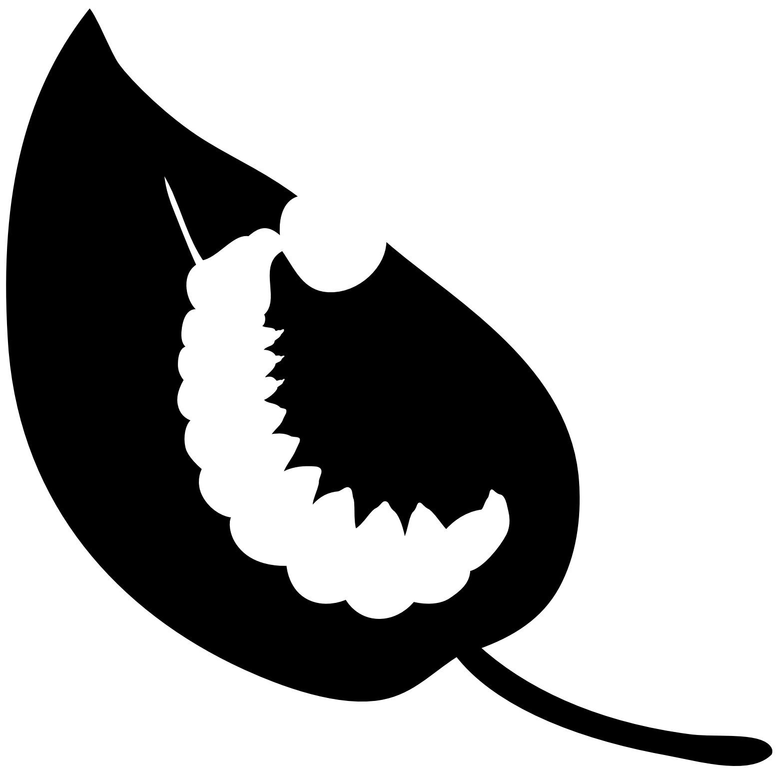
Ecology

Educator's Resource Guide



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Contents

Ecology is a branch of biology that looks at the relationships between organisms and their environment.[1, 2]

Ecology's scope can be relatively small or large, depending on the question and the study system. A researcher may zoom in on a single type of organism in an ecosystem, or zoom out to see how different organisms are interconnected; they may look at microscopic cells or large-bodied creatures.

Some ecologists have questions about how ecosystems work: how do organisms interact with living and non-living things?[2]

Other ecologists have questions about how ecosystems change when stressors are introduced.[2] Stressors can include disease, climate change, urbanization and increased contact with people. Taking a closer look at ecosystems under pressure can help us understand how they function, how they may look and behave in the future, and what we can do to best protect and preserve them.

Black oyster catcher,
Haematopus bachmani
Jamie Clarke

Predator Prey Relationships

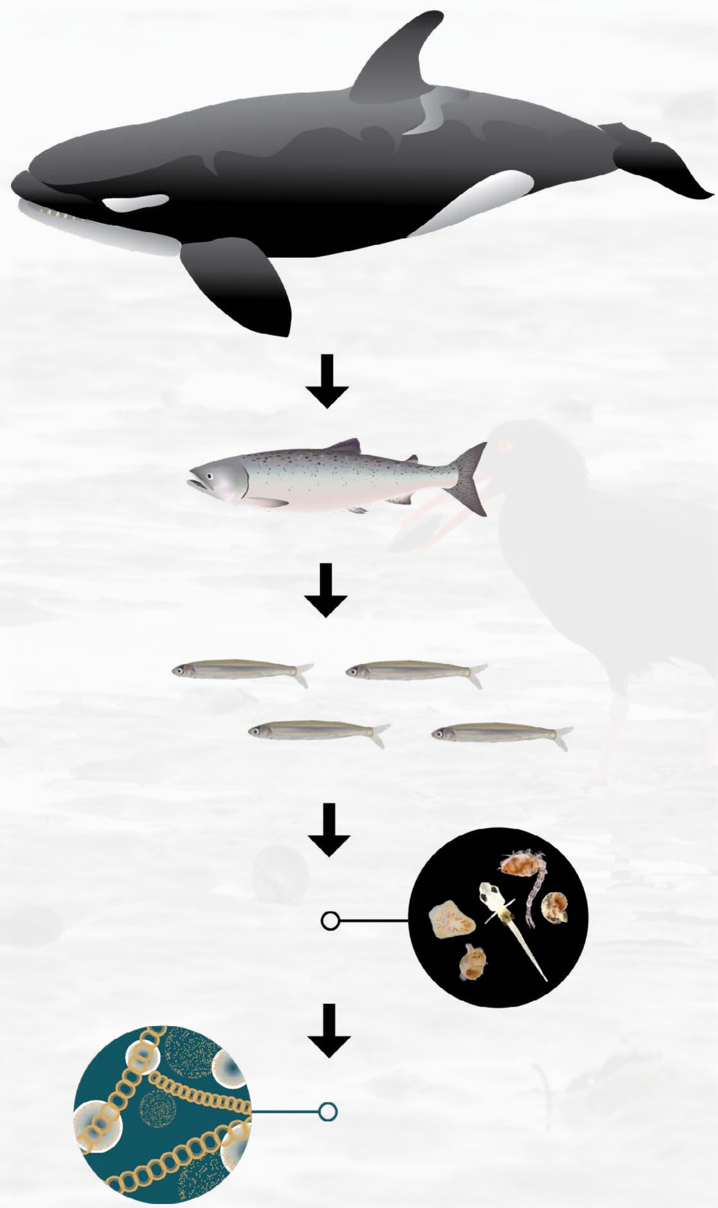
Stop and Think

What types of organisms eat other organisms?
What types of organisms make their own food?

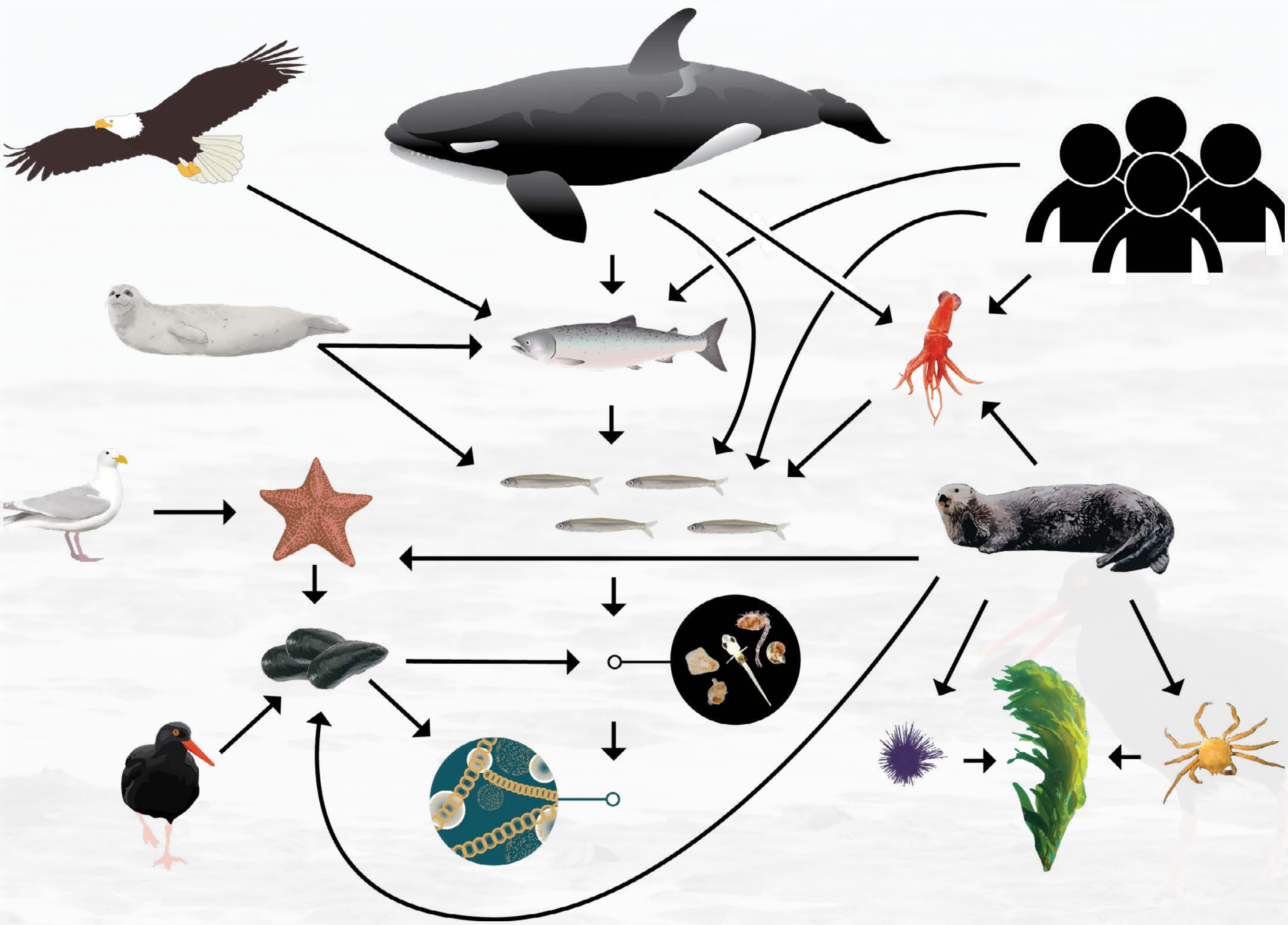
Predator-prey

One type of interaction between organisms is a **predator-prey relationship**. In predator-prey relationships, individuals of one species are hunted and eaten by individuals of another.

The flow of energy in an ecosystem is called a **food chain**. At the bottom of the food chain, primary producers like plants take carbon dioxide, water and energy from the sun and turn it into energy that other organisms can use. The plants are then eaten by herbivores, which in turn are eaten by carnivores, which may be eaten by other carnivores. Wastes and dead things are eaten up by detritivores and decomposers. An organism's position in the food chain is called its **trophic level**.



In real-world ecosystems, food chains get a bit more complicated. Lots of organisms feed on many different things at different trophic levels. This more complex, more nuanced flow of energy from organism to organism is called a **food web**.



Watch

Dr. Mei Sato's video on killer whales, chinook salmon and sonar.

explore.beatymuseum.ubc.ca/researchers-revealed/m_sato

Stop and Think

Where do killer whales fit in their food chain or web? Where do salmon fit?

Drs. Mei Sato and Andrew Trites are researching southern resident killer whales and the salmon they eat. Just like the whales the study team uses sonar - sound - to detect fish underwater. Mei and Andrew are trying to understand why southern resident killer whales are doing worse than other types of killer whales off the coast of BC. Does it have something to do with the quality or quantity of their salmon prey?

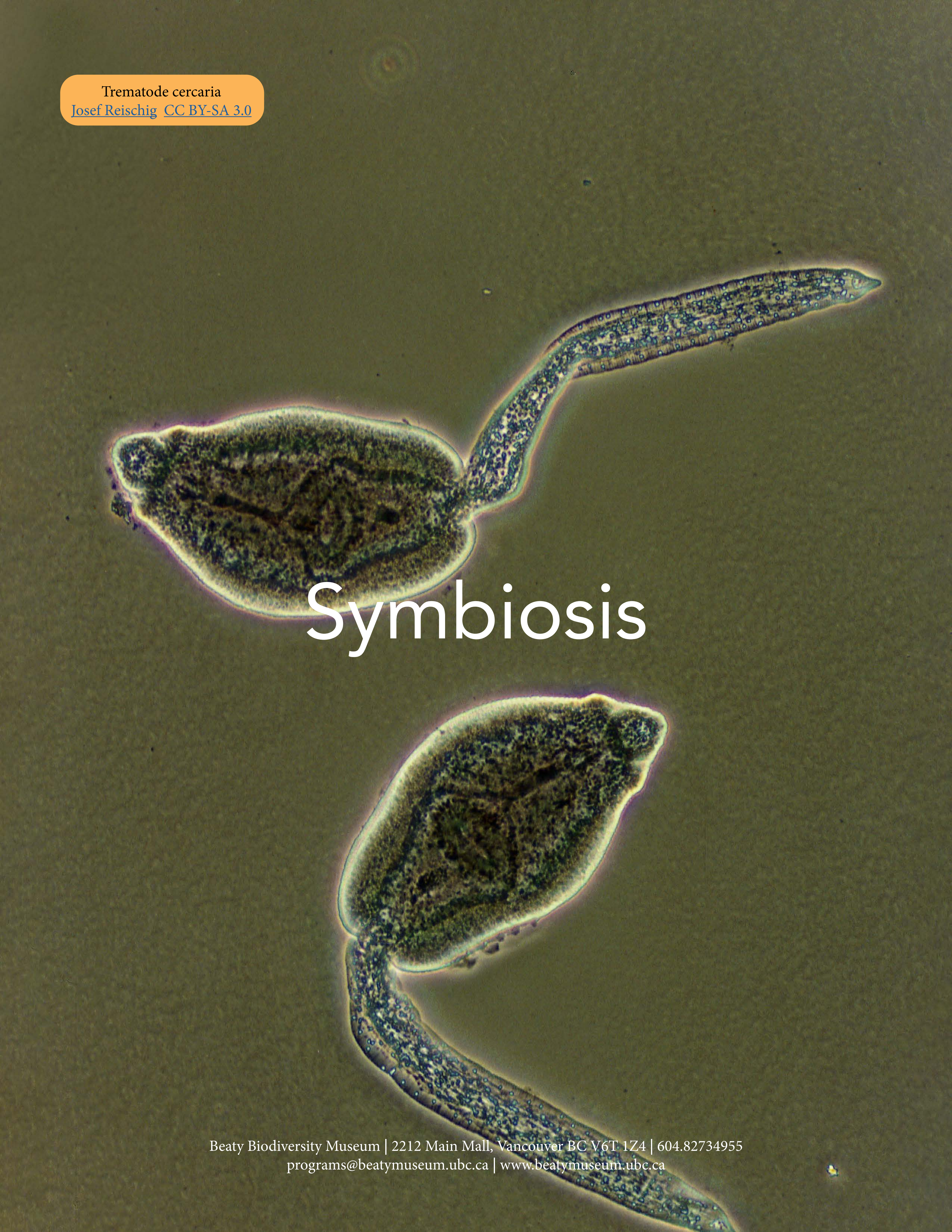
Killer whales are **apex predators** - predators at the highest trophic level. Their position at the top of the food chain means they can have big effects on the organisms that fall below them. Apex predators shape populations of their prey species: if there are lots of killer whales eating salmon, for example, there will be fewer salmon. If there are fewer salmon, there will be more of the fish that salmon eat, and less of the food those fish eat... And so on. By the same logic, apex predators are also affected *by* all the organisms below them on the food chain. If salmon - or any organism further down the chain - are less numerous, killer whales won't have as much to eat. In BC, less salmon prey means some types of killer whale are going hungry; some other types of killer whale are turning to new food sources they didn't used to eat, causing big changes to food chains they weren't a part of.[3]

Take a look at the information on killer whale ecotypes on Mei's page to learn more about the different killer whales living off of our coast. Then, take a look at how killer whales produce sound and what those sounds are used for.

+ ------- Supplementary Resources -------

Killer whale ecotypes and echolocation

explore.beatymuseum.ubc.ca/~/killer-whale-ecotypes-echolocation.pdf



Trematode cercaria
Josef Reischig CC BY-SA 3.0

Symbiosis

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Symbiosis

Another type of interaction amongst organisms is **symbiosis**. Symbiosis is a close, long-lasting relationship between individuals of different species.[4] In most symbiotic relationships, a larger organism - the host - provides an environment on or in which a smaller organism - the symbiont - lives. Examples of host environments include things like burrows or nests, or the host's body.

------- Stop and Think -------

What kinds of close, long-lasting partnerships between individuals of different species can you think of?

Symbiotic relationships can be broken down into 3 major categories, depending on the outcomes for the host and the symbiont:

Mutualism: An association in which both host and symbiont benefit

Commensalism: An association that is advantageous for the symbiont and doesn't affect the host

Parasitism: - An association in which the symbiont - the parasite - benefits at the host's expense

Let's take a closer look at mutualism and parasitism.

Mutualism

------- Watch -------

Dr. Filip Husnik's video on termite gut symbionts.

explore.beatymuseum.ubc.ca/researchers-revealed/f_husnik

------- Stop and think -------

What do gut microbes do for termites?
What do termites do for their gut microbes?

Dr. Filip Husnik looks inside termite guts to study the single-celled organisms hard at work there, breaking down the wood their hosts ingest as food. Wood's high cellulose content gives it its rigid structure, but also makes it very hard to digest. Relatively few organisms can do it at all![4] Termites rely on the bacteria, archaea and protists in their guts to break down the cellulose in wood and convert it to usable nutrients. Without these gut-dwelling organisms to break wood down, termites would starve even as they ingested food. These microorganisms are so important that newly hatched termites and molting juveniles must feed on the anal fluids of other termites to obtain or replace their own gut microbes.[4] The termites, in turn, provide a protected environment for the single-celled organisms and a steady supply of food.

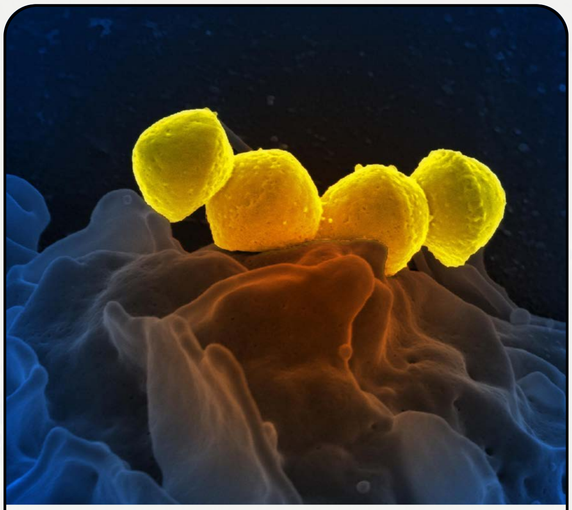
Since both the symbiont - the microorganisms - and the host - the termite - benefit from this partnership, their relationship is mutualistic.

Take a closer look at the different types of microorganisms in the termite gut. Then, think about a world without decomposers, and play a round of the Symbiotic Concentration Game to learn about other mutualistic interactions.

Microorganisms

Bacteria[5]

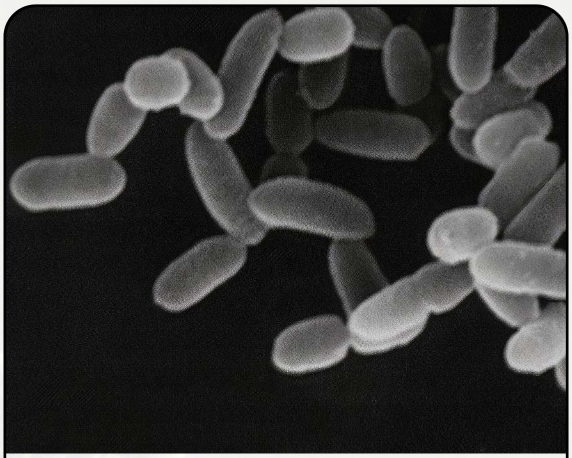
Bacteria are single-celled organisms with almost no cellular structures - not even a nucleus to house their genetic information. They are made up of one jelly-filled compartment inside which a loop of folded DNA (and a few other things) floats. Bacterial cells are bound by a membrane and, sometimes, a protective outer cell wall. These nucleus-less organisms come in a variety of shapes and sizes, from spheres to rods to corkscrew spirals. Bacteria are some of the most abundant and diverse cells on the planet.



Group A Streptococcus NIAID - CC BY 2.0

Archaea[5,6]

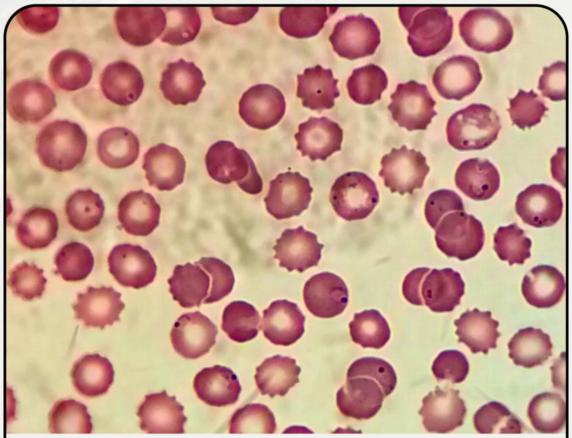
Like bacteria, archaea are single-celled with few cellular structures and no nucleus to hold their DNA - which is folded into a singular circular chromosome. It may come as a surprise, then, that archaea and bacteria are only distantly related to one another. Archaea occupy many environments that other cells do, but also inhabit some of the most inhospitable places on the planet - places that are deadly to most other forms of life.



Archaea Kaden11a - CC BY-SA 4.0

Protists[1]

Some organisms aren't quite bacteria, archaea, plants, animals or fungi. So what are they? These organisms fall into the "catch-all" group, protists. Protists can be made up of a single cell or many cells - just as long as they aren't arranged into tissues or organs. Since the group is formed of organismal "misfits," protists aren't necessarily very closely related to each other. Examples of protists you may know include amoebas, diatoms, slime molds and some algae, as well as the cells that cause malaria and "beaver fever."



Plasmodium in erythrocytic cycle
Juan Carlos Fonseca Mata - CC BY-SA 4.0

Termites are important members of their ecosystems. They eat dead and decaying woody plants - something that very few other animals do. In some parts of the world, termites are responsible for breaking down and recycling one third of the dead wood in their environments![7] Termites chew up wood using their mandibles and grind it up in a body part called the gizzard, making it easier for other organisms to later use the nutrients it contains.[7] Depending on their environment, they may also eat bark, straw, leaf litter and even animal hooves.

------- Stop and Think -------

What would a world without decomposers (organisms that break down dead matter outside their bodies) and detritivores (organisms that ingest and digest dead matter) look like?

Without decomposers and detritivores breaking down dead things and other wastes, our planet would be covered in the stuff: layers of fallen trees, spent plants, brown leaves, animal carcasses, poop… Imagine Earth covered in all that muck! How would living things be able to move around, find food and sunlight, and stay healthy in that environment? Locked up in these layers of decay would be vast quantities of nutrients, unavailable to living organisms. While dead stuff and poop might not seem particularly nutrient-rich, it contains essential components like carbon that must be cycled back into ecosystems for them to function properly.[8]

Luckily, we have decomposers and detritivores to break down dead material and waste, freeing up nutrients, bringing them back into food webs and clearing up the mess while they do it. Important decomposers - organisms that break down matter outside of their bodies - include fungi and microorganisms like bacteria, archaea and protists. Detritivores are organisms that ingest and digest dead stuff inside their bodies; these include earthworms, pill bugs and termites.

+ ------- Supplementary Resources -------

Symbiotic Concentration Game

explore.beatymuseum.ubc.ca/~/symbiotic-concentration-game.pdf

Parasitism

Dr. Colin MacLeod studies trematodes - parasitic flatworms. These creatures sap nutrients and energy from their partner species, diverting resources away from their hosts' growth, survival and reproduction. The parasite gains at the host's expense, making this relationship truly parasitic.

Trematodes usually infect two to three hosts during their complex life cycles, by taking advantage of predictable interactions between their host species to pass from one to the next. Because they infect several hosts during their lifetimes, trematodes can have big effects on their communities.

The suckers on a trematode's body help it hold in place on or inside its host species. As adults, they feed on the fluids, flesh or digested food of their hosts by pumping it into their mouths and absorbing it through their skin.[9] Some trematodes secrete substances from their guts or suckers to partially digest their hosts before ingesting them.

------- Watch -------

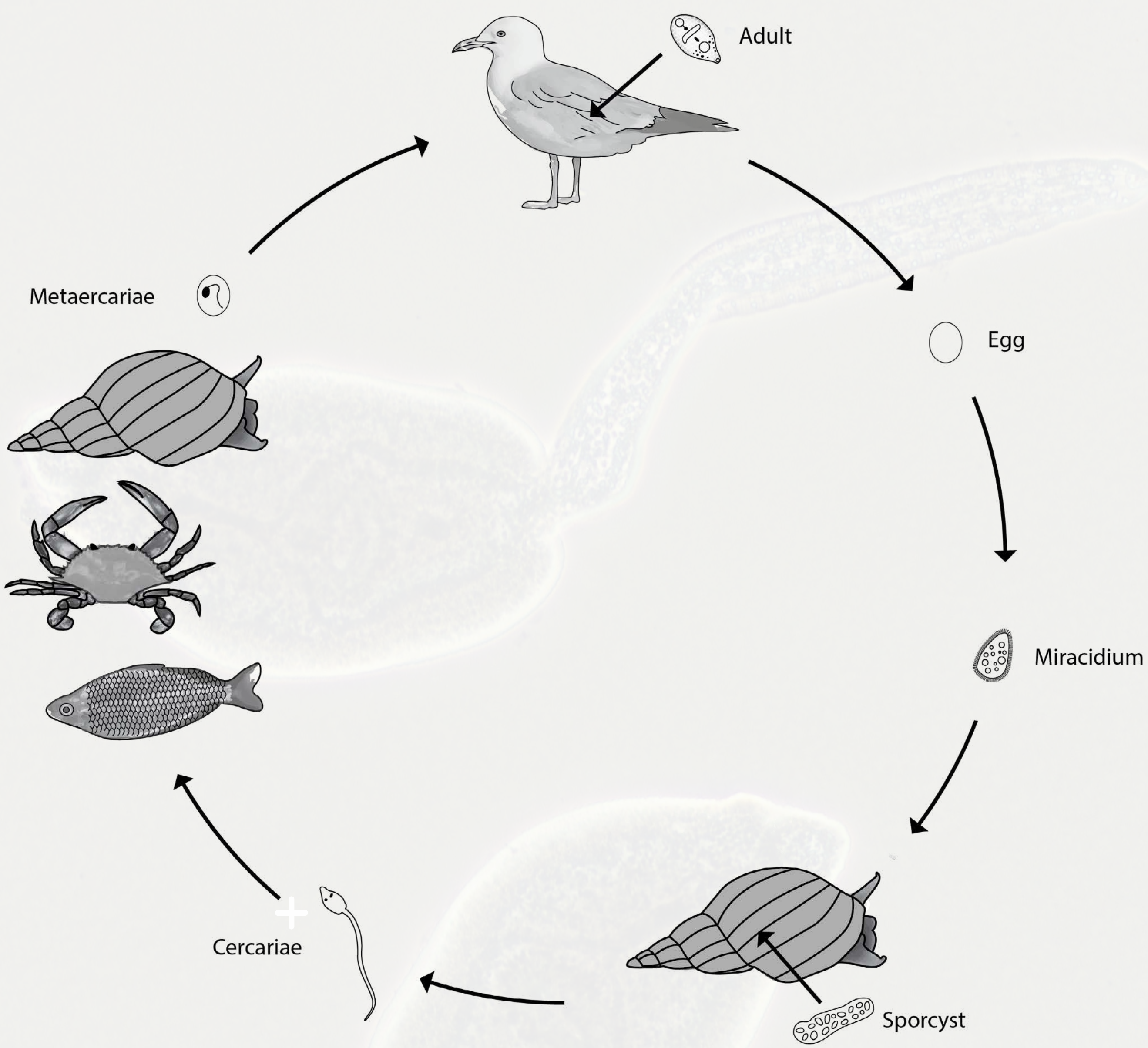
Dr. Colin MacLeod's video on trematode parasites.

explore.beatymuseum.ubc.ca/researchers-revealed/c_macleod

------- Stop and Think -------

What characteristics (body shape/size/structure, behaviours, life history) might make a parasite successful?

Trematode Life Cycle



+ ------- Supplementary Resources -------

Trematode Life Cycle

explore.beatymuseum.ubc.ca/~/trematode-life-cycle.pdf

Moose, *Alces alces*
Philippe Roberge

Ecological Stressors

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Ecological stressors

Many ecologists are interested in how stressors affect ecosystems. How do organisms, their relationships with each other, and their interactions with their environment change when things aren't "normal"?

Climate change

Human activity is causing Earth's climate to change.[12] When we burn fossil fuels and convert land into agriculture plots, we produce an excess of carbon dioxide and other greenhouse gasses.[13] Greenhouse gasses keep the heat that's emitted from the Earth's surface from escaping into space as easily.[14] Since a lot of the heat doesn't pass through, it must return back down to the lands and oceans.

The oceans have absorbed most of this extra heat into their waters.[15] To stabilize Earth's climate, oceans normally store and release excess heat. But when the ocean takes in more heat than it gives off, it's temperature rises. Sea surface temperatures have increased by about 0.13° C every decade for the past 100 years; the deep sea is also steadily warming.[15] While some organisms are able to adapt to rapidly warming environments, others can't evolve as quickly as the environment is changing. The process of evolution relies on new traits arising and being passed down to offspring - which can take a very long time. For many organisms, warming outpaces the speed of evolution. Ecosystems are already beginning to shift, change and disappear as a result.

The oceans also absorb carbon dioxide, making their waters more acidic (more like vinegar or lemon juice). Increased acidity makes it harder for calcifying organisms - sea creatures with external hard parts, like mussels, clams, corals, urchins and some plankton - to produce their shells and skeletons.[16] Acidic ocean water can also dissolve shells and skeletons that have already been made.[16, 17]

------- Stop and Think -------

How does the loss of calcifying organisms affect the wider ecosystem?

While this might not seem like a big deal to organisms without calcified body parts, it can be. Many calcifying organisms are food or provide valuable habitat for other creatures; they also filter seawater, cycle carbon, cycle nutrients, and all are part of the proper functioning of their ecosystems.[16]

Non-calcifying organisms can also be directly affected by ocean acidification. Changes in acidity can impact communication, reproduction, movement and growth, to name a few examples.[16] While some creatures might thrive in acidic waters, others will struggle to survive and reproduce in these new conditions.

The oceans are becoming more acidic very quickly - they have become 30% more acidic in the last 200 years.[16] Ocean chemistry hasn't changed this quickly in the last 50 *million* years.[16] Much marine life is very ancient, having evolved in fairly stable oceans for a long time, and so it can be difficult for ocean organisms to adapt to these big, fast changes.

------- Watch -------

Dr. Angela Stevenson's video on glass sponges and feather stars

explore.beatymuseum.ubc.ca/researchers-revealed/a_stevenson

------- Stop and Think -------

Sponges are very good at pumping water through their bodies and out their top opening. Watch the clip of the neon yellow liquid being pipetted near the glass sponge in a hot, acidic water treatment - do glass sponges seem to be resilient to climate change?

Dr. Angela Stevenson studies how ocean warming and acidification affect glass sponges. She found that a warmer, more acidic environment negatively impacts the glass sponge *Aphrocallistes vastus* - the cloud or clay pipe sponge - which is an important structural component of glass sponge reefs.[18, 19] Sponges exposed to warming and acidification treatments in the lab were not as good at pumping water through their bodies, had irreversible tissue damage, and were weaker and less stiff.[18]

What does all of this mean for the ecosystem cloud sponges belong to?

Unhealthy sponges don't pump as much water, which means they aren't filtering out and eating as many small, floating particles. Lots of the nutrients in these food particles, then, aren't being passed on from sponges to other organisms in the food web.[18]

Weaker sponges are more likely to break and are more easily damaged by the fishes and invertebrates that use sponge reefs as habitat.[18] As oceans warm and become more acidic, the organisms that live on and in the sponge reefs will start to break their own fragile houses. Angela predicts that, as a result, glass sponge habitats will lose biodiversity: the organisms that once used the sponge shelves for shelter, protection and food may have to move elsewhere or may disappear from that area.

Take a look at Fisheries and Oceans Canada's video on the glass sponge reefs of BC.

+ ------- Supplementary Resources -------

Fisheries and Oceans Canada video : Glass Sponge Reefs Marine Protected Area

dfo-mpo.gc.ca/videos/hecate-eng.html

Interactions with people

We - humans - are another kind of ecological stressor.

Growing human populations that construct bigger cities, expand further into the surrounding habitat, build more infrastructure and extract more resources can have negative effects on many kinds of wildlife - like large terrestrial carnivores, for example. Animals like bears, lions and leopards can have needs that conflict with our own wants and needs. We break up the big, continuous habitats large carnivores need with our construction and conversion, which affects them and the organisms they eat.[20]

Our perspectives on large terrestrial carnivores can also affect them. Wolves and other large mammal predators were culled from Yellowstone National Park during the 1900s, before people understood their place in the ecosystem.[21] They were hunted and removed mostly because they were thought to be a nuisance that preyed on livestock like cattle and sheep, threatening rancher's livelihoods.[21] We now understand the important role terrestrial carnivores like the wolves in Yellowstone play in our ecosystems - although poaching still threatens the wolves outside of the park boundary.

But there are ways that the needs of both people and wildlife can be met. Researchers like Dr. Cole Burton study how we can best coexist with wildlife - to make sure creatures like large terrestrial carnivores have the space and food they need, and people can respectfully share their habitats.

------- Watch -------

Dr. Cole Burton's video on terrestrial animals and their coexistence with humans

explore.beatymuseum.ubc.ca/researchers-revealed/c_burton

------- Stop and Think -------

What types of close interactions with wildlife do people have, and what are some of the effects of these interactions?

Cole's research focuses on the interactions between wildlife and people, and how wildlife reacts to the changes people make in the landscape. He mainly studies large terrestrial mammals, like bears, wolves and caribou - and he uses a technique called camera trapping to do that. Camera traps are placed in study areas and take pictures when warm creatures pass them, tripping a sensor.

Letting animals take pictures of themselves means researchers like Cole can study wildlife without having to be in the field all the time. As a result, we get a glimpse of how animals really behave and where they spend their time - since researchers aren't altering their behaviour and movement patterns. Camera traps also shed light on how animals are responding to changes in their ecosystems, which can help us figure out how best to coexist with them.

+ ------- Supplementary Resources -------

Watch Mitch Fennell set up a camera trap

explore.beatymuseum.ubc.ca/researchers-revealed/c_burton/#bottom

Additional Activities

Additional Activites

Quadrats and Transects In Your Schoolyard

explore.beatymuseum.ubc.ca/~/quadrats-transects.pdf

Ecologists often use quadrats and transects to answer questions they have about ecosystems. Try using these methods to learn about the organisms in your school or backyard - learn species names and see if you can find any patterns in their distribution!

Phylo Card Game

phylogame.org/game-play/

Use Phylo cards to build food chains, create stable ecosystems, sabotage your opponents' ecosystems and rack up points in the process!

Written by Jamie Clarke

Designed by Evan Craig

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