# *Theological Resources from the Biological Sciences*

## THE SEARCH FOR COMMON GROUND

*by George Wald*

Man's endless effort to know and understand is epitomized in science. Science is a systematic attempt to understand all reality. Facts—information—serve only as counters in the argument. The business of science is to discover order in nature, so that man can feel increasingly at home in an orderly universe.

One hears a great deal of the alienation of men from the modern world. That alienation, to the degree that it exists, may involve in part an estrangement from technology; yet it is only through misunderstanding that it can be supposed to involve science. Science as knowing can only help in integrating man with his environment. Any other view would be a plea for ignorance. If there is any quarrel with science, it can be resolved only with more and better science.

I think there has been such a quarrel with science, but I trust it is now past. It involves the fact that beginning roughly a century ago, science began to undercut drastically man's traditional beliefs; and for a time it was so busy clearing the ground, destroying old misconceptions, that it substituted nothing for them. But I think that time has passed. Science has gone from that period of iconoclastic analysis to synthesis. In recent years it has achieved a unity that it never possessed before and a unified view of our world. I think that that uni-

George Wald is professor of biology at Harvard University. His major research has been in biochemistry, notably relating to vision. He has also written extensively on the origin and development of life. He is a member of the Institute on Religion in an Age of Science and a member of Meadville's Scientific Advisory Board. This paper follows closely the lines of a series of lectures to be published shortly as a book by the Natural History Press (New York: Doubleday).

fied view offers perhaps the greatest assurance that men can now experience.

What is that unified view? Matter appears to us now in a hierarchy of states of organization that stretches from elementary particles to atoms, molecules, aggregates of molecules, living organisms, and on to animal and plant societies. This hierarchy of states of organization also reflects a history, for this is also the temporal sequence in which our world has evolved. We live in a historical universe, one in which not only living things but galaxies and stars are born, mature, grow old, and die.

Our universe is made of four kinds of elementary particles: protons, electrons, neutrons, and photons. Such a universe as this could be begun with neutrons, for neutrons, with a half-life of about ten minutes, can decompose to protons, electrons, and radiation, so that we should have all the particles needed.

Our universe is composed about 99 per cent of two elements, hydrogen and helium. About half of it is in the form of interstellar and intergalactic gases. At various times and places, a mass of such gases begins to contract, and in contracting heats up enormously. When it grows hot enough, at about five million degrees, the hydrogen begins to be converted to helium, and this is the source of starlight. This process marks the birth of a star; and for a long period of time, maintained by the conversion of hydrogen to helium, such a star remains upon the Main Sequence, its period of youth and maturity. Then it begins to run out of hydrogen, and goes into senescence as a Red Giant. It is at present believed that such heavier elements as carbon, nitrogen, and oxygen are formed in Red Giants, literally in dying stars. Spewed out into space from the Red Giants, sometimes in such stellar catastrophes as novae, these elements eventually condense again to form the substance of new galaxies, stars, planets, and (ultimately) living organisms.

For living organisms are composed almost entirely of these four elements: carbon, oxygen, nitrogen, and hydrogen. If we have understood the situation correctly—it seems altogether possible that the theory here will undergo further changes—life is possible only on planets attached to later-generation stars, for that reason having access to the carbon, nitrogen, and oxygen developed during the decline of an earlier stellar generation. That gives us some idea of what vast reaches of time have been involved in these developments. Our own galaxy, the Milky Way, is thought to be about fifteen billion years old. Our sun, consistent with its probable position as a second-genera-

tion star, is about six billion years old. The planet Earth is probably about as old, though it took its present form about four and one-half billion years ago. For reasons that are not well understood, the oldest rocks on this planet are only about three billion years old; and within the past few months we have had reports of what seem to be the remains of micro-organisms in some of those oldest rocks. In that case, it must have taken no more than about one billion years for life to appear on this planet. That is in line with many other kinds of evidence that make the origin of life seem to us now a much more probable phenomenon than it did relatively few years ago.

In stars, all the atoms are stripped; they are naked nuclei, unable at the high temperature of stars to hold onto electrons. It is only in cooler places in the universe that atomic nuclei can hold electrons so as to form complete atoms. That makes it possible for atoms to combine with one another, through the interaction of their electrons, to form molecules.

With elementary particles, one is in the realm of Heisenberg's Uncertainty Principle, which states that for such small structures one cannot simultaneously specify both locations and motions. Elementary particles have no definite shapes or sizes, and one knows where they are only statistically. With molecules, one enters the determinate world: with this development, matter acquires definite shapes, sizes, and positions.

During perhaps the first billion years of this planet, the molecules accumulated, interacted with one another, and eventually aggregated to give rise to the first living organisms. Just as molecules added a new dimension to matter in the form of determinacy, so life added a new dimension: individuality. The definition of a chemical substance is that its molecules are all identical. One sign of that identity is the capacity to crystallize, a state in which identical molecules take up fixed positions and orientations relative to one another. No two living organisms, however, are identical. Each of them, even the simplest, is unique.

Another intrinsic property of living organisms is the capacity for inherited change, always in the direction of optimization. The mechanism for this process is that described a little over one hundred years ago by Charles Darwin, and called Natural Selection. It involves the interplay of three factors: a mechanism of inheritance; a continuous production of random, inherited variations (mutations); and the struggle for existence, the competitive element. The outcome is the survival of the fittest—a continuous elimination of whatever functions less well, permitting what works better to go on. These forces have produced the

enormous diversity of living organisms as we now know them, and designed each in detail for the conditions of its life. This is organic as opposed to technological design, and it has produced by far the most intricate and effective mechanisms that we know.

The past few years have made us aware as we have never been before of the depth of kinship among all living organisms. For one thing, every organism alive today can boast a genealogy that goes back in an unbroken line to the first living organism on the planet; for if that line had been broken, how could that organism be here? Beyond that general thought, however, it has recently become apparent that over a great reach of this development we have been working on the same genes. It has recently become possible to determine the sequences of amino acids in representative proteins of a wide variety of organisms, and to infer from these the sequences of nucleotides in their genes. It turns out that surprisingly few changes have occurred in the structures of the proteins, and a still smaller proportion of changes in the genes that determine them. For example, one protein, the respiratory enzyme cytochrome C, displays only forty-three differences in a sequence of 104 amino acids as between man and yeast, implying not many more than forty-three differences in a sequence three times as large, or 312 nucleotides, in the gene that determines cytochrome C. Yeast is a contemporary organism, with which once in the remote past we shared a common ancestor. From that remote ancestor, yeast went its way, and we went ours. The journey has been made twice, yet has resulted only in such minor differences.

So all life is akin; and our kinship is much closer than we had ever imagined before. Yet within that family of living things, man also is unique and adds new dimensions.

What is the nature of the special human contribution? It lies, first of all, in man's being uniquely the knowing animal, the science-making animal. He appears on this planet as a kind of culmination of the developments that we have all too briefly reviewed, which involves, as we have seen, much of the history of our universe, and the gathering up of our substance from its far corners. These are enormous vistas, but surely much of our worth and dignity must consist in this: that man alone has those vistas.

It is as though in a sense these things had not happened until there was someone to know of them; and it is we alone, in this corner of the universe, who know. Recognition is itself a kind of creation. What are the elementary particles, the atoms, the molecules, the galaxies, the dying stars, until one such as man has recognized them? And man is

made of these things, so that it is as though he had passed through a history that culminates in the fact that the matter of the universe, having finally become organized in such creatures as man, *can know itself*. Were it not for this, man might be thought to be lost and altogether negligible in a universe so vast and ancient.

So in a universe that is becoming understandable, science places man in a central position, as the one who understands. (I would add, as perhaps equally important, he is the one who creates; he is the science-making and the art-making animal.) Is that position enough for theology? Can one make religion of it? I do not think one can make religion of it alone; but I do ask whether this view of man in his universe provides firm ground in which religion can be planted and can grow and flower. I have asked myself that question, and now I ask it of you.

That calls for a confession. I came to Chicago not to tell you things, but to ask you things. I have come with questions that are of deep concern to me and are distinctly questions for you.

This is only the second confrontation I have had with theologians. There was an earlier one some years ago, when I visited a distinguished theological school in the East. I gave a lecture to the graduate students, and then after dinner found myself in a large room at the center of a circle in which sat the whole faculty. I thought to myself, "Here is my chance to ask the question I have been waiting to ask for a very long time." What I really wanted to know is what a modern, intelligent, perhaps educated man who acknowledges a belief in God has as his concept of God. After that, I could do nothing but sit back and let the discussion roll over me. That faculty went at one another hammer and tongs. I think what surprised me most was the deep impression that this was the first time the question had ever come up. I went away, finally, perhaps needless to say, without an answer.

I wonder whether I will fare better this time. I rather doubt it. But that is all right with me because I am a scientist, and to a scientist the precious things are the questions and the relatively secondary things the answers.

That is where I should like to begin with my first question. Science goes from question to question. All answers are tentative. It is not that they necessarily are wrong; more usually they are incomplete or imperfect. It is not so much that after a time they are replaced (though that happens) as that they tend to grow. They become more general and more exact.

Now I have the impression that much of theology goes from question to answer, sometimes from answer to answer, and indeed some-

times to final answers. That seems to me a great pity, because therein lies not only the incompatibility of much of theology with science, and the great difficulty in communication that all of us experience when scientists and theologians try to talk together, but also a terrible vulnerability. There is so much to defend that is indefensible, so much to preserve that had much better be dropped. And so I ask my first question: cannot theology also go from question to question? What is wrong with a religion that is a religion of seeking, in which one seeks endlessly and perhaps never altogether finds?

That brings me to my second question. That unified view of nature which I have tried too hurriedly and superficially to outline for you, is full of acceptance. It is a yea-saying to the universe. I have the impression, however, that much of traditional theology involves rejection of rather oddly selected aspects of nature. Indeed there is a whole vocabulary of rejection. I have heard ministers making very odd distinctions in what is in fact the vocabulary of physics, dividing it up into terms of approbation and terms of denigration. So, for example, the word "matter" is used in disparagement. Matter is a low thing; it is indeed that worst of things: material. It is something one can equate with the flesh. Energy, however, is a vastly different thing. Energy is virtually spirit. Indeed one could state as a principle that the smaller the mass, the greater the spirituality. And yet we have Einstein's equation, now familiar to all, that says that energy and mass are interchangeable and connected by the simple equation $E = mc^2$.

So I ask, how indispensable is a religion of rejection? Cannot religion also say "yes" to the universe and all that is in it?

That leads to my third question. Though I find in the scientific view of the universe and man's place in it new sanctions for our concepts for the sanctity of human life and the dignity of man, I find no encouragement for a belief in personal immortality, or in that offshoot of personal immortality, a belief in personal resurrection. I can think of meanings that might be attached to the word "immortality" that science might sanction, but they are wholly impersonal. The only approach to personal immortality that I know involves living on in the memories of men, the immortality of such as Homer, Shakespeare, and Rembrandt. So I ask my third question: how indispensable in theology is the belief in personal immortality?

That brings me to my fourth question. I find no encouragement as a scientist for the belief in an external Being or Agency that answers prayers. It seems to me that the act or habit of prayer may have other sanctions. It may indeed be a most valuable activity. By praying, one

formulates one's needs and desires, and that in itself is a good thing. To an extent, one objectifies and experiences the catharsis of voicing one's desires; and perhaps that is even a step toward realizing them. But all those effects are internal. In that view of prayer, is one not praying to oneself, yet then perhaps to what one conceives as one's higher self, as all that one might be able to conceive oneself to be? Perhaps such a transcendent concept of the self is as near as one can come to a concept of God. In any case there is my last question: how indispensable in theology is the belief in one who answers prayers?

## COMMENTARY ON THEOLOGICAL RESOURCES FROM THE BIOLOGICAL SCIENCES

*by Hermann J. Muller*

I agree with Wald in feeling that science has a great deal in its content to offer to religion. Biology has shown clearly that what we call consciousness in its higher forms—the rationality, love, and charity which are considered by some of us to be the most admirable attributes in higher forms (at least) of religion—is the product of a long, long biological evolution. These forms of consciousness only come into existence with the workings of very highly specialized material, but they do exist, we do have them, and this is something which should give man more confidence in his being and in his possibilities. He has these attributes in a much higher degree than does anything else he knows, and having this knowledge, it is no longer necessary for him to look for external justification of the urges of his nature as expressed in these higher attributes.

Wald spoke very eloquently in defense of knowledge, regardless of its practical applicability. I am not against the application of knowledge, but I think that anyone who is truly human must take the position that knowledge is its own excuse for being even if it has no applications. If our ancestors had not had the urge to acquire knowledge even when they did not see any application for it, they would have remained be-

Hermann J. Muller is Distinguished Service Professor of Zoölogy, Emeritus, Indiana University.