1.8: Green Technology

Humans direct **technology** toward practical ends to make things they need with materials and to utilize energy in manufacturing, transportation, and the maintenance of hospitable living conditions. Long a matter of applied human ingenuity, technology is now mostly the product of engineering based on the fundamental knowledge of science and application of scientific principles. Technology uses the plans and means to achieve specific practical objectives provided by engineering to carry out desired objectives. Technology obviously has enormous importance in determining how human activities affect Earth and its life support systems.

Three great "growth spurts" in human populations that have taken place since modern humans first appeared on Earth have been enabled by developments in technology that enabled successively higher levels of human populations to exist. The first of these culminating about 10,000 years ago with a human population of perhaps 2 or 3 million was enabled by the primitive, but remarkably effective tools that early humans developed. One such technology was the bow and arrow which allowed for killing game at a much safer distance from the unwilling and often dangerous source of meat than that required for spearing or clubbing the quarry. The technology for making garments from animal hides allowed humans to avoid potentially fatal hypothermia from exposure to Ice Age climates.

About 10,000 years ago a second population growth spurt got underway as the "hunter/gatherer" societies that had sustained humans evolved into more reliable agricultural societies when humans learned to cultivate crops and domesticate animals used for meat, milk, and wool. These societies ensured a generally dependable food supply in smaller areas. As a result, humans were able to gather food from relatively small agricultural fields rather than having to scout large expanses of forest or grasslands for game to kill or berries to gather. Agricultural economic systems were based upon newly evolved technologies for cultivating soil, utilizing irrigation, and transporting food for trade by primitive sailing vessels. Ancillary technologies such as spinning wheels and looms for turning wool and plant fibers into cloth and water-powered mills for grinding grain also appeared. The development of agricultural systems had the major effect of allowing humans to remain in one place in settlements and, freed from the necessity of having to constantly hunt and gather food from their natural surroundings, humans could apply their ingenuity in areas such as developing more sophisticated tools. The agricultural revolution allowed a second large increase in numbers of humans and enabled the development of a human population of around 100 million 1000 years ago.

The third great growth spurt in human populations came with the industrial revolution, beginning slowly several centuries ago and made possible by the ability to utilize energy other than that provided by human labor and animal power. Initially wind power and water power were harnessed for mills and factories to use to produce goods. After about 1800 this power potential was multiplied many-fold with the steam engine and later the internal combustion engine, turbines, nuclear energy, and electricity, enabling current world population of almost 7 billion and growing at an eventually unsustainable rate (though not as fast as some of the more pessimistic projections from past years).

Unintended Consequences and the Need for Green Technology

According to the **law of unintended consequences**, the predicted benefits of new technologies are often accompanied by substantial problems, sometimes called revenge effects, due to the unforeseen ways in which people interact with new technologies. The individual freedom of movement and huge economic boost that resulted from the nascent automobile industry were accurately predicted by visionaries in the early 1900s, but they did not foresee the millions of deaths from automobile accidents, unhealthy polluted air in urban areas, urban sprawl, and depletion of petroleum resources that occurred in the following century. The tremendous educational potential of personal computers was visualized when the first of these came on the market. Less predictable were the mind-numbing hours that young people (and some not so young) would waste playing senseless computer games or viewing questionable content on the internet.

Defined as technology applied in a manner that minimizes environmental impact and resource consumption and maximizes economic output relative to materials and energy, **green technology** is designed to foresee and avoid revenge effects. Aided by increasingly sophisticated computer methodologies, the practitioners of green technology attempt to predict undesirable consequences of new technologies and put in place preventative measures before revenge effects have a chance to develop and cause major problems. A key component of the implementation of green technology is careful consideration of the practice of **industrial ecology**, which integrates the principles of science, engineering, and ecology in industrial systems through which goods and services are provided in a way that minimizes environmental impact and optimizes utilization of resources, energy, and capital. Above all a sustainable means of providing goods and services, industrial ecology considers every aspect of so doing from concept,

through production, and to the final fate of products remaining after use. It is most successful in its application when it mimics natural ecosystems, which are inherently sustainable by nature. Rather than organisms and populations of organisms working in natural ecosystems, industrial ecology works through **industrial ecosystems** consisting of groups of industrial concerns, distributors, and other enterprises functioning to mutual advantage, using each others' products, recycling each others' potential waste materials, and utilizing energy as efficiently as possible. Industrial ecology is discussed in some detail in Chapter 13, "The Anthrosphere, Green Chemistry, and Industrial Ecology."
