LISTEN TO THE QUESTION

# 1 Answer guidance

## 1.1 Community observations

Smaller fish and fewer fish caught. Experienced Cree fishers and Elders identified the change and its local significance, motivating a comparison across time and places and a question about possible causes. Catch observations are not the same as a direct census of abundance.

## 1.2 Evidence and reasoning

Accept an explanation connecting learned skills and long relationships with land and water to transmission of knowledge and care for future generations. MacLeod is a named Cree coauthor with a published contribution, not an anonymous representative of all Indigenous peoples.

## 1.3 Evidence and reasoning

Accept a testable initial explanation: selective harvest, food-related growth, age structure, sampling, or combined causes. Students should name evidence that could challenge it. Do not grade the starting idea as a final conclusion.

# 2 Answer guidance

## 2.1 Evidence and reasoning

Chalifour: generally smaller later, with nonsignificant female contrasts. Icon: reductions in available comparisons, limited females in 2017. Perch: female reductions and some male exceptions; no 2017 females. Takwa: comparatively stable in the original analysis. Qualitative directions are sufficient; do not demand invented numeric means.

## 2.2 Evidence and reasoning

The reference river tests whether change is widespread or associated with southern contexts. It cannot control all habitat differences, recruitment, movement, gear, sample composition, or fishing exposure. Assignment to harvest was not randomized.

## 2.3 Evidence and reasoning

No. A younger sample, changed growth conditions, or a different capture method could reduce mean length without inherited change. Size-at-age and genetics can add evidence, but their methods also need scrutiny.

# 3 Answer guidance

## 3.1 Evidence and reasoning

Records must match inspected fish. Accept inherited allele combinations and independent developmental variation; food is another source across treatments. All adults in a cohort share age 6, so age is not a source of within-adult-cohort variation in this model.

## 3.2 Evidence and reasoning

The offspring receives one of the mother's two alleles and one of the father's two at each locus. Check against the displayed parental genotypes; for example Gg can arise from Gg × gg, but GG cannot. Parent IDs need not be consecutive.

## 3.3 Evidence and reasoning

The same fish grow from age 1 to 6 and increase in length. Genotypes and allele frequencies remain exactly the same through this growth step. This is individual development, not a gene-pool change.

## 3.4 Evidence and reasoning

The histogram counts individuals in length intervals at the current stage. It does not show cause or inheritance by itself. The allele display directly summarizes the model gene pool, including a separate value for each locus.

TEST A SELECTION PRESSURE

# 4 Answer guidance

## 4.1 Evidence and reasoning

Larger-fish capture is expected to reduce adult mean length and G frequency over repeated cohorts. Random capture has no consistent directional target but can alter both through drift. No-harvest populations also drift because parents and transmitted alleles are sampled. Predictions should identify controlled variables.

## 4.2 Recorded outcomes

Require settings and both generations, not only the endpoints. Reference values for seed 42 at generation 6: no harvest 45.1 cm and 63.3% G; random 40% 42.1 cm and 45.6%; larger-fish 40% 39.2 cm and 29.4%. Rounding to 0.1 is appropriate. Check generation and adult stage.

## 4.3 Evidence and reasoning

Inherited variation contributes to length. Larger fish have greater capture weight. Surviving fish contribute alleles to the next cohort. G may become less common across generations because of differential survival and reproduction. Selection acts on individuals; population allele frequencies change. Fish do not choose new genes.

## 4.4 Repeatability and drift

Individual trajectories differ across seeds. Selective harvesting usually produces a downward trend in G; random removal and random inheritance produce chance changes. In 150 tested seeds, mean G change from generation 1 to 6 was about -27.9 percentage points for selective capture, +0.5 for random capture, and +0.7 with no harvest. These validate this model, not a real fishery.

## 4.5 Evidence and reasoning

The model shows that its specified mechanism can produce a pattern under its assumptions. It cannot establish the historical cause in Mistassini Lake, estimate actual harvest pressure, identify real growth genes, or assign responsibility to a group of fishers.

TRY ANOTHER EXPLANATION

# 5 Answer guidance

## 5.1 Evidence and reasoning

Low food produces a lower mean length; high food produces a higher mean. All three have identical genotypes and allele frequencies because the comparison holds fish fixed and varies only developmental food. This is an exact matched comparison by design.

## 5.2 Evidence and reasoning

At the same seed, no-harvest low- and normal-food trials have the same allele trajectories and different lengths. Their G frequencies may change across generations by drift, but they do not differ from one another. Food affects growth only in this model; the real-world scope is broader.

## 5.3 Evidence and reasoning

Accept a common-environment rearing design with replicated families from different source populations, matched ages and food, and measurements of growth. Also accept repeated size-at-age and environmental monitoring with limitations acknowledged. Include animal welfare, feasibility, consent, and community partnership as appropriate.

REVISIT THE RESEARCH

# 6 Answer guidance

### 6.1 Answer guidance

DNA comparisons can test for inherited population differences beyond body measurements. The original study reported candidate patterns, not a proven causal growth gene. Predicted declines in genetic diversity and effective population size were not supported.

### 6.2 Answer guidance

Accept a clear paired comparison. For example, the critique questioned small age samples and whether growth changed differently in north and south; the response defended its statistical approach while keeping the interpretation tentative. Or compare concern over missing DNA/filtering with the authors' acknowledgement of a filtering problem and disagreement with parts of the reanalysis. The critics did acknowledge Indigenous knowledge. The response argued that they gave it too little weight. Experienced Cree fishers contributed observations of fish size, catches, and fishing pressure over time, which helped shape and interpret the inquiry. These contributions remain important while the exact genetic mechanism and causal role of harvest remain uncertain. Do not require students to characterize the debate as one uniform Indigenous view against one uniform Western view.

### 6.3 Answer guidance

The longer record complicates a simple continual-decline explanation: some sizes stabilized or increased after 2015–2017, many remained below the early baseline, and patterns differed by river, sex, and measurement. Larger female fish in donated Chalifour gillnet samples affected the average. Monitoring of body size does not by itself show genetic reversal or prove recovery. Credit justified revisions in confidence, including attention to sample comparability.

### 6.4 Answer guidance

Look for a revised claim that uses community observations, the published debate, and model results with their limits. Students should distinguish reported changes from an inferred cause. Accept reasoned uncertainty. Meaningful roles for Cree knowledge holders include setting priorities, identifying locations or historical context, interpreting results, and shaping continued monitoring with consent. Do not require the conclusion that fishing caused genetic evolution.

PLAN FOR THOSE WHO FOLLOW

# 7 Answer guidance

## 7.1 Evidence and reasoning

At least three justified evidence types. Strong plans combine local observations, consistent size/age/environment records, and/or harvest/genetic information. Specify matching season, locations, methods, and repeated time points where appropriate.

## 7.2 Evidence and reasoning

Possible roles include setting questions, choosing locations and timing, interpreting unexpected findings, determining sharing protocols, and reviewing outputs. Seek consent, respect decisions not to share, compensate contributions where appropriate, and avoid treating public access to one account as permission to collect other knowledge.

## 7.3 Evidence and reasoning

Connect knowledge transmission, dependable records, fishery relationships, and the needs of people who follow. Human generations are not the model’s fish generations. Students should explain their own reflection rather than claim to represent the Nation.

## 7.4 Evidence and reasoning

Assess whether the student names a genuine change in reasoning and the evidence responsible, plus a remaining question. Accept justified stability in an initial idea if the student explains how evidence tested and refined it.

ASSESSMENT | 20 POINTS

# A short evidence-based rubric

Score each dimension from 0 to 4. Award credit for justified claims and thoughtful uncertainty. Do not require students to conclude that fishing caused genetic change in Mistassini Lake.

| Dimension | Evidence to look for |
|---|---|
| Inquiry and records | Predictions, controlled variables, stage labels, complete results, repeated trials, saved graphs. |
| Evolutionary explanation | Heritable variation, differential survival, reproduction, allele-frequency change, drift. |
| Evidence and uncertainty | Separates real evidence from simulation; considers alternatives and the published debate. |
| Knowledge, people, and place | Explains specific Cree contributions and meaningful roles in continuing inquiry. |
| Revision and reflection | Revises claims with evidence and proposes justified future observations. |

## Performance levels

**4:** accurate, specific, well-supported, with relevant limits. **3:** mostly accurate and supported, with a minor gap. **2:** partial understanding or uneven evidence. **1:** minimal evidence or a major misconception. **0:** no assessable response.

Questions 1.3 and 4.1 assess the quality of a prediction and its reasoning, not whether it anticipates the result. Reading/writing support and oral explanations may be used without lowering the scientific expectations.

ALBERTA BIOLOGY 20–30 | UPDATED 2014

# Curriculum connections

| Goal | Activity and assessable evidence |
|---|---|
| 30-D1.2k: gene-pool change | 3.2–3.4 and 4.3–4.4: inherited variation, selection, drift. Other listed processes are discussed as model omissions. |
| 30-D1.2s: investigate with a simulation | 4.1–4.4 and 5.1–5.3: control variables, repeat trials, record and compare results. |
| 30-D1.4s: communicate gene frequencies | 3.4, 4.2 and 4.4: labelled graphs, percentages, and evidence-based explanations. |
| 30-D1.2sts: use and evaluate models | 4.5 and 6.4: distinguish a mechanism demonstration from causal claims about a lake. |
| Recognize Indigenous contributions | 1.1–1.2, 6.4 and 7.2: local expertise motivates questions and contributes to ongoing interpretation. |
| Connect disciplines and relationships | 2.3, 5.3 and 7.1: genetics, growth, environment, people, and place considered together. |
| Care and future generations | 7.2–7.3: respectful collaboration, knowledge transmission, and continuing monitoring. |
| Support confidence in inquiry | 3.1–3.4: inspectable fish, paced steps, paired roles, written alternatives, and tables. |

Source: Alberta Education, Biology 20–30 Program of Studies, pp. 2 and 75–76 (government-hosted copy linked in sources.html). This resource supports selected outcomes; it does not teach all Unit D content or replace formal Hardy–Weinberg instruction.