

# Performance and Adoptability Biodegradable Mulch

biodegradabledmulch.org

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## Summary

*Biodegradation is the process by which microorganisms decompose compounds. These microbes are key to breaking down biodegradable mulches when they are tilled into the soil.*

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## Biodegradation – Putting Biology to Work

Biodegradation is the action of microorganisms to decompose a substance into its constituent elements or new compounds. This is the key process by which biodegradable plastics are broken down in the environment.

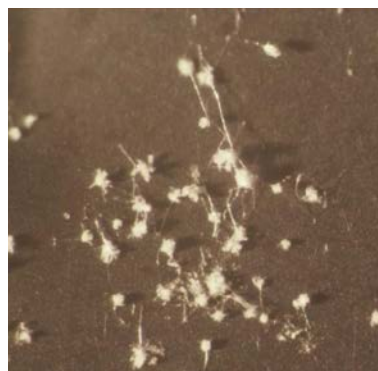
### What types of organisms are involved?

Biodegradation is carried out by microorganisms (bacteria and fungi) that naturally live in the environment. Bacteria are single celled organisms that dominate in soils. A single teaspoon of soil can contain between 1 million to 1 billion bacterial cells! Fungi are often microscopic, but many can grow as long threads called hyphae or fruiting bodies like mushrooms, which can be visible to the naked eye.

Bacteria and fungi have very diverse metabolisms: they use a wide variety of food and energy sources, and perform many important functions. One especially important function is decomposition.

Decomposers are bacteria and fungi that can break down organic matter and in doing so recycle nutrients. The most efficient

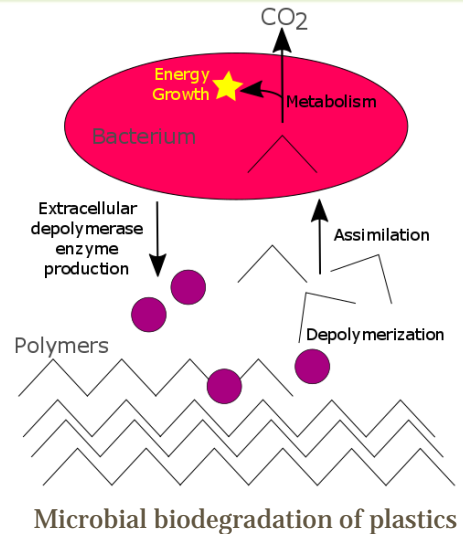
decomposers are those that use aerobic respiration, using oxygen in the process of decomposition. An example of how we use decomposers to clean up organic waste materials is composting: by providing the optimal mix of nutrients, moisture and oxygen, we can accelerate the growth and activity of aerobic microorganisms. Under the right conditions, these organisms are able to grow rapidly, using up the organic matter substrate (or feedstock) and generating heat, water vapor and carbon dioxide. *(continued, next page)*



*Penicillium* sp., a fungus growing on a biodegradable mulch (20x magnification). From Moore-Kucera et al. 2014

## How do plastics biodegrade?

Some decomposer microorganisms can use plastics as a substrate (“food”), and in consuming plastic for growth, they convert the plastic into harmless byproducts. Plastics are made up of **polymers**: long chains of repeating chemical units called monomers. Polymers are typically too large for microbes to take up, so first they must be broken into smaller pieces, a process called **depolymerization**. Microbes excrete extracellular enzymes called **depolymerases** that break the bonds of the chain. Once the chain is broken into its smaller monomers, microbes can then take those monomers inside the cell (**assimilation**) and further transform them using other enzymes, obtaining energy and growing in the process. Sometimes their metabolism results in a complete breakdown of the plastics, and only carbon dioxide and water are produced. Other times, the biodegradation is incomplete, and the plastic is transformed into other chemical compounds.



## What makes biodegradable plastics “biodegradable”?

Biodegradability describes how easily something breaks down as a result of biological activity. The American Society for Testing and Materials (ASTM) defines biodegradable plastics as those “in which the degradation results from the action of naturally occurring microorganisms such as bacteria, fungi and algae.” Most traditional plastics, such as those made from polyethylene, are not biodegradable. Even those that are sold as “degradable” or “oxo-degradable” are not biodegradable. The reason is that the polymers in these plastics have chemical bonds that are not common in nature, so microbes have never been exposed to them and do not have the enzymes or metabolic pathways to break down these polymers. This makes these types of plastics very durable, but it also means they will persist in the environment for decades or even centuries.

Biodegradable plastics are made from polymers that more closely resemble substances that microbes regularly encounter in nature. There are lots of natural polymers found in nature, and decomposer microbes have evolved enzymes to break down these compounds. For example, some microbes can decompose the natural polymers found in plants, which keeps leaves from piling up on the forest floor year after year. Biodegradable plastics use natural polymers derived from plant or microbial sources, or they use synthetically created polymers that have bonds similar to natural polymers. Thus, microbial enzymes will be able to “recognize” the polymers and break down the compounds.

For more information on biodegradable plastics, see [“Using Biodegradable Plastics as Agricultural Mulches”](#) factsheet.

### References and Further Reading

- Brodhagen M, Peyron M, Miles C, Inglis DA. Biodegradable plastic agricultural mulches and key features of microbial degradation. *Applied Microbiology and Biotechnology*. 2015;99: 1039-1056.
- Moore-Kucera J, Cox S, Peyron M, Bailes G, Kinloch K, et al. Native soil fungi associated with compostable plastics in three contrasting agricultural settings. *Applied Microbiology and Biotechnology*. 2014;98: 6467-6485.