1. **carbon cycle** The sequence of chemical reactions by which carbon circulates and is recycled through the ecosystem. Carbon from carbon dioxide is taken up by plants during photosynthesis and converted into carbohydrates, releasing oxygen into the atmosphere. The carbohydrates are then used directly by the plant - or by animals that eat plants - in respiration, in which they are oxidized to release carbon dioxide back into the atmosphere. Carbon dioxide is also released into the atmosphere by the burning of fossil fuels. Today, the carbon cycle is in danger of being disrupted by the increased consumption and burning of fossil fuels and the burning of large tracts of tropical forest, as a result of which levels of carbon dioxide are building up in the atmosphere and probably contributing to the **greenhouse effect**.

2. **Pollution** The hazardous effects on the environment caused by byproducts of human activity, principally industrial and agricultural processes (noise, smoke, automobile emissions; chemical and radioactive effluents in air, seas and rivers; pesticides, radiation, sewage) and household waste. Pollutants may enter the **food chain** and be passed on from one organism to another. They are frequently harmful and may cause additional damaging developments, such as **acid rain.** Much recent concern has centered on the fact that chemical pollution often travels great distances and may affect large areas or even the entire planet (causing climatic change).

3. Environmental considerations are now a major driving force for improvements in process operation and new product design. Two-thirds of the faculty are working on environmentally-related problems aimed at developing ecologically sound detergents, polymers that may be recycled or reused, innovative separation processes for removal of trace contaminants from water and gaseous streams before they are discharged to the environment, and solvent and process selection which minimize waste treatment. Chemical engineers are uniquely qualified to carry out the basic research needed to understand the physical and chemical processes occurring in the environment and to participate in the development of effective public policies.

4. Complementary activities in the Department are addressing the mechanisms of the formation and control of the combustion generated emission of soot, polycyclic aromatic hydrocarbons, nitrogen oxides, and sulfur oxides, the inputs to air quality models. The studies on soot and polycyclic aromatic compounds have been motivated by their putative role in the increase in lung cancer observed in urban areas. Identification of the high molecular weight intermediates in the buildup of the multiring aromatic compounds is guiding the formulation of kinetic models. An exciting by-product of the research has been the tracing of the pathways to fullerenes, which are found in high concentrations in some soots.

5. **Biotechnology.** Scientists have turned to nature for help in destroying toxic substances. Some microorganisms in soil, water, and sediments can adapt their diets to a wide variety of organic chemicals; they have been used for decades in conventional waste treatment systems. Researchers are now attempting to coax even higher levels of performance from these gifted microbes by carefully determining the optimal physical, chemical, and nutritional conditions for their existence. Their efforts may lead to the design and operation of a new generation of biological waste treatment facilities. A major advance in recent years is the immobilization of such microorganisms in bioreactors, anchoring them in a reactor while they degrade waste materials. Immobilization permits high flow rates that would flush out conventional reactors, and the use of new, highly porous support materials allows a significant increase in the number of microorganisms for each reactor.

6. **Membrane technology** Separations involving semipermeable membranes offer considerable promise. These membranes, usually sheets of polymers, are impervious to some kinds of chemicals but not to others. Such membranes are used to purify water, leaving behind dissolved salts and providing clean drinking water. Membrane separation techniques also permit purification of wastewater from manufacturing. Membrane separations are also applicable to gases and are being used for the recovery of minor components in natural gas, to enhance the heating value of natural gas by removal of carbon dioxide, and for the recovery of nitrogen from air. Research challenges include the development of membranes that are chemically and physically more resilient, that are less expensive to manufacture, and that provide better separation efficiencies to reduce processing costs.