[Chapter 1 - Studying Life]

Life can be found in some of the most extreme places on Earth. At the bottom of the ocean, some tubeworms call toxic, high-pressure vents “home sweet home.” In hot springs acidic enough to dissolve metal, microbes can be found straight-up chillin’.

And if you’re wondering how we know all of this—well, it’s because biologists have actually gone there. Biology is all about the study of life, from mushrooms to manta rays. Today, we’re going to rotate the microscope, flip those binoculars around, and pull back the curtain on one of the most interesting life forms of all: the biologists themselves.

Hi, I’m Dr. Sammy, your friendly neighborhood entomologist and this is Crash Course Biology. Cue that theme music!

[THEME MUSIC]

Despite the complexities of how we categorize and understand life, the field of biology is a club that's open to everyone – people who like math, bugs, nature, and even design. The more that biology has grown as a field, the more that it requires different types of thinkers to apply those findings to everyday life. You might say that we need diversity in bio just as badly as we need biodiversity.

[Chapter 2 - Your Local Biologist]

So yeah, it’s true that some biologists can be found dodging geysers or diving to the bottom of the ocean in the name of science. But you don’t have to journey to Earth’s extremes to find your nearest biologist, in fact, they're probably a lot closer than you think.

Biology touches everybody’s lives on a daily basis. I mean, biology literally is everybody’s lives on a daily basis. Biological processes are the secret, not-so-secret ingredient in the lunch you eat, the medicine that relieves your headaches, and the cat whose hair is all over your couch.

A biologist’s natural habitat is wherever questions about life’s processes are being asked. And sure, that includes remote caves and distant islands. But it also includes classrooms, laboratories, and doctor’s offices. Biologists are in state forests and at your local conservation department. They’re on boats and in cornfields. They’re even on the edge of skyscrapers, if the peregrine falcons they’re studying decide that’s a good nesting spot.

Many biologists work at research institutes or universities (like mine), where they might do a combination of research and teaching. You’ll find them at museums, zoos, and aquariums. They’re also walking the halls of government agencies, where they’re managing natural resources, monitoring diseases, and studying the effects of food additives, and more. In fact, the federal government is the largest employer of biologists in the United States. Not long ago they even employed me, and I’m super grateful by the way. Thanks, USDA!

Biologists also work at pharmaceutical companies, researching and testing medicines. They're at medical device companies, developing products that make it easier to diagnose, treat, and prevent illness. So the next time you're snorkeling near a thermal vent or strolling through Washington D.C. keep your eyes peeled.

[Chapter 3 - Biologists at Work]

Although biologists share a questioning curiosity about life's processes, their specializations drive what they do on a daily basis. Even if biologists are working on the same goal—say, the conservation of wild salmon—they approach it from distinct angles. To help us better understand the ways that biologists work, let's head over to the Thought Bubble…

Welcome to Biotown, a little city with a big river running through it. Wild salmon migrate up and down that river, just as they have for thousands of years, connected to all the things in their ecosystem. But with the construction of Biotown came disturbances to the salmon's ecosystem, everything from the introduction of dams to pollution runoff has contributed to the salmon's decline. But don't worry, all sorts of biologists are on the case.

Let's start on the outskirts of Biotown. Here we see a pair of biologists in the field, decked out in waders, bug spray, and huge hats. The one wrestling an armful of salmon is checking the fish's snout for a wire tag that identifies where it hatched. Looks like the salmon is winning. The other is recording data about the insects skimming the river and feeding off salmon carcasses. He wants to understand how the fish supply energy to other living things.

Following the river into town, we stumble on another biologist, crouching in front of a storm drain. Did she lose something? Nope, she's doing fieldwork, too— collecting data about chemicals on the roads that wash into the streams where salmon swim. Those samples will travel downtown to the Salmon Research Institute, where dozens of other biologists are hard at work in their own specialties.

There's the entomologist, analyzing data about the insects her team collected. There's the geneticist, running computer models to understand how the salmon's genetic diversity is changing over time. The population ecologist is hard at work on their own computer, writing up conclusions about how the salmon numbers are changing.

And what happens in the lab, doesn't stay in the lab. At a conference further up the road, this biologist is presenting her findings about a new virus affecting salmon in the region. Next door, this team of biologists is meeting with local tribal leaders: experts on salmon who they'll partner with on their next research project. They're planning how to work together to conserve salmon for future generations.

[Chapter 4 - Real Life Biologists]

Thanks, Thought Bubble! You're a biologist's best friend! So, all of the biologists in Biotown are just examples, but there are plenty of real-life scientists out there doing this kind of important work.

Like, take Stephanie Blair for example. A doctoral candidate and member of the Inupiaq and Ojibwe tribal communities. Blair understood firsthand the importance of regional salmon species to tribal livelihoods. She knew what lowered salmon populations would cost families and communities that relied on the fish.

In her research, Blair uncovered a toxic chemical in the river water of urban areas that was leading to higher mortality rates. Now, other scientists are using Blair's research to help create infrastructure to prevent the toxic chemical from entering urban waterways.

We know that biologists deal with all kinds of information in their work: DNA, water samples, numbers of organisms, and more. That's why biologists need to have data literacy—a strong handle on how to analyze and understand patterns in their observations. That means keeping all their data ducks in a row—which sometimes literally is data about ducks. Biologists have to plan how they'll gather that information and where it's all going to go.

In the unpredictable outdoors, some biologists take notes by hand in waterproof notebooks. But when not at risk of losing their work in a downpour, most biologists rely on computers to record their observations — whether that's a data worksheet or an online database that automatically saves to the cloud. And the only good observation is a consistently recorded one. Each slice of data has to be taken down the same way.

Say our field biologist is out measuring the salmon she counts. If she sometimes measures from the end of the snout to the middle of the eye, and sometimes measures from the end of the snout to the edge of the eye, those data can't be compared to each other. She has to follow the same process every time. Repetition is the name of the game when collecting data.

Valid experiments depend on thoughtful plans for data collection. And well-designed experiments can make a big difference. Take agricultural scientist George Washington Carver, for example. You may know him as the person who came up with, like, a million uses for the peanut or as the first Black American to get a Bachelor's of Science degree.

Carver was born in the U.S. South, and was enslaved as a child until the abolition of slavery in 1865. He saw firsthand the challenges of poor farmers and was determined to help them through his scientific research. So, Carver designed an experiment. He sought out the worst possible acre of land to match the conditions of nutrient-starved fields all over the U.S. South.

Instead of pumping the soil with expensive fertilizers, he experimented by planting different crops at different times. He observed how some plants—such as peanuts, peas, and soybeans—restored nitrogen that had been stripped away from the soil by other plants. Rotating those crops, he noticed, he could make the soil healthy again.

Carver widely publicized his crop rotation strategies and invented hundreds of uses for these alternative crops, including the first soy-based, non-dairy cheese. And as crop rotation methods spread, they helped rebuild both the soil and the people who depend on it.

Carver chose to study certain plants, peanuts included, because of their unique, soil-building traits. But many biologists focus on a species not for the traits that make them exceptional, but because of the traits they share with other living things, in an effort to better understand things like disease or evolution.

[Chapter 5 - Model Organisms]

These are the supermodels of science, also known as model organisms. They're the most widely studied species on the planet, researched in order to understand biological processes that apply to other organisms. And yes, they sometimes show up on magazine covers.

Mice and rats have been studied in laboratories for over 100 years, and they're still in style. But other fresh faces have popped up among Biology's Next Top Models. The zebrafish has become a recent favorite, an easy-to-maintain model with classic stripes that shares over 70 percent of its genes with humans.

Nematodes — tiny, transparent worms that you might find in your compost piles — make ideal models, easily raised in a petri dish. A fruit fly's adaptable habits stay fresh even though their food typically isn't. Whether they're buzzing around rotten bananas or reproducing by the thousands in a laboratory there's so much that they can teach us.

And in labs worldwide, Arabadopsis has become the model plant for all occasions, with its small size and quick-growing ways. Model organisms need to be easy to raise, easy to keep, and manageable in large numbers. So, while rhinoceroses sure are interesting, it's unlikely that they'll ever grace the scientific catwalk as supermodels.

As ideal laboratory subjects, model organisms help biologists understand other life forms—including humans. Science tells us that all living things share a common ancestor. So you share some genetic material with every sunflower, every elephant, and every mushroom that ever lived. And because even a nematode shares some genes with humans, we're able to study them to better understand diseases in people.

Even though model organisms can help us understand more about ourselves and the other life around us, they aren't well-suited to all questions. Like, there's not much a lab mouse can show us about the behavior and physiology of an alligator.

And sometimes a biologist might choose to study an organism because it's really well-suited to a particular question. Like, turtles aren't as easy to keep in labs as zebrafish are. But some of their soft tissue naturally switches to bone as their shells grow. So if you're interested in how one type of cell transitions into another type of cell, well, it's turtles all the way down.

[Chapter 6 - Review & Credits]

So, biologists can be found studying life in all its forms, from nematodes to narwhals. They work seated at computers, wading in streams, deep in museum archives, and at the helm of research ships.

And while biologists may tackle topics from different angles, they share an abiding curiosity about life and its processes. A curiosity they put to work by collecting data, planning experiments, and using model organisms to better understand diseases, genetics, and the interconnectedness of all life.

Next time, we'll see how life isn't just interconnected. It's also organized, in layers as tiny as a cell and as big as the totality of every living thing on Earth. I'll see you there.

This series was produced in collaboration with HHMI BioInteractive. If you're an educator, visit BioInteractive.org/CrashCourse for classroom resources and professional development related to the topics covered in this course.

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