of human sociopolitical institutions that defines social goals and values and thus strongly influences the growth of population and capital and the use and allocation of resources. Rather than represent these institutions separately, we chose to interweave their effects implicitly throughout the five sectors of the model. The assumptions that led us to that choice are important enough to warrant further discussion, and we shall return to them in section 1.7.

It is sufficient here to mention only the most important simplifying assumption we made about the social system. Since we were primarily concerned with the approach of the human population to the carrying capacity defined by physical limits, we assumed that the social system would not produce any global, discontinuous misuse of resources on a scale greater than that prevailing today. In other words, we did not attempt to model political events like those that might trigger a nuclear war, a massive work stoppage, or a complete disruption of international trade. World3 incorporates only factors representing the gradual effects of the social system as it changes human values in response to new economic or environmental situations.*

Degree of Aggregation

Once we had defined the five model sectors, it was necessary to decide how much detail to include within each one. Should the population be subdivided by age or nationality? Should economic variables be grouped by continent, type of economy, developing and developed nations? Should every kind of resource and pollution be represented separately? These are questions of aggregation, the degree to which elements with common characteristics are grouped together. Choosing the appropriate level of aggregation in any model involves a difficult trade-off. A highly disaggregated model with much detail may be unwieldy and incomprehensible; an aggregated model with little detail may leave out important relationships that could alter the behavior of the model and the conclusions drawn from it.

World3 is a highly aggregated model because we made comprehensibility an important goal and asked an imprecise question whose answer does not require great detail. The following five chapters describe and justify the degree of aggregation chosen for each of the model sectors. In World3 the population is partly disaggregated by age, but not by nationality or income. Capital is effectively divided into four categories: industrial, service, agricultural, and that used for obtaining resources (for example, refineries, smelters, mining equipment, and oil tankers). Land is separated into potentially arable, arable, and urban-industrial categories. Neither the pollution nor the resource sector is disaggregated to represent different materials. Each of these sectors contains only one state variable, characterizing a typical persistent pollutant and nonrenewable resource, respectively.

We did not disaggregate World3 into two submodels representing the industrialized and nonindustrialized regions of the world, although that disaggregation is an obvious one to make. It would have complicated the model by a factor of more than two. For our purposes, the added complication seemed to be unnecessary. The physical system connecting population with the environmental carrying capacity is structurally the same in any geographic subregion. The physical causes of instability and the policies that lead to material stability would also be expected to be the same (although the relative timing and emphasis of the steps toward stabilization in each region would differ). The systems that distribute and assimilate persistent pollutants and govern the technology and magnitude of resource use are essentially global. Thus we chose not to divide the model along economic or geographic lines. To investigate problems not addressed in this study, such as inequality in the distribution of wealth or income, we would construct a new model, designed for that purpose, rather than disaggregate and adapt World3.

*Our assumption of smoothly functioning social institutions makes World3 an optimistic model that indicates only the maximum physical options for the total system. Severe, discontinuous social malfunctions could reduce the limits to growth levels well below those indicated by the model.

1.7 POSTULATION OF MODEL STRUCTURE

Structural versus Parametric Assumptions

Having identified the relevant elements of the system, we next had to specify all the important relationships that interconnect those elements to form a system. We did this in two steps, in order of increasing precision. First, we postulated the general system structure; then we estimated the numerical values of the parameters that quantify that structure. The guidelines we used to carry out this process are discussed here. The resulting equations and parameters are treated in detail in Chapters 2–6.

Structural assumptions express the general causal links among model elements, indicating which elements are affected by changes in other elements. The following are examples of the structural assumptions included in World3:

1. An increase in food per capita will cause an increase in human life expectancy, if all other factors remain constant.
2. An increase in food per capita will cause a decline in the percentage of industrial output invested in the agriculture sector and an increase in investments made in the service and industrial sectors, all else being equal.
3. An increase in the area of cultivated land will cause an increase in food production and thus an increase in food per capita, all else being equal.

Since structural assumptions are not quantitative, they are not a sufficient basis for projecting the future behavior of the system. Each must be quantified by means of parametric assumptions. For example, a parametric assumption had to be added to World3 to indicate the exact number of years that would be added to average life expectancy if food per capita were increased from 1,800 to 2,500 calories per person per day. The general process of making and testing the parametric assumptions in World3 is discussed in section 1.8.

Representing System Structure

The structural assumptions that make up a system dynamics model are commonly expressed by a causal-loop diagram (see Figure 1-3). In a causal-loop dia-