

tion on the morphological method, here are some further references:

F. Zwicky, Morphology and Nomenclature of Jet Engines, *Aeronautical Engineering Review*, June 1947; The Morphological Method of Analysis and Construction, *Courant Anniversary Volume*, Interscience Publishers, 1948; Morphological Astronomy, *Observatory*, Vol. 68, 845 (1948); Morphology of Aerial Propulsion, *Helvetica Physica Acta*, 21, 299 (1948).

E & S has a limited number of reprints of these articles on hand if anyone is unable to come by them himself.

Metachemistry

SIRS: That was a fine article of Dr. Zwicky's in your November issue but I certainly could have wished for a fuller explanation of "metachemistry" (page 13). Is this something I should know all about? Is it a new science? Or is it just something like metaphysics?

T. L. Kelly '27

New York City

Metachemistry, as defined by Dr. Zwicky, is "the science of those reactions which involve initial metastable excited states of matter."

Says Dr. Zwicky, in fuller explanation:

In the search for ever higher concentrations of "packaged" energy the idea is proposed to attempt the stabilization *in bulk* and the *exploitation in macroscopic quantities of metastable high energy states of matter*. It is for instance of vital importance to make available propellants of high energy density in order to operate long distance rockets. Generally speaking both high energy per unit mass and per unit volume are important. The best ordinary chemical propellants pack of the order of 1 to 10 Kilocalories per cubic centimeter or per gram respectively. There exist, however, metastable states of atoms and molecules of long lifetime whose energy lies in the range from 10 to 100 Kilocalories per gram, or even higher.

The excited metastable states of atoms, ions and molecules can in principle be used in two ways for

the production of power, or more specifically for the generation of propulsive power.

1. The excited particles may be used wherever they are found naturally, for instance in the upper atmosphere and in interstellar space. This involves the solution of the tricky problem of artificially de-exciting the particles and of transferring the energy gained into propulsive power, for instance to drive a missile.

2. The excited particles may be collected and stabilized in bulk into a metachemical propellant of macroscopic density and energy higher than that which is characteristic for chemical propellants. The most obvious approach to the stabilization of metachemical propellants is through the use of very low temperatures.

In addition to the importance of metachemistry for propulsion, there exist intimate relations between metachemistry and the problem of directly exploiting the radiation from the sun as well as the problem of storing energy for varying periods.

BOOKS

MODERN ARMS AND FREE MEN

by Vannevar Bush

Simon and Schuster, New York,
273 pp. \$3.50

*Reviewed by Lee A. DuBridge
President, California Institute
of Technology*

This is a most important book. It is also both a fascinating and thought-provoking one. It is at times jarring, at times reassuring. It is never dull.

The subject matter covers a field which no one but Dr. Bush could treat in so authoritative a manner. As the author states it, "This book is about science and war and democracy and their inter-relations."

Dr. Bush is not attempting in this book to write a history of the Office of Scientific Research and Development, which he headed during World War II. Rather he seeks first to *analyze* the impact of the developments in science and technology on the weapons and techniques of modern war. For this purpose he treats briefly the techniques of World War I and the developments which occurred between the two

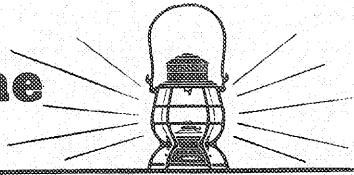
wars. He then takes up in considerable detail the technical developments which occurred during World War II as they affected the war on land, in the air, and on and under the sea. These chapters are most illuminating for they discuss not the technical details of various new weapons such as proximity fuses, radar, rockets and the rest, but their impact on the nature of war itself and how new techniques will affect future warfare.

He devotes two special chapters to an analysis of guided missiles and atomic bombs and their effect on future warfare. In view of the extravagant claims which have been made for the future potentialities of these weapons, and in view of the equally extravagant attempts to dismiss them as unimportant, Dr. Bush's careful analysis is a contribution of surpassing importance. As might be expected, this analysis reveals that extravagant claims on either side are likely to be false, and that the truth lies along a middle road. The atomic bomb is a weapon of devastating power. But the wiping out of a highly industrialized country by sending dozens or hundreds of

atomic-bomb-carrying planes may be a highly expensive business if the defending country is alert and well prepared. Dr. Bush is obviously skeptical of the thesis that the next war can be decided overnight solely by the operation of a huge fleet of atom-bomb-carrying planes. The jet plane and the guided missile offer promise of formidable defenses against fleets of strategic bombers. Though there may be no specific defense against the atomic bomb itself, there are potentially powerful defenses against the planes that must carry them.

But the heart of Dr. Bush's book is not his discussion of the techniques of warfare. Rather it lies in the chapters where he contrasts the ways in which these techniques can be developed and used by a democratic nation as compared with their development and use by a dictatorship. Here he presents a convincing case for the thesis that free men in a democracy are in a far better position to develop and perfect the techniques and instrumentalities of war and to achieve the industrial power needed to win a war than men whose freedom is suppressed under

The Main Line



JANUARY, 1950

Happy New Year!

With Christmas a thing of the past, and New Year's resolutions made and broken in most quarters, about all that remains is that recurring question of what to do with yourself for the rest of the winter.

Happily, we have the answer. Go to New Orleans.

Sea Food, Mama?

The restaurants alone should be lure enough. There's Gulf shrimp which is beyond comparison. Or oysters—on the half shell, Rockefeller, fried, or as you like them. There's pompano. And red snapper. And singularly succulent crab. You name it—they've got it.

The restaurateurs there have a flair for the dramatic. At the drop of a suggestion in come more flaming dishes than you can count—everything from cherries jubilee to a brandy hot-foot for the Maitre d'hotel. Simultaneously, singing waiters serenade you with a chorus of "La Madelon."

(Anti-inflation note: In the heart of the French Quarter is a wonderful, open-all-night market where you can buy three piping hot, freshly sugared doughnuts and a cup of New Orleans' famous coffee, all for a dime.)

Fat Tuesday

But food is only part of the story. Next month is the big month of the year in New Orleans. The "greatest free show on earth" gets under way on February 14 with parades, and there is no let-up through Tuesday, February 21—Mardi Gras day this year.

If you'd like to get in on the festivities, ask your nearest S.P. agent about it. There'll be a special tour train leaving San Francisco and Los Angeles February 15, with rates from \$210 to \$375 (from Los Angeles), including a private grandstand view of Mardi Gras parades, plus a flock of extra side-trips, parties and entertainment going and coming.

If you don't get in on this one, you might as well give yourself up—for Lent, anyway.

Rising Sunset

In addition to the special train, you can ride the improved *Sunset Limited* to the Crescent City. It will be a few months yet before it will be the new, \$15,000,000-dollar streamliner we've been telling you about. But in the meantime it's still the best way to visit the Old South. It's all Diesel-powered, and makes the run in 47 hours eastbound, 46½ hours westbound. Choice of all types of Pullmans and reserved seat reclining chair cars. We don't know for sure, but we think the dining car personnel trained in New Orleans restaurants. Anyway, the food is scrumptious.

Short Haul

If Louisiana seems a little distant to you, Palm Springs or Southern Arizona offer a fine alternative. You can shuck the winter doldrums in eighty-plus-degree sunshine. Fast schedules on the *Sunset* and *Golden State* with convenient Los Angeles connections, put you almost within commuting distance anywhere in the west.

Erratum Revisited

Last October we put our foot in it by announcing that the ski lift at Squaw Valley in the High Sierra was the "world's longest." We soon found out, though, that you don't get to be champ just by claiming the title. Anguished cries of "Foul!" from Oregon and Colorado sent us scurrying for our bifocals and another look at the record. What we should have said was "largest," not "longest"—or maybe skipped the superlatives altogether and simply said that it's a mighty fine spot for winter sports. Anyway, to each of you who has a longer ski lift, herewith our humble apologies.

(In passing, however, we might lay claim to the world's longest, most luxurious, least expensive ski lift at that. We have a slick new San Francisco-Reno parlor car service on the *Overland*. It serves Truckee and the High Sierra ski country and it's tailor-made for winter sports fans. Only \$7.50 one way, \$13.50 round-trip, plus tax. That's less than 3¢ a mile on the roundtrip.)

a dictatorship. Dr. Bush recognizes, however, that the strength of a democracy will remain great only if due attention is given to preserving it. His clear and decisive suggestions as to how the strength of democracy can best be preserved are in refreshing contrast to much of the partisan political bickerings to which we are being exposed during these difficult days.

It would be an injustice to Dr. Bush to attempt to summarize his arguments or even his major thesis in such a brief review, but the reviewer can say with assurance that the thoughtful reader will find pleasure and stimulation in following through Dr. Bush's arguments and analyses for himself.

It should be emphasized in conclusion that this is not a book written primarily for scientists or about scientists. Scientists will, no doubt, read it with unusual pleasure, but it is a book for every American citizen who is interested in the future welfare and security of his country.

HEREDITY EAST AND WEST: LYSENKO AND WORLD SCIENCE

by Julian Huxley

Henry Schuman, N.Y., 246 pp., \$3

Reviewed by Norman H. Horowitz
Associate Professor of Biology

It frequently happens that the findings of science come into conflict with accepted views. Indeed, this is an inevitable consequence of scientific inquiry, since it is the function of science to correct and deepen our understanding of things. Unfortunately, it is always painful and difficult to abandon the convictions of a lifetime, perhaps even to deny the evidence of one's senses, in favor of new and strange ideas. It may even be difficult to tolerate such ideas in others. Nevertheless, this is what we are required to do if we are to enjoy the benefits which science alone can bring. The free expression of ideas is essential for science, and wherever society adopts an authoritarian attitude, that is to say, wherever it in effect demands unanimity of opinion, the pursuit of science becomes impossible.

The genetics controversy in the USSR is the most recent episode in the long conflict with authoritarianism which has marked the rise of science. It so happens that the findings of genetics have come into opposition to certain tenets of the

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Communist Party and therefore of the Soviet government. Following a period of some uncertainty as to the outcome, the issue was recently resolved. Genetics has been proscribed in the USSR and has been banned from the schools and research institutes, and its supporters have either recanted or been removed from their positions.

In his new book, Julian Huxley, biologist and first director-general of UNESCO, undertakes to explain for the general reader the nature and history of this controversy in both its ideological and scientific aspects. The book is an expansion of an excellent article written by the author for the British journal *Nature*. It is, on the whole, the most dispassionate account of the Russian affair that this reviewer has seen.

Probably no one is in a worse position than the professional scientist to forecast the probable degree of success of an author in presenting the subject matter of his own field to the public. Whether or not this book will make the concepts and methods of genetics clear to the general reader I cannot say. But this is a matter of relatively minor importance. What is important, and what Huxley makes very clear, is that this whole affair is not, strictly speaking, a scientific controversy at all, but is an ideological and political one. It is not only a biological theory that has been rejected, but the scientific method, and the situa-

tion therefore has the widest implications.

To convince himself of the truth of this statement, the reader should turn to the stenographic report of the Proceedings of the Lenin Academy of Agricultural Sciences, July 31-August 7, 1948, recently made available in an English translation. This meeting marked the climax of the genetics controversy in the USSR. Numerous quotations from the report are to be found in Huxley's book, but to grasp to the full the flight from reason now under way in Soviet biology, the document itself is almost indispensable.

Through the looking-glass

One need not be a specialist in genetics to realize that here one is through the looking-glass and in a dream-world where, to quote Huxley, "they neither demand nor accept the same kind of evidence as professional scientists elsewhere; they confuse fact with doctrine and theory with hypothesis or with belief; they misuse or redefine terms to suit themselves; they appeal to past authority instead of to present established fact and to utility instead of truth; they accept other than scientific criteria, or even insist upon them, in what purports to be a scientific argument."

The scientific aspects of the controversy, such as they are, can be summed up briefly. Chiefly on the basis of two poorly documented experiments (one claiming to show certain hereditary effects of vernalization, the other of grafting) it is

proposed to abandon the gene theory and all that goes with it (including the personal verification of the basic experiments of genetics by countless individuals all over the world) in favor of a slightly modified form of Lamarckism, called Michurinism. The central point in this hypothesis, suggested by Lamarck in 1809, is that the characteristics which an organism acquires during the course of its life are transmitted to its offspring. This idea was widely accepted in the 19th century. Darwin was one of its adherents. Not only did it sound plausible, but it seemed to be a practically indispensable element in evolution theory. The only difficulty was that no convincing evidence could be found in its favor.

With the discovery of the real nature of inheritance by Mendel in 1865 and the development of the gene theory by T. H. Morgan and his coworkers, the Lamarckian hypothesis became unnecessary. Mendelian genetics plus natural selection account for everything that Lamarck set out to explain and much more besides. Moreover, the gene theory is based on a massive foundation of internally consistent, mutually supporting experimental evidence.

The gene theory has grown far beyond the stage where it can be annihilated by an inspired experiment. That it will, in the course of time, be improved and elaborated and eventually included in some more general formulation, there is little doubt. But to imagine that any scientific developments of the foreseeable future will necessitate that

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it be scuttled is to misunderstand the nature of scientific progress. To quote the late Morris R. Cohen, "If every discovery simply replaced all previous knowledge, we should have something like an oriental dynastic change where the new regime kills off all the remnants of the old regime which it displaces. The progress of science is not a complete replacing of the old by the new, but a process of continual self-correction."

It is just such a dynastic change which is now taking place in Soviet biology, ostensibly on the basis of experiments the interpretation of which is not merely dubious, but indeterminate, since they have not been properly described. How is this to be accounted for? Does it mean Russian scientists have forgotten how to evaluate evidence? I think not.

The prime consideration

The explanation is rather that the scientific evaluation of evidence is no longer considered of prime importance in Soviet biology. The prime consideration is conformity to the position adopted by the political leaders of the Party. This position was announced by Academician T. D. Lysenko, leader of the anti-Mendelian forces, at the closing session of the meeting of the Lenin Academy: "Comrades, before I pass to my concluding remarks I consider it my duty to make the following statement. The question is asked in one of the notes handed to me, 'What is the attitude of the Central Committee of the

Party to my report?' I answer: 'The Central Committee of the Party examined my report and approved it.' (*Stormy applause. Ovation. All rise.*)"

The Central Committee is apparently the ultimate authority in scientific matters. The situation was summed up by I. M. Polyakov in his speech of recantation following the above announcement: "... One must frankly say that the Michurinian trend is the highroad of development of our biological science, and this is the road we must follow. It is the only possible road for Bolsheviks, Party and non-party, who desire to work in the field of our biological science and bring benefit to our Soviet people, to our Country . . . It is necessary to understand the chief and fundamental thing, namely, that our Party has helped us to effect a profound and radical reconstruction of our science, has shown us that the Michurinian theory defines the basic line of development of Soviet biological science, and from this we must draw the conclusion and work to promote the Michurinian trend."

The sentiments of the Lenin Academy were soon implemented by decrees from the USSR Academy of Sciences and the Ministry of Higher Education ordering the abolition of genetics laboratories, the dismissal of geneticists, and the revision of textbooks. To quote Kaftanov, Minister of Higher Education, in an editorial in *Izvestia*: "... The struggle in the field of biology has ended in a complete triumph of Michurin's doctrine, presenting a

new stage in the development of materialistic biology. Thanks to the Bolshevik Party and, personally, to Comrade Stalin, ways for the further triumphant march of the most progressive Michurin biological science are now clear. The scientists of our colleges will apply, from now on, all their energy to the propaganda of Michurin's biology and to the support of the undivided rule of Michurin's biological doctrine in our higher institutions of learning." (From *Science*, Jan. 28, 1949.)

From science to oracles

The question remains: Why is it that the Soviet political leaders have adopted this particular line? This question is not an easy one to answer, and Huxley presents a discussion of the various contributory factors which were probably involved. At least one general conclusion is clear; namely, that errors of this sort are the inevitable consequence of authoritarianism in science. Wherever the principle is accepted that a higher authority exists for science than the authority of the scientific method itself, mistakes are bound to be made. For no matter how respected the authority and no matter how high its ideals, the deliverances of authority have, at best, the standing of hypotheses in science, to be doubted until proved. Where doubt is suppressed, science ceases to exist and gives way to oracles—and it has been the general experience of mankind that oracles do not always give the right answers.

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