

Who Is Doing What to Whom? Case Files from Four Ecosystems

Investigation question: Field notes from four ecosystems that share no species describe sixteen pairs of organisms but never name the relationship. Can your group decode who gains and who loses from the evidence, find the pattern the four ecosystems share, and predict the four missing interactions before they are revealed?

Evidence-based mystery

Groups of 4

1 session

Setup 5 · Activity 45 · Cleanup 3 min

MS-LS2-2 · assesses

Name _____

Group _____

Date _____

Your role today

- ☐ **Card reader:** Reads each card aloud in full, names partner A (the first organism in the title) and partner B, and keeps the deck moving so no card is placed on a guess.
- ☐ **Calculator:** Says aloud which two numbers are being compared for each partner and runs the one-tenth test whenever the two numbers are close.
- ☐ **Recorder:** Writes the ratings and evidence in the q1 table, places the card in the grid, and writes the group's gap predictions.
- ☐ **Challenger:** Before any rating is written, asks 'What number shows that?' and, for every plus-minus card, 'Does it eat the other one, or live on or in it?'; leads the argument over the gap predictions.

Safety

- Paper only: no live organisms, specimens or chemicals are used. The teacher cuts card stock with a paper cutter or scissors during prep; keep fingers clear of the blade.
- If you extend the lab by looking for lichens on schoolyard trees, students stay on paths, observe without scraping or picking, and wash hands afterward; no one picks or tastes mistletoe berries, which can make people sick.

Procedure

1. Lay out the grid. The card reader reads the two callouts on the recording sheet aloud, and the calculator works the one-tenth example so everyone agrees on the rule.
2. Deal the 16 cards face up. Take one card at a time. The reader reads it aloud and names partner A (the first organism in the title) and partner B, and the group finds the one comparison given for each partner.
3. Rate partner A, then partner B. Decide what 'doing better' means for that measurement (more young, more seeds or more food is better; more parasites or more searching time is worse), compare the two numbers, and run the one-tenth test whenever they are close. The challenger asks for the number before anything is written.

4. Name the interaction from the pair of ratings. For every plus-minus card, decide from the evidence whether one partner eats all or part of the other (predation) or lives on or inside a living host and feeds from it over time (parasitism). The recorder fills in the card's row in q1 and places the card in the grid.
5. When all 16 cards are placed, look along each row of the grid and write GAP in every empty cell (q2). Each row should have exactly one gap; if a row has none or two, recheck the cards in that row.
6. For each gap, write a prediction on a sticky note and in q3: two partners that could fill it in that ecosystem (named species or a general description), the rating you predict for each with a reason, and one measurement a field biologist could make to test it.
7. When all four predictions are written, show them to the teacher and collect the sealed envelope. Rate the four reveal cards exactly as before, place them in the gaps, and record in q3 whether each one matched the type you predicted. Matching the type matters; your species may differ.
8. Answer q4 as a group. Answer q5 to q12 on your own; q8 to q12 may be finished as homework. Return all 20 cards to the bag and envelope.

Record your observations

Lab 2 recording sheet: Who is doing what to whom?

How to rate each partner — Each card gives one comparison for each partner: how it does when the other species is present or common, and how it does when the other species is absent or scarce. First decide what 'doing better' means for that measurement. Rate the partner **+** if it does better with the other species, **–** if it does worse, and **0** if the two numbers differ by less than one-tenth of the larger number. Example: 50 and 47 differ by 3, and one-tenth of 50 is 5; 3 is less than 5, so the rating is 0.

The five codes — **++** mutualism. **+0** commensalism. **--** competition. **+–** is **predation** when one partner eats all or part of the other (in this lesson, plant eaters count as predators) and **parasitism** when one partner lives on or inside a living host and feeds from it over time.

Teaching data — Every organism and every relationship on these cards is real. The numbers are invented to show the kind of evidence ecologists collect; they are not measurements from any single real study.

Case-file cards (teacher prints and cuts apart; 16 cards)

1 K1 • Kelp forest • Señorita and blacksmith

The señorita is a slim, cigar-shaped fish. Blacksmith are dark, plankton-eating fish that hover in groups and sometimes hold still, head tipped down, beside a señorita. **Señoritas:** at midday, señoritas on reefs crowded with blacksmith had 30 food items in their stomachs, several of them tiny parasites picked off other fish; señoritas on reefs with few blacksmith had 21. **Blacksmith:** fish near señoritas carried 1 skin parasite each, on average; blacksmith on a reef with no señoritas carried 7.

2 K2 • Kelp forest • Giant kelp and young rockfish

Each spring, young rockfish of several kinds drift in from the open ocean and settle into kelp forests. They eat tiny drifting animals, not kelp. **Giant kelp:** stalk tips with many young rockfish around them grew 21 cm per day; stalk tips with few grew 20 cm per day. **Young rockfish:** divers counted 26 per 100 meters of swim path under the kelp and 3 per 100 meters over bare sand nearby at the same depth, where diving birds and bigger fish could spot them.

3 K3 • Kelp forest • Purple sea urchin and sea otter

Divers surveyed 12 rocky reefs where sea otters feed and 12 similar reefs with no otters. **Purple sea urchins:** 3 per square meter on otter reefs; 40 per square meter on reefs without otters. The urchins left on otter reefs hid deep in cracks in the rock. **Sea otters:** watchers on shore timed otter dives. On reefs where urchins were still common, an otter came up with food on 8 of every 10 dives; on reefs where urchins were scarce, on 5 of every 10.

4 K4 • Kelp forest • Woody-stemmed kelp and giant kelp

Woody-stemmed kelp is a short kelp, about as tall as a person, that grows beneath giant kelp, which reaches the surface. Both need sunlight on the seafloor to grow and to start new young plants. Divers cleared one kind from test plots and checked a year later. **Woody-stemmed kelp:** it covered 60 percent of the seafloor where giant kelp had been cleared and 15 percent under untouched giant kelp. **Giant kelp:** 9 young plants per square meter took hold where woody-stemmed kelp had been cleared; 2 per square meter where it was left.

5 D1 • Mojave Desert • Merriam's kangaroo rat and harvester ants

Kangaroo rats and harvester ants both gather the seeds of the same desert wildflowers and grasses. Biologists fenced kangaroo rats out of some plots, removed ant colonies from others, left some plots alone, and counted three years later. **Kangaroo rats:** 14 per plot where the ants had been removed; 11 per plot where ants were left. **Harvester ants:** 31 colonies per plot where kangaroo rats were fenced out; 20 colonies per plot where rats were present.

6 D2 • Mojave Desert • Catclaw acacia and desert mistletoe

Desert mistletoe is a leafless plant with green, jointed stems that grows in clumps on the branches of desert shrubs and trees. It makes some of its own food from sunlight, but its root-like strands grow into the branch wood and take water and minerals. **Catclaw acacia:** after a dry year, heavily infested shrubs made 35 seed pods each; shrubs with no mistletoe made 90. **Desert mistletoe:** clumps were found only on living branches, and clumps on branches that died also died within a year.

7 D3 • Mojave Desert • Joshua tree and yucca moth

A female yucca moth gathers pollen from Joshua tree flowers, flies to another tree, lays her eggs inside a flower and presses pollen onto it. Her larvae eat some of the developing seeds. **Joshua trees:** of 100 flowers that moths could reach, 28 became seed pods; of 100 flowers wrapped in fine mesh to keep moths out, 0 did. Pods with larvae inside still held most of their seeds. **Yucca moths:** the larvae eat nothing but developing Joshua tree seeds, and no larvae of this moth were found on any other plant at the site.

8 D4 • Mojave Desert • Desert dandelion and desert tortoise

Desert dandelion is a yellow spring wildflower. Biologists fenced some plots so tortoises could not get in and compared them with open plots. **Desert dandelion:** plants inside the fences made 40 seeds each; plants in open plots, where tortoises bit off flowers and leaves, made 22. Few plants were killed outright. **Desert tortoises:** tortoises whose home areas had thick patches of spring wildflowers gained 120 g over the spring; tortoises where wildflowers were sparse gained 30 g.

9 C1 • City park • Lichen and coast live oak

Lichens are crusty, gray-green patches on bark and stone. Each one is a fungus living with an alga or a cyanobacterium that makes food from sunlight. Lichens do not grow into wood or take sap. **Lichen:** patches on oak bark grew 4 mm wider per year; patches on the park's concrete benches grew 1 mm per year. **Coast live oaks:** trunks heavily covered in lichen added 2.0 mm of new wood per year; trunks with almost no lichen added 2.1 mm.

10 C2 • City park • Cooper's hawk and rock pigeon

Cooper's hawks are crow-sized hawks that now nest in many California city parks. **Cooper's hawks:** about 4 of every 10 prey brought to a nest were pigeons or doves. Hawk pairs in parks with many pigeons raised 4 chicks a year; pairs in parks with few pigeons raised 2. **Rock pigeons:** in a park where a pair of Cooper's hawks nested, the pigeon flock fell from 220 to 150 birds over two years; in a similar park with no hawks, it went from 210 to 205.

11 C3 • City park • Rock pigeon and feather louse

Feather lice are flat, wingless insects about 2 mm long. They spend their whole lives on one bird, eating the soft, fluffy parts of its feathers. **Rock pigeons:** over one cold winter, 80 of every 100 pigeons that had been treated to remove lice survived, compared with 60 of every 100 heavily infested pigeons. Pigeons with chewed feathers lose more body heat. **Feather lice:** on a living pigeon, lice lived for weeks and laid eggs on the feathers; lice that fell off a bird died within a few days.

12 C4 • City park • Western bluebird and European starling

Both birds nest in holes, such as old woodpecker holes in park trees, and a park has a limited number of them. Starlings often chase bluebirds away from a hole, but the fights cost them time and sometimes the hole. **Western bluebirds:** where starlings were common, 20 of every 100 bluebird pairs found a nest hole; where starlings were rare, 55 of every 100 did. **European starlings:** where bluebirds were common, 72 of every 100 starling pairs found a nest hole; where bluebirds were rare, 86 of every 100 did.

13 R1 • Rainforest • Mantled howler monkey and howler botfly

A botfly larva lives under the skin of a howler monkey, often on the neck, growing inside a small swelling for several weeks before it drops to the ground and becomes an adult fly. **Howler monkeys:** in a year with many botflies, 30 of every 100 young monkeys died; in a year with few botflies, 12 of every 100 died. Most adult monkeys carried a few larvae and survived.

Howler botflies: larvae of this kind of botfly have been found growing only in howler monkeys.

14 R2 • Rainforest • Canopy tree and orchids

Many rainforest orchids live perched high on tree branches. Their roots grip the bark and soak up rain; they make their own food from sunlight and take nothing out of the tree. **Canopy trees:** trees carrying many orchids added 12.0 mm to their trunk width in a year; trees carrying few added 12.5 mm. **Orchids:** of 100 young orchids tied onto branches 25 m up, 78 were alive a year later; of 100 planted on the dim forest floor, 9 were.

15 R3 • Rainforest • Leafcutter ants and their fungus

Leafcutter ants carry leaf pieces into their underground nest, chew them into mush and spread it on a spongy fungus garden. The ants and their young eat swollen tips that the fungus grows. A young queen carries a pellet of fungus with her to start each new nest.

Leafcutter ants: of 10 lab colonies whose garden was taken away, none survived a month, even with fresh leaves; all 10 colonies that kept their gardens survived.

Fungus: gardens kept without ants were overgrown by molds within a week, and this fungus has never been found growing wild away from leafcutter nests.

16 R4 • Rainforest • Jaguar and collared peccary

Collared peccaries are pig-like animals that travel in small herds. **Jaguars:** about one third of the prey remains in jaguar droppings were peccaries. Female jaguars in areas with many peccaries raised a litter about every 2 years; where peccaries were scarce, about every 3 years. **Collared peccaries:** in forest where jaguars hunt, 45 of every 100 young peccaries lived to their first birthday; in a nearby forest where jaguars had been hunted out, 70 of every 100 did.

1. Rate both partners on every card. Partner A is the first organism in the card's title. Write the two numbers you compared for each partner, then name the interaction.

Card	Partner A rating	Numbers compared for A	Partner B rating	Numbers compared for B	Interaction
K1					
K2					
K3					
K4					
D1					
D2					
D3					
D4					
C1					
C2					
C3					
C4					
R1					
R2					
R3					
R4					

2. Write each card code in the correct cell of the grid. Write GAP in every empty cell.

Ecosystem	Predation (+ -, eats)	Parasitism (+ -, lives on or in)	Competition (- -)	Mutualism (+ +)	Commensalism (+ 0)
Kelp forest					
Mojave Desert					
City park					
Rainforest					

3. Predict each gap before you open the envelope. Fill in the last column after the reveal.

Ecosystem	Missing interaction	Two partners we predict	Predicted rating for each, and why	One measurement that would test it	After the reveal: card code, and did the type match?
Kelp forest					
Mojave Desert					
City park					
Rainforest					

4. Which card caused the biggest argument in your group? Write its code, the two ratings or labels people argued for, and the evidence that settled it.

Analysis questions

5. Show the one-tenth test for (a) the starlings on card C4 and (b) the canopy trees on card R2. Give the rating for each.

6. Five cards describe one organism living on or inside another: C1, C3, D2, R1 and R2. Sort them by interaction and explain why where an organism lives cannot decide the label. Use two cards with different labels as your evidence.

7. Cards D4 (dandelion and tortoise) and D2 (catclaw and mistletoe) both rate + −, and in both the plant usually survives. What evidence on the cards makes one of them predation and the other parasitism?

8. The four ecosystems in your grid share no species at all. Describe the pattern across the four rows after the reveal, and explain why ecologists expect every ecosystem on Earth to contain all five interactions. Use the idea of limited resources in your explanation.

9. Card K3 shows that sea otters keep purple urchins scarce, and urchins eat giant kelp. Predict how much giant kelp grows on otter reefs compared with reefs without otters. Then predict what happens to the young rockfish on card K2 if otters disappear from a reef. Name the interaction at each link of your chain.

10. A high meadow and lake in the Sierra Nevada is an ecosystem none of the cards describe. Predict one competition and one mutualism you would expect to find there. For each, describe the two partners (a general description such as 'two kinds of seed-eating birds' is fine), give the rating for each partner, and describe one measurement that would test your prediction.

- 11.** Pick one card you rated 0 (K2, C1 or R2). Describe a new measurement that could change that 0 to a + or a −, and say which way you think it might go and why.

- 12.** Which card's comparison is weakest as evidence? Explain what else could explain its difference, and how a fairer comparison could be made.
