Human Uses of Prokaryotes - Advanced

• Identify human uses of bacteria.
• Identify two industrial and two agricultural uses of bacteria.

What is aromatic black pu-erh tea?
Aromatic black pu-erh tea is from the Yunnan Province in China. Leaves undergoes double bacterial and fungal fermentation and are compressed into different forms. Pu-erh tea is used for improving mental alertness and sharp thinking. It is also used for reducing high cholesterol.

Human Uses of Bacteria

Bacteria can be used by humans in a number of useful ways. Despite the fact that some bacteria play harmful roles, such as causing diseases and spoiling food, the industrial and economic importance of bacteria includes both their useful and harmful aspects. Examples of the role of bacteria in industry include the following:

• Fermentation processes, such as brewing, baking, and cheese and butter manufacturing.
• Chemical manufacturing, such as the production of ethanol, acetone, organic acids, enzymes, and perfumes.
• Pharmaceuticals, such as the manufacture of antibiotics, vaccines, and steroids.
• Energy, in the form of biogas (methane).
• Food products, such as beverages, dairy products, amino acids, proteins, and nutritional supplements.
• Decomposing sewage waste.
• Agriculture, such as composting processes and use as pesticides.

Food

Bacteria, often *Lactobacillus*, along with yeasts and molds, have been used for thousands of years to make fermented foods such as cheese, pickles, soy sauce, sauerkraut, vinegar, wine, beer, and yogurt (some of which are shown...
Bacteria are also used in the processing of coffee and cocoa beans but are not found in the end-products (coffee and chocolate). *Lactobacillus* bacteria also live in the intestines of humans and animals, where their growth inhibits the growth of potentially pathogenic bacteria. These beneficial bacteria are therefore sold as probiotic dietary supplements, such as “live” yogurts.

![Fermented Foods](image-url)

**FIGURE 1.1**
Various lactic acid bacteria, including *Leuconostoc*, *Lactobacillus*, and *Pediococcus*, are used to pickle vegetables, such as the kimchi dish on the left and sauerkraut (center left, with sausage). Fermented dairy products, such as cheese (center right) and yogurt (right), are made by lactic acid bacteria that digest the milk sugar, lactose. The distinctive flavors of these foods result from the lactic acid that forms when bacteria ferment the sugars in the vegetables and milk.

**Pollution Clean-Up**

Some organisms are able to break down compounds such as petroleum or pesticides, which makes them useful in mining, pollution clean-up, and waste processing. **Bioremediation** is any process that uses microorganisms, fungi, green plants, or their enzymes to clean a contaminant from the environment. Bacteria that can digest the hydrocarbons in petroleum (oil) can be used to clean up oil spills. After the *Exxon Valdez* oil spill in 1989, fertilizer was added to some of the beaches in Prince William Sound in Alaska, where the accident took place, in order to increase the growth of these naturally occurring bacteria.

Bacteria are also used for the bioremediation of industrial toxic wastes, such as mercury. Certain bacteria can digest organic compounds that are toxic to humans and other animals, such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and pesticides.

**Microbial Miners**

**Biomining** is the use of prokaryotes to extract certain minerals from ores. Using a bacterium such as *Thiobacillus ferrooxidans* to leach copper from mining leftovers has improved recovery rates and reduced operating costs for mining companies. Also, using microorganisms to leach out the minerals, instead of the traditional methods of high heat or toxic chemicals, is better for the environment.

**Waste Disposal and Biogas Production**

Aerobic and anaerobic bacteria are used to decompose sewage waste. They break down organic matter into harmless, soluble sludge in settling tanks. The methane gas produced is used as an energy source. **Figure 1.2** shows aerobic digestion of sewage. The wastewater is mixed up, or agitated, which keeps the water oxygenated, allowing aerobic bacteria in the water to break down the waste matter.
When organic matter is broken down anaerobically, methane gas is produced. Methane gas that is released from landfills and sewage treatment plants can be collected and used as fuel to produce electricity, heat buildings and water, or power vehicles, like the bus in Figure 1.3. When used as a fuel, methane is often called biogas. Biogas can also be made in special equipment called anaerobic digesters, where waste is broken down in the absence of oxygen. A biogas plant can be fed with crops, such as maize silage, or biodegradable wastes, including sewage sludge and food waste.

**Agricultural Uses**

Heterotrophic microbes are very common in nature and are responsible for the breakdown of large organic molecules which are generally indigestible to larger animals. They also return nutrients to the soil, such as the nutrients that are locked up in the dead leaves in Figure 1.4. Prokaryotes and other microorganisms also have important roles in biogeochemical cycles, the cycles that move molecules and nutrients through the biotic and abiotic parts of the environment. Examples include the nitrogen, carbon, and phosphorus cycles. To learn more about biogeochemical
cycles, see the *Recycling Matter* concepts in *Concept Ecology (Advanced)*.

**FIGURE 1.4**

These fallen leaves will be broken down by decomposing bacteria in the soil. Decomposition returns the nutrients in the leaves to the soil, where they can be used by other organisms. The aerobic breakdown of biodegradable organic matter, such as leaves, fruits, vegetables, grass clippings, and even animal materials, by microorganisms is called composting. The anaerobic breakdown of animal tissues by microorganisms is called putrefaction.

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**Nutrient Recycling**

Bacteria and other microorganisms that are able to digest complex molecules, such as lignin and cellulose, are important in composting. Lignin and cellulose are components of plant cell walls. **Composting** is the aerobic process of breaking down (decomposing) organic materials into simpler molecules to return nutrients to the soil. Composting is often used in organic gardening and farming. Nitrogen fixing bacteria are also used to increase the nitrogen content of soil. This is done by planting legumes, such as beans or clovers, and allowing the bacteria in their roots to fix nitrogen into the soil for some time. The legumes and their resident bacteria are then tilled into the soil so that other crops can be planted.

**Pest Control**

Bacteria can also be used in the place of pesticides. *Bacillus thuringiensis* are Gram-positive, soil-dwelling bacteria that are used to control certain plant pests. *B. thuringiensis* produces an endotoxin (called *Bt* toxin) that is toxic to mosquitoes, moths, and certain caterpillars. Because of its limited toxicity to certain insects, *Bt* toxin is regarded as environmentally friendly. It does not affect humans, wildlife, pollinators, and most other beneficial insects, such as ladybugs and bees. *Bt* toxin has been genetically engineered into crops (see *Concept Biotechnology (Advanced)*).
Summary

• Bacteria are used in fermentation processes, such as brewing, baking, and cheese and butter manufacturing. They are also used in agriculture, such as in composting processes and as pesticides. Bacteria play the key role in nitrogen fixation.

Review

1. Identify two industrial and two agricultural uses of bacteria.

References

1. ayustety; Maksim; Alex Anlicker; Omemos. Pickled vegetables: https://www.flickr.com/photos/kimtaro/239880180; Sauerkraut: https://www.flickr.com/photos/mdid/2851361160; Cheese: https://www.flickr.com/photos/34544693@N02/3218652336; Yogurt: http://en.wikipedia.org/wiki/File:Labneh01.jpg . Yogurt: Public Domain; Remaining images: CC BY 2.0