THE GREAT IDEAS ONLINE

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Heisenberg was famous for the Heisenberg "Uncertainty Principal" in which one could either know the position of an electron moving about an atom or its velocity, but not both simultaneously.

Dr. Heisenberg was scheduled to give a lecture at MIT. He was running late and so he was speeding through Cambridge in his rental car.

A police officer pulled him over and asked, "Do you know how fast you were going?"

"No," replied Heisenberg, "but I know where I am."

—Submitted by **Ken Dzugan**

Werner Karl Heisenberg

(1901–1976)

A SCIENTIST'S CASE FOR THE CLASSICS

Werner Heisenberg
Nobel Prizewinner for Physics

The man sometimes described as Einstein's successor tells why a sound training in the Greek philosophers is the most practical sort of education for a scientist—and how he first discovered them while serving as a schoolboy soldier against Communist rebels.

Many people are asking today whether a classical education is not too theoretical or unworldly—whether in our age of technology and science a more "practical" education would not be much more suited to equip us for life. I cannot deal with this question fundamentally, for I am not a teacher nor have I been particularly concerned with education. My own experience may be of some interest, however, since I had a classical education myself and later on devoted most of my work to science.

What are the arguments which defenders of the humanities usually produce for concentrating on ancient languages and ancient history? In the first place, they rightly point out that our whole cultural life, our actions, our thoughts, and our feelings are steeped in the spiritual roots of the West—in that attitude of mind which in ancient times was brought into being by Greek art, Greek poetry, and Greek philosophy. With the rise of Christianity, and with the formation of the Church, a great change took place; and finally at the end of the Middle Ages, there occurred the tremendous fusion of Christian piety with the freedom of spirit of antiquity. The world, as God's world, was radically altered by voyages of discovery, by science, and by technology. In every sphere of modern life whenever we look at the roots of things—whether methodologically, historically, or philosophically—we encounter those creations of the spirit which arose in antiquity and in Christianity. Thus we may say in favor of a classical education that it is always good to know the sources of our culture, even if they have few practical uses.

Secondly, we must stress the fact that the whole strength of our Western civilization, is derived, and always has been, from the close relationship between the way in which we pose our questions and our practical actions. Other peoples were just as experienced as the Greeks in the sphere of practical action—but what always distinguished Greek thought from that of all others was its ability

to change the questions it asked into questions of principle. Thus it could arrive at new points of view which impose order on the colorful kaleidoscope of experience and make it accessible to human thought.

It is this which made Greek thought unique. Even during the rise of the West at the time of the Renaissance, this habit of mind stood at the mid-point of our history, and produced modern science and technology. Whoever delves into the philosophy of the Greeks will encounter at every step this ability to pose questions of principle; in this way he can learn to command the strongest tool produced by Western thought. Finally, it is justly said that a concern with antiquity creates a sense of judgment in which spiritual values are prized higher than material ones. It is precisely in the tradition of Greek thought that the primacy of the spirit emerges clearly. Today some people might take exception to this fact. They might say that our age has demonstrated that *only* material power, raw materials, and industry are important, that physical power is stronger than spiritual might. It would follow, then, that it is not in the spirit of the times to teach our children respect for spiritual rather than material values.

DEBATES WITH LUNCH

But I am reminded of a conversation I had some thirty years ago in the courtyard of our university in Munich. At the time the city was in the throes of a revolution, and the inner town was occupied by the Communists. I, then a seventeen-year-old boy, and some of my school comrades had been assigned as auxiliaries to a military unit which had its headquarters opposite the university, in the theological seminary. Why all this happened is no longer quite clear to me, but it is probable that we found those weeks of playing at soldiers a very pleasant interruption of our lessons at the Maximilian Gymnasium.

In the Ludwig Strasse there was occasional, if not very heavy, shooting. Every noon we fetched our meals from a field kitchen in the university courtyard. On one such occasion we had a long argument with a theology student, debating whether these minor revolutionary struggles in Munich had any meaning. One of my younger schoolmates said emphatically that questions of power could never be settled by spiritual means—by speeches or by writing—but that force and force alone could lead to a real settlement of our conflicts with others.

The theology student replied that in the final analysis even the questions of what was meant by “we” and “the others,” and of

what distinguished the two, would obviously lead to a purely spiritual decision. He argued that in all probability we should gain a great deal if we could settle this question more reasonably than was commonly the case.

We could *hardly* object to this. Once an arrow has left the bow, only a stronger force can divert it from its path—but its original direction was determined by the one who aimed it; and without the presence of a spiritual being with an aim, it would never have been able to start on its flight. Consequently, we could do far worse than teach our youth not to undervalue the spiritual.

WAKING UP TO THE WORLD

My first real encounter with science occurred at the Maximilian Gymnasium. Most schoolboys are introduced to technology and science when they begin to play with instruments. By copying the example of a fellow pupil, or by playing with Christmas presents, or occasionally even through *school* lessons, they begin to have a desire to handle small engines and perhaps even to build one. This is precisely what I did with great enthusiasm during the first five years of my life at high school.

This activity would probably have remained a mere game and would not have led me to real science, if another event had not also occurred. At the time, we were being taught the basic axioms of geometry. First I felt this to be very dry stuff: triangles and rectangles do not kindle one's imagination, as do Hewers and poets. But suddenly one day, our best mathematics teacher, Wolff by name, introduced us to the idea that one could formulate generally valid propositions from these figures, and that some results—quite apart from their demonstrable geometric properties—could also be proved mathematically. The thought that mathematics somehow corresponded to the structures of our experience struck me as extraordinarily strange and exciting.

What had happened to me was what happens only too rarely with the intellectual gifts which are presented to us at school. Classroom lessons generally allow the different landscapes of the world of the mind to pass by our eyes without quite letting us become at home in them. According to the teacher's abilities, they illuminate these landscapes more or less brightly and we remember the pictures for a shorter or a longer time. However, very occasionally, an object that has thus come into our field of view will suddenly begin to shine in its own light first, dimly and vaguely, then ever more brightly, until finally it will glow through our entire mind, spill over to other subjects, and eventually become an important part of

our own life. This happened in my case with the realization that mathematics fitted the things in our experience—a realization which, as I learned at school, had already been made by the Greeks, by Pythagoras and by Euclid.

At first, stimulated by Herr Wolff's lessons, I tried out this application of mathematics for myself and I found that this game which went on between mathematics and immediate perception was at least as amusing as most other games. Later on, I discovered that geometry alone was no longer adequate for this mathematical game which had given me so much pleasure. From some books I managed to learn that the behavior of some of my homemade instruments also could be described by mathematics. I now began to read voraciously in somewhat primitive mathematical textbooks, in order to get the mathematics, especially the differential and integral calculus, needed for the description of physical laws.

In all this I saw the achievements of modern times—of Newton and his successors—as the immediate consequence of the efforts of the Greek mathematicians and philosophers. In fact, they were all seen as one and the same thing and never once did it occur to me to consider that the science and technology of our times represented a world basically different from that of the philosophy of Pythagoras or Euclid.

ATOMS WITH HOOKS AND EYES

Although in my youthful ignorance I was not fully aware of it, this enjoyment of the mathematical description of nature had introduced me to the basic trait of all Western thought: the fundamental inter-relationship between the way in which we pose questions and practical action. Mathematics is, so to speak, the language in which the questions are posed and answered—but the questions themselves are concerned with processes in the practical material world. Geometry, for instance, was designed for measuring agricultural land. Because of all this, I remained far more interested in mathematics than in science or instruments during most of my life at school. It was only in the two upper classes that I acquired a new liking for physics, oddly enough because of a fortuitous encounter with a part of modern physical theory. At the time we used a rather good physics textbook in which, quite understandably, modern physics was treated in a somewhat offhand manner. However, the last few pages dealt briefly with atoms, and I distinctly remember one illustration. The picture was meant to represent on a small scale the state of a gas. Some of the atoms were clustered in groups and were connected by means of hooks and eyes, supposed to represent their chemical bonds. But the text itself stated that, accord-

ing to the concepts of the Greek philosophers, atoms were the smallest indivisible building stones of matter.

I was greatly put off by this illustration, and I was enraged by the fact that such idiotic things should be presented in a textbook of physics. I thought that if atoms were indeed such structures as this book made out—if their structure was complicated enough for them to have hooks and eyes—then they could not possibly be the smallest indivisible building stones of matter.

In my criticisms I was supported by a friend from my youth club with whom I had gone on many hiking expeditions, and who was much more interested in philosophy than I was. This friend, who had read some essays on atomic theory in ancient philosophy, had also unexpectedly come across a textbook of modern atomic physics where he had seen visual models of atoms. This had led him to the firm conviction that the whole of modern atomic physics was false and he tried to convince me that he was right. At that time our judgments were obviously very much rasher and more dogmatic than they are today. I had to agree with him that these visual models of atoms were indeed false, but I reserved the right to look for the mistakes in the illustrators, rather than in the theory.

In any case, I wanted to become better acquainted with atomic physics, and here another accident was an unexpected help. At the time we had just started reading one of Plato's dialogues, but because of the troubles in Munich school lessons were irregular. Our military unit had no rigid plan of work, far from it; the danger of lounging about was very much greater than that of over-exertion. In addition, we had to be prepared to be called even at night, and thus we were without any control by parents or teachers.

It was then July 1919, and a warm summer. Shortly after sunrise, I would often withdraw onto the roof of the theological seminary and lie down there to warm myself in the sun, any old book in my hand, or I would sit on the edge of the roof and watch the day beginning in the Ludwig Strasse.

On one such occasion, it occurred to me to take a volume of Plato onto the roof, wanting to read something other than the assigned school lessons. With my somewhat modest knowledge of Greek, I came upon the dialogue called "Timaeus," where for the first time and from the original source, I read something about Greek atomic philosophy. This lecture made the basic thoughts of atomic theory much clearer to me than they had ever been before. I believed, at least, that now I understood something of the reasons which had

caused Greek philosophy to think of these smallest indivisible building stones of matter. True, I did not feel Plato's thesis in "Timaeus"—that atoms are regular bodies—to be fully convincing, but at least I was satisfied to learn that they did not have hooks and eyes. In any case, at that time I was becoming convinced that one could hardly make progress in modern atomic physics without a knowledge of Greek natural philosophy, and I thought that our illustrator of the atomic model would have done well to make a careful study of Plato before drawing his pictures.

THE TWO-HEADED STREAM

Without properly knowing how, I had become acquainted with the great thought of Greek natural philosophy which bridges antiquity with modern times and which only came to full fruition at the time of the Renaissance. This trend in Greek philosophy is typified by the atomic theory of Leucippus and Democritus and traditionally was described as materialism. Historically this is a correct description, but today it is easily misunderstood, since the word "materialism" was given a very one-sided meaning in the nineteenth century a meaning which is by no means in accordance with the development of Greek natural philosophy.

We can avoid this false interpretation of ancient atomic theory if we remember that the first modern investigator to return to the atomic theory in the seventeenth century was the theologian and philosopher, Gassendi, who surely did not use the theory in order to combat Christian dogma. Even for Democritus, atoms were merely the letters with which we could record the events of the world, but not their content. In contrast, nineteenth-century materialism was developed from thoughts of quite a different kind, thoughts which are characteristic of the modern age and which are rooted in the division of the world into a material and a spiritual reality, originating with Descartes.

We thus see that the great stream of science and technology of modern times springs from two sources in the fields of ancient philosophy. Although many other tributaries have flowed into this stream and have helped to swell its current, the origins have always continued to make themselves felt. Because of this, all the sciences can benefit from classical studies.

GETTING TO THE BOTTOM OF THINGS

True, those concerned with the more practical schooling of youth will assert that the knowledge of this spiritual foundation has little relevance—that we should rather acquire the necessities of modern

life: languages, technical methods, accounting, and commercial practice. These, it is argued, will set us on our feet; a classical education is said to be merely of decorative value, a luxury for those few who have an easier struggle in life than most.

Perhaps this is true for the many people who want to do nothing more in their later lives than to carry on a purely practical business. Those, however, who find this goal inadequate and wish to get to the bottom of things in whatever vocation they choose—be it technology or medicine—are bound sooner or later to encounter the sources of antiquity. Their own work will benefit if they have learned from the Greeks how to discipline their thoughts and how to pose questions of principle. I believe that in the work of Max Planck, for instance, we can clearly see that his thought was influenced and made fruitful by his classical schooling.

Another personal experience which occurred three years after I had left school seems, in retrospect, to be illuminating. While a student at the University of Cottingen, I discussed with a friend the problem of the atomic model which I had found disturbing even while still in high school. This question was obviously the basis of the puzzling phenomena of spectroscopy which were still unsolved at the time. This friend defended perceptual models, and he believed that all that was needed was to persuade modern technology to construct a microscope with a very great resolving power, for instance one employing gamma rays instead of ordinary light. Then we should be able to see the structure of the atom, and my objections to perceptual models would finally be answered.

This argument disquieted me deeply. I was afraid that this imaginary microscope might well reveal the hooks and eyes of my physics textbook, and once again I had to resolve the apparent contradiction between this proposed experiment and the basic conceptions of Greek philosophy. Here the education in disciplined thought which we had received at school was to help me a great deal; because of it I would not accept would-be solutions.

In contemporary discussion about the value of a classical education, one can no longer maintain that the relationship between natural philosophy and modern atomic physics is a unique or special case. For even if we rarely meet such questions of principle in technology or science, or medicine, these disciplines are basically connected with atomic physics. Thus, in the final analysis, they lead to similar questions of principle. The structure of chemistry is built up on the basis of atomic physics. Modern astronomy is connected with it most closely, and can hardly make progress without

it. Even in biology, many bridges are being built toward atomic physics. The connections between the different branches of science have become much more obvious in the last decades than they have at any previous time. There are many signs of their common origins—which, in the final analysis, must be sought somewhere in the thought of antiquity.

FAITH IN THE WEST

With this conclusion I have almost returned to my point of departure. At the origins of all Western culture there is this close connection between our way of posing questions of principle and practical action, and this we owe to the Greeks. Even today the whole force of our culture rests on this connection. From it springs all our progress, and in this sense a declaration of faith in classical education is an avowal for the West and for its culture. However, do we still have a right to this faith when the West has lost so terribly in power and prestige in the last decades? Our answer is that all this does not involve questions of right, but of our *will.* For the activity of the West does not stem from theoretical insights—our ancestors did not base their actions on theories—but from quite a different origin. What is and always has been our mainspring is faith. By faith I do not only mean the Christian faith in a God-given, meaningful framework of the world, but simply faith in our task in this world. Here, faith obviously does not mean that we hold this or that to be true. To have faith always means: I decide to do it, I stake my existence on it. When Columbus started on his first voyage into the West, he believed that the earth was round and small enough to be circumnavigated. He did not merely think that this was right in theory—he staked his whole existence on it.

In a recent discussion of this aspect of European history, Freyer has rightly referred to the old saying: *"Credo ut intelligam"*—"I believe in order that I may understand." In applying this idea to the voyages of discovery, Freyer introduced an intermediate term: *"Credo ut agam; ago ut intellegam"*—"I believe in order that I may act; I act in order that I may understand." This saying is relevant not only to the first great voyages, but to the whole of Western science, and to the whole mission of the West. It includes both classical education and science.

And there is no need to be over-modest. One half of the modern world, the West, has gained immeasurable power by applying in an unprecedented way the Western idea of controlling and exploiting natural resources through science. The other half of the world, the East, is held together by its faith in the theses of Marx, a European philosopher and political economist. Nobody knows what the fu-

ture will hold and what spiritual forces will govern the world, but our first step is always an act of faith in something and a wish for something.

We hope that spiritual life will blossom here once again, that here in Europe ideas will continue to grow and shape the face of the world. We stake our existence on this; and as we remember our origins, and recover the way to a harmonious interplay of forces in our part of the world, so will the external conditions of European life be happier than they have been these last fifty years. We hope that despite all outer confusion, our youth will grow up in the spiritual climate of the West, so that it may touch the sources of power which have sustained our continent for more than two thousand years. Let us not worry about the detailed ways in which this might be brought about. No matter whether we prefer a classical or a scientific education, what does matter above all is our supreme and abiding faith in the West.

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