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.

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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.

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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 determined, and new applications introduced. These applications have taken interesting directions: the earlier uses of rare-earth metal mixtures in the magnesium technology and of rare-earth oxides to improve the quality of carbon-arc light have been followed by new, rapidly expanding applications in metallurgy, ceramics, electronics, nucleonics, and space science.

A well-known phenomenon gives the rare-earth series a particular academic interest: the regular variation, along the series, of internal electronic structure, beneath the valence shell. The study of correlations between this regularity and physicochemical properties, for example, provides insight into the reasons for the latter. Initially yttrium, lanthanum, and thorium were seen to be similar to the 14 rare-earth elements proper and were normally associated with the series. The much more recent transuranium elements, together with the final natural elements of the periodic table, have been recognized as constituting a parallel series. From all this has emerged a unifying picture of an extensive group of elements of similar electronic structure and properties, constituted by the lanthanide series and the actinide series, plus yttrium. Altogether, these series comprise nearly one-third of all the chemical elements. This alone is enough to give a measure of their importance.

Increasingly numerous publications and periodicals on these elements, especially on the lanthanides, are appearing in Europe and the United States. In the United States an important series was initiated in 1961 by publication of the proceedings of the first of a series of symposiums on Rare Earth Research; the editors of this volume, F. H. Spedding and A. H. Daane, made a notable achievement by very effectively condensing the knowledge on the rare earths into a very well organized and unified book. The proceedings of three other symposiums have since appeared. The system and background of the lanthanide field having been set by Spedding and Daane, any of these proceedings can be better appreciated within the series, as additions and updatings.

The most recent volume, **Rare Earth Research, III** (LeRoy Eyring, Ed. Gordon and Breach, New York, 1965. 769 pp., illus. Professional edition, $19.50; reference edition, $39.50), is not, in itself, easily susceptible to adequate review. This fact is at the same time its most significant feature: it offers coverage of widely different aspects of current research on the lanthanides and associated elements, ranging from purely theoretical papers to accounts of elaborate experimentation. It collects the papers of the fourth symposium, held at Phoenix, Arizona, in April 1964. An invited contribution opens each of the five sections: I, Magnetic and Electrical Properties of the Rare-Earth Compounds; II, Properties of Rare-Earth Metals and Alloys; III, Optical Properties and Solution Chemistry of Rare-Earth Materials; and IV and V, Solid-State Chemistry of Rare-Earth Materials (A and B). The total number of papers is 46, most of them being grouped in sections IV and V. The title of section III may sound rather odd, and it becomes more puzzling when one sees that the corresponding invited paper deals with "Séparations et purifications par la voie sèche dans le groupe des terres rares."

An interesting account of the magnetic history of the lanthanides is given in the first section. Section III includes some analytical-chemistry procedures—a proposed new reagent for rare earths, a paper on partial differences between the lanthanides and trivalent actinides, and a dry-distillation approach to the classical problem of separating the rare earths from each other. Thermal analysis, mixed oxide systems, properties of carbides, and the preparation, physical chemistry, crystallography, and heats of formation of different compounds are frequent subjects in sections IV and V. In a similar fashion, section II deals with the metals and their alloys.

All the papers are accompanied by abstracts, with the exception of the one paper not written in English, where it would seemingly be more required. No records of discussions are given.

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Fighting

Konrad Lorenz has two roles. One is that of a highly respected observer of bird behavior and dean of the European school of ethology. The other is that of a popular writer of fascinating, romantic, and sentimental children's books on animal behavior, of which *King Solomon's Ring* is the best known. He has never attempted to keep these roles completely separate and does not do so in the present book, **On Aggression** (Harcourt, Brace, and World, New York, 1966. 320 pp., illus. $5.75). On the one hand he presents a serious chapter on the evolution of social behavior in ducks, and on the other he is perfectly capable of quoting Jack London and A. A. Milne in support of his ideas.

The book is a translation (by Marjorie Kerr Wilson) of one originally published in Austria in 1963 under the title *Das sogenannte Böse: Zur Naturgeschichte der Aggression,* which may be freely translated, "So-called Evil: On the Natural History of Aggression." One gathers that it was originally written as a reaction to the Freudian theory of aggressive instinct. Lorenz points out that social fighting has certain constructive, as well as destructive, functions, such as dispersion and the maintenance of adequate breeding territories. He also points out that many of the higher social, carnivorous mammals have evolved the capacity to develop forms of fighting which are relatively harmless, or "ritualized."

Beyond this, the book is full of ideas, some stimulating (such as the idea that adolescent human males go through a critical period in which they may take up a cause), some highly speculative (militant enthusiasm in man is a true autonomous instinct), and some merely absurd (man's social organization is very similar to that of rats).

As to facts, many of these are based on Lorenz's own serious scientific work and as many on his more casual observations. He has drawn a limited sample from the works of others, mostly from European research with which he is personally familiar. He has entirely omitted the great body of research on dominance orders in chickens by Allee, Guhl, and others. In describing fighting among mice and rats, he quotes certain limited European studies and does not refer to the much larger and often contradictory studies done by American workers. When he does quote non-German literature it is not always accurately. I doubt that Washburn and DeVore would agree that the baboon troop is ruled by a "senate of older males." Lorenz's observations on dogs leave much to be desired, and he repeats his old statement that the sub-