

## 1.1: Sustainability

The old Chinese proverb certainly applies to modern civilization and its relationship to world resources that support it. Evidence abounds that humans are degrading the Earth life support system upon which they depend for their existence. The emission to the atmosphere of carbon dioxide and other greenhouse gases is almost certainly causing global warming and climate change. Discharge of pollutants has degraded the atmosphere, the hydrosphere, and the geosphere in industrialized areas and has placed great stress on parts of the biosphere. Natural resources including minerals, fossil fuels, fresh water, and biomass have become stressed and depleted. The productivity of agricultural land has been diminished by water and soil erosion, deforestation, desertification, contamination, and conversion to non-agricultural uses. Wildlife habitats including woodlands, grasslands, estuaries, and wetlands have been destroyed or damaged. About 3 billion people (half of the world's population) live in dire poverty on less than the equivalent of U.S. \$2/day. The majority of these people lack access to sanitary sewers and the conditions under which they live give rise to debilitating viral, bacterial, and protozoal diseases. At the other end of the living standard scale, a relatively small fraction of the world's population consumes an inordinate amount of resources with lifestyles that involve living too far from where they work in energy-wasting houses that are far larger than they need, commuting long distances in large "sport utility vehicles" that consume far too much fuel, and overeating to the point of unhealthy obesity with accompanying problems of heart disease, diabetes, and other obesity-related maladies.

### As We Enter the Anthropocene

Humans have gained an enormous capacity to alter Earth and its support systems. Their influence is so great that we are now entering a new epoch, the **Anthropocene**, in which human activities have effects that largely determine conditions on the planet. The major effects of humans upon Earth have taken place within a minuscule period of time relative to that during which life has been present on the planet or, indeed, relative to the time that modern humans have existed. These effects are largely unpredictable, but it is essential for humans to be aware of the enormous power in their hands — and of their limitations if they get it wrong and ruin Earth and its climate as life support systems.

### Achieving Sustainability

Although the condition of the world and its human stewards outlined above sounds rather grim and pessimistic, this is not a grim and pessimistic book. That is because the will and ingenuity of humans that have given rise to conditions leading to deterioration of Planet Earth can be — indeed, are being — harnessed to preserve the planet, its resources, and its characteristics that are conducive to healthy and productive human life. The key is **sustainability** or **sustainable development** defined by the Brundtland Commission in 1987 as *industrial progress that meets the needs of the present without compromising the ability of future generations to meet their own needs*. A key aspect of sustainability is the maintenance of Earth's **carrying capacity**, that is, its ability to maintain an acceptable level of human activity and consumption over a sustained period of time. Although change is a normal characteristic of nature, sudden and dramatic change can cause devastating damage to Earth support systems. Change that occurs faster than such systems can adjust can cause irreversible damage to them. In addition to its main theme of green chemistry, a major purpose of this book is to serve as an overview of the science and technology of sustainability emphasizing sustainable chemistry as well as the general science and technology of sustainability.

### Rethinking Environmentalism and Sustainability

The common view of a good, sustainable environment as a rural, low-population-density area may be misleading. A convincing argument for this proposition is made in the 2009 book *Green Metropolis: Why Living Smaller, Living Closer, and Driving Less are the Keys to Sustainability*.<sup>2</sup> Classified as an "eco-urbanist manifesto," this book makes the somewhat surprising case that New York City's Manhattan is a model of sustainability for the modern overpopulated world. This densely populated compact city emits less than one third as much greenhouse gas per person compared to the average for the United States. One reason why this is so is that the large apartment buildings and other large structures in New York City are very efficient in conserving heat; that which leaks from one tends to end up heating another. Cold air produced by air conditioning in the summer is similarly conserved. Another reason that the city is energy-efficient stems from its outrageously congested traffic and lack of affordable parking meaning that the automobile is impractical for most residents thereby forcing reliance on far more efficient public transportation. Only about one-fifth of New York City's residents regularly commute with individual automobiles. In contrast, those who live "close to nature" in rural settings tend to dwell in free-standing houses that are inherently less energy efficient than apartment buildings and by necessity they must commute with energy-wasting vehicles. If they live on unimproved roads they may require especially inefficient large, rugged four-wheel-drive vehicles. Compensation cannot be made for such a lifestyle by measures advocated by many environmentalists, such as backyard compost piles and fuel-efficient vehicles.

According to *Green Metropolis*, New York City, which has a population density more than 800 times that of the U.S. as a whole and about 30 times that of Los Angeles, offers a model for a growing world population to exist within the confines of Earth's limited resources. The prescription for sustainability is to "live smaller, live closer, and drive less." To that may be added "reproduce less" in that dense urban environments tend to discourage large families. A major culprit in the development of modern environmental problems is the public obsession with the private automobile, which enables destructive urban sprawl and excessive consumption of gasoline. One of the unintended consequences of the laudable goal of increased fuel economy in automobiles is to make them more affordable to use, thus facilitating destructive urban sprawl. The automobile-based societies of the U.S. and many other industrialized nations has been made possible by the exploitation of relatively abundant and inexpensive petroleum. In years to come, as petroleum inevitably becomes more scarce and expensive, these societies will have to undergo wrenching changes, the best end result of which would be much more sustainable, compact urban societies

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