find one way PCR is used in biotechnology which was not discussed on the PowerPoint, and write about it in their lab notebooks.

3. Lead a brief discussion about PCR.
    - Ask students, "Where do you think scientists can find DNA polymerases that can withstand being heated or cooled?"
    - Why is it important to have the right primer and temperature?
    - What do you think would happen if there was contamination during the process?
    - How do you think PCR can change biotechnology?

4. Summary
    - Have students list three things they learned on the board.

## • LESSON 3: BIOINFORMATICS

1. Review Essential Questions. Post Essential Questions in the classroom.

- Why is the science of bioinformatics important?

2. Lead a discussion about what bioinformatics is.
    - Explain to students that scientists began to use bioinformatics to help manipulate the massive amount of data generated as more genes were sequenced and cloned.
    - Tell students bioinformatics evolved as a way for scientists to easily view each others' data and compare their own research to it.
    - Ask students, "What are some ways scientists can use computers to organize this data?"
        - Examples:
            - New software programs
            - Search databases for DNA sequence information
            - Use sequence data to predict sequences

3. Have students visit **http://www.ncbi.nlm.nih.gov/genbank/** and use BLAST to search for sequence matches.
    - Click "Standard Nucleotide BLAST."
    - Type in a DNA sequence.
    - Hit BLAST to search for any other cloned genes.
    - Have students record their findings in their lab notebooks.

4. Culminating Performance Task
    - Have students work on the polymerase chain reaction experiment.

## • ATTACHMENTS FOR LESSON PLANS

**Cloning**
**Polymerase Chain Reactions**
**Vocabulary Glossary**

## • NOTES & REFLECTION:

Students should be keeping their lab notebooks up to date. Periodically check their notebooks to be sure they are recording data properly. For the Culminating Performance Task, use a pre-made PCR kit unless you are able to borrow kits from a laboratory which loans them.

# CULMINATING PERFORMANCE TASK

### Culminating Unit Performance Task Title:

**Polymerase Chain Reaction Lab**

### Culminating Unit Performance Task Description/Directions/Differentiated Instruction:

Split students into small groups. Have them perform a Polymerase Chain Reaction using a pre-made kit or by following a procedure found online. Make sure they record the procedure and all data in their laboratory notebooks.

### Attachments for Culminating Performance Task:

# UNIT RESOURCES

## Web Resources:

**http://www.ncbi.nlm.nih.gov/genbank/**
**www.genomicglossaries.com**
**www.protocol-online.org**
**www.genome.wi.mit.edu/cgi-bin/primer/primer3.ci**
**www.pbs.org/wgbh/nova/genome/media/sequence.swf**
**www.dnalc.org**

## Materials & Equipment:

- Equipment, including PCR machines, gel rigs, and power supplies can be loaned via the GBTI at **www.gabiotech.org**.

## 21st Century Technology Used:

| | | | | | |
|---|---|---|---|---|---|
| X | Slide Show Software | | Graphing Software | | Audio File(s) |
| | Interactive Whiteboard | X | Calculator | | Graphic Organizer |
| | Student Response System | | Desktop Publishing | | Image File(s) |
| | Web Design Software | | Blog | | Video |
| | Animation Software | | Wiki | | Electronic Game or Puzzle Maker |
| | Email | X | Website | | |