

# Chapter 19 Outline and Notes

Biology Today: An Issues Approach, third edition

© Garland Science 2004

## THE BIOSPHERE AND THE ATMOSPHERE

The largest ecosystem, encompassing the entire planet, is called the Biosphere. The atmosphere is part of the biosphere because it interacts with all living organisms. The planet's water (including the oceans) are part of the Biosphere as well.

### LIFE ORIGINATED ON EARTH BY NATURAL PROCESSES

Louis Pasteur demonstrated that bacteria did not originate by spontaneous generation.

Alexander Oparin hypothesized that life originated on the early Earth under a REDUCING ATMOSPHERE containing ammonia, methane, water vapor, and hydrogen.

Stanley Miller tested Oparin's ideas experimentally and showed that organic compounds could originate under sterile conditions from Oparin's mix of gases.

Subsequent experiments have shown that many other gas mixtures will also work.

We now think that organic matter originated in this way, and that simple, self-replicating systems originated when organic matter reached a certain level of complexity.

### EVIDENCE OF EARLY LIFE ON EARTH

Meteorites contain many organic chemicals that we believe were formed without life by processes similar to those in Miller's experiment.

The earliest known rocks on Earth show evidence that they were formed under a reducing atmosphere in which no oxygen was present. Many of these early rocks contain fossils.

Petroleum deposits and other chemical fossils include the breakdown products of complex molecules like chlorophyll. Chlorophyll breakdown products were absent in the earliest rocks, but accumulated gradually over the time during which the atmosphere changed.

### LIFE AND THE ATMOSPHERE HAVE ALWAYS INTERACTED

We now believe that the atmosphere has changed along with the evolution of life.

The first types of organisms had various forms of metabolism that used organic chemicals and produced carbon dioxide as a waste product, so the atmosphere became rich in CO<sub>2</sub>.

Our present oxygen-rich atmosphere was built up slowly by photosynthetic action over a period of about half a billion years. Both the atmosphere and the process of photosynthesis have evolved along with life itself.

## POLLUTION THREATENS MUCH OF LIFE ON EARTH

### DETECTING, MEASURING, AND PREVENTING POLLUTION

To pollute originally meant “to make dirty” or to defile.

Nowadays, pollution can be defined as the presence of something in unwanted amounts at the time and place of its occurrence.

From this definition, it is clear that pollution is assessed by measuring quantities.

Small amounts of unwanted material may be acceptable or even undetectable.

Many substances are biodegradable, and become problematical only when quantities exceed the capacity of the ecosystem to break them down into usable materials.

People may disagree about the substances that are unwanted or the quantities that are problematical. There is generally more agreement when human health is impaired or when living organisms are killed.

Pollution can arise from household activities (e.g., food wastes, sewage), from industrial processes, from agriculture, or from vehicles. Careless disposal of wastes in inappropriate places is one type of problem whose remedy is relatively simple.

Toxicology is the study of poisons and their effects on organisms.

### AIR POLLUTION

Air pollution includes oxides of carbon, nitrogen, and sulfur released by nearly all forms of combustion, plus certain additional gases released by some industrial processes. Indoor air pollution also includes second-hand cigarette smoke.

An important first step is awareness of the ways in which we are polluting.

In many cases, reducing pollution brings other benefits such as saving money and fuel by carpooling or recycling. Many consumers now prefer to buy “earth-friendly” products.

Frogs and certain other species can serve as sentinel species — like the canaries carried by underground miners, they serve as sensitive indicators of unsafe conditions.

### ACID RAIN

Oxides of sulfur are oxidized in the atmosphere to sulfur trioxide, which dissolves in rain water to form sulfuric acid. Sulfur occurs as an impurity in coal and many mineral ores.

Oxides of nitrogen are released by motor vehicles; these eventually become nitric acid.

Acid rain (and acid snow) erodes marble (buildings and statues) and metals (including automobiles). Acidification of lakes also kills many fish. Acid rain releases toxic metals from pipes, causing lead poisoning and other toxic effects.

One large problem with acid rain is that it travels great distances. Much of the acid rain that falls in New England or upstate New York originates in states further west, while much of the acid rain in Sweden originates in Germany. Under political systems as they now exist, people (or legislatures) in New England or Sweden have great difficulty influencing corrective legislation in Illinois, Indiana, or Germany.

## POLLUTED HABITATS CAN BE RESTORED

### BIOREMEDIATION OF OIL SPILLS

Biodegradation is the natural biological decomposition of organic materials.

Bioremediation is the enhancement or manipulation of biodegradation by humans.

Bioremediation is sometimes used to help clean up oil and chemical spills.

Oil and other nonpolar chemicals do not mix well with water, since water is strongly polar.

If they are heavier than water, they sink to the bottom and kill many bottom-dwelling organisms.

If they are less dense, they float on the surface.

Oily compounds can be directly toxic to organisms.

More often, oily compounds can coat respiratory surfaces and kill organisms by interfering with gas exchange.

Oily compounds can also coat the fur of mammals and the feathers of birds, interfering with buoyancy and also with insulation.

## Chapter 19 Outline and Notes

Some oil-degrading microorganisms have been used to help clean up oil spills:

The oil must be tested to see what compounds it contains, and what kinds of microorganisms are capable of degrading those compounds.

The proper species of bacteria or fungi must be introduced if not already present.

Growth of the biodegrading microorganisms must often be enhanced by supplying a limiting nutrient such as nitrogen or phosphorus (nutrient enrichment).

### BIOREMEDIATION OF WASTEWATER

Wastewater is water that has already been used, for whatever purpose.

Biodegradable material in wastewater can be treated by bacteria, as in septic tanks (Fig. 14.15).

Wastewater lagoons are ecosystems that allow solids to settle and various algae and bacteria to grow under aerobic conditions and kill off more harmful bacteria that could cause disease.

Three-stage water treatment is used on a municipal scale:

Primary treatment removes solids and floating particles by skimming, filtering, and sedimentation (settling).

Secondary treatment uses aerobic organisms such as zoogloea to cause certain suspended particles to cling together into larger aggregates that settle more easily. Sludge from secondary water treatment may be disinfected with chlorine or spread on fields. Tertiary treatment uses activated carbon filters, electrical precipitation, denitrification, and various other processes to make the water fit for drinking once again. Because it is costly, tertiary treatment is not used everywhere.

Indicator bacteria are those which indicate that contamination by human wastes is present, and that harmful pathogens have been removed if the indicator species are no longer present.

*Escherichia coli* is the most commonly used indicator species.

Marshlands and other natural wetlands can sometimes be used as wastewater treatment systems.

### TREATMENT OF DRINKING WATER

Drinking water is typically purified in the following steps:

1. filtration and sedimentation (allowing particles to settle)
2. flocculation with alum (a process that removes many bacteria)
3. passing over beds of sand or diatomaceous earth (Fig. 14.17) (a process which adsorbs many microorganisms)
4. chlorination, to kill any remaining microorganisms
5. fluoridation, a public health measure which reduces tooth decay

### COSTS AND BENEFITS

Cost-benefit analysis is often used to assess proposed anti-pollution measures.

One problem is that the costs (e.g., of new equipment, or of disposal in another location) can easily be measured, while the benefits (in terms of lives saved, diseases prevented, or health improvement generally) are harder to quantify and subject to much greater uncertainty.

Even when benefits can be measured, they are often in terms that do not translate readily into dollar amounts: improvements in human health, greener forests, cleaner recreational areas, etc. Measuring environmental quality in a way that can be compared to costs is a new problem that societies must learn to deal with.

## CHLOROFLUOROCARBONS AND THE OZONE LAYER

### THE OZONE LAYER AND ITS IMPORTANCE

Ozone ( $O_3$ ) is a highly reactive form of oxygen that forms a layer in the upper atmosphere. This ozone layer filters out a large percentage of the dangerous wavelengths of ultraviolet (UV) light that would greatly increase cancer rates.

Chlorofluorocarbons (CFCs) in the atmosphere slowly migrate upward to the upper atmosphere and destroy ozone.

Measurements taken over Antarctica show a large and growing "hole" of ozone layer destruction.

According to current models, CFCs already released will continue to destroy ozone for 100 years or more, even if no more is released.

International treaties now ban the production and release of CFCs.

Spray cans containing CFCs disappeared as the result of market pressures, even before restrictive laws and treaties forced this action.

### CARBON DIOXIDE AND GLOBAL WARMING

Release of carbon dioxide (CO<sub>2</sub>) by respiration is roughly in balance with the uptake of CO<sub>2</sub> by photosynthetic organisms.

However, industrial processes that use fossil fuels add much more CO<sub>2</sub> than photosynthetic organisms can use. Most of this CO<sub>2</sub> accumulates in the atmosphere.

Atmospheric carbon dioxide contributes to a GREENHOUSE EFFECT that creates GLOBAL WARMING. Mid-ocean measurements in Hawaii and elsewhere confirm (a) a seasonal fluctuation in CO<sub>2</sub> levels and (b) a long-term upward trend over the last several decades.

Bubbles of air trapped in Arctic ice confirm that CO<sub>2</sub> levels have been increasing for hundreds of years, and that the rate of increase has accelerated since the Industrial Revolution began.

---

PERMISSION IS HEREBY GRANTED to instructors who have adopted the book BIOLOGY TODAY for classroom use to download, modify, and use these notes as needed to aid them in their teaching. Students of such instructors may likewise use and modify these notes as study aids.