I think we should do this one outside. This is better. This is beautiful. Just, oh God, of course... except for this. Litter - is a kind of pollution, but like barely. Like, I would rather it not be here. It makes me kind of angry and makes nature less pretty but environmentally, there's a pretty low chance that this can or even a million more like it is going to have a significant negative impact on an ecosystem. The kind of pollution that we really have to worry about is the kind that we can't see, either because it is invisible or because it's being done in places that are way out of the way that we are less likely to encounter. That's by design, of course. Because when people actually see the impact that their lifestyle can have on the world, they tend to sometimes change the way that they live. And also the way that they buy, and we can't have that! So, it's time to get our hands dirty.

(Intro)

Pollution is a kind of catch-all term for any substance that's in the wrong place or in the wrong concentrations in the environment. Trash in the environment, that's pollution. But chemicals, both naturally occurring and synthetic, those are the real killers.

Natural Compounds
(1:12) Now, we tend to think of pollution in terms of weird synthetic chemicals made in big chemical processing plants and they're certainly a problem. But as we'll see in a bit you've got to understand that natural compounds in the wrong concentrations can do just as much damage as whatever petro-insecticide we're making. One of the main ways we're altering concentrations of natural compounds is by messing with the bio-geo-chemical cycles that we talked about a couple of weeks ago.

Carbon
(1:35) You're probably tired of hearing about it, but the most obvious cycle that we're screwing up is the Carbon Cycle, which shuffles carbon around the planet into various reservoirs. The atmosphere, the oceans, rocks, the bodies of living things. The cycle keeps going on thankfully. But we're overloading it by digging up all that carbon-rich coal and oil and gas, and burning it to fuel our 21st century lifestyles. All of a sudden there's more carbon being released than the reservoirs can handle. Plants and animals are like "We're cool, we got all the carbon we need" And the oceans are like "Yeah, we're good on carbon too!" And it can't just go back into the rock. So, it hangs around in the atmosphere as a greenhouse gas, insulating our planet and changing the climate.

Nitrogen and Phosphorous
(2:11) We've also been tampering with the nitrogen and phosphorus cycles to similar effect. Nitrogen and phosphorus are nutrients which we, and other organisms, need, like, really need in order to grow and respire and exist. But when we go and make ludicrous amounts of these nutrients available, ecosystems get very confused. It's like the day in fifth grade when I realized that I could spend my entire allowance on Cadbury Creme Eggs at the After-Easter candy sale at Walgreens. It was fun at first, then it was not. Phosphates and Nitrates are basically the main ingredients in fertilizers and phosphates are also found in detergents, so when waste water from our houses or run off from farms, washes those compounds into rivers and streams. It can cause huge algal blooms that choke out the rest of the plants and animals in the stream. It's totally gross-looking. But that's not the end of it. When all the phosphorus and nitrogen are used up, the algae die and then bacteria gets started on decomposing that dead algae. But of course, the decomposers need oxygen, which they take out of the water and then the oxygen levels in the water plummet, killing all the fish and just about everything else that needs oxygen. This is how phosphate and nitrogen pollution causes dead-zones. The biggest example of this happening right this very minute is in the Gulf of Mexico, at the mouth of the Mississippi River. The Gulf of Mexico Dead-Zone covers 18,000 square kilometers of river delta and coast-line, and is basically a swathe of totally de-oxygenated water caused by all the fertilizers from the entire Mississippi River basin which drains 2.6 million square kilometers of land drained into this one point in the Gulf. The size of the dead-zone fluctuates seasonally as it depends on how much fertilizer is being used by pretty much half of the farms in America. So yeah, pollution isn't just synthetic compounds with just like 17-syllable-long names, sometimes they're just imbalances of chemicals that we need for our survival. However not all chemicals found in nature are good for us. In fact, sweet, old Mother Earth comes up with some of the most toxic stuff that you've ever heard of.

Cyanide
(4:05) Take cyanide for instance. It's in a lot of stuff that we come in contact with everyday, foods like almonds, spinach and Lima beans contain cyanide and so do the seeds of apples, which you have heard, and the pits of peaches. Cyanide is useful to plants because it's a primitive insecticide, causing a sort of molecular asphyxiation, preventing a bugs cells from being able to use oxygen. Now it takes a lot more cyanide than you'd find in an almond to finish off a human but guess what? We figured out how to collect a whole bunch of cyanide in one place because we really love gold. Gold! My precious! Mining operations use cyanide in large quantities in order to separate gold, silver and other precious metals from the ore. In the cyanide process of ore extraction, ground up ore is sprayed with a cyanide solution which dissolves the metal in the ore and draws it out. The solution is then collected and the precious metal is taken out. But the by-product of all this is, of course, a big pile of cyanide-laced rock powder, a.k.a hazardous waste to deal with or try to deal with anyway. Mines do all kinds of stuff to reduce the concentration of cyanide in these leftovers, called tailings, or they try and convert the cyanide into less-toxic cyanate, but the toxin is never totally eliminated. So then it can end up leaking into the groundwater supply.

Mercury
(5:15) Or it can just sit there and keep dissolving other toxic metals out of the rock that also end up in our water, like mercury. And mercury is another important pollutant, it's a super-toxic, naturally-occurring metal found in coal, among other places and it's just fine when it's hanging out underground in a coal seam, but when that coal is burned to make electricity, the mercury is released into the air. And then the mercury falls on the land, where it makes its way into groundwater and eventually into the food chain, especially into the marine food chain. As a result, only about 25% of the mercury released by U.S. power plants and factories actually ends up in the U.S. The rest enters the global cycle, which most people end up ingesting by eating fish. And mercury acts as a powerful neurotoxin in animals, interfering with our brains and our nervous systems.

Sulfur Dioxide and Nitrogen Dioxide
(5:58) Finally, two more naturally-occurring compounds that we keep pumping out are sulfur dioxide and nitrogen dioxide. The most common natural sources of these things are volcanic eruptions, or the waste of some algae and bacteria. But we release millions of tons of these things into the environment every year by burning fossil fuels like coal. And when these compounds react with water vapor in the atmosphere, they turn into sulfuric acid and nitric acid, and then return to the surface as acid rain. In soils, these acids can cause the release of natural, but toxic, elements like aluminum. In water, they can poison aquatic wildlife, and on land, the acidity can cause animals' eggs to not hatch and plants to lose nutrients. Now, things have gotten significantly better since a lot of countries put emissions controls into place, but for a while there, back in 1980, rain in much of North America had the same pH as tomato juice which, objectively speaking, is the grossest.

Synthetic Compounds
(6:51) So. That's how we're amping up the levels of naturally-occurring chemicals to toxic levels. But, of course, we're also synthesizing chemicals that Mother Nature never even dreamed of and they wreak their own special brand of havoc. The problem here is choosing just one as an example, because there are so many chemicals out there, doing so many different things.

Endocrine Disruptors
(7:09) There's a whole class of chemicals called endocrine disruptors, which we put in pharmaceuticals, pesticides and plastics, but some of them are also just byproducts of industry and agriculture. Endocrine disruptors, like bisphenol A or BPA, which baby bottle manufacturers have been scrambling to take out of their products in recent years, hang out in plastics and leach into our drinks or are flushed off of agricultural fields and into rivers or are just flushed down toilets when we pee them out because they're in some drug that we've been taking. The result is that they get into waterways, sometimes in high concentrations, and the animals there, they just soak 'em all in. The endocrine system, basically just your hormones, controls a vast array of an organism's functions, and as concentrations of EDCs have increased, we've spotted male fish in rivers all over the world with female reproductive tracts or testes that make eggs. Those fish are living in the water, but we...we're drinking it. People of all ages are susceptible to EDCs, but research suggests that those most at risk are fetuses and infants, because their organ and immune systems are still forming. Scientists are still studying the developmental, reproductive, and neurological effects that these compounds are having on us. And as far as I'm concerned they can't do it fast enough. So, the chemicals we're making are affecting us in ways that we could guess, and also probably ways that we've never even dreamed of. At the same time, we're rearranging where and how much some naturally occurring compounds are showing up and that adds to those 5 other impacts that we're having on the biosphere, and yeah, the past two weeks have been a real bummer, but hopefully an enlightening bummer. But this leads us to the next stage of ecology, and the last lesson in this course, conservation biology and restoration ecology, which together comprise the science of saving our planet, and ourselves from...ourselves.

Thank you for watching this episode of Crash Course Ecology and thanks to everyone who helped us put it together. If you want to review any of the stuff that we covered this episode, there's a table of contents over there that you can click on, or down in the description. And if you have questions or comments for us, we're on Facebook and Twitter and of course, down in the comments below.