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CHAIRMAN
Norman R. Davidson
Professor and Executive Officer
for Chemistry
Caltech

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MAX DELBRÜCK
Homo Scientificus
According to Beckett

MAX DELBRÜCK
is a professor of biology at Caltech. He began his scientific career in physics, getting his Ph.D. under Max Born and W. Heitler in Göttingen in 1930. He was interested in quantum theory and in nuclear physics. Stimulated by working with Niels Bohr in Copenhagen in 1932, he began to consider the application of principles of physics to biological problems. He came to the United States in 1937 and began his pioneering studies on bacterial viruses, for which he received the Nobel prize in physiology and medicine in 1969.

DAVIDSON: The original title suggested to our speaker by our valiant organizer was "Basic Research Responsibilities." The title submitted by the speaker to the organizer was "*Homo Scientificus* According to Beckett." As far as I know, there are two Becketts in history. One of them was killed in a cathedral and the other won a Nobel prize for writing plays. That's all I know about the seminar and I'm looking forward to hearing it.

DELBRÜCK: In December 1970 Bill Beranek wrote me a letter saying that he wanted one of these sessions devoted to the subject: "The Responsibility of the Scientist to Society with Respect to Pure Basic Research." He added a number of questions, which I will quickly answer, as best I can.

Question 1: Is pure science to be regarded as overall beneficial to society?

Answer: It depends much on what you consider benefits. If you look at health, long life, transportation, communication, education, you might be tempted to say yes. If you look at the enormous social-economic dislocations, at the prospect of an immense famine in India, brought on by the advances of public health science and nutrition science, at strains on our psyches due to the imbalance between technical developments and our limited ability to adjust to the pace of change, you might be tempted to say no. Clearly, the present state of the world—to which science has contributed much—leaves a great deal to be desired, and much to be feared. So I write down:

(1) SCIENCE BENEFICIAL?
DOUBTFUL.

Question 2: Is pure science to be considered as something potentially harmful?

Answer: Most certainly! Every child knows that it is potentially exceedingly harmful. Our lecture series here on environmental problems concerns just a small aspect. The menace of blowing ourselves up by atom bombs, doing ourselves in by chemical or biological warfare, or by population explosion, is certainly with us. I consider the environment thing a trivial question, by comparison—like housekeeping. In any home, the dishes have to be washed, the floors swept, the beds made, and there must be rules as to who is allowed to produce how much stink and noise, and where in the house. When the garbage piles up, these questions become pressing. But they are momentary problems. Once the house is in order, you still want to *live* in it, not just sit around enjoying its orderliness. I would be sorry to see Caltech move heavily into this type of applied research. Again I write:

(2) SCIENCE POTENTIALLY HARMFUL?
DEFINITELY.

Question 3: Should a scientist consider possible ramifications of his research and their effects on society, or is this something not only difficult to do but perhaps better done by others?

Answer: I think it is impossible for anybody, scientist or not, to foresee the ramifications. We might say that that is a *definition* of basic science. *Vide* Einstein's discovery in 1905 of the equivalence of mass and energy and the development of atomic weaponry.

(3) CONSIDER RAMIFICATIONS?
IMPOSSIBLE.

So much for Bill's original questions in December.

I agreed to come to the lectures and then decide whether I thought I had something to contribute. After having listened to a series of lectures on environmental problems, such as lead poisoning, mercury poisoning, on smog, on waste disposal, on fuel additives, and to Dan Kevles' and George Hammond's more general talks, I told Bill that I had found the series interesting and worthwhile but that I felt most uneasy about where I might fit in. So he wrote me another letter. Tenacious guy. With more questions. These again I can answer in short order.

Question 4: Why did you choose science as your life's work?

Answer: I think the most relevant answer that I can give to this question is this: I found out at an early age that science is a haven for the timid, the freaks, the misfits. That is more true perhaps for the past than now. If you were a student in Göttingen in the 1920s and went to the seminar "Structure of Matter" which was under the joint auspices of David Hilbert and Max Born, you could well imagine that you were in a madhouse as you walked in. Every one of the persons there was obviously some kind of a severe case. The least you could do was put on some kind of a stutter. Robert Oppenheimer as a graduate student found it expedient to develop a very elegant kind of stutter, the "njum-njum-njum" technique. Thus, if you were an oddball you felt at home.

(4) WHY SCIENTIFIC CAREER?
A HAVEN FOR FREAKS.

Question 5: What is the history of your research?

Answer: Perhaps the most significant aspect is that it throve under adversity. It throve *best* under adversity. I have two periods in mind. The first was in Germany in the middle 1930s under the Nazis when things became quite unpleasant and official seminars became dull. Many people emigrated; others did not leave but were not permitted to go to official seminars. We had a little private club which I organized and which met about once a week, mostly at my mother's house. First just theoretical physicists (I was at that time a theoretical physicist), and then theoretical physicists and biologists. The discussions we had at that time have had a remarkable long-range effect, an effect that astonished us all. This was one adverse situation. Like the great Plague in Florence in 1348, which is the background setting for Boccaccio's *Decameron*. The second one was in this country in the 1940s during the war. I came over in 1937 and was in this country during the war as an enemy alien. And as an enemy alien I secured a job as an instructor of physics at Vanderbilt University in Nashville, Tennessee. You might think that this was a very unpropitious place to be, but it worked out fine. I spent 7½ years there. This situation gave me, in association with Luria (another enemy alien) and in close contact with Hershey (another misfit in society), sufficient leisure to do the first phase of phage research, which has become a cornerstone of molecular genetics. I would not want to generalize to the extent that adversity is the only

road to effective innovative science, or art, but the progress of science is often spectacularly disorderly. James Joyce once commented that he survived by "cunning and exile" (and, you might add, by a genius for borrowing money from a number of ladies). I got along all right with the head of the Physics Department at Vanderbilt. He wanted me to do as much physics teaching as possible and as little biology research as possible. I had the opposite desires. We understood each other's attitudes and accommodated each other to a reasonable extent. So, things worked out quite well. At the end of the war I was the oldest instructor on the campus.

(5) HISTORY OF YOUR RESEARCH?
THROVE UNDER ADVERSITY.

Question 6: Why do you think society should pay for basic research?

Answer: Did I say that society *should* pay for basic research? I didn't. Society does so to a varying extent, and it always astonishes me that it does. It has been part of the current dogma that basic research is good for society, but I would be the last to be dogmatic about the number of dollars society should put up for this goodness. Since I answered the first question with "doubtful," I cannot very well be emphatic in answer to this one.

(6) SOCIETY PAY FOR RESEARCH?
HOW MUCH?

Question 7: How much control do you feel society should have on deciding which questions you should ask in your research?

Answer: Society can, and does, and must control research enormously, negatively and positively, by selectively cutting off or supplying funds. At present it cuts—not so selectively. That is all right with me, as far as my own research is concerned. I certainly do not think society *owes* me a living or support for my research. If it does not support my research, I can always do something else and not be worse off, perhaps better. However, the question, from society's point of view, is exceedingly complicated. I have no strong views on the matter.

(7) CONTROL OF RESEARCH BY SOCIETY?
A COMPLICATED MATTER, LARGELY OF PROCEDURE.

Question 8: Is there an unwritten scientific oath analogous to the Hippocratic oath which would ask all scientists to use their special expertise and way of thinking to guard against bad effects of science on society, especially today when science is acknowledged to play such a large part in the lives of individuals?

Answer: The original Hippocratic oath, of course, says that you should keep the patient alive under all circumstances. Also that you shouldn't be bribed, shouldn't give poisons, should honor your teachers, and things like that, but essentially to keep the patient alive. And that's a reasonably well defined goal since keeping the patient alive is biologically unambiguous. But to use science for the good of society is not so well defined, therefore I think such an oath could never be written. The only unwritten oath is, of course, that you should be reasonably honest. That is, in fact, carried out to the extent that, although many things you read in the journals are wrong, it is assumed that the author at least believed that he was right. So much so that if somebody deliberately sets out to cheat he can get away with it for years. The number of celebrated cases of cheating or hoaxes would make a long story. But our whole scientific discourse is based on the premise that everybody is *trying* at least to tell the truth, within the limits of his personality; that can be some limit.

(8) HIPPOCRATIC OATH FOR SCIENTISTS?
IMPOSSIBLE TO BE UNAMBIGUOUS.

Question 9: Is science something we do mainly for its own sake, like art or music, or is it something we use as a tool for bettering our physical existence?

Answer: This is a question that turns me on. I think that it bristles with popular misconceptions about the nature of *Homo scientificus*, and therefore maybe I have something to say. Let me start by reading a few passages from an unpublished paper on this species, written in 1942 by a rather preceptive friend, a nonscientist:

The species *Homo scientificus* constitutes a branch of the family *Homo modernibus*, a species easy and interesting to observe but difficult and perplexing to understand.

There are a number of varieties and subvarieties, ranging from the lowliest to the highest. We begin with the humble *professorius scientificus*, whose inclusion in this species is questionable, pass on up through the *geologia* and the large groups of the *chemisto* and *biologia*, with their many hybrids, to the higher orders of the *physicistus* and *mathematicus*, and finally to the lordly *theoretica physicistus*, rarely seen in captivity.

Habitat: These animals range the North American and European continents, and are seldom seen in South America, Africa, or Asia, although a few isolated cases are known in Australia and Russia. [This was written in 1942.] Individuals of the lower orders thrive in most sections of Europe and America but those of the higher orders are to be found only in a few localities, where they live together in colonies. These colonies provide a valuable research field; here one can wander about noting the size, structure, and actions of these peculiar creatures. There is little to fear, for although they may approach one with great curiosity, and attempt to lead one to their lairs, they are not known to be dangerous.

Description: Recent studies of this as-yet-little-understood species have ascertained a number of characteristics by which they may be distinguished. The brain is large and often somewhat soft in spots. In some cases the head is covered with masses of thick, unkempt wool, in others it is utterly devoid of hair and shines like a door-knob. Sometimes there is hair on the face but it never covers the nose. The body covering, when there is any, is without particular color or form, the general appearance is definitely shaggy. The male *scientificus* does not, like the cock or the lion or the bull, delight in flaunting elegantly before the female to catch her eye. Evidently the female is attracted by some other method. We are at a loss as to what this could be, although we have often observed the male scurrying after the female with a wuffley expression on his face. Sometimes he brings her a little gift, such as a bundle of bristles or a bright piece of cellophane, which she accepts tenderly and the trick is done. Occasionally an old king appears from the colony, surrounded by workers. He has soft grey hair on his face, and a pot belly. *Scientificus* is a voracious eater; this is not strange,

for he consumes a great deal of energy each day in playing. In fact, he is one of the best playing animals known.

The *scientificus* undoubtedly have a language of their own. They take pleasure in jabbering to each other and often one will stand several hours before a group, holding forth in monologues; the listeners are for the most part quiet, and some may even be asleep. However meaningful this language may be to them, it is utterly incomprehensible to us. Perhaps the thing which endears this mysterious creature to us most is his disposition; although there exists a kind of slavery (the *laboratorio assistantia* being captured to do the dirty work), the *scientificus* does not prey on other animals of his species and he is neither cruel, sly, nor domineering. [The author had only studied the species for one year at that time.] He is an easygoing animal; he will not, for example, work hard to construct a good dwelling, but is content to live in a damp basement so long as he can spend most of the day sitting in the sun and rummaging among his strange possessions.

The paper then goes on into more detail about the *biologia*. We will let this suffice by way of a general description of *Homo scientificus*. The description is nice as far as it goes, but too superficial.

Now I want to switch gears and read another piece which I think goes to the heart of the matter. This is taken from the novel *Molloy* by Samuel Beckett. Beckett not only wrote plays—"Happy Days," "Krapp's Last Tape," "End Game," and "Waiting for Godot"—but also a number of novels that are less well known. This one, *Molloy*, published in the 1950s, concerns an exceedingly lonely and decrepit old man, and the whole book is a kind of a soliloquy that he writes down about his life. I have picked one episode that I hope will illustrate the point I want to make (without having to rub it in too much). There will be several illustrations to go with this reading so as to make the argument perfectly clear. At the time of this episode Molloy is a beachcomber at some lonely place.

I took advantage of being at the seaside to lay in a store of sucking-stones. They were pebbles but I call them stones. Yes, on this occasion I laid in a considerable store. I distributed them equally among my four pockets, and sucked them turn and turn about. This raised a problem which I first solved in the following way. I had say sixteen stones.



four in each of my four pockets these being the two pockets of my trousers and the two pockets of my greatcoat. Taking a stone from the right pocket of my greatcoat, and putting it in my mouth, I replaced it in the right pocket of my greatcoat by a stone from the right pocket of my trousers, which I replaced by a stone from the left pocket of my trousers, which I replaced by a stone from the left pocket of my greatcoat, which I replaced by the stone which was in my mouth, as soon as I had finished sucking it. Thus there were still four stones in each of my four pockets, but not quite the same stones. And when the desire to suck took hold of me again, I drew again on the right pocket of my greatcoat, certain of not taking the same stone as the last

time. And while I sucked it I rearranged the other stones in the way I have just described. And so on. But this solution did not satisfy me fully. For it did not escape me that, by an extraordinary hazard, the four stones circulating thus might always be the same four. In which case, far from sucking the sixteen stones turn and turn about, I was really only sucking four, always the same, turn and turn about. But I shuffled them well in my pockets, before I began to suck, and again, while I sucked, before transferring them, in the hope of obtaining a more general circulation of the stones from pocket to pocket. But this was only a makeshift that could not long content a man like me. So I began to look for something else. And the first thing I hit upon was that I might do better to transfer the stones four by four, instead of one by one, that is to say, during the sucking, to take the three stones remaining in the right pocket of my greatcoat and replace them by the four in the right pocket of my trousers, and these by the four in the left pocket of my trousers, and these by the four in the left pocket of my greatcoat, and finally these by the three from the right pocket of my greatcoat, plus the one, as soon as I had finished sucking it, which was in my mouth. Yes, it seemed to me at first that by so doing I would arrive at a better result. But on further reflection I had to change my mind and confess that the circulation of the stones four by four came to exactly the same thing as their circulation one by one. For if I was certain of finding each time, in the right pocket of my greatcoat, four stones totally different from their immediate predecessors, the possibility nevertheless remained of my always chancing on the same stone, within each group of four, and consequently of my sucking, not the sixteen turn and turn about as I wished, but in fact four only, always the same, turn and turn about. So I had to seek elsewhere than in the mode of circulation. For no matter how I caused the stones to circulate, I always ran the same risk. It was obvious that by increasing the number of my pockets I was bound to increase my chances of enjoying my stones in the way I planned, that is to say one after the other until their number was exhausted . . . I should have needed sixteen pockets in order to be quite easy in my mind. And for a long time I could see no



pockets, each with its stone, I could never reach the goal I had set myself, short of an extraordinary hazard. And if at a pinch I could double the number of my pockets, were it only by dividing each pocket in two, with the help of a few safety-pins, let us say, to quadruple them seemed to be more than I could manage. And I did not feel inclined to take all that trouble for a half-measure. For I was beginning to lose all sense of measure, after all this wrestling

and wrangling, and to say, All or nothing. And if I was tempted for an instant to establish a more equitable proportion between my stones and my pockets, by reducing the former to the number of the latter, it was only for an instant. For it would have been an admission of defeat. And sitting on the shore, before the sea, the sixteen stones spread out before my eyes, I gazed at them in anger and perplexity . . . And while I gazed thus at my stones, revolving interminable martingales all equally defective, and crushing handfuls of sand, so that the sand ran through my fingers and fell back on the strand, yes, while thus I lulled my mind and part of my body, one day suddenly it dawned on the former, dimly, that I might perhaps achieve my purpose without increasing the number of my pockets, or reducing the number of my stones, but simply by sacrificing the *principle of trim*. The meaning of this illumination, which suddenly began to sing within me, like a verse of Isaiah, or of Jeremiah, I did not penetrate at once, and notably the word trim, which I had never met with, in this sense, long remained obscure. Finally I seemed to grasp that this word trim could not here mean anything else, anything better, than the distribution of the sixteen stones in four groups of four, one group in each pocket, and that it was my refusal to consider any distribution other than this that had vitiated my calculations until then and rendered the problem literally insoluble. And it was on the basis of this interpretation, whether right or wrong, that I finally reached a solution, inelegant assuredly, but sound, sound. Now I am willing to believe, indeed I firmly believe, that other solutions to this problem might have been found, and indeed may still be found, no less sound, but much more elegant than the one I shall now describe, if I can. And I believe too that had I been a little more insistent, a little more resistant, I could have found them myself. But I was tired, but I was tired, and I contented myself ingloriously with the first solution that was a solution, to this problem. But not to go over the heartbreaking stages through which I passed before I came to it, here it is, in all its hideousness. All (all!) that was necessary was to put for example, to begin with, six stones in the right pocket of my greatcoat, or supply-pocket, five in the right pocket of my trousers, and five in



the left pocket of my trousers, that makes the lot, twice five ten plus six sixteen, and none, for none remained, in the left pocket of my greatcoat, which for the time being remained empty, empty of stones that is, for its usual contents remained, as well as occasional objects. For where do you think I hid my vegetable knife, my silver, my horn, and the other things that I have not yet named, perhaps shall never name. Good. Now I can begin to suck. Watch me closely. I take a stone from the right pocket of my greatcoat, suck it, stop sucking it, put it in the left pocket

of my greatcoat, the one empty (of stones). I take a second stone from the right pocket of my greatcoat, suck it, put it in the left pocket of my greatcoat. And so on until the right pocket of my greatcoat is empty (apart from its usual and casual contents) and the six stones I have just sucked, one after the other, are all in the left pocket of my greatcoat. Pausing then, and concentrating, so as not to make a balls of it, I transfer to the right pocket of my greatcoat, in which there are no stones left, the five stones in the right pocket of my trousers, which I replace by the five stones in the left pocket of my greatcoat. At this stage then the left pocket of my greatcoat is again empty of stones, while the right pocket of my greatcoat is again supplied, and in the right way, that is to say with other stones than those I have just sucked . . . Do I have to go on? No, for it is clear that after the next three series, of sucks and transfers, I shall be back where I started, that is to say with the first six stones back in the supply-pocket, the next five in the right pocket of my stinking old trousers, and finally the last five in the left pocket of same, and my sixteen stones will have been sucked once at least in impeccable succession, not one sucked twice, not one left unsucked. It is true that the next time I could scarcely hope to suck my stones in the same order as the first time and that the first, seventh, and twelfth for example, of the first cycle, might very well be the sixth, seventh and sixteenth, respectively, of the second, if the worst came to the worst. But that was a drawback I could not avoid. And if in the cycles taken together utter confusion was bound to reign, at least within each cycle taken separately I could be easy in my mind, at least as easy as one can be, in a proceeding of this kind . . . But however imperfect my own solution was, I was pleased at having found it all alone; yes, quite pleased. And if it was perhaps less sound than I had thought in the first flush of discovery, its inelegance never diminished. And it was above all inelegant in this, to my mind, that the uneven distribution was painful to me, bodily . . . I felt the weight of the stones dragging me now to one side, now to the other. So it was something more than a principle I abandoned, when I abandoned the equal distribution, it was a bodily need. But to suck the stones in the way I have described, not haphazard, but with method, was also, I think,

a bodily need. Here then were two incompatible bodily needs, at loggerheads. Such things happen. But deep down I didn't give a tinker's curse about being off my balance, dragged to the right hand and the left backwards and forwards. And deep down it was all the same to me whether I sucked a different stone each time or always the same stone, until the end of time. For they all tasted exactly the same. And if I had collected sixteen, it was not in order to ballast myself in such and such a way, or to suck them turn about, but simply to have a little store, so as never to be without. But deep down I didn't give a fiddler's curse about being without, when they were all gone they would be all gone, I wouldn't be any worse off, or hardly any. And the solution to which I rallied in the end was to throw away all the stones but one, which I kept now in one pocket, now in another and which of course, I soon lost, or threw away, or gave away, or swallowed.

This is the parable of the *Homo scientificus* that I wanted to present. I want to stress two particular things in it. One is the uncanny description of scientific intuition. This is exactly the way Einstein must have struggled to explain the failure of all experiments attempting to demonstrate a motion of the earth relative to the "light-medium," until he very dimly realized that he had to abandon some "principle of trim," the principle of absolute time, and this must have come in some such way as here described. Other people have described intuition in cases where they were able to reconstruct a little of it. Jacques Hadamard, the French mathematician, has written a little book, *An Essay on the Psychology of Invention in the Mathematical Field*, which is a collection of data on this phenomenon and describes how intuition wells up from completely unfathomable depths, first appears in a peculiar guise, and then suddenly breaks out with lightning clarity.

Second, let us look at Molloy's motivation. He certainly is not motivated by the goal of bettering our physical existence or desire for fame or acclaim. Does he do his work "for its own sake," "like art and music"? He describes in detail how his little game "for its own sake" becomes an obsession, beyond all measure of reason. This is not the way you and I do art or music, but it does resemble closely the way the *creative* artist and composers do it. You don't have to look at Beethoven to become convinced of that. Look at any child of

five who is obsessed with a creative problem and breaks out in anger and frustration at his failures.

This obsessive fixation picks on anything, quite oblivious of its meaningful content of "revealing the truth about nature" or "bettering our physical existence." It is this quirk of our makeup, this sublimation of other psychic forces, that was delivered by evolution to cave man. More was here delivered by evolution than had been ordered. It carried us from cave man to space man, and may well carry us to our destruction. And why not? The little earthquake we had the other day should have served all of us as a timely reminder, if any reminding is needed, that we are not here to stay, not as individuals, nor as families, nor as nations, nor as the human race, nor as a planet with life on it. There is uncertainty merely as to the time scale.

The point I want to make is this. Man is not only *Homo faber*, the tool maker. The grand edifice of Science, built through the centuries by the efforts of many people in many nations, gives you the illusion of an immense cathedral, erected in an orderly fashion according to some master plan. However, there never was a master plan. The edifice is a result of channeling our intellectual obsessive forces into the joint program. In spite of this channeling, the progress of science at all times has been and still is immensely disorderly for the very reason that there can be no master plan.

So, what could we do if we decided that innovative science is too dangerous? I don't know, but one thing is certain: it would take a lot of manipulation of man—political, economic, nutritional, genetic—if you tried to control *Homo scientificus*.

| Discussion |

QUESTION: Returning to the third question, how can man with the characteristics you just mentioned resist considering implications of his work? This doesn't mean solving them—just considering them.

DELBRÜCK: I understood the question to mean: If I make a discovery, should I consider the implications and maybe not publish it even if it's a basic discovery? I think that it is impossible to foretell the implications. I couldn't agree more that you should *consider* the implications, say, of the genetic manipulation of mankind. You can't help it. It's of the utmost importance. Same with "zero population." I just don't consider this as the same thing as doing science,

this business of considering the implications . . . It's something entirely different, as I explained in answer to the second question.

QUESTION: It seems to me that many human beings are subject to neurotic obsession. But it's not clear how we, as scientists, choose problems. It seems to me conceivable that you might choose a problem because somebody tells you that it's an important problem for science. You can get upset about "why the hell can't I solve it" even if you don't care about the problem.

DELBRÜCK: I agree. Science gives the impression of being a magnificent cathedral, an enormous structure—a well-constructed thing, a cathedral built by the continuous effort of many generations through many centuries. Of course it isn't a cathedral because it wasn't planned. Nobody planned the scientific cathedral. To the student it looks as though it were planned. The student gets three volumes of Feynman lectures, 1300 pages of a splendid textbook titled *Organic Chemistry*, and other textbooks, and says "Aha! 150 years ago today they got this far. In the meantime all this was constructed, and now I continue here." My point is, that science is not that at all. Science is primarily playing willfully, and getting obsessed with it, and it is *not* being told: "Here, add your brick on page 1065 and do it properly or we won't give you a Ph. D." Such a student, if you ask him what he is doing, may possibly answer, "I am building a cathedral." More likely, he will say, "I am laying bricks," or even "I am making \$4.50 an hour."

QUESTION: Should we not think about how much society should support science?

DELBRÜCK: Oh, I don't want to think about it. It's a very complicated thing. Obviously the high-energy physicists want ever bigger machines that cost a hundred million, billion, etc., and they say the military spend more and the military say if we stop making war the economy will break down. These are all questions that are not very interesting. To me, anyway.

QUESTION: Would you be willing to relax a little bit on your attitude with respect to question 1, the question whether science is beneficial? Would you say this depends on how you define beneficial?

DELBRÜCK: Certainly. If we measure it in terms of energy production or infant mortality, then it's beneficial.

QUESTION: Well, I think it's very difficult to say what *is* beneficial.

DELBRÜCK: Yes, That's why I put a "doubtful" there. I didn't answer "no."

QUESTION: Most of the problem with science is that we don't even know what's beneficial to society.

DELBRÜCK: However, we can hardly evade the fact that the present state of the world leaves much to be desired, and that this is largely a result of the efforts of people like Molloy.

QUESTION: Then one might talk about whether the earlier stage of the world was an awful lot better.

DELBRÜCK: Of course you can. Please do. I don't feel like arguing.

QUESTION: Do you think it is common that scientists proceed in a way that is neurotic? Don't you think that occasionally they do something just because it's interesting?

DELBRÜCK: I didn't mean to use the term neurotic in a derogatory way. Our culture is a product of our neuroses—I mean a product of the diversion of psychic forces from their original function into other directions.

QUESTION: How could you do your research with such a pessimistic attitude? Did you have the same attitude when you started out?

DELBRÜCK: I can't answer that—how I was 40 years ago. If you call it pessimistic, I'm a very cheerful pessimist. I think there's something to be said for the pessimist. It merely means not glossing over some basic facts.

QUESTION: Your picture of a scientist is very personal, so your answer to the first question, "Is science beneficial?", should be "Yes, it's beneficial to the doer." Molloy's pebbles were the same to him as special relativity was to Einstein and the hydrogen bomb to Edward Teller. The difference is that Molloy wasn't going to hurt anybody. Now, if you say that science is beneficial to the scientist because he gets satisfaction from it, and the scientist isn't thinking about the implications, does this imply that somebody else should think about the implications and say, "Molloy, you're OK; Einstein, you're doubtful; Teller, you're out"? Who should make these decisions?

DELBRÜCK: My point was that that's quite impossible. Molloy and Einstein are identical. Einstein worried about relative motion experiments and came up with a solution of the paradoxes which implied, incidentally, an equivalence of mass and energy. This was just as esoteric as shuffling around the sucking stones. I mean that nothing could be more impersonal, impractical, more remote from any social implications than what Einstein did in 1905. To him, anyhow. Later, when the atomic arms race escalated one more round, and Einstein considered that he had been involved in their

starting the atom bomb, both by inventing relativity in 1905 and by writing to Roosevelt in 1939, he regretted that he had ever entered science, but I don't think he really had thought about how deeply science is part of human nature. I think discoveries are all potentially equally harmful. Like the circulating of the sucking stones. Maybe Molloy is discovering a principle of permutation or number theory—God only knows the implications of this. Didn't the pictures look like some of the metal organic covalent bond shifting there? Didn't Harry Gray get an inspiration from it for something that's going to be utilized in some horrible contraption in a few years?

QUESTION: Can you draw a distinction in terms of creativity between Einstein thinking up ideas and Edward Teller making bombs—one being playful and the other being purposeful?

DELBRÜCK: I don't have to make this distinction because, if I want to control the bad effects of science, I have to stop Einstein. Why should I try to make a distinction between him and Teller? Teller is an excellent scientist. Although I don't know what he specifically did with the H-bomb, he certainly contributed a great deal to quantum mechanics and chemical physics. So then the question is: Should the scientist stop publishing his science so that the bad appliers won't misuse it? Have a private club? I used to have a slide of a poster I found at MIT, a poster with a quotation from Einstein saying how sorry he was that he had ever, etc., and that if he could start life again he would just become a lighthouse keeper or something like that. Underneath on this poster there was an invitation from somebody saying: "Will you join us in a commune of scientists who will talk among ourselves and not publish anything—just do it by ourselves?" And somebody had scrawled on the side: "Commie." The idea of doing science in a commune and not publishing it seems absurd to me. Why should we get together to follow these pursuits which are not really pleasurable? Molloy had a certain relief and was satisfied that he had found a solution, but the main thing for him was that he was easy in his mind. As easy as one can be in a matter of this kind; suck them turn and turn about. I mean, he had to relieve the uneasiness of his mind. That's where the neurosis comes in—the obsession.

QUESTION: I've been uneasy without being able to articulate it very well, because it seems to me that you say something about the personal obsessions of scientists and the irrelevance of the goal or consideration of a moral principle in their work. I think it's probably

only a half-truth. Einstein was a deeply moral man, very concerned. I have a feeling that scientists in their work are buoyed and reinforced by the belief that the answer to question 1 is "yes."

DELBRÜCK: Yes, of course you can be buoyed by the feeling that you've done society good; you can be buoyed by the feeling that you're acquiring fame and prizes. My point is this: Prior to these reinforcements, and more fundamental, even the only, decrepit beachcomber cannot avoid being a scientist, in an obsessive way (exactly the way Einstein was), although both the accessory components are missing. As for Einstein as a young patent clerk in Berne, in 1905, I doubt that he then made a connection between his physics and his responsibilities to society. That's the point I wanted to make. Thank you for making me point it out again. I mean these other components are there, of course, and if you read Jim Watson's book *The Double Helix*, you might think that getting a Nobel prize is everything. However, this would be a grievous misconception.

QUESTION: How many scientists on a desert island would do science for their own benefit?

DELBRÜCK: Even Molloy would. But not for their benefit. He doesn't do it for his benefit. He does it compulsively. I think we all do. No, I take it back. Maybe not. It's a difficult question to answer because most of us are so dulled in our sensitivities that we may be quite incapable of any such complicated argument or reasoning or have the amount of relaxation that this man had. Of course, he had to be able to sit there for hours on the beach and dream up interminable martingales. If you put people on a desert island, probably quite a few of them would dream up interminable martingales and be satisfied with finding something that works.

QUESTION: I wonder if the one place where this parallel between Molloy and other scientists doesn't hold is that Molloy doesn't seem to have any intentions of communicating his results to anyone else. Do you think Einstein would have done his work if he had had no intention of publishing the results? And a personal question: Would you have done science if you had thought no one would be interested in the results?

DELBRÜCK: No, certainly not. In this first essay from which I quoted, by the Scripps girl, it said that scientists are *playing* animals. They not only play alone but they also play together, and if they are not too morose, they actually prefer to play together. And most scientists do prefer to play together. In the case of Einstein, of course, he would

never have heard of the paradoxes of prerelativistic physics if he had not been in communication. No, a great joy of the business is communication. All I wanted to point out is the obsessive component of the immediate act of doing science. The channeling of this component toward the erection of a large structure, the institutionalization of it, that is a creation by society and that is something different. That is not a primary characteristic of *Homo scientificus*.