13 December 1957, Volume 126, Number 3285 SCIENCE

Science and the Citizen

Warren Weaver

On each Thursday afternoon some three hundred years ago, a group of gentlemen gathered at the Bull-Head Tavern in Cheapside, London: Sir Christopher Wren, who was primarily professor of astronomy at Oxford, but who also designed the military defenses of London and many famous and lovely buildings, including St. Paul's Cathedral; Robert Boyle, who was a great physicist and who also was the author of the *Defense of Christianity*; Lord Brounker, a patron of all the branches of learning; Bishop Wilkins, who in addition to being a cleric was master of Trinity College and an expert on Copernican theory; Sir William Petty, who was a political economist, a professor of anatomy at Oxford, and a professor of music at Gresham College; Samuel Pepys, the diarist, man-about-town, and Secretary of the Admiralty; and at a later time our two great American Benjamins—Franklin and Thompson, the latter better known as Count Rumford. There were in this group members of Parliament, critics, civil servants, and pamphleteers. There were explorers and travelers, antiquarians, and *bon vivants*. They were obviously men of wide interests, men of both intellectual and physical vigor. They were men of curiosity, and men of parts. They met there, every Thursday afternoon, to carry out experiments, to eat and drink together, but, primarily, they met there to discuss science.

This was the beginning of the Royal Society Club, a group which, together with others, received from the King on 15 July 1662 the charter of the Royal Society, that great organization which has been the center of British—and for that matter, much of Western—science for nearly three centuries.

It is good for us to think about this group of men. They were no sheltered scholars, no narrow specialists. They were men of varied and of important affairs. And they thought it worth while to meet once a week to think about science.

Their meeting began in the afternoon and lasted through dinner. That this took some pretty stout and manly lasting will be clear from one of their menus (Fig. 1). The menu does not bother to mention the ale with which they began; the port, madeira, and claret with which they continued; or the champagne, the brandy, and the rum with which they accompanied the cheese, raisins, and nuts.

It is well for us to think of these men; for they devoted themselves to an activity, the serious study of science by a general group of individuals from all types of professions and business, which is today less common and at the same time more important than it was then.

For to these lively spirits of the 17th century, observing as they currently could the great beginnings of modern science, it was nothing much more than an intellectual luxury to know something about the then new ways of testing, of analyzing, and of understanding nature. Science had as yet so little touched their daily lives and works that they could, in fact, have known essentially nothing about science and still have lived well-balanced and useful lives. The Industrial Revolution was to be faced by their great-great-grandchildren, not by them. One did not need to know any science to decide whether one wanted to be a Cavalier or a Roundhead. One could appreciate the epoch-making character of the Bill of Rights of 1689 and could have his opinions about the personal government of Louis XIV without making use of any facts from physics or chemistry. One could trim the candle or saddle the horse or dispatch a servant with a handwritten note without getting involved in any scientific equipment.

Science Today

But for us it is a different story. The most superficial, even if the most multitudinous, aspect of the contrast is that each one of us now makes constant use of devices that are essentially scientific in character—the telephone, radio, and television; the automobile and the airplane; the air conditioner and the electric blanket; electrically driven and largely automatic washing machines, dryers, refrigerators. Not long ago I counted the number of electric motors in our house. There are 32. And it is, of course, the mechanical, electrical, and electronic devices in thousands of more remote places which act to surround our daily lives with all the materials and services which we take for granted.

Our clothes closets are filled with suits and dresses whose fibers come, not from cotton plants or off the backs of sheep, but from test tubes. Our medicine cabinets are filled with drugs that have been produced, not by the herbalist, but by the organic chemist and the biochemist. In our own living rooms we look at, and listen to, far-distant events. We are warm when it is cold, and cool when it is hot. Our health is protected and restored by the exquisite skill of modern medicine and surgery. Even our worries are calmed by chemicals.

We have vast and incredibly rapid electronic devices that calculate, that have memories, and that can carry out and control the repetitive procedures in factories, banks, and businesses. Some of these machines even play chess, or translate from Russian into English. Man is participating in the process of cosmic

Dr. Weaver is on the staff of the Rockefeller Foundation. This article is based on the orientation lecture which he delivered at the opening of the Scarsdale, New York, "Auditorium Course" series, 1 Oct. 1957 (see p. 1222).

creation in the sense that, for the first time since time began, he has built for himself a satellite—his own private moon. We are throwing rockets and guided missiles into the skies, whispering of accurate flights from one continent to another, and even dreaming of expeditions to other planets.

We are learning something of genetics and exploiting this knowledge to improve our crop plants and our edible animals. Modern scientific agriculture, with its knowledge of improved plant materials, of fertilizers, of insect and disease control, of proper agronomic practices, could doubtless double the world's food supply.

We have just seen the first great advance against poliomyelitis. Cancer, cardiac disorders, the degenerative diseases of older age—one can clearly sense the exciting progress that is being made and the exciting prospect for really important advances against them.

We are starting to utilize solar energy, and we are beginning to understand the way in which the green plant converts the energy of sunlight into a chemically stored form. We talk about making rain, and with the vast energy now at our disposal we even consider the possibility of affecting climate on a world-wide scale. We have learned how to tear apart and glue together the nuclei of atoms, and as a result we have an array of man-made radioactive isotopes which constitute powerful new tools of research, we have a future in which the supply of energy is essentially unlimited, and we have weapons of such destructiveness that we are quite capable of destroying civilization. Indeed, when we entered the nucleus of the atom we opened a Pandora's box of problems of the most complex and formidable kind.

Practical Problems

I read in a recent article in *Harper's* (*1*) that ". . . most people don't give a damn about most things, unless those things are part and parcel of their concrete lives." But don't you think that science *is*: don't you think that the time has come when you *must* give a damn about science?

The atom, the cell, the star—the mind of modern man has invaded all of these. This new knowledge has brought new beauty into life, new satisfaction of understanding, and new power over nature. But it has also brought great and unavoidable problems. Many of these are economic, social, political, and moral problems; but they are also inescapably scientific problems. Thus, these are not isolated problems for a few queer specialists. They are problems for every citizen.

No longer is it an intellectual luxury to know a little about this great new tool of the mind called science. It has become a simple and plain necessity that people in general have some understanding of this, one of the greatest of the forces that shape our modern lives. We must know—all of us must know—more about what science is and what it is not. We must appreciate its strength and value, and we must be aware of its limitations. We must realize what conditions of freedom and flexibility of support must be maintained for pure scientific research, in order to assure a flow of imaginative and basic new ideas. Without some of this understanding we simply cannot be intelligent citizens of a modern free democracy, served and protected by science. Without this we will not know how to face the modern problems of our home, our school, our village, state, or nation.

Our daily lives are surrounded by problems with scientific implications. When do we—or do we not—consult the psychiatrist or accept a free shot of a new serum? How about vitamins, hormones, sleeping pills, and tranquilizers? How about nutritional regimens and slimming schedules? How about the emotional and psychological problems of present-day children? How about birth rates, death rates, population increases, and food supplies? How about cigarette smoking and lung cancer?

How about secrecy in science? How about visas for foreign scientists? I was shocked recently to hear a well-informed scientist remark that if the disaster of war should come, one of our greatest handicaps would be the fact that our secrecy policy has separated us from our friends.

How about the support for pure science? Where should it come from and how should it be dispensed? How can we as a nation keep a healthy balance between pure science and applied science? How can we recruit and train enough good scientists and, at the same time, not interfere with the recruitment and training of enough good philosophers, businessmen, poets, doctors, musicologists, lawyers, theologians, and so forth?

How about the more scientific aspects of foreign technical aid? How about automation? How about nuclear power and weapon testing and radiation damage and induced mutations and the future genetic purity of the race?

How about medical x-rays? In Sweden every x-ray machine is standardized, and inspection is reported annually. Do you think we ought to have such regulations here?

Do you believe that there can be such a thing as a "clean bomb," or do you think that war is inherently dirty? For how long will it serve the common good for us to have a monster Government agency in the atomic energy field, which spends billions of dollars inside a protective wall of secrecy, sometimes treating the public as though we were all small children, too young to know or face the facts? (*2*). Is this agency, using the power of its money, going to shift more and more research out of universities and into its own establishments; and what do university presidents—say a group in the Middle West—think about this policy?

What are the duties of a citizen in relation to the more scientific aspects of conservation of our natural resources? Do you realize that today we have to mine and process copper ore that is only one-tenth as rich as that which we used fifty years ago; that we now bring iron ore from as far away as Liberia; that we used to obtain oil by drilling only a few feet, whereas now we drill wells that are literally miles deep? Where is our water going to come from, as the demands increase every day and the water table gradually sinks?

How about the many millions of dollars the Federal Government is putting into science through the National Institutes of Health, the National Science Foundation, the Department of Agriculture, the scientific agencies of the branches of the Armed Services? Is this too much of our taxpayer money; or is it in fact too little? Is too much of our national effort in science being channeled through military agencies? Is the money being put in the right places, and for the right things?

Who, in a democracy, really makes the decisions, and how can the decisions, in a modern scientific world, be made wisely and decently unless the public does have some real understanding of science?

Deeper Aspects

The challenge to know something about science, moreover, is by no means limited to these practical questions, important as they are. For if we restricted our interest to motors and drugs, to electronic computers and guided missiles, to radiation genetics and atom bombs, we would move step by ugly step towards a mechanized future in which the purpose of our lives would be nothing much more than a rather selfish sort of convenience and safety precariously posited on power. It is therefore of even more basic necessity that we understand the deeper aspects of science—its capacity to release the mind from its ancient restraints, its ability to deepen our appreciation of the orderly beauty of nature, the essential and underlying humbleness of its position, the emphasis it places upon clarity and honesty of thinking, the richness of

Veale Soup	Haunch of Venison
Fresh Salmon and Smelts	Soup and Bouille
Two dishes of Chicken	Cod and Smelts
Boiled Turkey and Oysters	Aladobe
Lamb pie with Cockscombs	Ham
Rump of beef	
RIDERS	
Two dishes fruit	Two Jellies and Syllabubs
Two Almond Leach and Olives	
SECOND COURSE	
Two dishes Teal and Larks	Tansie
Pear Pye, Creamed	Marrow Pudding
Hare	Two dishes Asparagus and Loaves

Fig. 1. A menu for a meeting of the Royal Society.

the partnership which it offers to the arts and to moral philosophy.

What, then, is science? Being an operationalist, I can only reply that science is the activity practiced by scientists. But this is only the start of an answer. Who and what are scientists? How do they act? What motivates them? Do they all have beards and wild eyes? Can you spot one on the street? To what extent and in what way are they different from nonscientists? When you prick them, do they not bleed? When you tickle them, do they not laugh? When you poison them, do they not die?

Scientists are men and women, not gods, not freaks, not magicians, not monsters. "To think of science as a set of special tricks, to see the scientist as the manipulator of outlandish skills—this," as Bronowski (*3*, p. 249) has said, "is the root of the poison mandrake which flourishes rank in the comic strips."

On the average, scientists tend to be pretty bright, and a very few of them are so exceedingly bright that they must be called geniuses. But by and large, scientists are very much like other folks. They doubtless have rather more than the average curiosity about the insides of things, and they may perhaps have a rather special natural appetite for sharply focused and logical thinking as contrasted with intuitive, artistic, and emotional reactions. But their one really basic difference, I believe, is an intellectual inheritance, transmitted to them in their education as scientists, from the centuries of tradition about the scientific method and the scientific attitude towards the world. To understand what I mean by this we must make a considerable diversion, eventually coming back to the scientist.

Physical Science

The physical world happens to be put together in such a way (I consider this one of God's really bright ideas) that one can usefully take it apart and study an isolated bit of it at a time. Such a study then reveals useful and analytically describable uniformities. For example, pull a spring with a force of one pound and it stretches two inches. Pull with two pounds and it stretches four inches. The generalization (Hooke's Law) is that for all springs (all elastic material, in fact) the stretch is directly proportional to the pull.

Now why do I interrupt remarks about the nature of scientists to talk about springs? Because of this remarkable fact that when you stretch them, all springs behave in the same way. Stop and think how strange and useful this is! For when you stretch the credulities of a lot of persons, they behave in all sorts of ways. You can, moreover, take a spring out of a watch and usefully study it as a spring, forgetting its origin. But you cannot take the pituitary gland out of a man, or a child out of its home, or a line out of a poem, or a spot of color out of a painting, or a note out of a symphony, and usefully study these isolated bits, neglecting their origins.

It is the dissectability of the physical world which permitted science—primarily physical science—to get such a good start so long ago. It was for this reason that Galileo could learn all about pendulums and the laws followed by *all* objects when they fall, whether these objects be lead balls or bird feathers. Newton could discover a *universal* law of gravitation. Ampere could find out the *basic* laws for electric currents, laws which continue to be true in modern electrical devices that Ampere could not have dreamed of.

Thus, this way of analyzing nature—of designing experiments to learn the facts, of formulating general rules for describing nature's uniformities, of dreaming up possible new and even more general rules and then testing by experiment to see whether the rules are valid—this scientific way proved to be tremendously powerful. It worked. Step by step and accumulatively it gave men an understanding of physical nature and, along with that understanding, the power to control and, in the good senses of the word, to exploit. Thus the physical sciences—physics, chemistry, mathematics, astronomy, and the more specialized branches such as geology, meteorology, oceanography, and so forth—had an early start, went through their adolescence in the 17th and 18th centuries, had a solid and accelerating growth throughout the past century, and then sharply after the turn of the present century, with the advent of relativity theory and quantum theory, swiftly exploded into activity, moving with a dizzy pace from one spectacular triumph to another.

Biological Science

In the world of living things, the progress of science was not so rapid, and we ought to be able to surmise why this was bound to be so. As far as its stretching (at a fixed temperature) is concerned, one single descriptive number completely describes a spring. A second descriptive number tells one how the behavior varies with temperature. One single number describes how hard, so to speak, it is for direct current to pass through a certain wire. One single and simple equation describes the temperature-volume-pressure behavior of all perfect gases. One concise law states the gravitational attraction between all particles of matter in the entire cosmos. Although there are indeed great complications and refinements in modern physical and chemical theories, the amazing fact is that enormous and very practical progress could be achieved with exceedingly simple and yet exceedingly general laws.

But how many variables does it take to describe a flower, an insect, or a man? How many subtly interacting and essentially interlocked factors must be taken into account to understand an emotional state? How complicated is the set of influences that affect behavior?

In other words, physical science was able to get started several centuries ago primarily because the world is so built that physics is relatively easy. There are, at the center of physical theories, a few general laws of great simplicity and generality and power; and these laws are relatively accessible to man because they are clearly and individually exhibited in rather simple examples. Biology, broadly speaking, is several cuts harder. A living organism is essentially more complicated and has many more interacting characteristics. It is much more restrictive (and can be wholly misleading) to study these characteristics one or two at a time, and underneath all is the massive fact, at once mystical and practical, that when one takes a live organism apart, to study it, an essential aspect of the problem has vanished, in that what is on the experimenter's table is no longer an organism and is no longer alive.

There is a second reason—really a closely related one—why the life sciences could begin to flower only after the physical sciences had borne considerable fruit. For, as we are seeing more and more clearly today, a real understanding of life processes often requires study at a submicroscopic or even molecular scale of dimension, with tools and techniques that have only recently been developed in the physical sciences. An illustration will clarify this point. In 1910 a disease was identified, hereditary in nature and confined to Negroes, which had a clear external pattern of fever, cough, headache, ulcers on the extremities, and sometimes eventual death. Little by little we have closed in on this disorder until it is now known to be caused by a purely *molecular* abnormality: the hemoglobin molecules in the red blood cells of the affected person possess an abnormally high positive electrical charge. The charge causes these hemoglobin molecules to link up together in a way that distorts the external shape of the red blood cells—makes them sickle-shaped rather than doughnut-shaped—and this in turn lowers the physiological effectiveness of the red blood cells and causes a special kind of anemia. The point of the illustration is that the cough, the fever, the decline and death are obvious facts of the ordinary large-scale world, but the explanation could be found only when science had devised tools which could explore inside molecules.

When we pass further up the scale of complexity, subtlety, and essential interrelatedness and consider the field of the mental sciences—normal and abnormal psychology, psychiatry, and so on—and ask questions concerning memory, the subconscious, the learning process, the relation between the mind and the brain, and other matters of that kind, then we should not be surprised that the answers are on the whole still more tentative, the basic generalizations still fewer, the dependability and utility of the relevant knowledge still more questionable.

It is tempting to go one stage further and consider the realm of human behavior, including all those social, economic, and political aspects of individual, group, and mass actions which constitute the social sciences, and to comfort oneself with the assurance that progress in understanding, and eventually in controlling, these phenomena is just as sure to occur as is progress in understanding the cell. We must not be impatient or critical—surely not contemptuous—of the tentative and fragmentary nature of the successes to date.

So we have this great pageant of scientific progress, beginning with the austere precision of mathematics, the grandeur of astronomy, the great conquests of physics and chemistry, together with the impressive technologies they have made possible, followed by the marvelous although still partial progress made in understanding the living world, together with beneficent applications of this biological knowledge to medicine and agriculture, and finally the first exciting invasions into the world of the mind and of behavior.

Scientific Attitude

This—in necessarily sweeping and approximate terms—is what the scientists have been doing since those memorable Thursdays at the Bull-Head Tavern. One stubborn and complicated problem after another has given way before the evolving techniques of science. These techniques, which sometimes seem so specialized and formidable, with a baffling private language, with concepts of great abstractness, and with instrumentation that not even Hollywood can exaggerate, are in simple fact but highly purified forms of the methods of inquiry and reasoning which *Homo sapiens* has used ever since he first began to become *sapiens*.

Thus the scientists have learned by experience that it pays to stop and think; that it is sensible to suspend one's prejudices and try to find out what the relevant facts are; that trying to decide what *is* relevant is of itself an illuminating procedure; that if the facts, as determined under sensibly controlled conditions and by competent persons, run contrary to tradition or hearsay or the position of arbitrary authority, then it is necessary to face and accept the story which is told by the facts; that logical precision in thinking is very useful when one is dealing with the more quantitative aspects of experience; that high standards of personal honesty, openmindedness, focused vision, and love of truth are a practical necessity if one is going to be successful in dealing with nature; that curiosity is a worthy and a rewarding incentive; that nature is orderly and reasonable, not capricious and mad, with the result that it is possible to attain greater and ever greater understanding of the world about us.

These attitudes—usually phrased more formally—just about cover what is ordinarily called "the scientific method." But I have purposely used terminology that, on the one hand, makes it clear that science has no exclusive claim on these useful procedures, and that, on the other hand, should make it clear that persons in all fields of activity ought to inform themselves about the way in which science uses these procedures, since they obviously have validity in many other fields.

Having listed some of the best characteristics of the scientific method we should, at least parenthetically, take note of the fact that scientists, being mortal, very frequently fail to utilize these valuable techniques when they step outside of their professional specialties. We have all too frequent examples of the overemotional, poorly informed, and indeed sometimes quite nonsensical behavior of scientists when they express themselves on business, social, or political affairs.

Faith

And at this point I must indeed return to the scientists, whom we left waiting in the lobby several pages back. We said that science is what scientists do. We said that scientists are on the whole pretty normal folks, eating and sleeping, laughing and loving and dying like all the rest of us. But we said that they do differ from other persons in one way—in the intellectual inheritance which they receive from their schooling in scientific method, their knowledge of the vast successes which science has had, their proud partnership in the profession that has measured the star, split the atom, and probed the cell.

This inheritance is, I am bound to tell you, magnificent but dangerous. To too great an extent the word *science* has been identified with the more technological aspects of man's conquest of physical nature. To too great an extent we associate this noble word with the mechanical, deterministic, physical science of fifty years ago. Too little do we remember—because the subject is essentially not simple, because too few scientists spend the energy to try to be clear, and because too few citizens spend the energy to try to understand—that, as thinking has progressed, the earlier rigid mechanical determinism has vanished out of science, so that the science of today deals with concepts that involve abstractness, imagination, the beauty of conciseness, and at the very core of the subject something which can properly only be called faith.

Overawed by electronic computers and atom bombs, appreciative of all the material comforts science has made possible, humbly thankful for the skill and tools of the modern doctor, misled by the mechanically complicated but intellectually simple gadgetry which is so often falsely paraded as science, confused by strange symbols and formidable looking apparatus, the average citizen has, I fear, established an uncomfortable relation to science. He tends to think of it as all-powerful and unchallengeable, because ultimately exact and perfect. The really great scientists never fooled themselves on this matter of exactness. Newton would have been the first to welcome and praise the corrections Einstein brought to gravitational theory, for Newton himself, speaking of the check with which he calculated two aspects of the force of gravity—first, as necessary to hold the moon in its orbit and second, as necessary to make an apple fall to the ground —remarked simply, "I found them answer *pretty nearly*."

The fact is that the average citizen tends to fear science, when he should, of course, learn about it, so that it can be an exciting intellectual companion and a useful servant. He tends to think that science is entirely mechanistic, and that its successes in the biological field depress the dignity of the inner man; whereas, as Robert Oppenheimer has said, he should ". . . have known that human life was far too broad, deep, subtle, and rich to be exhausted by anything the scientist would find out in his own field" (*4*).

Rather than pretending to be perfect and ultimate, any scientific theory represents only a stage of progress in successively better approximations. Concerning one of the most basic theories in physics, Oppenheimer said (*4*), ". . . it is a theory which is almost closed, almost self-sufficient, and almost perfect. Yet it has one odd feature: if you try to make it quite perfect, then it is nonsense." I would suggest that an absolutely critical distinction between science and religion may be that science never will and never can actually reach the final goal of perfection, whereas religion can do so and has done so.

The average citizen tends to think that science has destroyed the element of faith in religion; instead, he should realize that science is itself founded on faith. He tends to think that science is an ugly sort of foe of the gentler arts, whereas he should recognize that, as Bronowski has said (*3*, p. 250) "There is a likeness between the creative acts of the mind in art and in science. . . . The scientist or the artist takes two facts or experiences which are separate; he finds in them a likeness which had not been seen before; and he creates a unity by showing the likeness." This discovery of unity is at the center of science, and it is also at the center of art. Whenever Coleridge tried to define beauty he returned to a central deep thought. Beauty, he said, is "unity in variety."

We must all learn to understand this great modern intellectual force, to utilize it properly so that it may serve our lives and enrich our appreciation of the world around us, to respect the abilities of science at the same time that we realize its limitations, to know enough about science to be able intelligently to meet the responsibilities of modern citizenship. "I am strongly of the opinion," wrote Sir Edward V. Appleton, "that it is the scientist's mission not only to uncover nature but also to interpret his results to his fellow men. Scientific knowledge is itself neutral. It is the use that is made of it that is good or evil. Decisions concerning that use are not for the scientist alone. The layman must therefore make his own efforts at understanding. To assist him, the scientist must, in turn, be ready to leave his laboratory to act as a guide."

References and Notes

1. R. L. Heilbroner, "Public Relations; The Invisible Cell," *Harper's Magazine* 214, 23 (June 1957).
2. On the day on which I wrote this sentence I read, in an essay by E. B. White [*The New Yorker* 1957, 43 (27 July 1957)], "I see by the paper this morning that a steel drum containing radioactive sodium waste is floating at sea. . . . The news story says the Atomic Energy Commission has authorized the dumping of radioactive sodium waste in the ocean. I sometimes wonder about these cool assumptions of authority in areas of sea and sky. The sea doesn't belong to the Atomic Energy Commission; it belongs to me."
3. J. Bronowski, "Science and Human Values," *Universities Quart.* 10, No. 3, 247 (1956).
4. R. Oppenheimer, *Phys. Today* 10, No. 7, 12 (July 1957).

National Academy of Sciences

Abstracts of Papers Presented at the Autumn Meeting, 18–20 November 1957, Rockefeller Institute and New York Botanical Garden, New York

Pedigrees of Exconjugants in Escherichia coli K-12

Mating between morphologically distinguishable Hfr and F− bacteria (*Escherichia coli* K-12) has been observed in the light and electron microscopes. [J. Lederberg, *J. Bacteriol.* 71, 497 (1956); E. L. Wollman, F. Jacob, W. Hayes, *Cold Spring Harbor Symposia Quant. Biol.* 21, 141 (1956)]. In order to follow the subsequent details of recombination and segregation, individual couples of conjugating bacteria were isolated with a micromanipulator. After the mates had separated from each other, pedigrees of isolated exconjugants were obtained by isolating successive daughters and analyzing the genetic markers of clones derived from individual fifth to tenth generation bacteria. The Hfr exconjugants divided regularly and formed no recombinants. In contrast, a typical fertile F− exconjugant, in which recombination or segregation, or both, was occurring, divided irregularly to yield many dead bacteria, the F− parental type, F− types with altered morphologies, and a number of different viable recombinant types. The latter did not segregate to give pure clones until after the third, and sometimes not till after the tenth division. These results suggest (i) that the genetic material transferred from an Hfr to an F− bacterium persists in the F− bacterium for a number of divisions during which time it may recombine frequently with the F− genetic material; (ii) that many combinations may be nonviable; and (iii) that many viable recombinants may involve *morphological characters* not utilized in the genetic analysis.

The experiments reported here were carried out in the laboratory of Dr. A. Lwoff at the Institut Pasteur, Paris, while I held a Fulbright research scholarship and a fellowship from the John Simon Guggenheim Memorial Foundation.

THOMAS F. ANDERSON
Johnson Foundation,
University of Pennsylvania

Structure of an Antibiotic Allenic Polyacetylene from the Basidiomycete Drosophila semivestita

Culture liquids of *Drosophila semivestita* contain several polyacetylenes. Among these are two which are closely related to or identical with drosophilins C and D, antibiotic polyacetylenes isolated previously from *Drosophila subatrata*.

For the polyacetylene corresponding to drosophilin C, formula I is proposed on the basis of its ultraviolet and infrared absorption spectra, its behavior with alkali, and analysis of its reduction product.

$$HC{\equiv}C{-}C{\equiv}C{-}CH{=}C{=}CH{-}CH{=}CHCH_2COOH \quad (I)$$

The alkali conversion product is be-