Chapter 15: Detailed Summary

Optimizing Food Production

The formation of most all food begins with *photosynthesis*, the biochemical process used by plants to create carbohydrates and oxygen from solar energy, water, and atmospheric carbon dioxide. Photosynthetic organisms are known as *producers*. The producers support all other living organisms, which are known as *consumers*. Primary consumers consume the producers directly. Secondary consumers consume the primary consumers, while the tertiary consumers consume the secondary consumers, and so forth. The abundance of energy deceases up this food chain such that quaternary consumers have less consumable energy available to them than do the tertiary consumers. The population of consumers, therefore, generally decreases with increasing trophic level.

The *macronutrients* required by plants include those needed in large quantities, such as nitrogen, potassium, and calcium. Nitrogen comes in the form of ammonium and nitrate ions, which are produced by lightning, but mostly by the action of microorganisms in the soil. This nitrogen is particularly important for the formation of amino acids in the plant. Potassium ions are important for photosynthesis, while calcium ions are essential for building cell walls. Nutrients needed in only small quantities are called *micronutrients*. Examples include the ions of iron, manganese, and molybdenum.

Soil is not dirt. It is a fine mixture of sand, silt, and clay that supports countless living organisms, both large and small. Three layers of soil, also called *soil horizons*, include the topsoil, subsoil, and substratum. Fertile topsoil is a mixture of mineral particles, water, air, and organic matter. Large soil particles create larger pockets of space than do smaller soil particles. The flow of water through soil is called *percolation*. The more porous the soil, the greater the rate of percolation. Soil that is too porous will lose its nutrients more readily due to *leaching*. Soil that is too compact will not have sufficient oxygen, which is required by plant roots. The *humus* component of soil is organic matter, which contains many negatively charged ions. The humus, therefore, helps the soil to retain positively charged ions, such as ammonium and potassium ions. Carbon dioxide released from a plant's roots forms hydronium ions, which displace mineral ions held to the humus. These mineral ions thus become more available to the plant. A slightly acidic pH for soil, therefore, is optimal.

The plants we grow for food tend to have a relatively high demand for nutrients. The farmer growing these plants on the same plot of land from season to season, therefore, needs to replenish the soil with fertilizers. A fertilizer that contains only one nutrient is called a *straight fertilizer*. Any fertilizer containing a mixture of the three most essential nutrients, (nitrogen, phosphorus, and potassium) is called a *mixed fertilizer*, which is graded by the N-P-K system.

In addition to adequate nutrition, a high-yield crop needs a defense against a host of natural enemies, which is the purpose of *pesticides,* including

insecticides, herbicides, and fungicides. Most species of insects are beneficial or even essential to agriculture. Chemical agents used to fight against the small minority of damaging insects include the chlorinated hydrocarbons, such as DDT, which was widely applied to crops in the United States in the 1940s and 1950s. By the 1960s, however, the insect population began to develop a resistance to DDT. Meanwhile, DDT *bioaccumulated*, which means the toxic chemical entered the food chain at lower trophic levels and became more concentrated in organisms higher up the food chain. Populations of osprey, hawks, eagles, and falcons in the United States declined markedly until a ban on the use of DDT was put in place in the early 1970s.

The main problem with weeds is that they compete for valuable nutrients. Traditionally, weeds are simply plowed under the soil, but doing so is labor and energy- intensive. The alternative is to apply chemicals—herbicides—that selectively kill the weeds. Herbicides, such as 2,4,5-T, selectively kill broad-leafed plants but not grasslike crops such as corn and wheat. Glyphosate is a nonselective herbicide that interferes with the biosynthesis of the amino acids tyrosine and phenylalanine. Glyphosate has low toxicity in animals because most animals do not synthesize these amino acids, obtaining them from food instead.

Excessive use of fertilizers and pesticides and poor maintenance of topsoil have been the major agricultural mistakes made within our recent past. Over the past several decades, however, there have been strong movements, such as *regenerative agriculture*, toward developing methods and technologies that will sustain agricultural resources over the long term. Problems associated with irrigation, for example, can be solved by *microirrigation*, which is any method of delivering water directly to plant roots. To protect against pests, farmers can alternate the crops planted on a particular plot of land. A pest that thrives on one season's crop of corn, for example, will do poorly on the next season's crop of alfalfa. *Integrated crop management* is a method of farming that involves managing crops profitably with respect for the environment in ways that suit local soil, climatic, and economic conditions. Over the past couple of decades, advances in genetic engineering have also led to profound developments in agriculture. Several major crops have been engineered with genes that create proteins having insecticidal properties. Worldwide, more than 75 million acres are currently cultivated with transgenic crops each year.

Summary of Terms

Bioaccumulation The process whereby a toxic chemical that enters a food chain at a low trophic level becomes more concentrated in organisms higher up the chain.

Compost Fertilizer formed by the decay of organic matter.

Consumer An organism that takes in the matter and energy of other organisms.

Decomposer An organism in the soil that transforms once-living matter to nutrients.

Horizon A layer of soil.

Humus The organic matter of topsoil.

Integrated Crop Management A whole-farm strategy that involves managing crops in ways that suit local soil, climatic, and economic conditions.

Integrated Pest Management A pest-control strategy that emphasizes prevention, planning, and the use of a variety of pest-control resources.

Microirrigation A method of delivering water directly to plant roots.

Mixed Fertilizer A fertilizer that contains the plant nutrients nitrogen, phosphorus, and potassium.

Nitrogen Fixation A chemical reaction that converts atmospheric nitrogen to some form of nitrogen usable by plants.

Organic Farming Farming without the use of pesticides or synthetic fertilizers.

Pheromone An organic molecule secreted by insects to communicate with one another.

Producer An organism at the bottom of a trophic structure.

Regenerative Agriculture A form of agriculture holding that proper practices can be sustainable as well as help us to recover from past harmful practices.

Salinization The process whereby irrigated land becomes saltier as the irrigation water evaporates.

Straight Fertilizer A fertilizer that contains only one nutrient.

Trophic Structure The pattern of feeding relationships in a community of organisms.