cipal class components by simple means. It is only necessary to filter the extract slowly through a close-packed column of fine chalk, and color bands appear which become sharper as more fluid passes through. At the bottom are the yellow carotene bands which may be driven lower by pouring still more fresh solvent through the filter till the yellow colors collect in the flask at the bottom. From carotene, as we have already seen, all animal life is able to derive vitamin A. Without it there ensues blindness and general failure of the body mechanism.

Next, above the carotene band in our filter column are the reddish orange xanthophylls whose chemistry is unfortunately less well understood. They are, however, related to the hydrocarbon carotenes and differ from them principally by being dialcohols. (Vitamin A is a monoalcohol.) Among the xanthophylls which have been isolated is the red pigment of the tomato, lycopin and fuco-xanthin which colors the brown algae in our ponds. Another xanthophyll has already been mentioned as an essential component of the light filter of a chicken's eye and also as present in the yolk of its egg.

Above the xanthophylls in our filter column appear the green bands of the chlorophylls. Here is the spectrum of nature's color beauty: the yellow of the carotenes, the reds of the xanthophylls and the blue greens of the chlorophylls. Herewith she bedecks the flowers, fruits and foliage of her myriad higher plants and has some to spare for the wattles of the turkey and for the bodies of inconspicuous and forgotten primitive bacteria, mosses and fungi.

Something very like chlorophyll is in your blood—at least a huge portion of its molecular skeleton is there. Hemin is the prosthetic group or business end of the hemoglobin of mammalian blood. It contains four pyrrole rings joined in a giant circle with four intervening CH groups. At the center is an atom of iron which is "it" in this game of ring-around-the-rosy. The molecule of chlorophyll shows the same players in the same game except that now magnesium is "it." It is true that some of the little girls have different ribbons on their pigtails, but you could not mistake their identity.

Their common structural element is known as porphyrin. This vast carbon-nitrogen skeleton recurs again and again in the breathing systems of plant and animal life as an integral part of the substances which we have come to refer to as the respiratory pigments. When the hemin of blood is heated with soda lime, porphyrin is obtained identical in every detail with the porphyrin derived from chlorophyll. When you peel an apple with a steel knife and see the fresh cut surface darken presently in the air, you are witnessing the action of a porphyrin-containing oxidase. Put a drop of hydrogen peroxide on the surface and watch the oxygen evolve due to another porphyrin-base enzyme of the apple or of most any other vegetable tissue. It is called catalase.

Another well-nigh if not universal constituent of tissues is cytochrome, which may be recognized with a spectroscope by its absorption bands associated with its porphyrin nucleus. If yeast is kept from contact with the air the cytochrome bands appear strongly. They fade and return as oxygen is admitted and again excluded. Choke a wax moth and the absorption bands of cytochrome appear throughout its body tissues, the more quickly as its struggles exhaust its internal oxygen supply. Let it breathe freely again and the bands disappear. Cytochrome is one of a number of links in the chain whereby glucose is oxidized by living tissues. It serves to transfer oxygen from the air to the food molecule which is to be oxidized. We do not know that animals depend on plants in any way for their daily supplies of porphyrin base enzymes, but we can guess whence they inherited the skill to use them.

Surely we need not labor through further examples. The revelation provided by vitamin chemistry seems sufficient to convince the skeptic that while nature has *altered* much in proceeding from amoeba to Einstein or Dorothy Lamour, she has *preserved* even more through all the vicissitudes of evolutionary history.

(*To be concluded in the issue of Science for November 28*)

THE USE AND MISUSE OF SCIENCE IN GOVERNMENT[1]

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IN this country we do not believe in bureaucracy. Our national genius has evolved a system by which the activities of officials are continually subject to the advice and help and criticism of public-spirited citizens. The wise officials appreciate this; the stupid ones do not. Let us never abandon this principle, otherwise, with our traditions, we are in for a long spell of trouble. Let us rather praise and extend it, whatever our totalitarian youth may say. One way to extend it is to insist that independent scientific advice shall be given a constitutional place, and a con-

[1] From an address given at the Conference on Science and World Order of the British Association for the Advancement of Science, organized by the Division for the Social and International Relations of Science.

stitutional right to be heard, in government departments.

Even, however, if departments were saturated with scientific advice, it would still be necessary to ensure that the Cabinet itself should be properly served. The Scientific Advisory Committee and the Engineering Advisory Committee, both under the chairmanship of Lord Hankey, now fulfil that function here. The arrangement is new, but undoubtedly it works well. Dealing as they do with the reactions of science and technology with policy, at present particularly but not exclusively in connection with the war, the committees can not busy themselves with details which naturally go to departmental bodies, and most of their activities can not in wartime be publicly described. The chairman, as a minister of high rank, working under the Lord President of the Council, who is the member of the War Cabinet primarily responsible for research, has access to all ministers and departments. A new link has thus been forged, and science at last is in contact with the center of government.

In the United States a similar link exists. The director of the Office of Scientific Research and Development in Washington is directly responsible to the President. Under this organization come the National Defense Research Committee, the National Advisory Committee for Aeronautics and the Medical Division of the National Research Council. This arrangement is quite new, and in many ways different from our own; but it is like it in the sense that in the United States, as here, science now has direct access to the center of government. May it so continue in both countries!

I have dealt with the attitude of mind from which the problems of science in government must be approached, and with the organization needed at departmental and Cabinet level. It remains now to deal with the scientists themselves and the problem of how to keep them alive. It is essential, if the scientific minds of the scientists in government employment are to be saved from sterility, and their souls perhaps from damnation, that there should be as little distinction as possible between them and those in the universities, in industry and in other independent institutions. In wartime there is little distinction; we are all in it together. What I say applies to the more normal times of peace.

Government scientific employment in general has certain characteristics:

(1) It has security of tenure, fixed hours of work, regular promotion and a pension.

(2) Adequate equipment is usually available, and there is not a continual struggle for funds.

(3) The object and direction of investigation are usually laid down by authority.

(4) Discussion and publication are usually limited, sometimes because of the real or alleged necessity of secrecy, often simply by tradition.

(5) Teaching duties generally do not exist, and there is often no necessity to follow the scientific literature except in a special field, with the result that interests are likely to become narrow.

(6) Attendance at meetings of learned societies, conferences and congresses, the holding of colloquia and discussion meetings and contacts with scientists in other fields are rare.

(7) Visiting workers, particularly foreign workers, are few or absent altogether.

For such reasons, unless a man has exceptional ambition and originality, his initiative and keenness tend to be blunted. There are several ways to avoid this:

(*a*) To ensure that directors of research, heads of laboratories, etc., are people of exceptional quality, not only in ability, originality and experience, but also in their human relations and sympathy. Such men in such positions are rare, but they exist; their value is very great. It is essential that they should remain investigators at heart, and as far as possible in action, and not become mere bureaucrats.

(*b*) To adopt a common pension scheme, similar to that of the Federated Universities System, with the universities, with industrial laboratories and with all institutions in which scientific work is done.

(*c*) To encourage junior and senior workers alike to interchange freely with other departments, with industrial laboratories or with universities.

(*d*) To provide facilities for visiting workers, for colloquia and discussion meetings and for attendance at meetings of learned societies.

(*e*) To adopt a system analogous to that of the reserve of officers and other ranks by which the fighting services prepare for times of emergency. Many of the ablest workers elsewhere would rightly value a period of service in government laboratories, although not prepared to devote the whole of their lives to it. After their period of service, they would return to their chosen jobs in universities and other places, with occasional "refresher" periods later.

I have urged before that this system of building up a reserve of scientific officers should be adopted as soon as normal conditions return. It would be the greatest pity if the many able men who have done such excellent service in Government establishments should then lose touch permanently. Wide-spread support of this proposal has been evident. It has many advantages; sudden expansion in emergency would be much easier, the universities and other institutions would be kept in touch with government scientific establishments, and *vice versa,* those who joined the government service would not be permanently isolated from the scientific workers outside, and the highly interesting and important work which is done in government laboratories would be more commonly appreciated and known. By forming such a reserve, the intellectual status and the fruitfulness of government science would inevitably be raised and the universities would be brought into closer touch with realities.

There is no need to go into details; they can be settled later. The broad principle is that in every way we need to break down barriers between universities, independent research institutions, industrial laboratories and the scientific establishments and service of the government. This can be done by regular interchange of personnel, by a common pension system, by providing in the government laboratories all those facilities for discussion, for meetings, for criticism, for initiative, for collaboration—even perhaps for teaching—which are found elsewhere. We must not be deterred in this project by bureaucratic objections, by false economy, by the red-herring of secrecy or by alleged administrative difficulties. In science also we must deliberately follow the line of our national genius and ensure the fullest cooperation and interchange between independent science and science controlled by the state.

This plan for a reserve of officers and for frequent and regular interchange between different kinds of institutions need not be limited to science; it should be open to the government service as a whole. Drastic changes are needed in the Civil Service. Personal ability and personal integrity, essential as they are, are not sufficient; the outlook, the methods, the organization, the traditions of the Civil Service must be altered, and contact must be maintained with the real world and its methods outside. The war has shown, what many suspected already, that for all its devotion and its high traditions, the Civil Service has largely failed; the same might well be said of Parliament, but that is another matter. Nothing could be better for the Civil Service, for industry, for the universities, than to institute a regular interchange of personnel; to treat the universities as staff colleges to which workers from the Civil Service or from industry return at intervals for refreshment; to treat industry and the Civil Service as the workshops in which for a period university dons can obtain practical experience; to give to government offices a touch with reality, and to industry a touch with national needs, by the mutual temporary interchange of some of the ablest men on either side. We are concerned here to-day primarily with science in government. Science, however, will never be given full scope until a revolution has occurred in the methods and outlook of government itself.

May I finish on a note, not of criticism but of hope? Under the old régime of *laissez-faire,* which we intend that the proper use of science in government shall replace, our public health services were organized mainly on the principle of trying to cure people when they were sick, our architecture on mending the pipes when they burst after a frost, our industry on paying people a dole when they were unemployed, our national defense on getting ready when a war had begun. It is obvious, however, that scientific planning and the planning of our national resources can make many of our troubles unnecessary. By designing our houses properly the pipes need never get frozen up; by proper attention to nutrition, to public health and physical education, sickness can be largely avoided; by deliberate planning of public works, unemployment can be greatly reduced and the standard of living raised; by adopting a period of national service, universal for men and women alike, as the highest form of democracy, we can avoid blundering unprepared again into war, and can add a new dignity to our citizenship. Scientific planning and planning with the aid of science are what we look forward to; planning, however, in which any new order we arrive at is fitted to our traditional freedom.

OBITUARY

WILLIAM ALBERT NOYES, 1857–1941

WILLIAM ALBERT NOYES departed this life on October 24, 1941, at his home in Urbana, Illinois, aged 83 years, 11 months.

How familiar the form of such an announcement! It marks the beginning and ending of life, the two covers of the book, but of the contents—particularly rich in this case—not a word.

Dr. Noyes was born in the country near Independence, Iowa, November 6, 1857. His family, of New England Congregational stock, lived under pioneer conditions not favorable to the study of chemistry and physics; nevertheless, as a boy he managed to get hold of some scientific books and became interested in these subjects at an early age. In the midst of farm work he prepared himself for college, almost without a teacher. In the Iowa college of that day little chemistry was taught, but this was supplemented by a large amount of self-instruction. At the end of four years the young man was W. A. Noyes, A.B. and B.S., in spite of the fact that he had taught school every winter to pay expenses. He conducted much of his graduate work himself while carrying a full load of teaching, so that he was able to take his doctor's degree in chemistry at Johns Hopkins under Remsen in a year and a half, before reaching the age of twenty-five.

Such unremitting labor was characteristic of Dr. Noyes throughout his long life. During a year as