KENAN FELLOWS PROGRAM
FOR TEACHER LEADERSHIP

Cichlid Sex Determination - A DNA POGIL

Description

POGIL is an acronym for Process Oriented Guided Inquiry Learning. POGIL is a tool that allows for the simultaneous teaching of core content and higher-order thinking skills. This lesson includes content regarding DNA structure and storage in the cell, as well as its use in coding for proteins, and thereby determining phenotype. Models are based on data and procedures used in the Roberts lab at NC State University. Two possible timelines for implementation are provided.

Packet Contents

Introduction

One of the fundamental concepts to be studied in any general biology course is the role of DNA. Yet, this is also one of the most challenging concepts for students to understand. The processes involved are complex, and not easy to visualize, and this results in many students who are able to memorize key facts, but lack a deeper understanding of the material. This lesson uses a POGIL format, combined with real data and lab procedures (most notably dissection, DNA extraction, and polymerase chain reaction (PCR)) to help students understand what DNA does and how, as well as why scientists study it.

Curriculum Alignment

North Carolina Essential Standards - Biology

Bio.1.1.3 Explain how instructions in DNA lead to cell differentiation and result in cells specialized to perform specific functions in multicellular organisms.
Bio.3.1.1 Explain the double-stranded, complementary nature of DNA as related to its function in the cell.
Bio.3.1.2 Explain how DNA and RNA code for proteins and determine traits
Bio.4.1.2 Summarize the relationship among DNA, proteins and amino acids in carrying out the work of cells and how this is similar in all organisms.

Next Generation Science Standards

HS-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells.
HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.

Objectives

Students will be able to describe how cichlid sex can be distinguished based on physical characteristics.
Students will be able to describe the importance of studying an organism's DNA.
Students will be able to relate the DNA extraction process to how DNA is stored within a cell.
Students will be able to explain how DNA replication relies on its double-stranded structure.
Students will be able to explain the process by which DNA codes for proteins, which determine traits.

Time & Location

Lesson can be taught in the regular classroom setting, but requires students to have access to the internet. Time required is approximately 180 minutes, which may be divided in a variety of ways, depending on class length. Two suggested timelines are given in the activities section.

Teacher Materials

Master copy of POGIL with suggested answers
Timer
Projector or document camera

Student Materials

Individual copy of POGIL worksheet (printed or as writeable doc)
Individual copy of POGIL reflection questions
Internet enabled device
Headphones (recommended)
Grant proposal overview and rubric (optional extension)

Safety

Ensure that students are aware of rules of safe computer use.

Student Prior Knowledge

Option 1 - If the lesson is being used as the conclusion of a unit on DNA, students should be familiar with the structure of DNA, how it is segmented into genes, the processes of transcription and translation, and how proteins, once synthesized, relate to traits.

Option 2 - If the lesson is being used in sections, interspersed throughout a unit, students only need to know that DNA is found in cells and helps determine who we are.

Teacher Preparations

Review POGIL and answers. Determine student groupings.

Activities

Option 1 - lesson used at the conclusion of a DNA unit. All models are completed sequentially as written.
Option 2 - lesson used throughout unit. Models 1-3 are used to introduce the unit, then followed by a lesson on DNA structure and (if possible) a DNA extraction wet lab. After this, Model 4 is completed, followed by lesson(s) on transcription and translation. The unit is concluded with Model 5 and extension questions.
Regardless of which option is chosen, each Model should be followed by a large group review of the most challenging questions. Possible methods for this are Poll Everywhere, Kahoot survey, whip around, numbered heads together, popcorn, etc.

Introduction - 15 minutes

At the beginning of class, students will be asked to complete a warm up by answering the questions, "What does it mean to be male? What does it mean to be female?" After giving students several minutes to write their responses, volunteers will be asked to share out answers, particularly asking for answers that have not yet been heard. Teacher may ask a student volunteer to record answers on the board. Teacher will then provide each student with a copy of the POGIL document. This can be done on paper, or electronically (especially if color copies are not an option). Teacher will read the introduction (Why?) section, and briefly review the structure of a POGIL. Important points to discuss include:

- Work only on the section you are directed to
- Each section will be timed; manage your time so that you are able to get to all the questions, then go back to elaborate if you have extra time
- Work with (and only with) the partner or group you are assigned for a particular section
- Understand that you will likely feel confused at times, but that things will become clearer as you work through the POGIL

Model 1 - 20 minutes

Teacher will assign each student a partner and allow 10 minutes for work on Model 1. Student pairs should work together to review the model, discuss answers to the questions, and write them on their own sheets and in their own words. Teacher will circulate to monitor progress, and use probing questions to guide students only if they are at a complete standstill.

After 10 minutes, teacher will instruct students to stop their work and give students an opportunity to share points of confusion, and attempt to clarify for each other. During this discussion, teacher will act only as a moderator and not provide answers.

Model 2 - 25 minutes
Teacher will review the instructions for Model 2 and guide students through the completion of specimen 001. Use a projector or document camera to look at each picture for specimen 001 as a whole group and point out important features (as marked on the master copy) and show students how to fill their information into the data table.

Students will then be given 10 minutes to complete the data table for the remaining fish, with teacher giving time warnings so that students work quickly enough to determine sex for all fish. Students will then be placed in groups of 3-4 and asked to discuss questions 6 and 7, then write down their own answers (which may not match those of their group members), then develop common answers for questions 8 and 9.

Model 3 - 30 minutes
Teacher will assign each student a new partner and allow 30 minutes for students to review the models (including completion of the virtual DNA extraction) and answer the questions. During this time, teacher will circulate to assist as needed. If many students are getting stuck on the same question, teacher may choose to pause work time and address the question as a whole class.

Model 4 - 35 minutes
Teacher will instruct students to work independently for 25 minutes, reviewing the model (including completion of the virtual PCR) and answering questions 17-24. Teacher should ensure that students are aware of the text below the animations in the virtual lab. After 25 minutes, students will be assigned partners to compare answers and make any necessary adjustments.

Model 5 - 30 minutes
Teachers will assign students to new partners and allow 10 minutes for completion of questions 25-28. After 10 minutes, each pair should get together with another pair and spend 5 minutes discussing answers. Students will then spend 15 minutes in their new groups of four answering questions 29-35.

Extension Questions - 20 minutes
Teacher will instruct students to form into groups of 3-4 of their choosing and spend no more than 20 minutes completing question 36. Questions 37 and 38 will be assigned for homework.

Reflection - 10 minutes
Assign students to complete POGIL reflection handout for homework. At the beginning of class the following day, guide students in discussing their answers, encouraging them to focus on both product (what they learned) and process (how they learned).

Assessment

Assessment may be done in two ways. At minimum, teacher will collect completed POGILs and check answers using provided master copy. Students should be given written feedback and an opportunity to revise as necessary.

If teacher wishes to extend the lesson, or as an adaptation for higher level students, a project may be assigned in which students work in groups to write a mock grant proposal for new research related to that discussed in the POGIL. This assignment and grading rubric are included.

Critical Vocabulary

Cichlid - freshwater fish from the family Cichlidae that is widely distributed in tropical regions
Chromosome - a threadlike structure of nucleic acids and protein found in all living cells, carrying genetic information in the form of genes
DNA - deoxyribonucleic acid, the carrier of genetic information in nearly all living organisms
Extract - take out
Gene - a portion of a chromosome which serves as the basic unit of heredity, transmitting information which control an organism's traits
Genetic - relating to genes or heredity
Gonad - a gland that produces reproductive cells, such as the ovary and testis
Molecular - caused by molecules, the smallest physical unit of an element or compound
Morphology - physical form
Organism - individual life form
Protocol - scientific procedure

Author Information

April Bernier:

Johnston County Early College Academy, Johnston County Schools, Smithfield, NC
Biology, grades 9-10
Teaching experience - 7 years
Contact: april.n.bernier@gmail.com

Reade B. Roberts:

PhD, Cell & Developmental Biology, Vanderbilt University
BS, Biochemistry, Susquehanna University

Assistant Professor in the Department of Biological Sciences, North Carolina State University
Active in the Genetics Program, The Keck Center for Behavioral Biology, and the Comparative Medicine Institute (all at NC State)
Named a 2014 Beckman Young Investigator

The objective of all of the research in my lab is to understand the genetic basis of traits in natural context. That is, how does DNA evolve to produce useful traits for species, and ultimately the diversity of life we see on the planet today? The overarching strategy of my research program is to inventively fill gaps in biological knowledge by drawing on unexpected tools in the existing diversity of life. Most of our research scrutinizes East African cichlid fish, which have astounding diversity and relationships that allow interesting comparisons; main projects focus on sex determination, adaptation to diet, and behavior. We also dabble across the tree of life, collaborating on projects examining the genetic basis of traits in insects, amphibians, and mammals, including humans. My research career started in biomedical research, using classic mouse models to study human health. Later, I made a switch to study evolutionary genetics in non-model organisms. I hope that my experience gives me unique perspective. My goal is to produce new knowledge with dual impact - informing both our understanding of how genes and species evolve, and providing basic biology insights that may improve the human condition.

Contact: rbrober2@ncsu.edu