The Hydrologic and Carbon Cycles: Always Recycle! - Crash Course Ecology #8

Crash Course: Ecology
https://youtube.com/watch?v=2D7hZpIYlCA
https://nerdfighteria.info/v/2D7hZpIYlCA

Adorable story alert! So I was hanging out with my adorable 2-year-old second cousin in the ocean in Florida and we're jumping up and down with the waves and it's fun but then the water got all calm and I said 'oh, no more waves!', because, like, that's the top tier of communication I'm going for with a 2-year-old, but then he said 'don't worry, there'll be more!'

And I was like, 'how do you know?'

And he was like 'it's a cycle!

Yes! It is a cycle! The Earth is filled with cycles! And if my 2-year-old second cousin knows it you should know it too!

The universe is the great recycler. All of the stuff we have on Earth, every last particle of matter or calorie of energy has been around since the Big Bang, it just keeps getting repurposed over and over again. And when it comes to matter, at least, the Earth is essentially a closed system, all the matter gets passed around in continuous biogeochemical cycles, which are pathways for molecules like water or elements like carbon and nitrogen and phosphorous to move through all of the Earth's various ecological and geological compartments.

Now of course we couldn't possibly talk about how all matter gets cycled around Earth in one video, 'cause the Earth is pretty big, but consider this as an introduction to biogeochemical cycled starring my two personal favorites, carbon and water.

(Intro)

Now I'm sure you already know about at least one type of planet-wide recycling because it's the most obvious to us: the hydrologic cycle which describes how water moves on, below and above the surface of the Earth driven by the energy supplied by the Sun and the wind.

And in talking about the hydrological cycle it's most useful to think about all of the water on Earth being held in a series of reservoirs. The ocean, for instance, or the atmosphere in the form of clouds or in polar ice caps. So not only does water cycle through different places, it also takes different forms in different parts of the cycle, in liquid, solid and gas.

And since it's a cycle there is no beginning and no end so where we start our discussion is arbitrary but I'm going to start it off with precipitation.

Rain, hail, snow, sleet, graupel, all of that stuff is precipitation. It happens when water that's being held in the atmosphere condenses, or turns from a gas into a liquid and then occasionally freezes into a solid, right up in the air.

The opposite of precipitation, of course, it evaporation, the conversion of a liquid into a gas, and when a substance converts straight from a solid into a gas that's sublimation and when it's from a gas to a solid that's deposition. And now you know.

But back to condensation. It is responsible for the formation of clouds, which happens when air containing water vapour rises and cools or is compressed to the point that it can no longer be a gas. At this point, the vapour forms droplets. This is the same thing you see happening on your glass of ice tea on a humid day. The water in the air around the glass gets cold, and turns from gas into liquid.

So clouds are just a big pile of condensed water droplets, in a sense, it's a gigantic floating reservoir. Clouds are a handy feature of the hydrologic cycle because as they drift over the landscape they move water around the globe so water that evaporates over the ocean can be deposited somewhere else. Otherwise, if water always got deposited right where it evaporated the precipitation would be almost always right over the ocean because that's where most of the evaporation on Earth takes place.

So wind moves clouds, and as water keeps condensing clouds get heavier and heavier until our old friend gravity takes over and pulls the condensed droplets to the ground in the form of rain or in the form of snow or hail or sleet or graupel.

So now the water's on the ground, but gravity continues to work on it pulling it towards its resting place wherever that might be. It either pulls the water across the surface of the land to the lowest point in a process called runoff, or it pulls it underground.

Water can be trapped or stored for a little while in places like lakes and ponds and wetlands but most of the water that falls as precipitation gets pulled lower and lower and lower as runoff through the creeks and streams and rivers until it reaches the ocean.

In really cold places, water of course freezes and hangs around as ice in places for thousands of years at a time like at the poles and glaciers and on mountaintops, but when it melts, most of it too runs off into the ocean.

So you see where this is going. Oceans are a big deal, they're pretty much the biggest deal, they're the reason that we have the hydrologic cycle in the first place, they're also the reason that we have awesome stuff like weather, and life, on Earth.

The weird thing about oceans though is that they're salty. And there is a reason for this! As water runs it erodes minerals like salt from soil and carries it to the ocean. Now water heading to the ocean may not taste salty but the salt's in there.

But here's the thing: when the water evaporates again, the salt doesn't evaporate with it, it gets left behind. You keep this up for a few billion years with the pure water evaporating from the ocean and returning with tiny amounts of salt and that's your recipe for a billion cubic kilometers of brine.

And all of this shows us that the world's oceans are literally the last stop for all the liquid on Earth, the only way to get out of there is through evaporation and that leaves all your minerals behind.

Now living things also have their role to play in the hydrologic cycle, and both plants and animals that break down carbohydrates to produce energy produces water as a waste product. So we lose water through evaporation from our skin and exhale water vapour and of course we pee it out.

Indeed most organisms on Earth are made mostly of water although that water cycles in and out of us pretty quickly. In plants, water is sucked up through the roots and moves up to the leaves (the gas exchange organs) where it evaporates quickly. This process is called evapotranspiration and since there are so many plants here on Earth it is responsible for a good amount of the water that enters the atmosphere. This process is essentially the opposite of condensation in that it turns liquid water into gas. The energy of the sun drives evaporation whether it's the surface of the ocean or the treetops and leaves, and then once all of that water evaporates into the atmosphere we will be right back where we started.

It's a cycle!

So now that you know a little bit about the hydrologic cycle it's a little easier to understand how the carbon cycle works. Carbon is one of the most abundant elements in the universe and here on

Earth it's always on the move, just like water, jumping from one reservoir to the next.

And that's a good thing because A) all living things require carbon for their structure and to fuel their bodies and B) it's a big component in a bunch of non-living things as well, it's in rock and in the ocean, trapped in ice, plus, it's in the atmosphere, where it helps regulate the temperature. Without carbon dioxide the Earth would basically be a frozen wasteland, so lucky for us, there's a whole pants-load of carbon out there, we need it!

Let's start off with the carbon in living things. If you were to take all of the water out of your body, carbon would constitute about half of what remained in the little pile of dust that used to be you. And the first biological reservoir of carbon is plants. Plants absorb a whole lot of carbon dioxide out of the atmosphere because they need it to photosynthesize. CO_2 is also one of the by-products of respiration, the process by which they use that energy. So plants take in carbon dioxide from the atmosphere during photosynthesis and release CO_2 back out into the atmosphere during their respiration process to make ATP for all their cellular functions.

And right now, you're like 'wait-wait-wait-no isn't it the deal that plants get to take in all the carbon dioxide and animals get to breathe it out?' Well, yes and no, it's just that plants take in more CO_2 from the atmosphere than they give off in respiration. The rest is like their profit, what becomes the body of the plant. That's right, that big-ol' massive tree, all that mass, came from gas. Pretty cool.

So carbon absorbed by plants has three possible fates. It can be respired back into the atmosphere, it can be eaten by an animal, or it can be present when the plant dies. And if a tree falls in the right kind of forest and it's not able to decompose normally because a bunch of other plants all fell right on top of it, and they die and they get buried and squished together and form rocks like coal. We call these carbon-rich geological deposits fossil fuels.

Lately one of humanity's very favorite pastimes has been digging up all of this carbon in the form of carbon and and natural gas and burning it to fuel our, pretty much everythings-but I'll get to that later.

Another extremely important carbon reservoir is the ocean. Now carbon dioxide dissolves really easily in water and once it's in there all of it's used by phytoplankton (plant-like organisms that form the base for the marine food chain). They use it to do photosynthesis and they also use it to form calcium carbonate shells. And when these guys die, their shells settle to the bottom of the ocean, pile up, and become compressed and over time, make rocks like limestone.

Now limestone, obviously doesn't burn super well so it's not considered a fossil fuel but as limestone deposits are eroded by water the calcium carbonate is broken down to eventually form, among other things, carbon dioxide and carbonic acid.

We make lime and cement by heating limestone which produces a pretty good amount of carbon dioxide and when we do burn fossil fuels such as coal and petroleum products and natural gases it also releases carbon in the form of carbon dioxide that's been stored for hundreds of millions of years in the geosphere, which is just a fancy science-y word for Earth-rocks.

This process is what started the atmosphere carbon dioxide rising like crazy in the past couple of hundred years, and the excess of the carbon in the atmosphere causes global climate change 'cause CO_2 in the atmosphere causes some of the sun's energy from re-radiating back out into space. Oh yeah, our planet has been getting warmer because we've been burning through this reservoir of carbon that we have locked underground. This is causing all kinds of problems that we can see already and it's very likely to keep causing bigger and bigger problems with time.

And the situation could be helped a lot if we could just stop unlocking all of that carbon and spitting it into the atmosphere, but in some respects we don't even have control over the situation any more, because of ice.

Remember how I said that carbon is often trapped in ice? Well, in places like Siberia, and northern Canada and Alaska, cold places that also have plants, they contain huge carbon reserves that are trapped in permafrost (ground that's frozen year-round). These places are basically frozen wetlands that add another layer of dead plant matter every year. But as permafrost melts, these dead plants decompose, and huge amounts of carbon dioxide and methane are released into the atmosphere, creating a positive feedback loop.

Our carbon burning lifestyle is releasing this other huge carbon reservoir to keep the whole greenhouse effect going with or without us.

Sorry to end on such a frightening and depressing note but the stability of the global climate is not as stable as we would like it to be and the fact that we're throwing it out of whack is one of the most important reasons to study ecology in the first place.

This episode of Crash Course was written by myself, Jesslyn Shields, and Blake de Pastino. Our technical director is Nick Jenkins who is also our editor and is also standing behind the camera right now. Graphics are courtesy of Amber Bushnell and Peter Winkler, and our sound designer is Michael Aranda.

If you want to review any of what we went over in today's episode, check out the table of contents over there. And if you have any questions or comments or corrections or ideas for us, we're on Facebook and Twitter and, of course, down in the comments below.