

Teaching and the Expanding Knowledge

The simplification that comes with expanding knowledge enables teaching to encompass this knowledge.

Albert Szent-Györgyi

Our attempt to harmonize teaching with expanding—or rather exploding—knowledge would be hopeless should growth not entail simplification. I will dwell on this sunny side. Knowledge is a sacred cow, and my problem will be how we can milk her while keeping clear of her horns.

One of my reasons for being optimistic is that the foundations of nature are simple. This was brought home to me many years ago when I joined the Institute for Advanced Studies in Princeton. I did this in the hope that by rubbing elbows with those great atomic physicists and mathematicians I would learn something about living matters. But as soon as I revealed that in any living system there are more than two electrons, the physicists would not speak to me. With all their computers they could not say what the third electron might do. The remarkable thing is that it knows exactly what to do. So that little electron knows something that all the wise men of Princeton don't, and this can only be something very simple. Nature, basically, must be much simpler than she looks to us. She looks to us like a coded letter for which we have no code. To the degree to which our methods become less clumsy and more adequate and we find out nature's code, things must become not only clearer, but very much simpler, too.

Science tends to generalize, and generalization means simplification. My own science, biology, is today not only

very much richer than it was in my student days, but is simpler, too. Then it was horribly complex, being fragmented into a great number of isolated principles. Today these are all fused into one single complex with the atomic model in its center. Cosmology, quantum mechanics, DNA and genetics, are all, more or less, parts of one and the same story—a most wonderful simplification. And generalizations are also more satisfying to the mind than details. We, in our teaching, should place more emphasis on generalizations than on details. Of course, details and generalizations must be in a proper balance: generalization can be reached only from details, while it is the generalization which gives value and interest to the detail.

After this preamble I would like to make a few general remarks, first, about the main instrument of teaching: books. There is a widely spread misconception about the nature of books which contain knowledge. It is thought that such books are something the contents of which have to be crammed into our heads. I think the opposite is closer to the truth. Books are there to keep the knowledge in while we use our heads for something better. Books may also be a better place for such knowledge. In my own head any book-knowledge has a half-life of a few weeks. So I leave knowledge, for safe-keeping, to books and libraries and go fishing, sometimes for fish, sometimes for new knowledge.

I know that I am shockingly ignorant. I could take exams in college but could not pass any of them. Worse than that: I treasure my ignorance; I feel snug in it. It does not cloud my

naiveté, my simplicity of mind, my ability to marvel childishly at nature and recognize a miracle even if I see it every day. If, with my 71 years, I am still digging on the fringes of knowledge, I owe it to this childish attitude. "Blessed are the pure in heart, for they shall see God," says the Bible. "For they can understand Nature," say I.

I do not want to be misunderstood—I do not depreciate knowledge, and I have worked long and hard to know something of all fields of science related to biology. Without this I could do no research. But I have retained only what I need for an understanding, an intuitive grasp, and in order to know in which book to find what. This was fun, and we must have fun, or else our work is no good.

My next remark is about time relations. The time spent in school is relatively short compared to the time thereafter. I am stressing this because it is widely thought that everything we have to know to do our job well we have to learn in school. This is wrong because, during the long time which follows school, we are apt to forget, anyway, what we have learned there, while we have ample time for study. In fact, most of us have to learn all our lives, and it was with gray hair that I took up the study of quantum mechanics, myself. So what the school has to do, in the first place, is to make us learn how to learn, to whet our appetites for knowledge, to teach us the delight of doing a job well and the excitement of creativity, to teach us to love what we do, and to help us to find what we love to do.

My friend Gerard quoted Fouchet as advising us to take from the altar of knowledge the fire, not the ashes. Being of more earthly disposition, I would advise you to take the meat, not the bones. Teachers, on the whole, have a remarkable preference for bones, especially dry ones. Of course, bones are important, and now and then we all like to suck a bit on them, but only after having eaten the meat. What I mean to say is that we must not *learn* things, we must *live* things. This is true for almost everything. Shakespeare and all of literature must be *lived*, music, paintings, and sculptures have to be *made*, drama has to be *acted*. This is even true for history: we should live through it, through the spirit of the various periods, instead of storing their data. I am glad to say

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that this trend—to live things—is becoming evident even in the teaching of science. The most recent trend is not to *teach* the simpler laws of nature, but to make our students *discover* them for themselves in simple experiments. Of course, I know data are important. They may be even interesting, but only after we have consumed the meat, the substance. After this we may even become curious about them and retain them. But taught before this they are just dull, and they dull, if not kill, the spirit.

It is a widely spread opinion that memorizing will not hurt, that knowledge does no harm. I am afraid it may. Dead knowledge dulls the spirit, fills the stomach without nourishing the body. The mind is not a bottomless pit, and if we put in one thing we might have to leave out another. By a more live teaching we can fill the soul and reserve the mind for the really important things. We may even spare time we need for expanding subjects.

Such live teaching, which fills both the soul and the mind, may help man to meet one of his most formidable problems, what to do with himself. The most advanced societies, like ours, can already produce more than they can consume, and with advancing automation the discrepancy is increasing rapidly. We try to meet the challenge by producing useless things, like armaments. But this is no final answer. In the end we will have to work less. But then, what will we do with ourselves? Lives cannot be left empty. Man needs excitement and challenge, and in an affluent society everything is within easy reach. And boredom is dangerous, for it can easily make a society seek excitement in political adventure and in brinkmanship, following irresponsible and ignorant leaders. Our own society has recently shown alarming

signs of this trend. In a world where atomic bombs can fly from one end to the other in seconds, this is tantamount to suicide. By teaching live arts and science, the schools could open up the endless horizons and challenges of intellectual and artistic life and make whole life an exciting adventure. I believe that in our teaching not only must details and generalizations be in balance, but our whole teaching must be balanced with general human values.

I want to conclude with a few remarks on single subjects, first, science. Science has two aspects: it has to be part of any education, of humanistic culture. But we also have to teach science as preparation for jobs. If we distinguish sharply between these two aspects then the talk about the "two cultures" will lose its meaning.

A last remark I want to make is about the teaching of history, not only because it is the most important subject, but also because I still have in my nostrils the acid smell of my own sweat which I produced when learning its data. History has two chapters: National History and World History. National history is a kind of family affair and I will not speak about it. But what is world history? In its essence it is the story of man, how he rose from his animal status to his present elevation. This is a fascinating story and is linked to a limited number of creative men, its heroes, who created new knowledge, new moral or ethical values, or new beauty. Opposing this positive side of history there is a negative, destructive side linked to the names of kings, barons, generals, and dictators who, with their greed and lust for power, made wars, fought battles, and mostly created misery, destroying what other men had built. These are the heroes of the history we teach at

present as world history. Not only is this history negative and lopsided, it is false, too, for it omits the lice, rats, malnutrition, and epidemics which had more to do with the course of things than generals and kings, as Zinsser ably pointed out. The world history we teach should also be more truthful and include the stench, dirt, callousness, and misery of past ages, to teach us to appreciate progress and what we have. We need not falsify history; history has a tendency to falsify itself, because only the living return from the battlefield to tell stories. If the dead could return but once and tell about their ignominious end, history and politics would be different today. A truer history would also be simpler.

As the barriers between the various sciences have disappeared, so the barriers between science and humanities may gradually melt away. Dating through physical methods has become a method of research in history, while x-ray spectra and microanalysis have become tools in the study of painting. I hope that the achievements of human psychology may help us, also, to rewrite human history in a more unified and translucent form.

The story of man's progress is not linked to any period, nation, creed, or color, and could teach to our youngsters a wider human solidarity. This they will badly need when rebuilding political and human relations, making them compatible with survival.

In spite of its many chapters, our teaching has, essentially, but one object, the production of men who can fill their shoes and stand erect with their eyes on the wider horizons. This makes the school, on any level, into the most important public institution and the teacher into the most important public figure. As we teach today, so the morrow will be.