Our Place in the Scheme of Things

J. Bronowski's **The Identity of Man** (published for the American Museum of Natural History by Natural History Press, Garden City, N.Y., 1965. 119 pp. $3.95) is a brief but comprehensive essay on the current scientific revolution. Bronowski does not spend words in it descanting on C. P. Snow's "two cultures." It is clear by now that culture must be *one*, if it is to be at all, and this is the essential point that he makes in his brilliant and lucid style, familiar to us already from *Science and Human Values*. It is only recently, thanks to the crisis in the theoretical bases of science, that so many scattered aspects of our knowledge can be brought together into a whole, which becomes both history and philosophy. The author moves from the grave question: what is the so-called self? to lead us to the mind-body problem itself. Bronowski enjoys provoking the soft-minded and the pompous, so often bedfellows; he marks their successive lines of retreat from the "uniqueness" of man, as one heresy after another gained acceptance in our world-view, from Bruno's heroic belief in the plurality of worlds in 1600 down to the latest one, that man simply is a part of nature. The anxiety to find a special dispensation for man beyond the laws of nature strikes him as a philosopher's fraud. Nature is all miraculous down to the last particle, and if people boggle at the unrepentant "materialism" of science, he is ready to repeat Tyndall's famous and "blasphemous" pronouncement: "I discern in that Matter which we, in our ignorance of its latent powers, and notwithstanding our professed reverence for its Creator, have hitherto covered with opprobrium, the promise and potency of all terrestrial life."

At that time in the last century, Man could already be described as a colloid machine working on chemical energy—no Self allowed. Can the new biochemistry help us further? Surely, the body of man rejects grafts from the nonself, as do all vertebrates. That kind of protective self-identity continues all the way down the scale, until it ceases somewhere between the hagfish and the lamprey. Not a good criterion. What then about the famous unpredictability, glorified into free will? It cannot imply total lawlessness, otherwise life would be a series of epileptic fits. Existentialists have brought up the *acte gratuit*, a subtle kind of arbitrariness which is withal not incoherent. There remains a large area of lawfulness and predictability. Spinoza told us long ago that man's actions both flow from and flow into his character. Man remains in the grip of configurations that are inalterable. Yet, supposing I repeated exactly the same casual gesture over and over again, I would not only surprise others, the author says, "I would embarrass my wife." This "I" needs even larger fields of experience. The self is a process into which experience flows and becomes knowledge. We are entering epistemology.

Self-Conscious Machine

Artificial intelligences might provide the new step. That is the current hope. A somewhat facile one. To be sure, automata are not what they used to be. We can think of machines that learn, that can change their output. But there are so many modes of knowledge which cannot be spelled out formally and taped to direct a machine. Darwin complained in his late years that his mind seemed to have become a machine for collecting facts. Yet he was able to realize and lament it. "It was this other mode of knowledge which caused him to leave the *Origin of Species* unpublished for twenty years, in part at least because he knew that it would embarrass his wife." A good point.

We once thought of the brain on the model of a telephone exchange, receiving information and switching it along. The Lockeian idea mechanized. Alas, perception is an infinitely subtle and complicated process, in which the picture is not just received, it is shaped by the mind interacting with the senses, which provides an image of the world highly interlocked in its parts. And induction itself—that grievous problem—is a series of categorized lightning choices, which embrace the whole of our knowledge, as we build up our language. Here, too, come our new ideas about language, built up out of the experience of physics and out of structural linguistics. There is a certain Kantian revolution here, in our way of thinking about words and things, which is not mere nominalism. It has become clear that language is the mother and not the servant of our thoughts; and it meets nature's language only occasionally. We are not made for the certainty that philosophers asked for. Scientific knowledge is knowledge for action, not contemplation.

This is one kind of knowledge. But even as we move out of the machine into the organism, the author is led perforce to other kinds of knowledge, represented by art. We are still within nature for all that. Goethe used to say, long ago, that the only way to understand an organism would be to build one. We can confidently state now that if ever we build an animal, it will be long before we are able to formalize the theory. I commend this paradox to Bronowski, who knows how to express himself in cogent images. In this science of structures and organisms, artistic imagination comes to the fore. Understanding is linked with harmony and multivalent ambiguity. And this is another key to the knowledge of the self. In part 3 of his book, Bronowski turns into a literary critic, and a very good one at that, as we might have expected from his early work on Blake. But it would take his own examples, drawn from Shakespeare, Robert Frost, and many more, and penetratingly analyzed, to carry his message. The sum of it is that a poem or a drama widens our awareness by getting us to identify with others. What we learn from it is not information but self-knowledge, which is a many-valued affair; while scientific knowledge is single-valued. Science itself, like all living languages, is not free from ambiguity; but in poetry ambiguity becomes of the essence, as also in humor. The sense of community with others that makes the experience of poetry cannot be formalized. It cannot even be "animalized," for animals lack both scientific and poetic imagination. It is only *we* who can relive in consciousness the experience and conflicts of others. Machines do not act in plays, and animals do not pretend to be other animals. Science and art are both imagination; they belong together as matched halves of human experience; and it is the imaginative processes which make up what we call consciousness.

The Art of Science

If the problem was the Identity of the Self, an ample answer has first been outlined (and then is more fully developed in the last part) which is adequate to rescue science from her splendid but dreary isolation of the last century. If it is still accepted that "atoms blindly run," if genetics and molecular biology have increased the inalterable aspect of our configurations, if our logic *is* that of a machine—yet even that logic remains open. Contrary to the positivists' attitude: it cannot reach out at the borderline of the known, as Goedel and Ramsey have proved, and pure mathematics will never be a closed science. And so it is—much more so—with the rest of our concepts. Bronowski has skillfully woven together the new vistas presented by the critical changes in epistemology to show how far they can lead us. "We have the luck to receive the question when for the first time it can be answered." Utterly true. But is it as unique as it is made to look? It is one of the charms of the history of science to show that real questions, new attentions, have sprung up only when the time was ripe for an answer. Even the "stodginess" of the 19th century is largely due to stodgy historians, and to stodgy pontiffs. Today's "new" lies largely in the writer's skill in presentation. It is hardly new that in watching Lady Macbeth's agony we do not simply conclude that she is headed for a breakdown, or even discover that she is not colorblind (the answer remaining: so what?) but are really led to feel, like her physician, "God, God forgive us all"—and yet, put in its proper place, this understanding reminds us that all of real knowledge is imaginative, that the artistic element in science, rediscovered, might pull current philosophy out of the horse latitudes. Science becomes again natural philosophy, as it was in the times of Galileo, Newton, and Kant, and the future is open. Bronowski's book is really a matter of persuasion and good sense rather than of flashing intuitions. A kind of Aristotelian serenity hovers over his prose. Is that quiet persuasion enough for all, as it would have been for a Stoic public, when "physics" was already paramount? There are still some true scientific minds lying in wait for the profound that may come. As Heraclitus says: "If you do not await the unexpected, you will not find what is true." Bronowski prefers to keep to one aspect of Parmenides: "This too thou shalt learn, how what appears can render a proper account of itself as it goes through all things as a whole." But this is not said in the Way of Truth: it comes from the Way of Opinion.

GIORGIO DE SANTILLANA
Department of Humanities, Massachusetts Institute of Technology, Cambridge

The Flying Machine

Charles H. Gibbs-Smith, of London's famed Victoria and Albert Museum, has for many years made very detailed studies of the origins of the airplane. In much thinner form much of his information has been made available in (London) Science Museum publications, which culminated in his book *The Aeroplane: An Historical Survey of Its Origins and Development* (1960). Now, in **The Invention of the Aeroplane (1799–1909)** (Taplinger, New York, 1966. 384 pp., illus. $14.95), Gibbs-Smith has pulled together his very considerable knowledge of the beginnings of aviation to discuss the development of the flying machine as a study in the history of science. He takes the view that there were two vital decades, exactly 100 years apart, in which the important developments took place. The first of these was from 1799 to 1809, when Sir George Cayley made his remarkable studies, treated in full detail in J. Laurence Pritchard's biography of Cayley (Horizon, 1960), and the second from 1899 to 1909, when the Wright brothers dominated. The difference between the two periods, Gibbs-Smith stresses, was due to the fact that the Wrights envisioned the airplane as a unique problem and not merely as a surface vehicle propelled through the air. Although it is true that the Wrights were able through the invention of the gasoline engine to achieve powered flight, what they really contributed was pilotage, the ability to control an airplane in flight. They learned this from their gliders and they built their airplanes to be inherently unstable.

Once the Wrights had demonstrated their machines in Europe, Europeans took up their work and improved upon it, as did Glenn Curtiss in the United States, to such an extent that by 1909 the Wrights were beginning to lose their lead, and by 1914 had lost it altogether. That this was so may be explained by the facts that in Europe the early development of the airplane was taken up by monied young men of better education and that, owing to the international rivalries of the day, public support was available, not to mention the interest of governments. The latter began to take an active interest by 1909 when the British established the Advisory Committee for Aeronautics.

Gibbs-Smith's work is superbly illustrated—many of the photographs in the latter part reminding one of the recent movie *Those Magnificent Men in Their Flying Machines*—and includes sketches of how the controls were worked. From a scholarly standpoint there are one or two minor irritations. The index is not comprehensive (for instance, C. S. Rolls is mentioned on page 190, but not in the index). References are either in the text or in notes at the back of the book, but citations from newspapers sometimes only give the month and year. But these are minor faults. The book itself enables the reader to see how the airplane became a practical machine.

ROBIN HIGHAM
Kansas State University, Manhattan

Recent Research on Rare Earths

In a short time, almost unnoticed by many, knowledge about the "rare earths" has grown from little more than a mere list of oddly named elements, exceedingly difficult to separate from each other because of a supposedly striking similarity of behavior, to a full subfield of chemistry, actively diversifying into several branches and affecting the neighboring sciences, such as metallurgy and nucleonics.

Although a comparatively well-developed amount of knowledge had, in fact, been accumulating over more than a century, this knowledge was rather restricted to a few specialists. The "scarcity" and the difficulty of individual isolation of these elements kept them "rare," and their detailed study was hindered for a long time, until the sudden interest in uranium- and thorium-bearing minerals, with which rare-earth compounds are frequently associated, brought them to the practical attention of modern chemistry. In the last few decades a number of separation procedures have been developed, many properties of the pure rare-earth metals and their compounds deter-