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Why do invasive species spread?

B1-B2 | AGES 16+ | 90 MINUTES | THE CAUSE LAB S01

Two bays receive the same non-native organism. It disappears from one bay but forms a growing population in the other. What could explain the difference? Your task is to build and test an explanation, not to find one person to blame.

START WITH A PREDICTION

If transport is the same in both bays, which other factors might matter?
Write two predictions before looking at the factor cards.

ARRIVAL	→	PERSISTENCE	→	SPREAD
Organisms reach a new place		A population maintains itself		The occupied area expands

Not an automatic conveyor belt: any stage may fail. Harm is a separate question, not a guaranteed final stage. A non-native species has been moved beyond its natural range by people; being non-native alone does not make it invasive. [1]

HOW THE LAB WORKS

Sort eight factor cards → build a causal map → test two factors → change one condition → design a stronger explanation.

Work in teams of 3–4. Rotate the roles of mapper, challenger, data analyst and explainer.

All experimental results and bay scenarios are invented for classroom reasoning. No live organisms, field sampling or laboratory equipment are needed.

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Sort the drivers

CUT-OUT FACTOR CARDS | ONE SET PER TEAM

S02

Place each card under H = direct human activity, E = ecological process, or I = interaction / human-altered conditions. A card may cross categories if you justify it. Then label its main stage: arrival, persistence or spread.

A / BALLAST DISCHARGE

Organisms travel inside a ship's ballast water and enter another port when water is discharged. [2]

B / RELEASE FROM CAPTIVITY

People put aquarium organisms into an outdoor water body beyond those organisms' natural range. [3]

C / REPEATED ARRIVALS

Several boat movements introduce organisms repeatedly. More arrival events create further opportunities for survival. [1]

D / WATER CURRENTS

After introduction, currents carry larvae or fragments to connected sites. Movement still depends on what survives. [1]

E / REPRODUCTION

Surviving organisms produce offspring. Their population can grow only if births and survival allow it. [1]

F / WARMER WINTERS

Human-driven warming changes winter conditions. Some introduced species may survive where it was previously too cold. [4, 5]

G / HABITAT DISTURBANCE

Construction changes a shoreline. New surfaces or reduced competition may favour some arrivals, but effects vary. [1]

H / LOW PREDATION

An introduced population experiences relatively little predation in its new setting. More individuals may survive; this is not true of every introduction. [1]

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Build a causal map

A MODEL OF CONNECTIONS / NOT A LIST OF CAUSES S03

Choose at least four cards. Write their letters in the boxes or place them on your desk. Draw arrows and label them with “brings”, “helps survival”, “allows reproduction” or “moves onwards”. Show where the chain could stop.

HUMAN ACTIONS

ENVIRONMENTAL CONDITIONS

SURVIVAL / REPRODUCTION

SECONDARY SPREAD

These boxes are planning spaces, not fixed arrows. Draw connections between them or construct a larger map on a separate sheet. Put a question mark beside a link that depends on the species or local conditions.

EXPLAIN ONE CONNECTION

A cause → the mechanism → a possible outcome → a condition or limit.

Try: “Warmer winters may help … survive, but only if …”.

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Test two factors

VIRTUAL EXPERIMENT | SIMULATED RESULTS, NOT REAL RESEARCH S04

Imagine 40 sealed experimental tanks, randomly assigned to four groups of 10. Each contains the same fictional aquatic organism. At the start, either 2 or 10 individuals are introduced. No organisms are added later. Water temperature is either 10°C or 16°C. Other conditions and observation methods are kept the same.

THE MEASURED OUTCOME

After eight weeks, count the tanks in which living adults AND new offspring are present. This is evidence of survival and reproduction during the experiment, not proof of long-term establishment, spread or harm in nature.

Group	Introduced once	Temperature	Positive tanks / 10
A	2 individuals	10°C	1
B	10 individuals	10°C	3
C	2 individuals	16°C	4
D	10 individuals	16°C	8

1. Compare A with B: what changes, and what stays the same?

2. Compare A with C. Which factor is being tested?

3. Calculate the percentage of positive tanks in each group.

4. Does warmer water guarantee success? Use a number.

For this fictional species, the warmer treatment gives higher observed success. Do not generalise that warming benefits every species. The temperature comparison is not itself an experiment on the causes of climate change.

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Change one condition

COUNTERFACTUAL LAB / WHAT WOULD BE DIFFERENT IF … ? S05

Use your map and S04. For each change below, predict an outcome, explain the mechanism and name one uncertainty. Do not invent a numerical effect that the experiment did not measure.

1 / FEWER ARRIVALS

A biosecurity measure reduces introduction size from 10 to 2 individuals while temperature remains 16°C.

2 / NO NEW ARRIVALS

Transport into a bay stops after a population has already become self-sustaining there.

3 / A CONNECTED BAY

A current connects the occupied bay to a second bay, where salinity may be unsuitable for the organism.

Key question: Why might stopping new arrivals help but not remove an existing population?

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Teach the mechanism

CREATE A THREE-PANEL SCIENCE EXPLAINER S06

Create a museum-style mini-exhibit entitled **"Why do invasive species spread?"** Use three panels: a question, an explanation and a qualified conclusion. Produce it on a separate A3 sheet or digitally. Use original sketches and short captions, not a fear-based campaign.

PANEL 1 / THE PUZZLE

Show the same arrival but two possible outcomes. Ask a question that your explanation will answer.

PANEL 2 / THE CONNECTIONS

Illustrate at least four factors. Label causal arrows. Include one controlled comparison from S04 and identify the data as simulated.

PANEL 3 / THE LIMITS

Explain why transport is not enough, why "human or natural" can mislead, and where one justified intervention could act.

Total text: 120–160 words across the panels. Everyone must explain one connection in a two-minute gallery presentation.

Useful language: "If …, then … may …"; "This happens because …"; "However, …"; "The simulated results suggest …".

Gallery review: Can another team follow the arrows? Is the comparison fair? Are limits explicit? Use one question from another team to revise your exhibit.

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Teaching the cause lab

B1-B2 | TEACHER GUIDE | 90 MINUTES T01

Learning outcomes: distinguish transport from conditions for persistence; classify interacting drivers; construct a causal model; interpret a two-factor comparison; explain why intervention effects depend on context.
Prepare: print S01–S06; one S02 card set per group. Provide scissors, pens and A3 paper or a digital canvas. The virtual experiment is a dataset exercise: do not introduce or culture organisms.

Minutes	Activity
0–8	S01: predict why identical arrivals might have different outcomes.
8–20	S02: sort cards; retain justified disagreements.
20–35	S03: build and explain causal maps.
35–50	S04: controlled comparisons and numerical interpretation.
50–62	S05: change one condition; test the map.
62–82	S06: prepare the three-panel exhibit.
82–90	Short gallery presentations, peer questions and revision.

Differentiation
B1–B2: named arrow verbs, four-factor map and guided pairwise comparisons. Pre-teach survive, reproduce, offspring and condition. Allow oral rehearsal before captions.

Scientific framing: current global warming is human-caused; a warmer winter is an environmental condition, not a synonym for natural causation. Warming may favour some species, not all. Natural secondary dispersal does not erase the human-mediated introduction.
Access: offer enlarged cards, read-aloud text and typed captions. Rotate roles and assess reasoning separately from artistic skill.

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Reasoning and solutions

TEACHER KEY / ALLOW QUALIFIED ALTERNATIVES T02

Card sorting

A and B: H, arrival. C: H as described, repeated arrival. D: E, secondary spread. E: E, persistence and population growth. F: I, survival/persistence and potential range expansion. G: I, habitat conditions; the action is human, the effects ecological. H: E as written, survival; human changes to predators could make it I if explicitly added.

These are reasoned classifications, not mutually exclusive laws. Biological reproduction is not evidence that the introduction itself was natural.

S04 / NUMERICAL KEY

A = **10%**, B = **30%**, C = **40%**, D = **80%**.
Introduction-size contrast: **+20 percentage points** at 10°C; **+40 points** at 16°C.
Temperature contrast: **+30 points** with 2 individuals; **+50 points** with 10 individuals.

Interpretation: the descriptive interaction contrast is 20 percentage points: (80 – 40) – (30 – 10). On this scale, the introduction-size effect is larger in the warmer treatment. Ten tanks per group and invented counts do not establish statistical significance. A versus D changes both factors. Two tanks fail even in D, so success is not guaranteed.

Design limits: one fictional species, two temperatures, short duration, simplified tanks. The outcome measures reproduction and survival, not long-term establishment or ecological harm. Useful additions include more replicates, longer observation and additional species or environmental conditions.

S05 / Counterfactuals

1: D → C: observed success falls from 80% to 40%, a 40-point decrease in the simulation; this is not a guaranteed effect in nature.

2: a self-sustaining population may persist without new arrivals; prevention can reduce further introductions without removing it.

3: currents can carry organisms onward, but unsuitable salinity could prevent survival. Transport is not sufficient for establishment.

Model link: human transport → arrival; winter conditions → survival; reproduction → persistence; currents → possible secondary spread. Every arrow needs a mechanism and may depend on local conditions.

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Assessment and sources

FORMATIVE CRITERIA / BACKGROUND READING T03

Criterion	Strong / 2	Developing / 1	Limited / 0
Causal model	Mechanisms + limits	Links partly explained	List / confusion
Data use	Fair + accurate contrast	Partial comparison	Confounded / absent
Scientific judgement	Stages + uncertainty	Some qualification	Overgeneralisation
Communication	Clear visual explanation	Mostly understandable	Meaning unclear

8 points maximum. Judge language against the edition's intended band. Do not grade drawing talent. The resource supports reasoning in English and science; it is not an official examination task.

1 / IPBES: Drivers of biological invasions

OPEN SOURCE

2 / IMO: Ballast Water Management

OPEN SOURCE

3 / APHA: Tackling invasive species

OPEN SOURCE

4 / USGS: Climate change and invasive species

OPEN SOURCE

5 / IPCC: AR6 Synthesis Report, Summary for Policymakers

OPEN SOURCE

Original material: tasks, diagrams, cards and simulated results were created for this resource. The dataset is not a published experiment. Source concepts are paraphrased; no external worksheets or images are reproduced.

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