

Biology



Biology

The Integrity of Organisms

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We often hear our time called the "computer age"—giant computers predict election results with great accuracy barely a few hours after the polls open, confirm travel reservations all over the world, and post and bill millions of credit accounts daily. You have grown up in the shadow of the computer, but you probably still stand in awe of its fantastic capacity for information storage and retrieval, prediction and projection, simulation and response. In your mind, the computer may sometimes even assume human qualities and, as in science fiction, may seem to control and direct itself. Modern digital and analog computers are truly phenomenal, but they are nothing compared to living organisms, which can do all the same things even better.

The first idea for a computer came in 1830 A.D.; the first idea for an organism, about 3.5 billion B.C. The first operational computer (called a differential analyzer by its inventor, Vannevar Bush) was made in 1930 A.D.; the first operational organism (which had no name because no one was there to give it one) dates back to about 3 billion B.C. The first job of the computer was a military one, to aim antiaircraft guns during World War II; the first job of organisms also was somewhat military—to struggle to survive.

Man has tinkered with computers, developing models and discarding them as newer ideas took shape. Nature likewise has tinkered with organisms, developing and discarding models as newer ones took shape. It has been estimated that of all the different models of organisms that have been tried out, probably over 90 percent have been discarded!

Indeed, there are striking similarities between computers and organisms in operational activities, in structural design, and in their modifiability with time and experience. An analogy often is helpful in gaining understanding, but if we press this one too far, it may lead to misunderstanding. Is the computer really an organism? Or is an organism merely a hybrid digital/analog computer? Does a computer have a life blood, and is an organism only a refined set of circuits? Is a computer alive, and is an organism a machine?

You probably can answer the question about the nature of the computer: it has some but not all of the characteristics of living things, and it definitely depends on man to program and modify it. You probably would agree that the computer is a machine.

You also may argue that organisms are not machines: a unique set of characteristics sets them apart from nonliving

things (even if you cannot define all those characteristics). You may feel that though organisms are made up of atoms and molecules from the physical world, the particular concoction that has been brewed up is qualitatively different from what you would predict from the properties of those atoms and molecules.

Let us not argue the case at this early point. Conclusions on the nature of life should come from an examination of the evidence, and that is what we present in the rest of the book. Not all the evidence is here: that would require a whole library. Enough is given, though, so that you can look carefully at the question of whether we can predict the nature of life if we know enough about its constituent parts or whether the peculiar combination of those parts yields an unpredictable uniqueness or integrity. Because it is sometimes convenient to have handles for concepts such as these, we can refer to the former view as reductionist or mechanistic, and the latter as holistic or vitalistic. In the reductionistic view, we *reduce* life to its constituent parts and see their operation as *machinelike*. In the holistic view, we enlarge life and say that as a whole it is greater than the sum of its parts and that the operation of these parts is thus qualitatively different from what we would predict from knowing about them.

You already may feel you are on one side of this argument. That is all right, but only so long as you do not close your mind to the evidence for the other side. In fact, your learning may be greater if you do approach the question with an existing bias: then the proof must be more convincing, and the position to which you finally come better founded.

As you read, ponder, and study the nature of life, you may get so bogged down in some of the information and ideas that you lose the major points. As in the old saying, you may see the trees but never the forest. Look at the trees carefully, but keep in mind the whole forest, the whole picture of the programming and organization of organisms, of homeostasis and adaptation.

Programming of Organisms

Organisms respond in programmed fashion, that is, automatically and involuntarily, to their environment. Even in those organisms that can judge, reflect, or learn, most functions are handled without thought. Do you think about swallow-

ing when you eat or drink, which muscles to use when you run, or sit, or which chemicals to use to digest a protein?

Where and when does or did this programming take place? Is it inherent in the particular atoms, molecules, and compounds that compose living things? Is it some added quality that comes when these physical entities are enclosed within a membrane, as is the case in a cell? You may have heard that the genes or the DNA (deoxyribonucleic acid) is responsible for all the programming. Then how was the DNA itself programmed? Is there something mysterious and vitalistic, or something explainable and mechanistic that gives DNA these properties?

How does reprogramming take place? In some experiments, simply structured organisms like flatworms can alter their usual response to an environmental stimulus by turning more often in one direction than in another. More complexly structured organisms like humans alter not only their own patterns, but also those of other persons and organisms. Can we explain this learning or conditioning process completely on physical and chemical grounds? Are there other valid explanations? How much do we know and not know? When do we know that we do not know?

Organization of Organisms

We just mentioned "simply structured" and "complexly structured" organisms. Do not be misled by these terms: some organisms are simply structured in the sense that they lack a skeletal or blood circulatory system. When you examine cells from all kinds of organisms at high magnifications, though, you see that their structural complexity is truly fantastic.

It is easy to see only the trees when you look at cells and their organelles; the many variations and differences are captivating. Even more exciting, however, is the similarity among the cells. There really are only a few basic ideas of what is "put" in a cell. How diverse and how similar are cells? What function does this serve? What do difference and sameness imply about the nature of life?

When you look beyond cells to whole organisms, you see a seemingly bewildering array (Figures 1-1, 1-2). How confusing it is unless you look for patterns and similarities instead of differences (Figure 1-3). Historically, people interested in organisms first grouped them according to their common features—thus worms, insects, flowering plants, vertebrates, and so on. When these groups were well defined, efforts were directed toward detecting differences between kinds. The existence of common patterns, however, suggests that there are common problems that face living organisms, and there are only a few major solutions to these problems. Specific differences, on the other hand, suggest that some organisms can perform special functions or that specific solutions to certain problems faced by certain organisms exist. How were and are these general and specific solutions reached? What

selects the successful organism? Does an answer to this question help resolve the larger issue of the nature and integrity of life?

At a yet more complex level of structural integration, you can see organisms associated with other organisms in seemingly endless patterns of community and societal assemblages. Little organisms live on big organisms; some organisms can make their own food and others must be supplied with food. But again, different associations are more alike in both structure and function than appears at first glance. How did this structure come about? Why do so many different kinds of organisms live together? What could a large community do that a small one could not? How do these questions apply to the nature of life?

Homeostasis

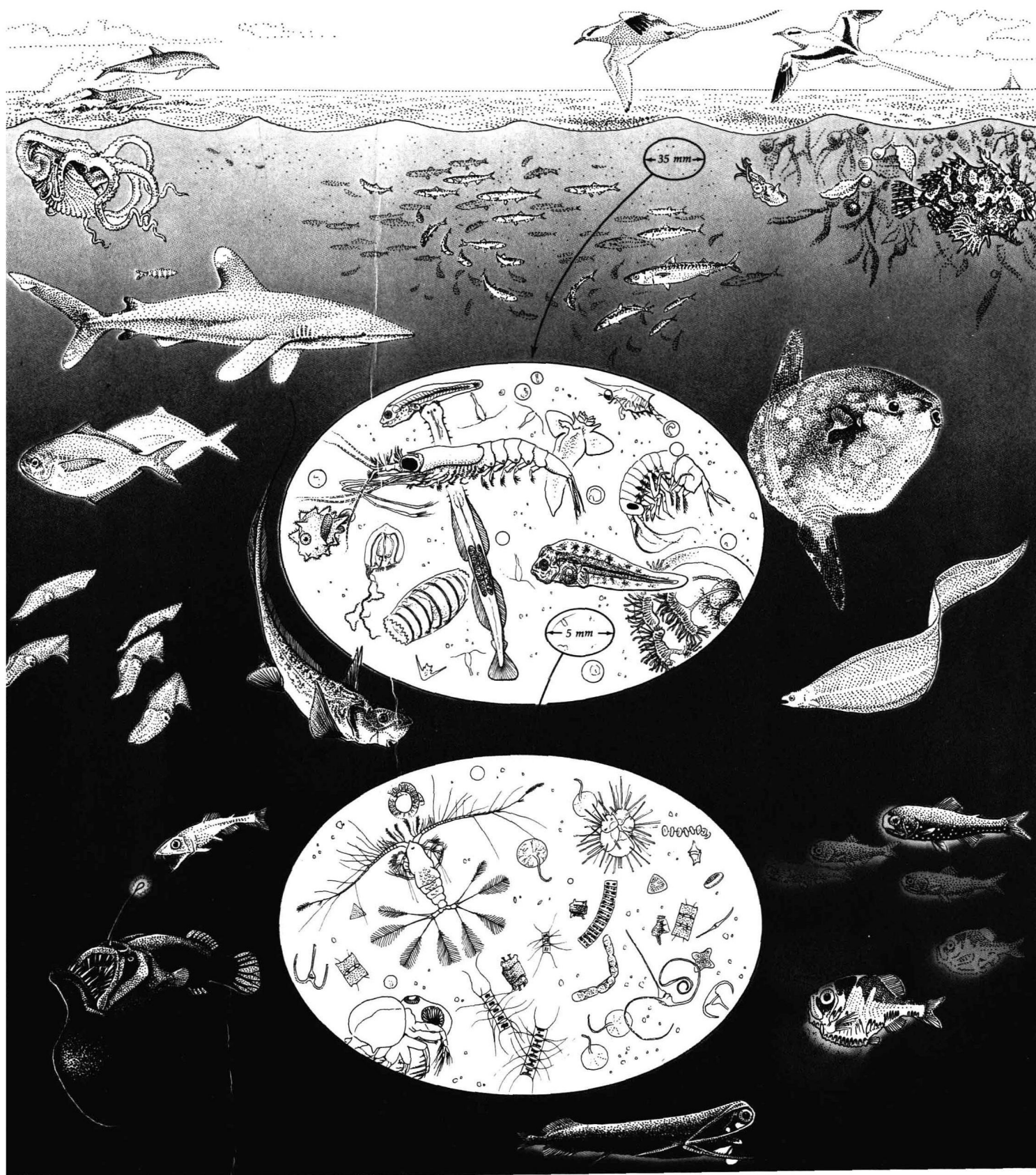
One intriguing property of cells, individual organisms, and members of a community of organisms is the ability to maintain a high degree of constancy of structure and function in spite of stress that should result in change. For example, in warm-blooded animals, major external changes in temperature are not reflected by major internal changes in temperature. Whether it is 0°C or 38°C outside (32°F or 100°F), human body temperature remains just a little below 38°C (98.6°F).

This regulation takes place unconsciously and automatically and can thus be called self-regulation. What accounts for it? Part of the explanation is that at higher external temperatures the sweat glands open and there is increased evaporation and consequent cooling of the skin; at lower temperatures not only is there little sweat gland function, but also shivering, a muscular activity that releases heat internally, occurs. What controls each of these opposing actions? What controls those controls?

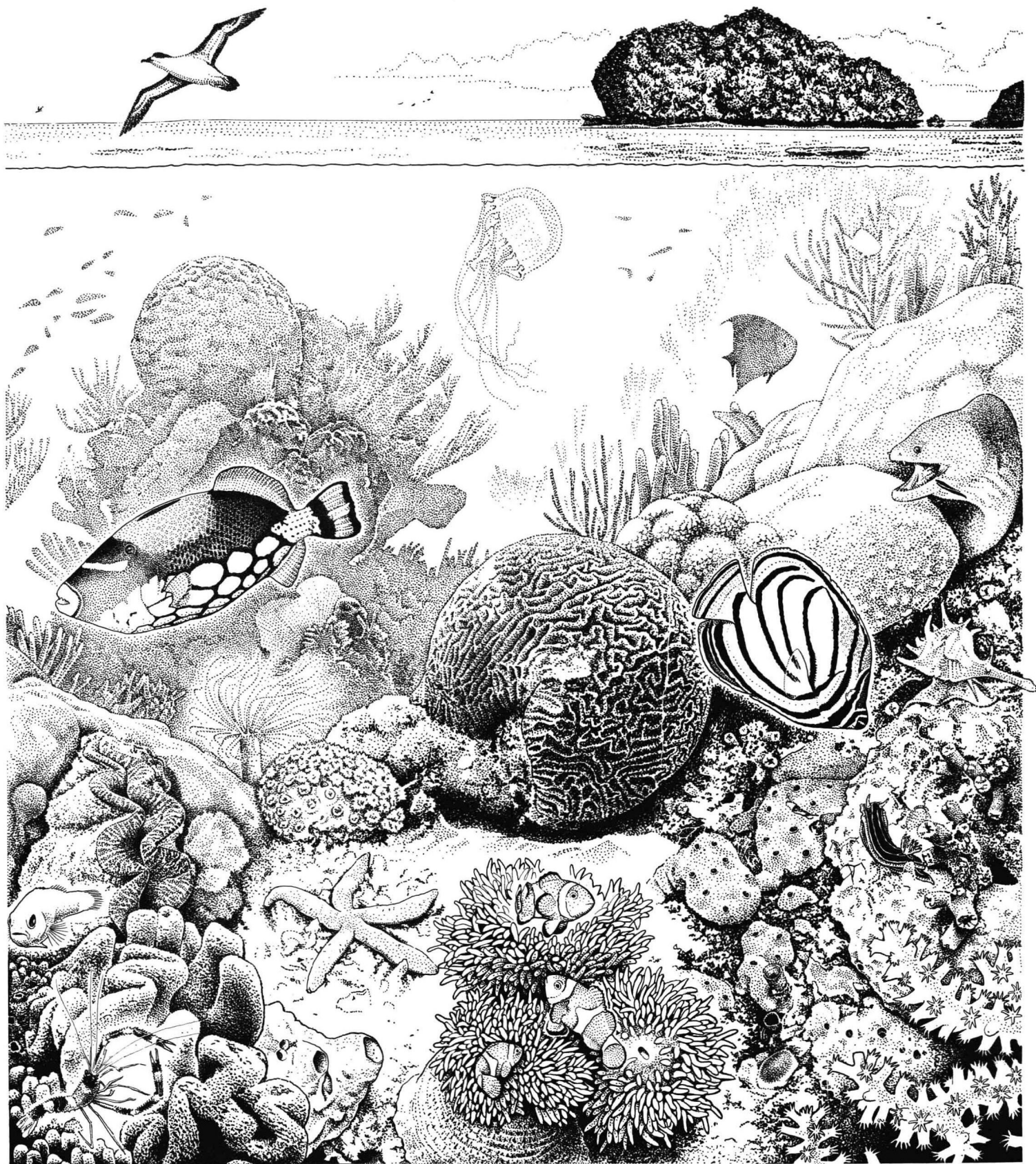
What triggers a cell to take in and get rid of materials selectively, so that it maintains an internal constancy of inorganic elements and compounds? What accounts for a population of organisms maintaining itself at a relatively constant level in the absence of such seemingly necessary controls as predators and competitors? Is something inherent in the organization of cells, organisms, and populations that is more than can be accounted for by their physical makeup? What evidence supports this view?

Adaptation

You may remember that white light actually consists of different wavelengths and, if broken by a glass prism or raindrops, can be seen to consist of a spectrum of colors extending from violet to red. These different wavelengths (or "colors") have different energy levels, peaking in the blue and red parts of the spectrum. It is intriguing that the plant pigment chlorophyll absorbs light in those energy-rich por-



1-1 Some of the seemingly endless variety of plant and animal life in the ocean.



1-2 Many different plants and animals live in a coral reef.