Elaborate: CSI: Curious Species Investigation – Solving the Mystery of Evolution

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Welcome, Evolutionary Detectives!

You have a big mystery to solve: How did a new species evolve?

You'll explore clues in a gallery walk, where you'll look at evidence like maps, DNA sequences, and animal traits. After gathering clues, you and your team will figure out what happened and explain it to the class.

This packet will help you every step of the way. Don't worry—we're here to help!

Key Words

- **Speciation**: When one species splits into two different species.
- **Isolation**: When groups of animals or plants get separated so they can't meet or mate.
- **Traits**: Special characteristics like color, size, or behavior.
- **Selection Pressure**: Things in the environment that push animals or plants to change, like food shortages or weather.

What You'll Do

1. **Explore the Evidence**
   Walk through the gallery, where you'll see maps, DNA charts, and pictures of animal traits. Take notes on what you see.
2. **Solve the Mystery**
   Work with your team to figure out how a new species evolved.
3. **Share Your Ideas**
   Present your findings to the class. You'll explain your theory and answer questions from your classmates.

Name: _____ Date: _____

How to Get Started

Step 1: Walk Through the Gallery

Visit the gallery stations around the room. Each station has evidence for your case:

- **Station 1: Environmental Maps**
  Look at the maps to see the habitat where the animals live.
    - Are there mountains, rivers, or oceans that could separate groups of animals?
    - Did something in the environment change?
- **Station 2: DNA Sequences**
  Look at the DNA (the genetic code) of the new species and its relatives.
    - Are there big differences in the DNA?
    - What do these differences tell you?
- **Station 3: Species Traits**
  Look at the pictures and descriptions of the species.
    - How do the new species look or act differently from their relatives?
    - Why might those traits help them survive?

Step 2: Solve the Mystery with Your Team

After you visit all the stations, sit with your team and talk about what you learned.

- Answer these questions:
    1. What caused the animals to get separated?
    2. How did their traits change to help them survive?
    3. How do we know they're a new species?
- Create a **timeline** showing what happened step by step.

Step 3: Share Your Ideas

Your team will explain your theory to the class. Be ready to:

- Show your timeline.
- Explain how the evidence supports your ideas.

- Answer questions from your classmates.

Cases for the Gallery Walk

Each team will work on one of these mysteries:

1. **Island Birds**
   A storm separated some birds onto different islands. Now, they look very different from their mainland relatives.
2. **Lake Fish**
   A new fish species appeared in a lake that used to be part of a river. These fish have bright colors and eat different food.
3. **Desert Beetles**
   Sand dunes divided beetles into two groups. Over time, they became very different in color and behavior.
4. **Mountain Lizards**
   Some lizards live at the bottom of a mountain, while others live at the top. They've evolved to survive in very different climates.
5. **Cave Crustaceans**
   Crustaceans in a dark cave lost their eyesight and changed how they move and eat.
6. **Arctic Foxes**
   Ice sheets separated foxes into two groups. They adapted to different habitats, like the forest and the tundra.

Your Detective Toolkit

- **Notes**: Write down what you see at each station. Use simple sketches if that helps!
- **Team Discussions**: Share your ideas with your teammates. Listen to their ideas too.
- **Choose 2 Stations to Report on -**
- **Sentence Starters**:
  - *"I think the map shows that _____ caused the animals to get separated."*
  - *"The DNA differences show _____."*
  - *"This trait helps them survive because _____."*

How You'll Be Graded

Name: _____ Date: _____

1. **Participation in the Gallery Walk** (20%)
    - Did you visit all the stations and take notes?
2. **Teamwork and Timeline** (40%)
    - Did your team work together to solve the mystery?
    - Is your timeline clear and correct?
3. **Presentation** (30%)
    - Did you explain your ideas clearly?
    - Did you use the evidence to support your theory?
4. **Questions and Answers** (10%)
    - Did you answer questions from the class?

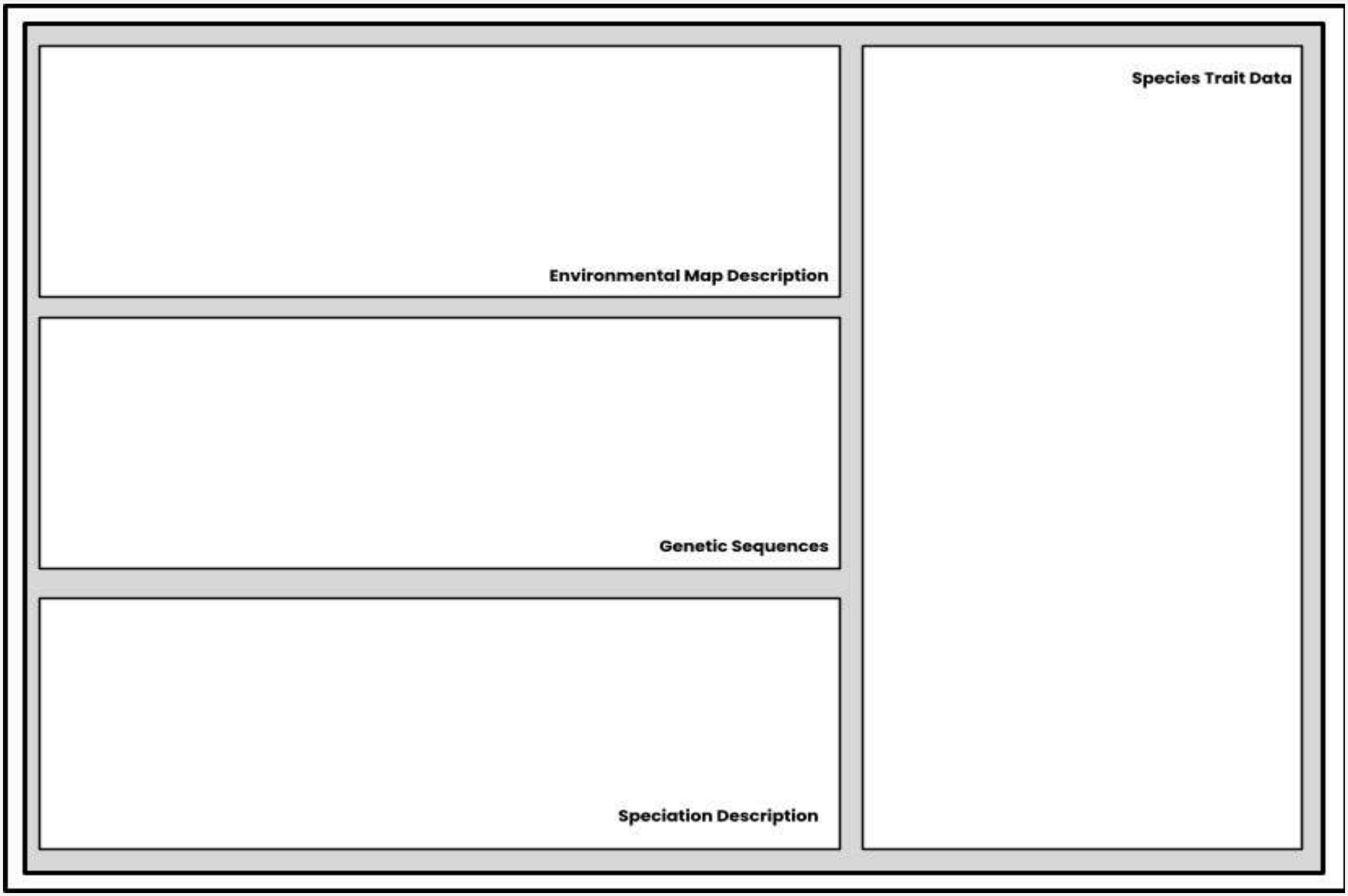
Tips for Success

- Work together—everyone on your team has something to add!
- Look carefully at the evidence. Sometimes small details can give you big clues.
- If you're confused, ask your teacher or a teammate for help.

Good luck, detectives! Let's solve the mystery of how new species evolve!

Name: _____ Date: _____

Student Date Report Sheet



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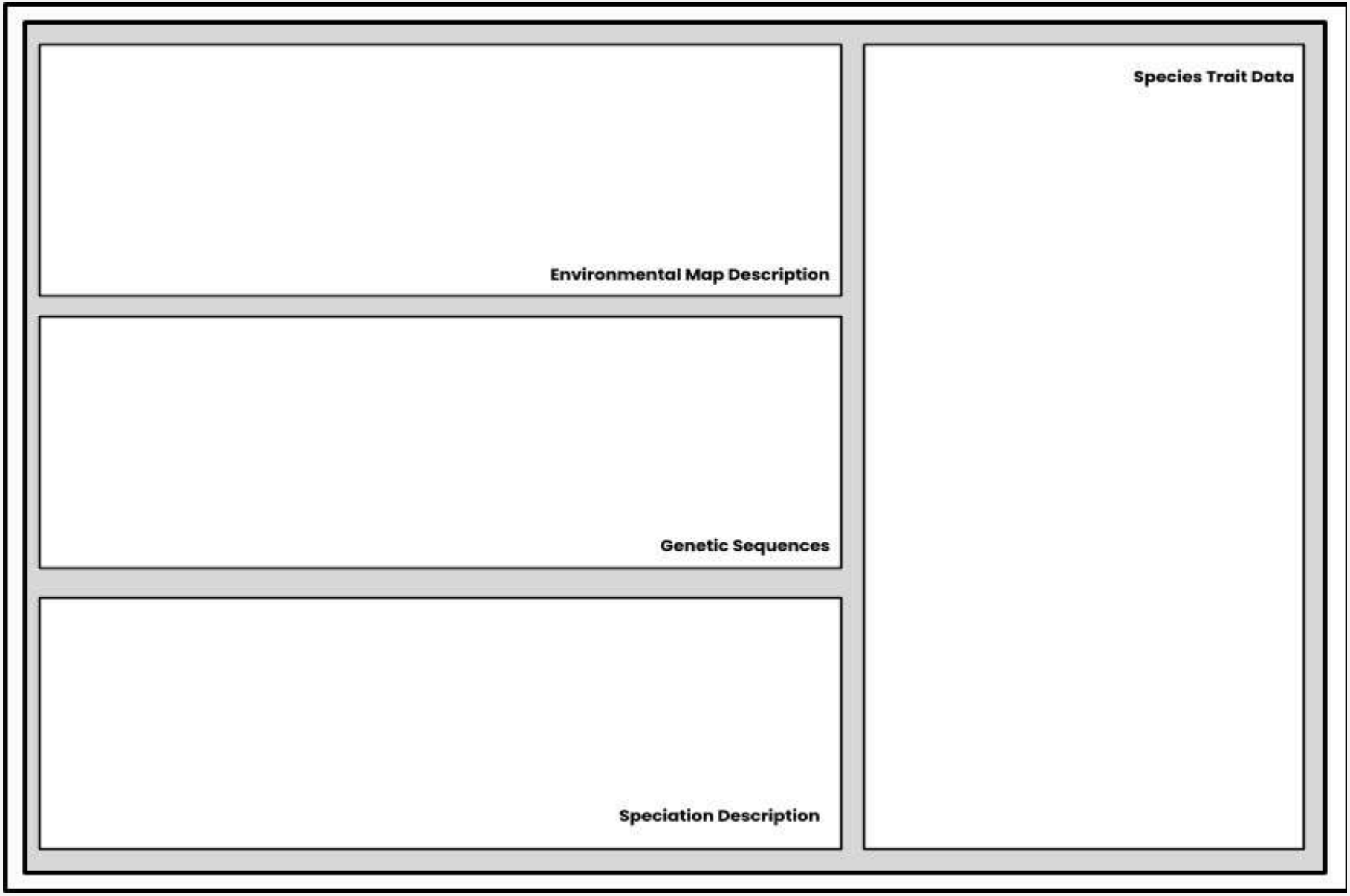

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Case 1 – Scenario:

A fierce storm swept a flock of mainland seed-eating birds to an isolated archipelago. These islands vary in size and climate, from humid jungles to dry scrublands. Over generations, the birds faced unique environments, leading to adaptation and eventual speciation.

Mechanisms of Speciation:

- **Geographic Isolation:** The open ocean separates the islands and the mainland, preventing birds from returning or interbreeding.
- **Behavioral Isolation:** Birds on different islands developed unique songs to attract mates, reducing inter-island mating.

Selection Pressure:

- Small islands with sparse resources selected for insect-eating birds with smaller, agile beaks.
- Dense forests encouraged bright plumage to attract mates in low light.

Environmental Maps:

- **Features:** Archipelago map showing distances from the mainland, island sizes, and climates ranging from humid to arid.
- **Barriers:** Vast ocean prevents migration back to the mainland or between islands.

Genetic Sequences.

Mainland Finch: ACTGGAATCGTACCGTAGCT

Position	Original Base	Island 1	Island 2	Island 3	Island 4	Island 5
7	G	G	G	G	T	G
9	T	T	G	T	T	T
13	A	G	A	A	A	A
15	T	T	T	C	T	T
17	A	A	A	A	A	T

Species Traits Data:

- **Mainland** birds: large, strong beaks for cracking seeds.
- **Island birds:** small, pointed beaks for insect hunting, with brighter plumage.

Name: _____ Date: _____

Case 2 – Scenario:

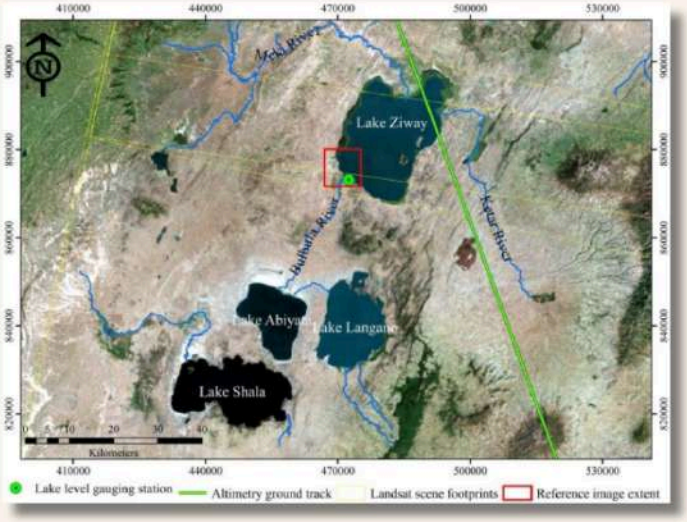
An isolated lake in the Rift Valley became home to a group of river fish that became stranded by geological changes. Over thousands of years, these fish evolved to exploit unique niches in the lake's rocky depths.

Mechanisms of Speciation:

- **Geographic Isolation:** Waterfalls and steep cliffs isolated the lake from the river.
- **Reproductive Isolation:** Bright red coloration became a key mating signal, preventing interbreeding with dull-colored river fish.

Selection Pressure:

- Rocky lake habitats selected for algae-eating fish with specialized teeth.
- Competition for food drove the development of new feeding strategies.



Environmental Maps:

- **Features:** Rift Valley map showing the isolated lake system, varying depths, and nearby river.
- **Barriers:** Geological cliffs and waterfalls prevent movement between lake and river.

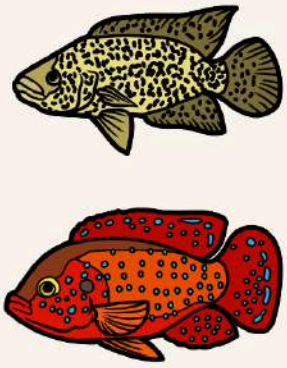
Genetic Sequences.

Original Cichlid: ACTGGAATCGTACCGTAGCT

Position	Original Base	Lake 1	Lake 2	Lake 3	Lake 4	Lake 5
5	C	C	C	C	T	C
9	T	T	G	T	T	T
13	A	C	A	A	A	A
15	T	T	T	A	T	T
17	A	A	A	A	A	T

Species Traits Data:

- **River fish:** dull coloration, generalized feeding habits.
- **Lake fish:** bright red coloration, specialized teeth for algae scraping.



Name: _____ Date: _____

Case 3 – Scenario:

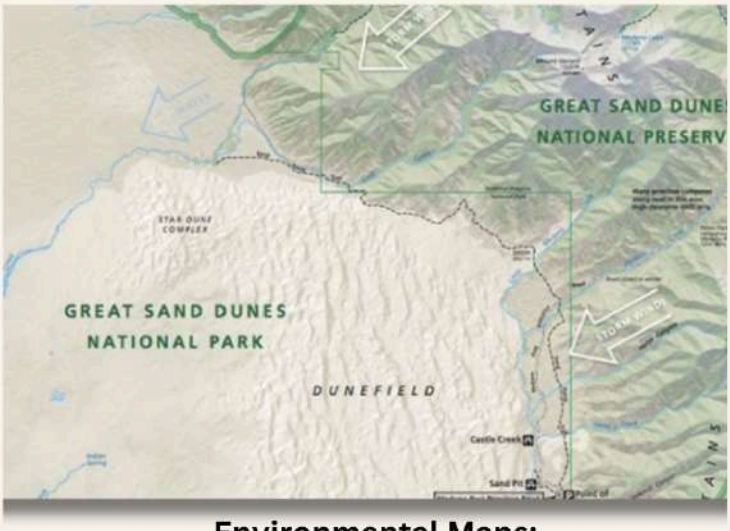
A once-lush savanna turned into a patchwork of sand dunes due to climate change. Beetle populations were trapped on either side of the dunes, adapting to their new environments.

Mechanisms of Speciation:

- **Geographic Isolation:** Expanding sand dunes act as a physical barrier.
- **Genetic Drift:** Small populations on either side of the dunes experience random genetic changes.

Selection Pressure:

- Rocky habitats favored darker beetles for camouflage.
- Sandy areas favored pale beetles and nocturnal activity to avoid heat.



Environmental Maps:

- **Features**: Map showing sand dunes dividing rocky and sandy regions.
- **Barriers:** Extreme temperatures and lack of vegetation prevent beetles from crossing.

Genetic Sequences.

Original Beetle: ACTAGGCTCGTACGATAGCT

Position	Original Base	Northern	Southern	Eastern	Western	Central
6	G	G	T	G	G	A
9	T	C	T	T	C	T
14	A	A	A	G	G	A
17	A	A	A	A	A	A

Species Traits Data:

- **Northern beetles:** dark coloration, diurnal activity.
- **Southern beetles:** pale coloration, nocturnal behavior.

Name: _____ Date: _____

Case 4 – Scenario:

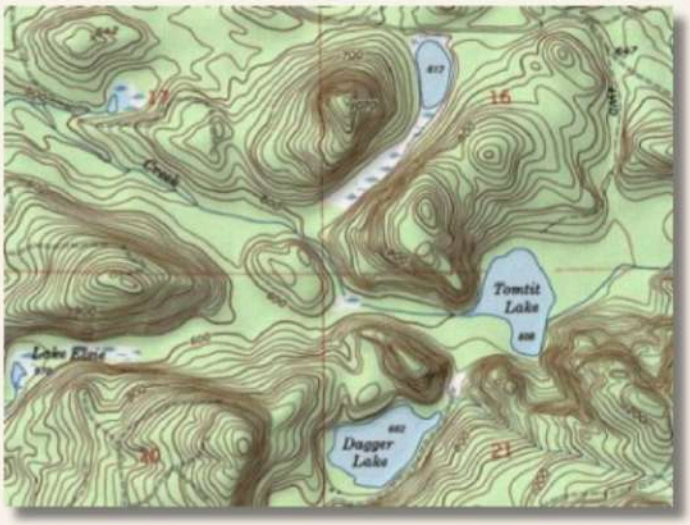
Lizards in a mountainous region were separated by steep slopes and elevation changes. Over time, populations adapted to lowlands and highlands, evolving distinct traits.

Mechanisms of Speciation:

- **Geographic Isolation:** Steep slopes and cold peaks limit movement.
- **Behavioral Isolation:** Lizards at different elevations developed distinct mating displays.

Selection Pressure:

- **Low-altitude lizards:** bright green coloration for forest camouflage, active year-round.
- **High-altitude lizards:** brown coloration for rocky terrain, hibernation for winter survival.



Environmental Maps:

- **Features: Topographic** map showing steep slopes and fragmented forest habitats.
- **Barriers:** Temperature and elevation prevent movement.

Genetic Sequences.

Original Lizard: ACTAGGCTCGTACGATAGCT

Position	Original Base	Lowland	Low-Altitude	High-Altitude	Mid-Elevation	Mountain Peak	Cliff-Dwelling
6	G	G	A	G	G	G	G
8	T	T	T	C	T	T	T
9	C	C	C	C	C	C	T
12	A	A	A	A	G	A	A
15	A	A	A	A	A	T	A
17	C	C	C	C	C	C	C

Species Traits Data:

- **Low-altitude lizards:** active metabolism, green coloration.
- **High-altitude lizards:** slower metabolism, brown coloration.

Name: _____ Date: _____

Case 5 – Scenario:

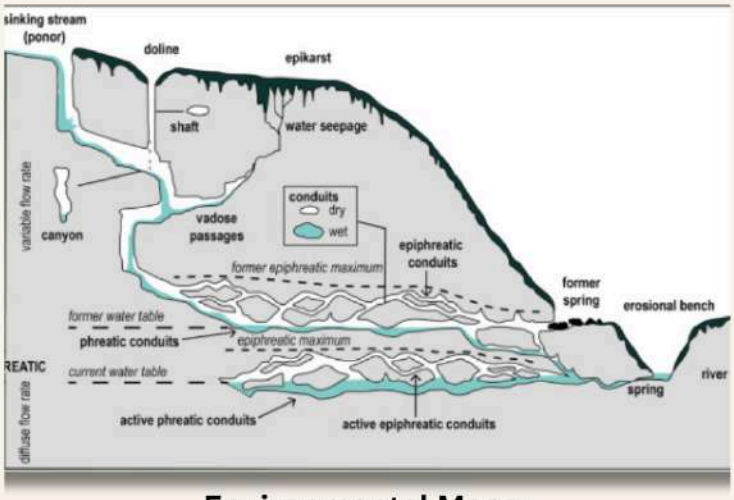
A flood swept surface crustaceans into an underground cave system. In the total darkness, they evolved to survive without light.

Mechanisms of Speciation:

- **Geographic Isolation:** Underground rivers connect caves but cut off surface access.
- **Genetic Drift**: Small populations experience random changes over time.

Selection Pressure:

- Total darkness selected for enhanced sensory antennae and loss of pigmentation.
- Limited food availability favored slower metabolisms.



Environmental Maps:

- **Features:** Cave system map showing isolated underground rivers.
- **Barriers:** Lack of surface access and extreme darkness.

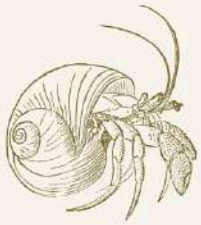
Genetic Sequences.

Original Crustacean: GCTAGCTGAGTACGTCGAT

Position	Original Base	Cave 1 (Blind)	Cave 2 (Albinism)	Cave 3 (Modified Exoskeleton)	Cave 4 (Stress Tolerance)	Surface
7	G	A	G	G	G	G
10	C	C	C	T	C	C
12	C	C	C	G	C	C
14	G	G	T	G	G	G
17	A	A	A	A	A	A

Species Traits Data:

- **Cave crustaceans:** blind, pale, large antennae, slow metabolism.
- **Surface crustaceans:** pigmented, smaller antennae, faster metabolism.



Name: _____ Date: _____

Case 6 – Scenario:

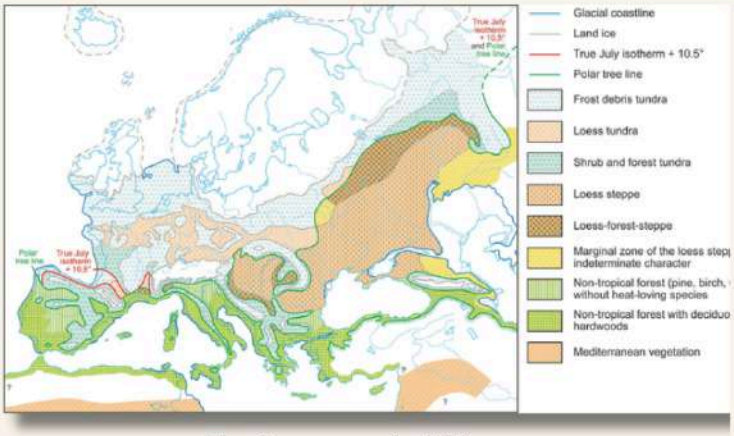
During the Ice Age, glaciers separated fox populations into tundra and taiga habitats. These populations evolved distinct traits to survive in their respective climates.

Mechanisms of Speciation:

- **Geographic Isolation:** Glacial barriers prevented gene flow.
- **Reproductive Isolation:** Seasonal differences in mating times arose between populations.

Selection Pressure:

- **Tundra foxes:** white fur for camouflage, short ears to conserve heat.
- **Taiga foxes:** brown fur for forest camouflage, larger ears for heat dissipation.



Environmental Maps:

- **Features:** Ice Age map showing glaciers separating tundra and taiga regions.
- **Barriers:** Glacial ice sheets prevent migration.

Genetic Sequences.

Original Fox : GATCGCTAGTACAGGACAT

Position	Original Base	Tundra Fox	Taiga Fox	Subarctic Fox	High Altitude Fox	Coastal Fox
6	A	T	A	A	A	A
12	T	T	T	G	T	T
14	T	T	A	T	T	T
16	A	A	A	A	A	C
18	G	G	G	G	A	G

Species Traits Data:

- **Tundra foxes:** short ears, thick fur, specialized fat storage.
- **Taiga foxes:** larger ears, thinner fur, more generalist diet.

Name: _____ Date: _____

Teacher Instructions for "CSI: Speciation Investigation" (Revised)

Objective:

Students will use evidence to investigate the speciation process, analyzing genetic data, environmental maps, and species traits to understand how different mechanisms of speciation (geographic isolation, behavioral isolation, reproductive isolation, gene flow, and genetic drift) contribute to the formation of new species.

Materials Needed:

- **Student Handouts** (including Case Details and Data Sheets)
- **Environmental Maps** (showing geographic barriers, habitats)
- **Genetic Sequences** (showing DNA sequences and mutations)
- **Species Traits Data** (describing morphological and behavioral differences)
- **Computers/Tablets** (for accessing digital resources or performing analyses)
- **Markers/Sticky Notes** (for gallery walk)
- **Posters or Presentation Boards** (for each team to present findings)

Preparation Steps:

1. **Organize Students into Teams:**
    - Divide students into small teams of 3-4 students. Ensure that each team has a balanced mix of ability levels, including students who are stronger in reading, writing, or analytical skills, as well as students with special education needs or English learners.
    - Assign each team one of the speciation case studies (e.g., Island Birds, Lake Fish, Desert Beetles, etc.).
2. **Set Up Stations for Gallery Walk:**
    - Place "Case Evidence" materials (Environmental Maps, Genetic Sequences, Species Traits Data, Speciation Examples) at different stations around the room. Each station should include a set of materials for one case.
    - Prepare sticky notes or markers so students can leave comments or ask questions about the evidence they examine.
3. **Review the Speciation Concepts:**

- Briefly review key concepts: **speciation**, **natural selection**, **genetic drift**, **gene flow**, **geographic isolation**, **behavioral isolation**, and **reproductive isolation**. Use simple language and visuals, making sure all students understand the core concepts.
- Consider using a visual diagram that shows how speciation occurs over time, starting with a single species and branching into new species due to isolation.

Instructions for Students:

Step 1: Investigate the Evidence (Gallery Walk)

1. Each team will start by analyzing the "evidence" for their assigned case at one of the stations. They will read through the provided materials (maps, genetic data, species traits) and take notes.
   - **Environmental Maps:** Look for geographic barriers that might have isolated populations (mountains, oceans, rivers).
   - **Genetic Sequences:** Examine how the DNA sequences differ between populations and look for mutations that may indicate divergence.
   - **Species Traits Data:** Compare physical and behavioral traits between the populations. What adaptations can you link to the environment?
   - **Speciation Example:** Review a related real-world case of speciation and compare it to the case you are investigating.
2. **Gallery Walk Tips:**
   - Move between stations to review all evidence (if applicable to the case). At each station, use sticky notes to leave questions or thoughts about the data.
   - As you move between cases, compare and contrast the mechanisms of speciation: geographic isolation, behavioral isolation, reproductive isolation, and others.

Step 2: Solve the Speciation Mystery

1. Using the evidence provided, each team will:
   - Propose a hypothesis about how speciation occurred in their case (e.g., how isolation and selection pressures led to the emergence of a new species).
   - Use the genetic, environmental, and species trait data to support your argument.
   - Create a timeline or flowchart that illustrates the speciation process for their case.

Step 3: Share Findings with the Class

1. After investigating and discussing their findings, each team will share their results with the class. Teams should:
    - Present their hypothesis on how speciation occurred.
    - Share the genetic, environmental, and species trait evidence they analyzed.
    - Discuss how different mechanisms (geographic isolation, behavioral isolation, etc.) contributed to the speciation process.
2. **Presentation Guidelines:**
    - **Organize your findings clearly**: Begin by introducing the case and stating your hypothesis. Then, walk through the evidence you analyzed, explaining how it supports your hypothesis.
    - **Visual Aids**: Use charts, diagrams, and maps to support your presentation and make the case clear to others.
    - **Explain your reasoning**: Discuss how each piece of evidence (genetic sequence, environmental data, species traits) connects to the speciation process.

Step 4: Peer Feedback and Discussion

1. After each team presents, other teams will provide feedback by asking questions and offering insights. This can be done through a brief **Q&A session** after each presentation.
    - Encourage students to think critically and ask questions about the evidence presented by other teams.
    - Teams should be prepared to revise their hypotheses or explanations based on feedback and new insights.
2. **Class Discussion:** After all the teams have presented, hold a class-wide discussion on the following:
    - What are the common patterns you observed in the cases (e.g., how did geographic isolation contribute to speciation in each case)?
    - Were any cases particularly surprising? Why?
    - How does genetic divergence and selection pressures shape the diversity of life?
3. **Exit Ticket:** Have students write a brief reflection on how speciation occurs, which case they found most interesting, and what evidence most strongly supported their group's hypothesis.

Differentiation Strategies:

1. **For English Learners (ELs):**

- **Provide Glossary**: Create a glossary of key terms with visuals and simple definitions. Include terms like "mutation," "speciation," "adaptation," and "gene flow."
- **Pair with a Buddy**: Pair EL students with more proficient English speakers for collaboration and language support.
- **Visual Aids**: Use diagrams, videos, and maps to support understanding.
- **Simplified Instructions**: Provide instructions in clear, short sentences and use graphic organizers to help students organize their thoughts.

2. **For Students with Special Education Needs:**
   - **Clear and Concise Instructions**: Provide step-by-step instructions and checklists to ensure all students understand the task.
   - **Use of Technology**: If available, use apps or digital tools that can read text aloud or assist with note-taking.
   - **Flexible Grouping**: Place students in groups where they can contribute based on their strengths, such as writing, drawing, or verbal explanations.
   - **Extended Time**: Allow additional time for students who need it, particularly for the research and presentation steps.
3. **For Students with Learning Gaps:**
   - **Peer Tutoring**: Pair students with learning gaps with stronger peers who can help explain complex ideas.
   - **Simplified Case Studies**: Modify the complexity of the case studies for students who need extra support by reducing the amount of genetic data or environmental variables.
   - **Interactive Activities**: Use hands-on activities like drawing evolutionary trees or creating simple timelines to reinforce understanding.
4. **For Advanced Students:**
   - **Additional Cases**: Assign advanced students additional cases to solve or have them research related real-world examples of speciation.
   - **Deeper Analysis**: Challenge students to think critically about the evidence and consider alternative explanations for speciation.
   - **Independent Research**: Allow advanced students to present more complex ideas, such as discussing the molecular mechanisms behind mutations or how environmental pressures specifically influence gene expression.

Assessment:

- **Formative Assessment:** During the gallery walk and group discussions, assess students' understanding by checking for accurate use of speciation vocabulary, their ability to explain the mechanisms, and how well they analyze evidence.
- **Summative Assessment:** Evaluate students' final presentations based on their ability to make a clear, evidence-based argument for how speciation occurred in their case. Criteria should include:
    - Clarity of the hypothesis.
    - Quality of the evidence presented (maps, genetic sequences, species traits).
    - Ability to explain and connect different pieces of evidence.
    - Participation in the peer feedback process.