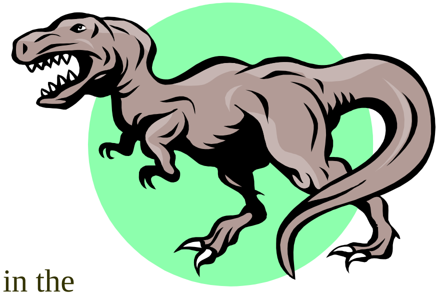
Dinosaur Breath Activity — Student Background Reading: Life of a Carbon Atom



All living organisms, including plants and trees, fish in the ocean, and our own bodies are based on the carbon atom. In fact, 18% of our bodies are made of carbon! Carbon atoms continually move through living organisms, the oceans, the atmosphere, and the Earth's interior and crust. This movement is known as the carbon cycle. The paths taken by carbon atoms through this cycle are very complex and may take millions of years to complete a full circle. All animals, from humans to the dinosaurs that lived during the Jurassic Period, are part of the carbon cycle. When animals (including humans) eat food, they gain carbon in the form of carbohydrates and proteins. In animal cells, oxygen combines with food to give energy for daily activity. Carbon is waste product of this process, which is known as cellular metabolism. As a waste product, carbon combines with oxygen to form carbon dioxide (CO2) and is released back into the atmosphere when animals breathe and exhale.

Consider the journey of a typical carbon atom that existed in the atmosphere as part of a CO2 molecule 360 million years ago, during the Carboniferous Period. This particular CO2 molecule drifted into the leaf of a large fern or other green plant growing in the extensive tropical swamp forests of that time. Through photosynthesis, which is the way plants make food and energy, the oxygen (O2) from the CO2 molecule was released back into the atmosphere, while the carbon atom (C) was removed from the CO2 molecule and used to build a molecule of sugar. The sugar molecule could have either been broken down by the plant to release its stored energy, but this particular sugar molecule was transformed into a long-lived structural part of one of the plant cells. Soon after, the fern died and the remains sank into the muck at the bottom of the swamp. Over thousands of years, more plants grew in the swamp and their carbon-containing remains also sank into the swamp, forming a layer of dead plant material many meters thick.

Gradually, the climate changed, becoming drier and less tropical. Sand, dust and other materials slowly covered the ancient swamp and sealed the decaying vegetation under a thick layer of sediment. The sediment hardened, turning into sedimentary rock. The carbon atom stayed trapped in the remains of the long-vanished swamp while the high pressure of the layers slowly turned the material into what we know today as “coal”. Today, about 360 million years later, humans mine these ancient coal beds and burn coal in power plants to create electricity to fuel industrial civilization. The process of burning releases the energy stored in the carbon compounds in the coal and reunites the carbon atom with oxygen in the air to form CO_2 again. The CO_2 is released to the atmosphere through the smokestack, and the journey continues.

Now let’s consider what would have happened to the carbon molecule if it had been eaten by a dinosaur living during the Jurassic Period. Let’s say a brontosaurus, a plant-eating dinosaur (herbivore), ate the fern for breakfast, ingesting carbon from the fern in the form of carbohydrates and proteins. In the brontosaurus’ cells, oxygen combined with the ingested carbon-containing carbohydrates and proteins to provide energy for the dinosaur’s daily activity. CO_2 was a waste product of this process and was expelled from the dinosaur’s body when he took a deep breath and exhaled, hours after the digestion process was completed, when he was still feeling content from his morning meal. So, the carbon contained in the leafy fern was released into the atmosphere in the form of CO_2.

Consider that this CO_2 molecule happened to be floating with other CO_2 molecules over the ocean surface. In a place where the water is warm, it is likely that the water absorbed these molecules. Oceans soak up a tremendous volume of carbon to prevent too much CO_2 from remaining in the atmosphere. Once our CO_2 molecule was dissolved in the ocean water, it could have been captured by a tiny marine organism that used it to make its shell. There are trillions upon trillions of little ocean creatures, including foraminiferans, coccoliths and calcareous algae, that capture atmospheric carbon in the form of CO_2 and use it to make calcium carbonate ($CaCO_3$) shells. For example, the shells of clams and snails are made of calcium carbonate.

Most of the carbonate shells are produced by microscopic creatures called plankton, which float in all oceans of the world. Although they do not live very long, plankton absorb vast quantities of carbon in their shell-building activities. By keeping carbon contained within their shells, marine organisms keep it from being re-evaporated into the atmosphere, where it would accumulate as CO_2. When they die, their shells sink to the bottom of the ocean floor to form sediments of limestone and natural chalk. These sediments are raised above sea level by tectonic activity and create large rock formations. For example, the white cliffs of Dover are gigantic chalk cliffs originally formed from these types of sediment.

People mine large amounts of natural chalk from these from these rock formations. However, much of the chalk sold today is man-made and is not composed of natural carbonate. Through a simple chemical reaction with vinegar, we can release the carbon stored in this chalk into the atmosphere, where it will combine with oxygen to form CO2. It is possible that this is the same CO2 that was exhaled by dinosaurs during the Jurassic Period!

Investigating Questions

1. What the does the term “carbon cycle” mean?
2. How do all animals, from dinosaurs to humans, relate to the carbon cycle?
3. Explain how a carbon atom that existed as carbon dioxide (CO2) during the Carboniferous Period could have ended up at the bottom of a murky swamp.
4. How did this carbon atom eventually form coal? What is coal used for today?
5. Now explain how the same carbon atom (that existed as CO2 during the Carboniferous Period) could have ended up in a dinosaur’s stomach.
6. How did this carbon atom become re-released into the atmosphere?
7. How did the carbon atom meet a tiny marine organism? What did the carbon atom help the marine organism build?
8. How did the carbon atom become natural chalk?
9. How can we release the carbon contained in the natural chalk, which *could* be from the exhaled breath of a dinosaur?