What are environmental microorganisms?

Microorganisms include viruses, bacteria, fungi, protozoa, algae, and nematodes, in roughly decreasing order of size. They are the oldest form of life on Earth and are found virtually everywhere, from boiling hot springs deep in the Earth to the depths of the oceans to the Arctic.

Why do we study environmental microbiology?

Environmental Microbiology introduces students to the diversity of microbial populations and their important roles in **environmental** processes in air, water, soils, and sediments. Microbial community ecology and interactions with plants and animals will also be discussed.

Which country is best for Microbiology?

In regards to the country's most notable for robust Microbiological science, the **U.S.**, U.K., Germany, France, Australia, Japan and India are all near the forefront.

How are microorganisms harmful to the environment?

The primary **harmful** effects of **microbes** upon our existence and civilization is that they are an important cause of disease in animals and crop plants, and they are agents of spoilage and decomposition of our foods, textiles and dwellings.

What are the harmful microorganisms?

Examples of harmful Microorganisms: Harmful microorganisms include **fungi**, **bacteria**, **protozoa**, etc. They cause several diseases in human beings, animals, and plants which can even lead to death. The harmful microorganisms not only damage the human body but also the food we eat.

What is water microbiology?

Water microbiology is the scientific discipline that is concerned with the study of all biological aspects of the microorganisms (bacteria, archaea, viruses, fungi, parasites and protozoa) that exist in **water**. This is also known as marine **microbiology**, which is a sub discipline of environmental **microbiology**.

What is bioremediation and how does it work?

Bioremediation is the use of microbes to clean up contaminated soil and groundwater. Microbes are very small organisms, such as bacteria, that live naturally in the environment. **Bioremediation** stimulates the growth of certain microbes that use contaminants as a source of food and energy.

What is microbial adaptation?

Microbial adaptation is the term used to describe the ability of **microbes** to endure the selective pressures of their environment.

What is gene in microbiology?
: a specific sequence of nucleotides in DNA or RNA that is located usually on a chromosome and that is the functional unit of inheritance controlling the transmission and expression of one or more traits by specifying the structure of a particular polypeptide and especially a protein or controlling the function of ...

Where are microorganisms found in the environment?

Microbes live in the soil, on rocks, inside roots, buried under miles of Earth, in compost piles and toxic waste, and all over the Earth's surface. **Microbes** are **found** in boiling hot springs and on frozen snowfields. **Microbes** live in homes, in schools and on statues.

Which is better biotechnology or microbiology?

All the **best**. Go for **Microbiology** it will give you more options in future when you start searching jobs. **Biotechnology** will narrow down your future path and it will be difficult to get good job after post-graduation. While **microbiology** gives you wider prospects in got jobs specially.

What are the 5 branches of microbiology?

The different branches of microbiology are classified into pure and applied sciences as well as taxonomy.

- Bacteriology.
- Mycology.
- Protozoology.
- Phycology.
- Parasitology.
- Immunology.
- Virology.

- Nematology.

How do microbes clean our environment?

The microorganisms help to **clean the environment** by decomposition of dead and decaying organic matter. **The** organisms are recycled by **the microorganisms** after **their** death thus restoring **the** nutrients back to **the** 'atmosphere'.

How are microorganisms beneficial to humans?

For example, each **human** body hosts 10 **microorganisms** for every **human** cell, and these **microbes** contribute to digestion, produce vitamin K, promote development of the immune system, and detoxify harmful chemicals. And, of course, **microbes** are essential to making many foods we enjoy, such as bread, cheese, and wine.

What is the most dangerous microorganism?

Nine of the most dangerous antibiotic-resistant bacteria

- *Salmonellae.*
- *Helicobacter pylori.*
- *Enterobacteriaceae.*
- *Campylobacter spp.*
- *Neisseria Gonorrhoeae.*
- *Pseudomonas aeruginosa.*
- *Enterococcus faecium.*
- *Staphylococcus aureus* (MRSA)

What is the most common bacteria found in water?

Of the many infectious microorganisms found in the environment, bacteria (such as Shigella, Escherichia coli, Vibrio, and Salmonella), viruses (such as Norwalk virus and rotaviruses), and protozoans (such as Entamoeba, Giardia, and Cryptosporidium) may be found in water.

What bacteria can live in water?

For example, bacteria that live in the intestinal tracts of humans and other warm blooded animals, such as Escherichia coli, Salmonella, Shigella, and Vibrio, can contaminate water if feces enters the water. Contamination of drinking water with a type of Escherichia coli known as O157:H7 can be fatal.

Introduction to Environmental Microbiology

1.1 ENVIRONMENTAL MICROBIOLOGY AS A DISCIPLINE

We define “environmental microbiology” as the study of microbes within all habitats, and their beneficial and detrimental impacts on human health and welfare.

Environmental microbiology is related to, but also different from, “microbial ecology,” which focuses on the interactions of microorganisms within an environment such as air, water or soil. The primary difference between the two disciplines is that environmental microbiology is an applied field in which we attempt to improve the environment and benefit society. Environmental microbiology is also related to many other disciplines (Figure 1.1).

Microorganisms occur everywhere on Earth. An adult human body contains 10 times as many microbial cells as mammalian cells, consisting of approximately 1.25 kg of microbial biomass (Wilson, 2005). Although the study of microbial inhabitants of humans resides within clinical microbiology, it was the discovery of environmental pathogenic microorganisms that invaded the human body that resulted in the beginning of environmental microbiology.

These roots were enabled by the work of Louis Pasteur and Robert Koch, who developed the Germ Theory of Disease in the 1870s, following which, the presence of waterborne human pathogens then became the initial focus of environmental microbiology. In developed countries, applied environmental studies related to drinking water and wastewater treatment dramatically reduced bacterial waterborne disease. However, other

microbial agents such as viruses and protozoa, which are more resistant to disinfection than enteric bacteria, still cause problems, resulting in water quality continuing to be a major focus in environmental microbiology. There is an estimated 20,000,000 cases of illness per year due to drinking contaminated water (Reynolds et al., 2008). The largest waterborne outbreak of disease in the United States occurred in 1993, when over 400,000 people became ill and around 100 died in Milwaukee, Wisconsin, due to the protozoan parasite Cryptosporidium (Eisenberg et al., 2005). In developing countries, poor sanitation resulting from a lack of water and wastewater treatment still results in millions of deaths annually.
Controlling the contamination of our food supply also continues to be a concern; and the Centers for Disease Control estimates that in the United States each year there are 48 million cases with 128,000 people hospitalized and 3000 deaths. The third most deadly outbreak of foodborne infection in the United States occurred in 2011, when 29 persons died from Listeria contamination of cantaloupe.

FIGURE 1.1 Environmental microbiology interfaces with many other disciplines.

1960s when concern over a toxic dump was highlighted by Rachel Carson’s landmark book Silent Spring. In essence, this resulted in the birth of the environmental movement in the

United States, and a new field of study for environmental microbiology known as “bioremediation.” Many chemicals discharged into the environment without regard to the consequences have been shown to result in adverse human health impacts. However, since hydrocarbons, chlorinated solvents and most pesticides are organic in nature, they can potentially be degraded by heterotrophic microorganisms including bacteria and fungi. The field of bioremediation within environmental microbiology involves enhancing and optimizing microbial degradation of organic pollutants, resulting in environmental cleanup and reduced adverse human health effects. The efficacy of bioremediation was demonstrated in 1989, when the Exxon Valdez oil tanker spilled approximately 11 million gallons of crude oil into Prince William Sound. Optimization of bioremediation was a major factor in cleaning up and restoring Prince William Sound. Bioremediation has also been shown to be critically important in cleaning up the more recent 2010 Gulf of Mexico oil spill (see Chapter 31).

Also in the 20th century, soil microbiology, a component of environmental microbiology, became important as a means to enhance agricultural production. Studies of the rhizosphere (the soil surrounding plant roots), and specific studies on root-microbial interactions involving nitrogen fixing rhizobia, and mycorrhizal fungi that enhanced phosphorus uptake, were all utilized to improve plant growth. Other studies of plant growth-promoting bacteria that reduced the incidence of plant pathogens were also effective in aiding the “Green Revolution,” which resulted in stunning increases in crop yields throughout the United States and in many parts of the world. Overall, these fundamental study areas have helped shape the current discipline of environmental microbiology, and all affect our everyday life.

1.2 MICROBIAL INFLUENCES ON OUR DAILY LIVES

Some of the influences that microorganisms have on our daily lives are shown in Table 1.1. These influences can be summarized in terms of:

l .2.1. The overall health of the planet
l .2.2. What infects us
1.2.3. What heals us
l .2.4. What we drink
l. 2. 5. What we eat
l .2. 6. What we breathe

1.2.1 Overall Health of the Planet

Life on Earth depends on the biogeochemical cycle’s that are microbial driven. For example, carbon dioxide is removed from the atmosphere during photosynthesis by both plants and photosynthetic microbes. The result of this process is that carbon dioxide is converted into organic carbon building blocks as plant or microbial biomass, which ultimately results in the formation of organic matter. Fortunately, this organic matter is ultimately degraded by microorganisms via respiratory processes, which again release carbon dioxide into the atmosphere.

Without microbial respiration, a vast array of organic matter would accumulate. Similar biogeochemical processes exist for all other elements, and are also driven by microorganisms. All life on Earth is dependent on these biogeochemical cycles. In addition, these cycles can benefit human activity, as in the case of remediation of organic and metal pollutants, or be detrimental, as in the formation of nitrous oxide which can deplete Earth's ozone layer (Ravish Ankara et al., 2009).

A major indirect effect of environmental microbes may be the influence of soil microbes on global warming. However, currently there is still debate about the net impact of microbes on this process (Rice, 2006). Soils can be a source of "greenhouse gases" such as carbon dioxide, methane and nitrous oxide due to microbial respiration, or they can be a sink for carbon due to enhanced photosynthetic activity and subsequent carbon sequestration. Although the debate has yet to be resolved, it is clear that even relatively small changes in soil carbon storage could significantly affect the global carbon balance and global warming. In turn, many scientists believe that continued global warming will ultimately have catastrophic impacts on human health via extreme weather events and natural disasters.

1.2.2 What Infects Us

Humans are subject to microbial attack from a plethora of pathogens that can be viral, bacterial or protozoan in nature (Table 1.2). Likewise, the route of exposure is variable and can be through ingestion or inhalation of contaminated food, water or air, or from contact with soils or fomites. The infections resulting from microbial pathogens can be mild to severe, or even fatal. In extreme cases, pandemics can occur, as in the case of the 191821919 influenza pandemic, which spread worldwide and killed more people than the number that died in the First World War (Brundage and Shanks, 2008). More recently, concern has centered on the potential for a pandemic originating from avian influenza (H5N1) virus
(Malik Peiris et al., 2007). Overall, every person on Earth has experienced some form of infection, and every location on Earth can be a source of infections. For example, hospitals that are designed to house patients recovering from various maladies can be a source of methicillin resistant *Staphylococcus aureus* (MRSA).

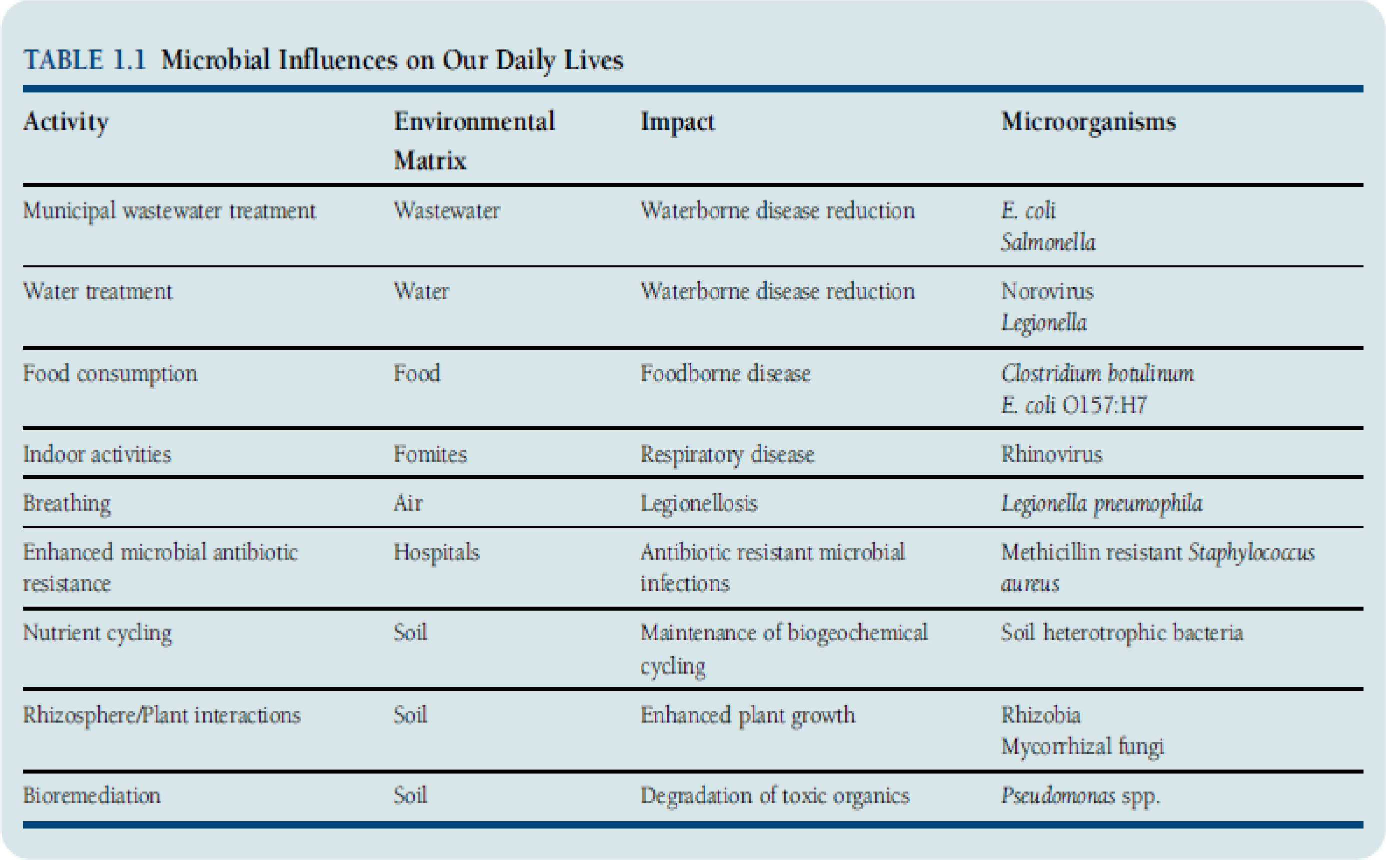


TABLE 1.1 Microbial Influences on Our Daily Lives

Activity	Environmental Matrix	Impact	Microorganisms
Municipal wastewater treatment	Wastewater	Waterborne disease reduction	*E. coli* *Salmonella*
Water treatment	Water	Waterborne disease reduction	Norovirus *Legionella*
Food consumption	Food	Foodborne disease	*Clostridium botulinum* *E. coli* O157:H7
Indoor activities	Fomites	Respiratory disease	Rhinovirus
Breathing	Air	Legionellosis	*Legionella pneumophila*
Enhanced microbial antibiotic resistance	Hospitals	Antibiotic resistant microbial infections	Methicillin resistant *Staphylococcus aureus*
Nutrient cycling	Soil	Maintenance of biogeochemical cycling	Soil heterotrophic bacteria
Rhizosphere/Plant interactions	Soil	Enhanced plant growth	Rhizobia Mycorrhizal fungi
Bioremediation	Soil	Degradation of toxic organics	*Pseudomonas* spp.

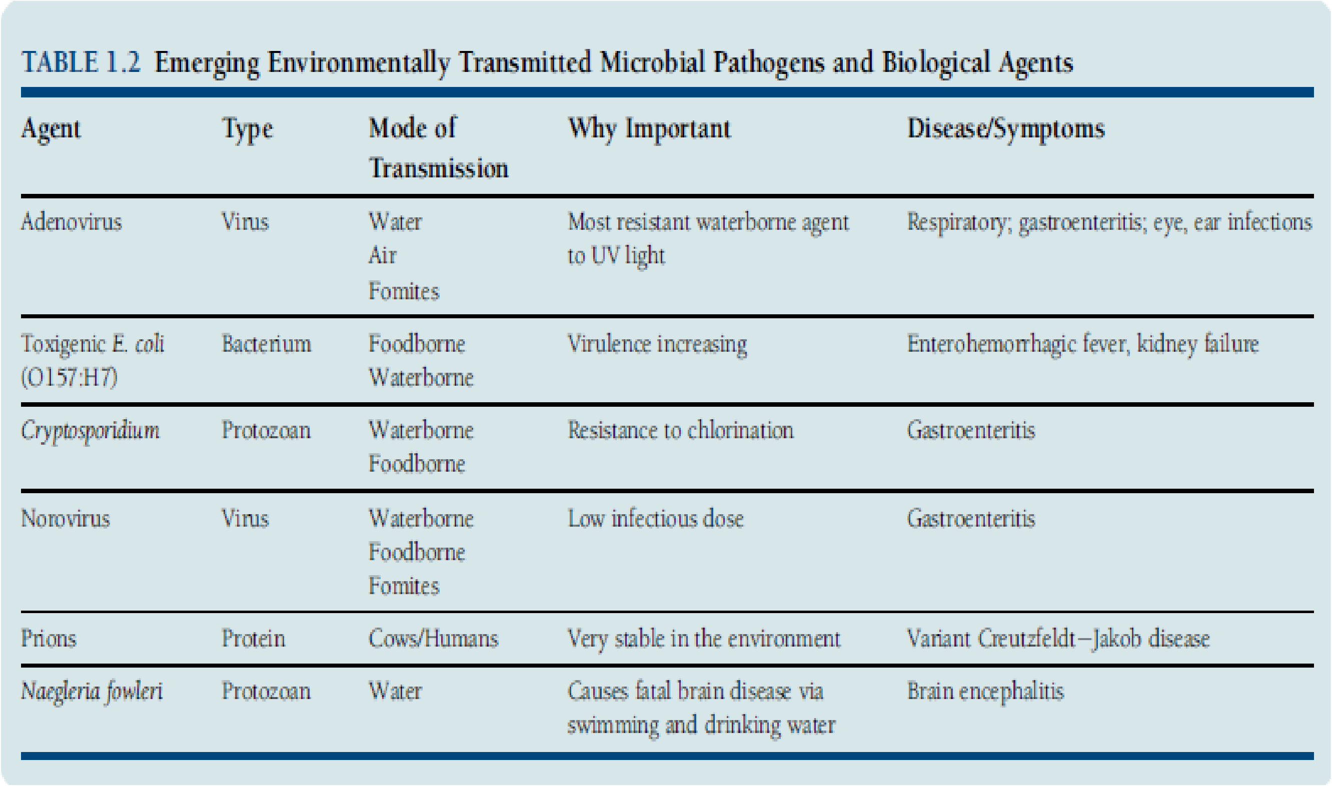


TABLE 1.2 Emerging Environmentally Transmitted Microbial Pathogens and Biological Agents

Agent	Type	Mode of Transmission	Why Important	Disease/Symptoms
Adenovirus	Virus	Water Air Fomites	Most resistant waterborne agent to UV light	Respiratory; gastroenteritis; eye, ear infections
Toxigenic *E. coli* (O157:H7)	Bacterium	Foodborne Waterborne	Virulence increasing	Enterohemorrhagic fever, kidney failure
Cryptosporidium	Protozoan	Waterborne Foodborne	Resistance to chlorination	Gastroenteritis
Norovirus	Virus	Waterborne Foodborne Fomites	Low infectious dose	Gastroenteritis
Prions	Protein	Cows/Humans	Very stable in the environment	Variant Creutzfeldt–Jakob disease
Naegleria fowleri	Protozoan	Water	Causes fatal brain disease via swimming and drinking water	Brain encephalitis

1.2.3 What Heals Us

Although numerous microbes are pathogenic to humans, many others provide a treasure chest of natural products critical to maintaining or improving human health. The earliest classes of compounds to be discovered were the antibiotics. Antibiotics are compounds produced by environmental microorganisms that kill or inhibit other microorganisms.

The first discovered antibiotic was penicillin isolated from the soil-borne fungus Penicillium by Sir Alexander Fleming in 1929. Later, Selman Waksman discovered streptomycin in 1943, a feat for which he received the Nobel Prize. This antibiotic was isolated from *Streptomyces griseous*, and, since then, soil actinomycetes have been shown to be a prime source of antibiotics.

In addition to bacteria, fungi are also a source of natural products that aid human health. In particular, endophytes, which are microbes that colonize plant roots without pathogenic effects, are a rich source of novel antibiotics, antimycotics, immunosuppressant and anticancer agents (Strobel and Daisy, 2003). Microtubule-stabilizing agents (MSA) such as paclitaxel have been isolated from endophytic fungi associated with species of the yew tree (Taxus spp.). Because paclitaxel acts as a cell poison that arrests cell division, it has become a highly potent anticancer agent (Snyder, 2007). Endophytes have also been shown to have useful applications in agriculture and industry (Mei and Flinn, 2010). A new technology known as “genomic mining” has resulted in new discoveries of useful natural products. These molecular technologies are allowing for the identification of new drug products that result from gene clusters that are not normally expressed under laboratory conditions (Gross, 2009). These new approaches bode well for future sources of new natural products that will improve human health.

1.2.4 What We Drink

Environmental microbes also influence the quality of the water we drink, both directly and indirectly. Direct adverse effects can include the contamination of surface water or ground waters with pathogenic microorganisms.

Microbes can also exacerbate chemical contamination of water, as in the case of arsenic. Specifically, some soil microbes utilize arsenate as a terminal electron acceptor under anaerobic conditions, thus converting arsenate to arsenite which is a more toxic and mobile species that is more likely to contaminate groundwater (National Research Council, 2007). On the other hand, microbes

1.2.5 What We Eat

Soil is a fundamental requirement for food production since the vast majority of food grown for human or animal consumption is derived from soil. Soil in close proximity to the plant roots is known as the rhizosphere, which contains vast numbers of soil microorganisms essential for plant growth. Without rhizosphere organisms, plant growth is severely repressed, since beneficial microbes enhance nutrient uptake. In addition, specific soil bacteria known as rhizobia fix atmospheric nitrogen into ammonia for leguminous plants, and mycorrhizal fungi enhance plant uptake of phosphate. Adverse effects of microorganisms on what we eat also include contamination with pathogenic microbes and microbial toxins (Information Box 1.1).

1.2.6 What We Breathe

Microbes can be aerosolized through both natural and human activities. Humans influence the transport of aerosolized microbes through a variety of activities including, for example, land application of wastes. The introduction of cooling towers and hot showers also creates a route for human exposure to aerosolized Legionella bacteria which can result in life-threatening infections. With as much as 80% of our time now spent indoors, air quality in these environments can also result in “sick building syndrome” and asthma attacks.
Microbial derived allergens are also readily transported into and through the air. Mycotoxins produced by soil fungal molds including *Aspergillus, Alternaria, Fusarium and Penicillium* can cause a variety of health problems. For example, aflatoxin produced by *Aspergillus flavus* is a potent carcinogen (Williams et al., 2004).

1.3 ENVIRONMENTAL MICROBIOLOGY

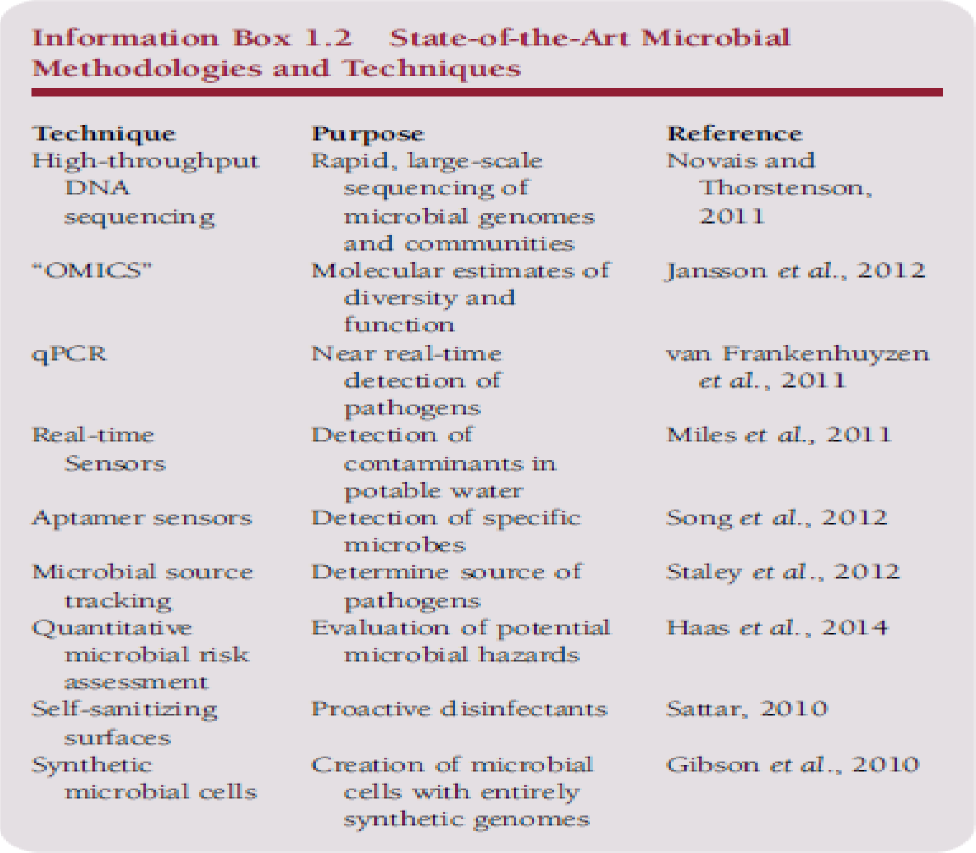
Issues continue to emerge where solutions depend on an understanding of environmental microbiology. For example, an outbreak of avian bird flu raised concerns about a worldwide pandemic, with little hope of quickly developing a vaccine. Better information was needed on how this virus spread through the environment from one person to another, in order to develop successful interventions. It became evident that little was known about how important routes of transmission occurred (i.e., air vs. fomites vs. water), and how they influenced transmission of the influenza virus. It was critical that these exposure routes be better understood so that appropriate environmental controls could be developed. In 2010, the Gulf of Mexico oil release following an explosion on an oil rig devastated the economies of local communities, but intrinsic and enhanced bioremediation was significant in mitigating the hazard (Figure 1.2) In 2011, a new virulent strain of E. coli (O104:H4) was the source of a foodborne microbial outbreak in Germany that killed more than 50 people (Rasko et al., 2011).

On a positive note, new techniques and methodologies are aiding our efforts to contain adverse microbial contaminants (Information Box 1.2). New molecular techniques including qPCR (quantitative polymerase chain reaction) are allowing for "near real-time" detection of pathogens.

Microbial source tracking now allows us to pin-point sources of microbial contamination. New sensors are allowing us to monitor microbial water quality in real time.

Advances in quantitative microbial risk assessment are now allowing us to determine whether particular activities such as land application of biosolids and animal manures are "safe." New molecular ecological techniques, including next-generation genome sequencing technologies, are allowing us to create better estimates of microbial diversity in the environment, and exploit that diversity for new sources of natural products. Advances in DNA synthesis and transplantation technologies are enabling the construction of "synthetic microorganisms" and may revolutionize our approach to characterizing and mining the genomes of environmental microorganisms. Self-sanitizing surfaces will potentially provide for proactive disinfection of fomites that will reduce microbial infections.

Overall, the field of environmental microbiology is mature, yet evolving, and well situated to deal with the variety of microbial issues that face today's (and tomorrow's) society. Join us on the exciting journey as we examine the state of the science.



Information Box 1.2 State-of-the-Art Microbial Methodologies and Techniques

Technique	Purpose	Reference
High-throughput DNA sequencing	Rapid, large-scale sequencing of microbial genomes and communities	Novais and Thorstenson, 2011
"OMICS"	Molecular estimates of diversity and function	Jansson *et al.*, 2012
qPCR	Near real-time detection of pathogens	van Frankenhuyzen *et al.*, 2011
Real-time Sensors	Detection of contaminants in potable water	Miles *et al.*, 2011
Aptamer sensors	Detection of specific microbes	Song *et al.*, 2012
Microbial source tracking	Determine source of pathogens	Staley *et al.*, 2012
Quantitative microbial risk assessment	Evaluation of potential microbial hazards	Haas *et al.*, 2014
Self-sanitizing surfaces	Proactive disinfectants	Sattar, 2010
Synthetic microbial cells	Creation of microbial cells with entirely synthetic genomes	Gibson *et al.*, 2010