CSI: Wildlife - DNA Barcoding Mystery

A 75-Minute Inquiry Activity for Grade 11 Biology

Grade Level: Grade 11 Biology University Preparation (SBI3U)
Duration: 75 minutes
Format: Pairs or small groups (2-3 students)

Unit/Strand:	**D: Genetic Processes**
Specific Expectations:	**D2.1** Describe the structure and function of DNA and explain the processes of DNA replication and protein synthesis **D2.5** Apply techniques such as DNA barcoding, gel electrophoresis, and DNA fingerprinting to identify and compare organisms **D3.5** Explain the applications of biotechnology in areas such as medicine, agriculture, forensics, and conservation
Scientific Investigation Skills:	**A1.3** - Identify and locate print/electronic sources (NCBI BLAST, BOLD Systems, CITES databases) **A1.6** - Compile and organize data in appropriate formats (evidence tables, analysis worksheets) **A1.11** - Communicate ideas and conclusions using appropriate formats
Specific Skills Introduced/Developed/Mastered:	**DEVELOP:** Data Collection & Organization Experimental Design & Controls Data Analysis & Interpretation Scientific Communication

Overview

Students take on the role of forensic biologists investigating an illegal wildlife trafficking case using authentic bioinformatics tools (NCBI BLAST and BOLD Systems). They obtain DNA sequences from three evidence samples (tissue, blood, and hair) and use public databases to identify species. Students research conservation status, connect DNA evidence to suspect statements, and determine which suspects are guilty based on evidence-based reasoning. This investigation emphasizes organizing information from multiple sources—evidence descriptions, suspect profiles, BLAST results, and conservation databases—requiring high cognitive load and mental organization as students manage and synthesize diverse data types.

Rationale

This inquiry engages students in authentic forensic analysis using real bioinformatics tools and databases, reflecting genuine practices in wildlife conservation and law enforcement. Students gradually transition to independent thinking as they take on more responsibility for organizing and interpreting diverse, complex information sources. The main output is a comprehensive worksheet featuring critical thinking discussion questions rather than structured fill-in-the-blanks, as responsibility for learning continues to gradually shift toward students. This inquiry demands significant cognitive engagement: students must collect information from multiple sources (case file, suspect statements, BLAST database results, and conservation databases), mentally organize these disparate pieces, and synthesize them into evidence-based conclusions. By managing this complexity, students develop research skills, evidence-based reasoning, and scientific literacy while connecting genetic science to real-world conservation challenges and legal proceedings.

Learning Objectives

1. Use bioinformatics tools (NCBI BLAST and BOLD Systems) to identify species from DNA sequences
2. Understand DNA barcoding using the cytochrome c oxidase I (COI) gene as a molecular marker
3. Analyze and interpret BLAST results, including percent identity, E-value, and species matches
4. Apply inquiry skills to solve a real-world forensic problem using evidence-based reasoning
5. Connect to conservation issues, understanding wildlife trafficking and biodiversity protection

Materials Needed

For Each Pair of Students:

- Computer or tablet with internet access
- Student Investigation Packet (provided in this document)
- Evidence Analysis Worksheet
- Access to NCBI BLAST: https://blast.ncbi.nlm.nih.gov/
- Access to BOLD Systems: http://www.boldsystems.org/

For the Instructor:

- Projector/screen for crime scenario presentation
- Answer key (included)
- Optional: Printed crime scene photos or evidence cards

Public Databases Used

NCBI BLAST (Basic Local Alignment Search Tool)

- Compares query DNA sequences against GenBank database
- Returns matches with statistical significance scores
- Free and accessible to students worldwide

BOLD Systems (Barcode of Life Data Systems)

- Specialized database for DNA barcodes
- Includes specimen data, images, and taxonomy
- Provides species identification tools and phylogenetic trees

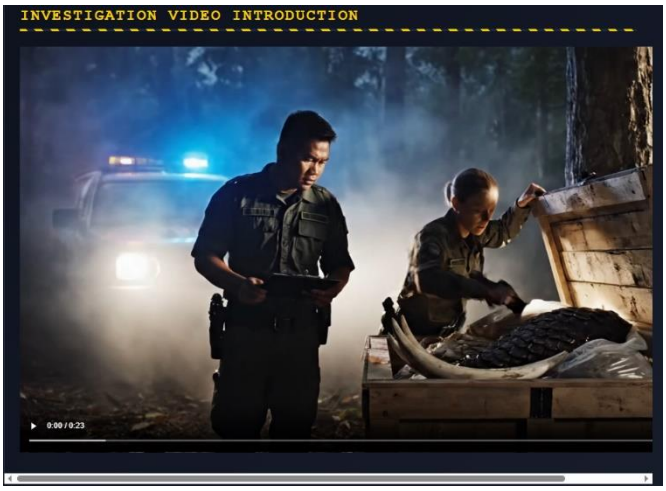
Why This Activity Works

This activity connects to real-world applications:

- Wildlife forensics: Agencies like USFWS use DNA barcoding to combat illegal wildlife trade
- Conservation biology: Identifying species helps protect endangered populations
- Food fraud detection: Verifying species identity in seafood and meat products
- Biodiversity research: Cataloguing species for ecological studies

Inquiry “Hook” (online assets available at https://bbq6ix.com/bio/)

- Greet class and let them know of a serious situation
- Tell them we have a video from the Operation Wildlife Shield investigation team
- Play VIDEO from webpage



- Provide BACKGROUND INFORMATION on DNA BARCODING



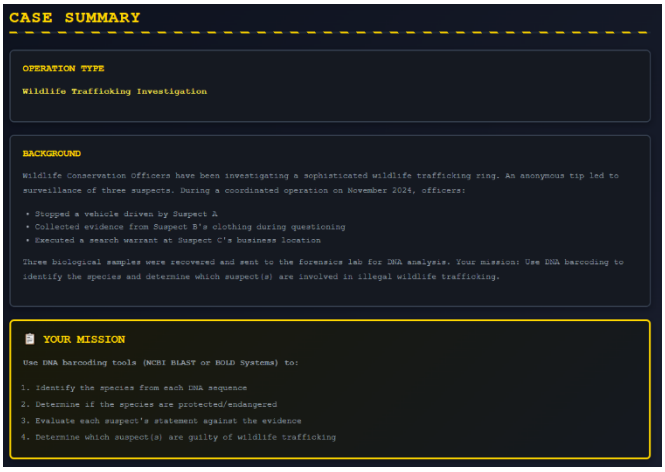
Discuss the Forensic Method
Before you investigate this wildlife trafficking case, it's important to understand the forensic method that will help you solve it: DNA barcoding.

Discuss “What is DNA Barcoding?”
DNA barcoding is a taxonomic method that uses a short standardized region of DNA to identify species. For animals, the cytochrome c oxidase subunit I (COI) gene from mitochondrial DNA is the standard "barcode" region. This ~650 base pair sequence:

Why Barcoding works

- Varies Between Species: Different species have different COI sequences, allowing us to distinguish them from one another
- Conserved Within Species: Members of the same species share very similar COI sequences, enabling reliable identification
- Works with Small Samples: Can be amplified from tiny tissue samples - even small bits of tissue, blood, or hair contain analyzable DNA
- Catalogued in Databases: Scientists have uploaded millions of known COI sequences to public databases like NCBI BLAST and BOLD Systems for comparison

- Discuss STORY/CASE SUMMARY
  Wildlife Conservation Officers have been investigating a sophisticated wildlife trafficking ring operating in the region. An anonymous tip led officers to conduct surveillance on three individuals suspected of involvement in illegal wildlife trade.



  During a coordinated operation, officers:
  - Stopped a vehicle and discovered suspicious biological material in the trunk
  - Collected blood evidence from a suspect's jacket
  - Seized materials from a storage warehouse

  Three suspects have been detained, each with different stories. Your job as forensic biologists is to:
  1. Identify the species from DNA evidence collected at the scenes
  2. Determine which species are protected under wildlife conservation laws
  3. Analyze suspect statements to determine who is lying
  4. Make a recommendation on charges based on the evidence

Inquiry Lesson Structure

Phase 1: Introduction and Case Briefing (5 minutes)

Instructor Actions

1. Present the crime scenario “Hook” using the narrative above
2. Show suspect photos/profiles on screen (optional)
3. Explain that students will use real forensic tools used by conservation officers
4. Review learning objectives and success criteria
5. Demonstrate how to access NCBI BLAST (quick overview)

Key Questions to Pose:

"How can we identify a species from just a tissue sample?"
"What makes DNA evidence reliable in criminal cases?"
"Why is wildlife trafficking a serious crime?"

Phase 2: Evidence Collection and Analysis Planning (5 minutes)

Student Actions:

1. Receive Investigation Packet containing:
   - Three DNA sequences (Evidence A, B, C)
   - Suspect profiles and statements
   - Evidence Analysis Worksheet

2. Read through the evidence descriptions
3. Discuss with partner: What species might be involved?
4. Form initial hypotheses about which suspect might be guilty

Inquiry Prompts During Teacher Circulation or Class Discussion:
"What do you notice about where each piece of evidence was found?"
"What patterns do you see in the suspect statements?"
"Before running BLAST, what species do you predict might be involved?"

Phase 3: Database Investigation (35 minutes)

- This is the core inquiry phase where students in small groups (2-3) and use bioinformatics tools.
- See Step-By-Step Protocol for student instructions.
- Teacher circulates and guides students with questions
- Optional: Teacher can have all students stop at each Part of the Worksheet and have class discussions before moving through each phase

Guiding Questions for Groups/Whole Class:
"Does the DNA evidence support or contradict each suspect's statement?"
"Which suspect has the weakest alibi based on the species identified?"
"Could multiple suspects be working together?"
"What additional evidence would strengthen the case?"

Phase 4: Group Presentations and Debrief (20 minutes)

Student Presentations (10 minutes):
Select 2-3 groups to present their findings (2 min each)

Each group should:

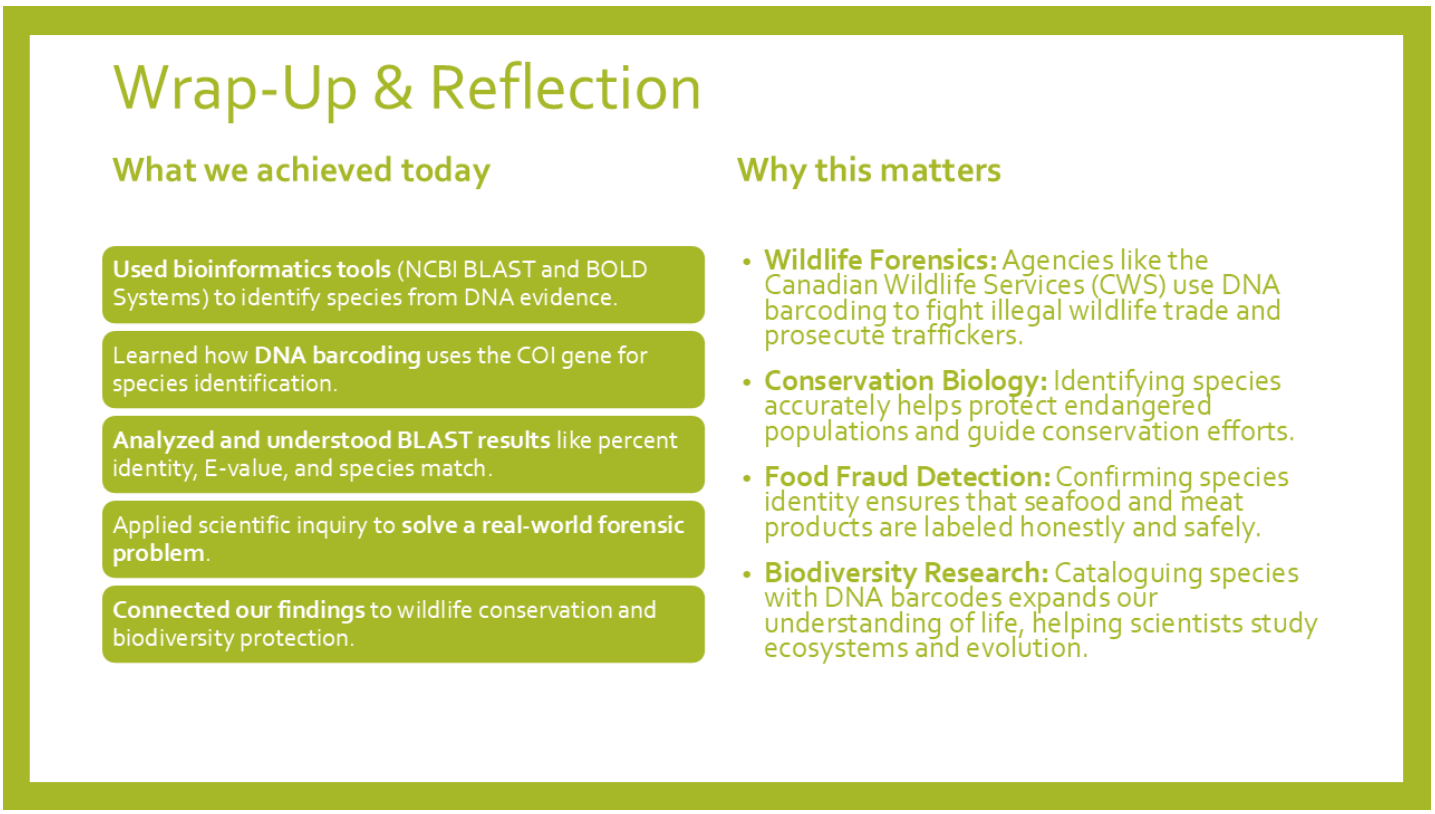
- State which species they identified from each evidence sample
- Explain conservation status of each species
- Identify which suspect is guilty and why
- Show one piece of key evidence (BLAST result screenshot or BOLD page)

Class Discussion (8 minutes):
Forensic Science Questions:
"What made DNA barcoding reliable for this case?"
"What are limitations of DNA evidence?" (contamination, degradation, database gaps)
"How is this similar to/different from human DNA fingerprinting in criminal cases?"

Conservation Connections:
"Why is wildlife trafficking a global problem?"
"How does DNA barcoding help conservation efforts beyond forensics?"
"What role do international laws like CITES play?”

Career Connections:
"What careers use DNA barcoding?" (conservation officers, forensic biologists, customs inspectors, biodiversity researchers)
"How does bioinformatics support these careers?"

Wrap-Up Slide (2 minutes)



Reflection Questions for Teachers

After implementing this activity, consider:

1. **Engagement**: Which phase had highest student engagement? Why?
2. **Inquiry Skills**: Did students generate their own questions during investigation?
3. **Technical Proficiency**: How comfortable were students using bioinformatics tools?
4. **Conceptual Understanding**: Did students grasp the relationship between DNA sequences and species identification?
5. **Conservation Awareness**: Did the activity raise awareness about wildlife trafficking?
6. **Time Management**: Did the 75-minute timeframe work, or would adjustments improve the experience?
7. **Differentiation**: Were modifications needed for diverse learners?