evaporation by curling, or the way a lizard controls body temperature by shifting between sun and shade. They may operate more slowly through physiological adjustments, as shown by the way fish adapt to changes in water temperature by changing the temperature characteristics of many of the body functions.

These studies at the level of the individual require many of the tools of physiology and behavior, as well as those of micrometeorology. Both in the laboratory and in the field, this is a well-instrumented and highly technical subject. In the last few years, problems of instrumentation have begun to interest Bio-engineers, while problems of complex data analysis have attracted those proficient in computer techniques.

Many contributions to this field are made by scientists searching for better ways to produce crops, or better strains of animals and plants. Today many different strains of a few species of cultivated or domestic organisms available, each able to function most efficiently in some particular environment.

At the next level of complexity, population ecology is concerned with processes that influence population density, production, and persistence. Interactions between populations from competition for common needs, or from predation of one upon another, are included. A generation ago as many mathematicians as biologists participated in the development of population ecology, and a strong mathematical orientation persists today. The major analytic tools are those of demography and statistics. Population models that have emerged are used in the construction of most management programs of fish, game and forests throughout the world. Many of these models have mathematical analogues in molecular kinetics, or in economics and sociology.

More recently, physiological and behavioral measures have been extended to the population level. In one line of application, the behavioral and physiological traits of individuals are integrated into prodictive models of population behavior. Such systems may be very complex, and depend upon computers and systems analysis. In a different approach, physiological measures are made directly on populations, producing estimates of population metabolism and population feeding efficiency. In both cases, population analysis is brought more forcefully to bear upon the interactions between populations and their environments than has previously been the case.

Population genetics and population ecology have only recently been combined to any extent. It is now evident that gene frequencies can change much more rapidly than previously believed, so that genetic change can be important during ecological studies. It is also evident that selection factors involve more complex ecological relations than previously considered, so that changes in density or age structure can be significant in genetic studies. Most of the mathematical models used in each of these areas can be handled with ordinary methods of analysis, but their combination in genetic ecology leads to cumbersome expressions that require the computer.

Many of the principles of population ecology have been derived from applied areas, including forestry, fishery management, wildlife management, and insect pest control.

Within the last generation population ecology has become popular in biology departments. Because population ecologists are mathematically oriented, and because geneticists have changed from a mathematical to a chemical orientation, the teaching of biometrics in many departments has shifted from the geneticist to the ecologist.

The largest unit of study in ecology is the ecosystem. This is the total system of populations together with all non-living components that interact in a defined region of space and time. Hundreds or thousands of species are included. These systems are open at their boundaries, some more so than others. An ecosystem can be a whole lake, or only the open water in the center. It can be a woodlot, or a large forest. In the laboratory it can be a microcosm in a jar. The entire earth can be treated as one ecosystem, with biogeochemistry serving as the basis for studying nutrient cycling.

In the past, ecosystems have been regarded primarily as backgrounds against which studies of components are executed. Ecosystems may be identified by naming dominant characteristics, such as a beech-maple forest, a short-grass prairie, or an alkaline pond.

Several aspects of ecosystems have been the subject of quantitative analyses. Those encountered most frequently are the total densities of different groups of organisms; the diversity of species present in different groups; the pattern of