dren and Adults, annual conv., Denver, Colo. (NSCCA, 2023 W. Ogden Ave., Chicago 12, Ill.)

19–22. International College of Surgeons, Western regional, San Francisco, Calif. (W. F. James, 1516 Lake Shore Drive, Chicago 10, Ill.)

22–27. Automation and Instrumentation, 5th conf., Milan, Italy. (Federezione delle Societa Scientifiche e Techniche di Milano, via S. Tomaso 3, Milan)

22–1. Radioisotopes in Animal Biology and the Medical Sciences, conf., Mexico City, D.F. (International Atomic Energy Agency, 11 Kärntner Ring, Vienna 1, Austria)

Letters

Coconut Water

I would like to make a suggestion on coconut (*Cocos nucifera,* L.) terminology. Many scientists have been attracted to the use of coconut liquid endosperm because of its nutritive properties for plant tissue-culture work and sporulation of fungi. Readers are somewhat confused with the terms used to indicate the liquid found when a coconut is opened. American workers refer to it as coconut milk; others, as coconut water.

In most Asian countries the term *coconut milk* refers to the milky-white sap expressed from grated nut meat or solid endosperm, *coconut water* to the liquid endosperm. Many more uses of the latter are likely to develop. I therefore suggest, for uniformity in terminology, that only one term—*coconut water*—be used to refer to the liquid endosperm, in order to avoid confusion.

CONCEPCION L. VALERA
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Modern Biology

I began Commoner's article "In defense of biology" [*Science* **133**, 1745, 1961] in the peace and quiet, almost the somnolence, of a comfortable armchair and it wasn't until the bottom of the second column that it broke upon me that biology was being defended against none other than myself. Commoner is concerned, it seems, over the attitude taken toward biology in my book, *The Intelligent Man's Guide to Science*, and, in particular, is horrified at my statement that "modern science has all but wiped out the border-line between life and non-life."

In response, Commoner says: "Since biology is the science of life, any successful obliteration of the distinction between living things and other forms of matter ends forever the usefulness of biology as a separate science. If the foregoing sentence is even remotely correct, biology is not only under attack; it has been annihilated."

I could not help but be moved by the anguish clearly detectable in this *cri de coeur*, and I long to assure Commoner that he need not fear. Biology will not be annihilated even if the boundary between life and nonlife vanishes.

There was, after all, a time when astronomical advance removed the boundary between earth and the other planets, and that did not annihilate geology as a separate science. The advance of knowledge in biology removed the boundary between man and other species, and that has not annihilated sociology as a separate science. In fact, both geology and sociology became more meaningful when both could draw upon and, in turn, enlighten, a broader field of inquiry.

If the distinction between life and nonlife vanishes, the science of biology will persist as the study of a particular collection of material systems that we will *still* call "life" for simplicity's sake, just as we still speak of "organic chemistry" more than a hundred years after the distinction between organic chemistry and inorganic chemistry vanished.

In fact, the importance of biology will be heightened when physicists and chemists come to realize that biology's deepest insights will be of direct service to their own fields of specialization.

Science is a unit, and if it seems broken up into arbitrary divisions, that is the fault of the age of intellectual overspecialization in which we live. Scientists who labor to make these artificial partitions between the arbitrary divisions impenetrable and unsurmountable are doing science a great disservice. Nor are they truly serving their own fields by their careful shielding of them from all contact with outside thought.

Commoner is also annoyed at my statement: "All of the substances of living matter—enzymes and all the others, whose production is catalyzed by enzymes—depend in the last analysis on DNA."

His statement, opposing that, is: "life is unique and . . . it cannot be reduced to the property of a single substance or of a system less complex than a living cell."

With reference to this remark (which he labels his "chief argument"), I can only applaud his courage, not his judgment, in declaring anything at all to be unique. There was a time when the earth was considered unique, as the only motionless object in the universe; when each species was a unique creation; when the organic chemical was uniquely a product of life, and the "organized ferment," uniquely a creature of the intact cell. Where are these uniquenesses and a hundred others? The history of science is filled with the bleached bones of uniqueness, dead at the thrust of knowledge that has become more and more comprehensive.

As to Commoner's remark that life cannot be reduced to the property of a single substance or of a system less complex than a living cell (and with what courage he pronounces his negative fiat), I repeat my own remark that life depends, *in the last analysis*, on DNA.

To depend "in the last analysis" does not necessarily imply a simple or direct dependence. The dependence is a supercomplex one, in fact, but that in itself does not alter matters.

One can say that American law is based, *in the last analysis*, on the Constitution, but that does not mean that any amount of reading of the Constitution *alone* will explain the nature of the city ordinances of Tulsa, Oklahoma. For that matter, a close reading of the 14th Amendment will not elucidate the social structure of Mississippi. Yet it remains fair to say that the Constitution is the basic law of the land.

And life depends, in the last analysis, on DNA.

If Commoner disapproves of the incoming tide and wishes to amuse himself by standing on the shore and commanding it to stop, he may. He may also quote as many authorities as he likes in order to impress the waves.

But he will get his feet wet just the same.

ISAAC ASIMOV
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Barry Commoner is to be congratulated on his succinct and elegant article on the status of "traditional" and "modern" biology, and on his proposal to restore the science of life. If one assumes general agreement on this goal, the question arises, "How is one to proceed?" I believe that things might be initiated if all modern biologists were asked to take three giant steps backwards and to ask themselves the question: "What is really being studied when we study life?"

Perhaps the chief factor which has placed modern biology in a situation analogous to that in which 19th-century physics found itself in the first part of this century is that modern biologists have failed to realize that the study of life is the study of living organisms and living cells. As Commoner has pointed out, Bohr's theory of complementarity should set the limits as to how far one can go in biology, just as Heisenberg's principle of indeterminacy sets obvious limits in physics. It seems almost axiomatic that putting physicochemical questions to a physical-chemical system results in answers only in terms of the units used, and not in terms of the holistic nature of the organism or intact cell. Furthermore, the fact of epigenesis, and the apparent requirement of DNA for a cellular environment to execute its action, should put into more proper perspective the tingling sensation and fascination which arises at the mention of DNA. The imbalance of interest in DNA certainly stems from such statements as Asimov's that "modern science has all but wiped out the border-line between life and non-life." Such a statement has accuracy only within the framework of what one considers life to be. Replication of molecules is not life.

The regrettable schism between "breakthrough" areas and traditional areas of biology has resulted in a state of affairs that needs obvious correction. Some examples from my personal experience come to mind: (i) ridicule of the direct observational method and a predilection for indirect methods; (ii) introductory courses given over completely to nontraditional biology; (iii) a course in protozoology devoted entirely to a single species; (iv) a professor telling his freshman students that remembering names of species and classification was a discredited method and was not required in his course (he then went on to have them memorize the Krebs cycle, which is really a kind of classification); (v) an internationally known modern biologist, who, having given a seminar on nucleoproteins of frogs, was

asked what species of frog was used; his answer, "I don't know, they were bought from some supply house"; (vi) a predoctoral graduate student in biophysics, supported by a large government stipend, declaring that his only wish was to see a protein molecule divide under a microscope (light); (vii) the teaching in many universities that viruses are organisms and bridge the gap between living and nonliving phenomena; (viii) financial support for "breakthrough" areas rather than additive areas of varying magnitude; and (ix) obsession with confidence limits and evaluations. I am certain that any reader can compile an even longer list.

We might learn a lesson from physics, where the mother-child relationship has not been so prodigal. The wave and corpuscular theories of light are still used and found necessary to explain certain phenomena, notwithstanding the quantum theory. I think Commoner has done a great service to all biologists in making a plea for the integrity of traditional and modern disciplines. Furthermore, it is my belief that the bewildered mother would receive again her fast-talking child, and would even take on some of the child's habits, should the road be made open and should agreement be reached as to what each was examining.

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I believe that most of Asimov's remarks require no comment beyond what has already been said in my original article. However, one of his statements tends to give the reader a misleading idea of the content of my article, which I should like to correct.

With respect to the distinctions between living and other forms of matter, Asimov states: "Scientists who labor to make these artificial partitions between the arbitrary divisions impenetrable and unsurmountable are doing science a great disservice. Nor are they truly serving their own fields by their careful shielding of them from all contact with outside thought."

In the second of the foregoing sentences Asimov has precisely reversed the main point of my article—which is that the real distinction between life and nonlife ought to be recognized *so that physics and chemistry can be more effectively applied to biological problems.* Far from avoiding "contact with outside thought," my article consists of arguments in support of the uniqueness of life which are derived *from* physical and chemical principles.

In the first of the quoted sentences, Asimov has also misinterpreted that part of my article which deals with the significance, for biology, of the principle of complementarity put forward by Bohr. Bohr points out that for reasons which are fundamental to the present structure of quantum physics, a subatomic particle can be described, at any one time, by either its corpuscular or its wave properties, but never by both together. He suggests—and I support this view—that a similar complementarity governs the relationship between two features exhibited by living organisms—the manifest living state and the physicochemical events which go on within it. Asimov is at liberty to regard this proposal as an "artificial partition between the arbitrary divisions" of life and nonlife. But in that case he ought, in the name of logic, to say the same about the distinction between the corpuscular and wave properties of subatomic particles. Yet, much of modern physics has been founded on this distinction.

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Daedalus and Minos

Dedijer's very interesting article "Why did Daedalus leave?" [*Science* **133**, 2047 (1961)] leaves open a tantalizing question: How about the fate of Minos? In those countries in which the social and political environment is unfavorable to the development of science, does not the return of the Daedali deeply threaten the social system which led to their flight? Would not their return and creation of new traditions necessary to their existence construct a bath to scald Minos to death? And is not Minos, unconsciously perhaps, behaving in his own self-interest in putting last on his priority list "a quantity of problem-solving Daedali?"

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