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Think One Person Can Change The World? Plants Already Have

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If the natural history of planet Earth were represented as a 24-hour clock, humans have existed for less than 2 minutes. I think we can pretty much agree that, in those two minutes, we have changed our environment to the extent that the world is unrecognizable. We have created cities and infrastructure, our population has boomed, and greenhouse gasses that we have released into the atmosphere has lead to changes in our climate. Does that make us special? Have we really changed this planet more than anything else? Those looking through all of natural history likely agree that, while we humans have brought all sorts of destruction upon the environment in our short time here, we are far from the only organisms that have revolutionized the makeup of this planet. Plants have been taking over and rewriting the story of Earth for hundreds of millions of years.

Photosynthesis is a way for certain organisms to make food by using light energy to power a series of reactions for producing glucose from carbon dioxide. Oxygen is a byproduct of this reaction, which is poisonous to many organisms if they do not have the structures to process it. Around 3.4 billion years ago, one type of bacteria called cyanobacteria became the first to develop the ability to undergo photosynthesis, which led to a mass extinction of organisms that did not have the ability to tolerate oxygen. The atmosphere had more oxygen than it had ever had before, and it would never go back down to its original levels—a permanent change. Photosynthetic organisms would continue to be important to the world's ecosystems—the base of most food chains, harnessing the sun's energy to produce sugars that other organisms would later rely on for their sustenance. Eventually, a Eukaryotic cell would

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engulf a cyanobacteria, which, as time goes on, would become what we know today to be a chloroplast. The descendants of these Eukaryotic cells with chloroplasts would develop into multicellular organisms that we now call members of the Plant Kingdom, and the world would never be the same.

Plants would eventually begin to take over. The first land plants, called bryophytes, showed up during the Ordovician period (470 million years ago) and were mosses, liverworts, and other non-vascular plants. The bryophytes didn't have stems or leaves, but they were the organisms that attracted arthropods onto land, leading to the first initial population of land by animals. This would shape life on Earth from this point on. Because arthropods—the group that contains insects, arachnids, trilobites, and other familiar creepy crawlies—have hard exoskeleton-covered bodies, they were pre-adapted to the structural support needed for life on land and therefore were able to quickly populate and diversify. This would eventually attract amphibians, the first land vertebrates, onto land, causing rapid increases in diversity due to the new habitats, new foods, and new evolutionary pressures.

Plants are often the first to colonize new environments. This is also shown in the modern day through the process of succession—in a damaged ecosystem, the first organisms to repopulate are the plants, which are followed by other organisms. Because plants are producers, they drive the ecological direction of a new habitat, which explains their position as a requirement for ecosystem development.

The mid-Silurian, 420 million years ago, saw the first vascular plants, which are plants that have roots and stems. Plants had to adapt to the river environments around them, but they changed the river environments as well. Before vascular plants, streams tended to have a braided structure without the winding and wandering in structured channels that we see in most major rivers today. Once vascular plants began to populate land, the roots bound the sediment, slowing the movement of the fluid and changing the shapes of the rivers. Streams began to form meanders and, once trees began to take over the land, floodplains had complex ecological forms for when rivers periodically overflowed. This information is shown in the sedimentary rocks formed during this period. The shapes of rivers depositing sediment affect the forms in the sedimentary rocks.

Paleobotanists are paleontologists who focus on plant fossils and their surrounding sedimentary rocks to understand how plants shaped the world around them. These specialists have been studying the relationship between plant and river evolution, and have found that they are intertwined. So much of what we currently consider different types of environments have to do with the vegetation that populates these environments. Once trees could populate a floodplain, there were swamps (with giant, meter long dragonflies buzzing around) and, without many decomposers, even higher oxygen content in the atmosphere than there is today (hence the giant dragonflies). Thus, there were comparatively lower levels of carbon dioxide, dropping the global temperature (due to less greenhouse effect) and leading to coal deposits. Today, we are burning coal from these deposits, re-releasing carbon dioxide into the atmosphere and causing an enhanced greenhouse effect, which is leading to an increase in global temperature.

The first angiosperm, or flowering plant, fossils appeared around 125 million years ago during the Cretaceous period. Angiosperms lead to a huge diversification event among pollinating animals through the end of the Cretaceous—yet another example of plants having major effects on their environment. Current living angiosperms are likely most closely related to the earliest angiosperms that were pollinated by insects. This trend continues today; bees, ants, butterflies, and beetles are all pollinators who have, in some way, a reliance on plants due to the way they co-evolved with flowering plants, which either provide a reward such as nectar or edible pollen to the insect, or at least appear to have a reward for the insect, like having flowers that resemble mates. This relationship between plant and pollinator has existed for only a little over 100 million years (just about half an hour on the 24-hour clock), and yet, it is a prominent part of life on Earth today.

Not only have plants had a profound effect on the history of life, but they are also useful tools for learning more about natural history. Paleobotanists can study plants to key the type of environment an area may have been in the past when the sedimentary rocks do not provide enough information. These scientists do this by looking at the types of organs present. Wide leaves with entire margins (meaning no serrated edges) and drip tips are generally associated with a very wet environment. This is not an infallible method for learning about a past environment

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(biology is full of exceptions), but it can be a helpful way of providing direction in a study.

Phytoliths are rigid microscopic structures made from silicates (a type of rock) that were taken up by plants and, in the fossil record, can record all kinds of information, such as the type of plant or the shapes of the plant's cells. Because they are made of silicates, they preserve really well in the fossil record. Phytoliths are affected by light intensity, so they can be used to indicate past light levels in certain locations. The existence of phytoliths in fossilized animal dung (coprolites) also can indicate what certain animals may have eaten while they were alive. Preserved leaf fossils can show bite marks from insects, allowing insect paleontologists to reconstruct insect mouthparts.

Plants have had profound effects on natural history, so much so that they work well as indicators of all different aspects of the environment. Plants get a bad rap among the average introductory biology student because they do not move much in a way that is visible or noticeable to the naked eye, but if we watch over geologic time and are patient, then maybe you can see they're more dynamic than you think.

For more information on this topic, check out Congrad Labandeira's article "The Origin of Herbivory on Land" from *Insect Science*.