EXPONENTIAL GROWTH
Supplement to Box 1.7., page 34 of the Text

"The institutions of modern industrial society are constructed to promote growth rather than to control or direct it – growth in population, production, consumption, and waste."

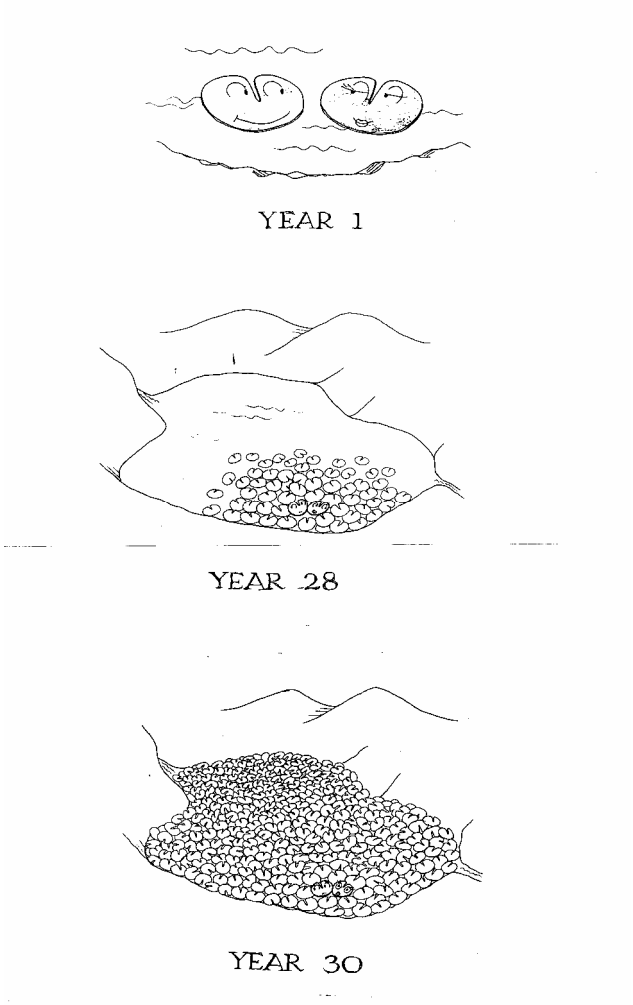
Energy and the Structure of Social Institutions
Lynton Caldwell (1976)

"There seems to be no way that a society committed to endless growth and universal abundance could ever solve its energy problem."

Forgotten Fundamentals of the Energy Crisis
Albert A. Bartlett (1978)

"In the energy crisis, we have a classic case of exponential growth against a finite source."

James Schlesinger
Secretary of Energy in President Carter's Cabinet (1977)



Schlesinger's point is illustrated by the graph on "The History of Energy Consumption in the United States" that I handed out earlier. The top curve in that graph shows that energy consumption in the U.S. grew from 2 QBtu/yr in 1850 to 80 QBtu/yr in 1990, corresponding to an average growth rate of 2.6% per year and a doubling time of 70/2.6 = 27 years. Public awareness of resource depletion and environmental degradation during most of this 140-year period of industrial growth was minimal. There is great concern now, however, about the sustainability of this kind of growth. It's hard to imagine new energy sources that could support another factor of 40 increase in energy consumption in the U.S. – not to mention the environmental impacts of such growth.

The danger of exponential growth (constant percentage growth per year) is that it *sneaks up on you* – going unnoticed for a long time and then suddenly overwhelming the support system in the last few doublings. This property of exponential growth is illustrated in this handout for the case of lily pads on a lake. Initially there are just two pads living happily with the whole lake to themselves. Suppose the lake is so nurturing that the total number of lily pads doubles each year, and that it takes 1 billion lily pads to completely cover the lake. The number of lily pads on the lake after 10 years is 2^{10} = 1,024; hardly noticeable, covering only about one millionth of the lake's surface. After 20 years the number is 2^{20} = 1,048,576 which still covers only 1 thousandth of the lake's surface. After a quarter century the lake is still only 3% covered by lily pads. At year 28, however, the lake is one quarter covered and crowding and lack of nutrients may be a serious problem. In only *two more years* the lake is completely covered.