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# ORGANIZATION OF AMERICAN SCIENTISTS FOR THE WAR.[1] II

By Dr. KARL T. COMPTON

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## WAR-TIME SCIENTIFIC ORGANIZATION

In spite of the apparently complete peace-time organization which I have just described, it has always been our experience, in the time of great emergency, that it appears advisable to establish temporary new agencies to deal particularly with the emergency. For example, I happened to be attached to one of these temporary agencies during the last war and I mention the matter not only by way of illustration but also because it will enable me to relate an anecdote about your late distinguished colleague, then Sir Ernest Rutherford.

This agency was the Research Information Service, set up jointly by our Military Intelligence, Naval Intelligence and Council of National Defense, with offices in Washington, London, Paris and Rome. The function of these offices was essentially the same as that of the scientific liaison offices which have been operating so effectively between units of the British Commonwealth and the United States during the present war.

The head of the Research Information Service in London was the late Professor Bumstead, whom some of you doubtless remember. I was attached to the Paris office and happened to be temporarily in charge during the time when an allied conference on submarine detection was arranged in Paris under the auspices of this office.

One of the delegates from Great Britain was Sir Ernest Rutherford, who had been collaborating closely with the French physicist, Paul Langevin, in the development of underwater supersonic devices. The day

[1] Pilgrim Trust Lecture, under the auspices of the Royal Society of London, May 20, 1943.

before the conference, when the British and American delegations came over from London, Rutherford was not present, but he sent me a letter, delivered by Professor Bumstead, stating that some very recent experiments which he and his research assistant had been carrying on in the Cavendish Laboratory had apparently indicated success in disintegrating the nucleus of the hydrogen atom. "If this is true," Rutherford wrote, "it is a fact of far greater importance than the war." He went on to say that he was in the midst of a second experiment to check these startling findings and that he would be delayed a couple of days pending the termination of this experiment. Then Rutherford added as a postscript: "Tell nobody about this because I may be mistaken." Later it developed that what Rutherford had actually done had not been to disintegrate the hydrogen nucleus, but rather to disintegrate the nuclei of nitrogen atoms. So far as I know, Rutherford's letter to me was the first written indication of success in the long, long struggle to produce by artificial means a transmutation of one chemical element into another. I wish I had kept that letter and had turned it over to Professor Eve at the time when he was writing his interesting biography of Ernest Rutherford. But to return to our topic:

I have frequently tried to analyze the reasons for the establishment of special scientific agencies during times of crisis. The reasons I think are varied and rather fundamental. One of them is that every great crisis involves conditions so different from the normal situation that the types of organizations which can survive and operate during peace-time are not adequate to meet the emergency. It may be, for example, that the emergency calls for exercise of very extensive administrative functions, such as the supervision of research projects and the disbursement of large governmental funds to a far greater extent than in peacetime. Hence a peace-time body of scientists organized primarily to exercise advisory functions may not be organized in a manner suited to prompt and efficient executive action. Another reason is the impossibility of always maintaining in the administrative positions of peace-time agencies the personnel who would be most effective for handling important projects in a war emergency. Men who have the proper capabilities are frequently too busy and too active in other directions to be willing to hold down positions in a peace-time organization which is relatively inactive. Consequently, when the emergency comes, the only alternatives may be to change the leadership in the existing organizations, a difficult if not impossible process, or to set up new temporary agencies to deal with the emergency.

Whatever the reasons may be, this present war emergency has run true to form and has resulted in the establishment of a group of special agencies of temporary character which I shall proceed now to describe. It is these agencies which are carrying the principal burden of the scientific research and development work related to the war, in the United States.

*The National Roster of Scientific and Specialized Personnel* was established early in July, 1940, when President Roosevelt approved a project for making available in one central office an index of all American citizens who have special scientific or professional skill. Headed by President Leonard Carmichael, of Tufts College, this agency operates under the War Manpower Commission under the Office for Emergency Management of the executive office of the President.

As a result of information secured from questionnaires mailed to all members of all scientific and professional organizations in the country, and supplemented by other information, an elaborate punch-card system has been set up in which practically every person in the country with specialized training or skill is listed with reference to his or her major professional fields and with the addition of a great deal of supplementary information regarding special interests, languages read or spoken, foreign countries traveled in, previous experience in the armed services or in industry, etc.

There are altogether 59 special fields listed in the Roster, falling under the general categories of administration and management, agricultural and biological sciences, engineering and related fields, humanities, medical sciences and related fields, physical sciences and social sciences. At the present time the total number of persons in this Roster is about 600,000, including, as of last October, 71,511 chemists, 7,297 mathematicians, 10,080 physicists or astronomers, 4,559 radio engineers, 14,729 electrical engineers, only 408 professional philosophers, and the smallest entry in the list is 142 speleologists.

As an illustration of the manner of use of this Roster I quote the following paragraph from a report by Dr. Carmichael: "How would you like to get an order for the names of all Americans who possess a knowledge of epidemiology and chemotherapy, who are competent in the diagnosis and control of *Endamoeba histolytica,* and other protozoan infections, have a knowledge of the Hindustani language, are skilled in the operation and use of specialized bacteriological research apparatus and who have traveled in the tropics?" To secure this information the stops of the punch-card sorting mechanism are pushed in at the appropriate places, the cards are ground through the machine, and all those which conform to the above specifications fall out together.

The Roster was originally conceived to serve governmental agencies who might request information on scientific personnel. More recently, as serious manpower shortages have developed both in industry and in education, and as the armed services have become more and more concerned over the most effective use of all scientifically trained personnel, the Roster has been used to an increasing degree in connection with placement work and to give the supply and shortage data on professional groups. Up to the middle of last month the National Roster had certified more than 140,000 names of specialists to various agencies engaged in the war program in the United States.

*Office of Scientific Research and Development (OSRD).* Most important of the scientific agencies established specially to deal with problems of this war is the Office of Scientific Research and Development, whose director is Dr. Vannevar Bush, president of the Carnegie Institution of Washington. It was created by executive order of the President in June, 1941, and under it operate the National Defense Research Committee, which had been established just a year earlier, and also the more recently established Committee on Medical Research. The OSRD is directed to coordinate, and where necessary supplement, the scientific research and development work relating to the war among civilian agencies as well as those of the government, including the Armed Services. To facilitate this coordination the advisory council to the director of OSRD includes high-ranking representatives from the War and Navy Departments, the chairman of the National Advisory Committee for Aeronautics, the National Defense Research Committee and the Committee on Medical Research and, by invitation, the president of the National Academy of Sciences and the director of the newly established Office of Production Research and Development of the War Production Board.

The principal research and development activities of the OSRD are carried on under contracts with appropriate research institutions, these contracts being financed out of an annual Congressional appropriation. At the present time these contracts involve expenditures at the rate of about $100,000,000 per year, and there are currently active about 1,400 contracts with about 200 industrial laboratories and 100 educational or special research institutions. About 6,000 scientists and engineers of professional grade are engaged on these contracts, with the assistance of a considerably larger number of technicians of various types.

To facilitate interchange of information between OSRD and our British colleagues, an OSRD Liaison Office was established with offices in Washington and London, now headed by Dr. Caryl P. Haskins and Bennett Archambault, respectively. These, in cooperation with the similar liaison services of Great Britain, Canada and, less extensively, Australia and South Africa, have served well to knit together our joint scientific efforts.

*The National Defense Research Committee (NDRC)* operates to recommend to the director of OSRD research and development contracts in the field of instrumentalities, devices and mechanisms of warfare. Under the chairmanship of President James B. Conant, of Harvard University, this committee is composed of four civilian scientists, plus one representative each from the Army and Navy, and the Commissioner of Patents. Feeding into it come the recommendations from 19 divisions, most of which are subdivided into several sections. These divisions and sections are each built around a specific functional concept, such as fire control or sub-surface warfare or explosives. However, there are two divisions which are in the nature of "catch-alls." For example, the Division of Physics and the Division of Chemistry can be defined as handling everything in these respective fields which does not fall under any one of the more sharply defined divisions.

In addition to the 19 divisions of NDRC there are two panels concerned respectively with applied mathematics and engineering. The difference between a division and a panel is suggested by the fact that the Fire Control Division, for example, is concerned with the development of fire control instruments, whereas the Applied Mathematics Panel is not concerned with the development of applied mathematics as such, but rather with the use of mathematics to aid in accomplishing the objectives of the various divisions. For this reason the applied mathematics panel includes membership on each divisional committee in which applied mathematics is likely to be important. The Engineering Panel serves all the divisions to expedite the transition from the stage of research and development to the stage of quantity production under Army or Navy contract.

Intimate contact between NDRC and its divisions on the one hand, and the Armed Services on the other, is maintained at several levels by an extensive organization of Army and Navy liaison officers who have proved invaluable as channels for acquainting NDRC with the needs and desires of the Armed Services for new equipment and for making arrangements for demonstrations and service tests.

Proposals for research or development projects come to NDRC from a wide variety of sources—requests or suggestions from the Army or Navy, proposals from industrial or academic research laboratories, promising inventions transmitted to NDRC from the National Inventors' Council, or in many cases projects originating within the NDRC committees themselves. However, the NDRC has complete freedom in making its decisions on the projects which it recommends to the director of OSRD and the priority attached to these projects, and the director of the OSRD has complete freedom in his own judgment to authorize the recommended contracts.

For reasons of security no person serves as a member of any NDRC committee unless he has been "cleared" by the Army and Navy Intelligence Offices, after investigation. Similarly, all personnel of the contractors working on the research and development projects are "cleared" by these intelligence offices to whatever degree is deemed advisable in virtue of the degree of secrecy attached to the project.

*The Committee on Medical Research* (*CMR*), under the chairmanship of Dr. A. Newton Richards, of the Medical School of the University of Pennsylvania, is in every respect parallel to the National Defense Research Committee in its organization and methods of operation. It deals exclusively with problems of war medicine such as shock, immunization or protection against types of diseases characteristic of the present theaters of war, etc. Though considerably younger and smaller than NDRC in both personnel and budget, it already has a record of substantial accomplishment.

*Joint Committee on New Weapons and Equipment* (*JNW*). The organizations described thus far have proven effective in organizing and administering research projects and in maintaining close relationships and exchange of information with the Armed Services and our British allies. In respect to the Armed Services, however, these relationships are primarily at the research and development level and for a time lacked one very important element necessary to make the work fully effective in the war. This missing element was an intimate relationship between the research and development agencies and the Highest Command of the Army and Navy who have the responsibility of planning the military or naval operations in which newly developed weapons might be used effectively or for which new devices should be developed. In order to fill this gap the U. S. Joint Chiefs of Staff in May, 1942, established the Joint Committee on New Weapons and Equipment, composed of Dr. Bush, director of OSRD, as chairman, the Assistant Chief of Staff G4 of the Army (now Brigadier General Moses) and the Chief of the Readiness Division of the Navy (now Rear Admiral De Laney).

JNW is charged by the chiefs of staff with correlating the research programs of Army, Navy and civilian agencies. It acts through subordinate bodies of which the special mission in which I am presently engaged in England is an example.

Through JNW any new weapon whose potentialities appear to be unusually significant is brought directly to the attention of the High Command for their consideration in the planning of future operations. Conversely, JNW offers a direct channel through which the High Command can pass down to the research scientists a request for development of any particular instrumentality which could be particularly effective in connection with some contemplated operation. This type of liaison between the scientists and the High Command is now in the United States. Its possibilities are still being explored and developed but it can be said definitely that it has already demonstrated its possibilities of great value in the war. It is a move in a desirable direction in which you have gone farther than we have gone.

*National Inventors' Council.* War is a great stimulus to invention, not only in the research laboratories of a country, but on the part of great numbers of its citizens, some of whom are technically competent and most of whom are uninformed but sincere in their desire to be helpful. Any actively operating research organization like the OSRD or the Naval Research Laboratory could be quickly bogged down under the deluge of ideas and inventions induced from all sources by the war. It is very important for purposes of morale that these inventors and would-be inventors be sympathetically handled. It is also important that their ideas be expertly examined to make sure that really worth-while ideas are not brushed aside, even though experience has shown that perhaps only one in one hundred thousand is new and significant.

To give such sympathetic and expert consideration and to screen the interesting suggestions out of the great mass, the National Inventors' Council was established in June, 1940, in close association with the U. S. Patent Office in the Department of Commerce, under the chairmanship of Dr. Charles F. Kettering, vice-president in charge of research for the General Motors Corporation. All suggested inventions relating to the war from any source and submitted to any agency or person in the government are channeled through this National Inventors' Council (unless they happen to come initially to an appropriate agency which is immediately interested in pursuing the matter). They pass through the hands of an expert staff of examiners who select those inventions which appear to have merit and bring them to the attention of the appropriate agency.

*Office of Production Research and Development* of the War Production Board. Until recently the organized war research efforts in the U. S. failed to include the very important category of research aimed at the development of substitute materials in fields where shortages exist, or of improved methods of production and manufacture. It was apparently assumed that the commercial interest of the production companies would lead them automatically to take care of this situation. However, under the pressure of war production orders, limitations of manpower and materials and financial regulations, the normal peacetime incentives to such research and development work by companies proved inadequate to meet the needs of the situation. Consequently, last September, there was established in the War Production Board an Office of Production Research and Development under the directorship of Dr. Harvey N. Davis, president of the Stevens Institute of Technology. This agency is still in the process of organization to operate somewhat along the lines of the Office of Scientific Research and Development but with primary responsibility for materials and method of production rather than devices and instrumentalities of warfare. It is regrettable that we did not have the foresight to establish this much-needed agency at a much earlier date, but it has already begun its operations and we hope that it may be enabled to play an important role during the balance of the war.

*Engineering, Science and Management War Training Program.* Though not directly concerned with scientific research, a review of the scientific war agencies in the U. S. would not be complete without at least a brief reference to the efforts to increase the supply of technically trained personnel to meet the increasing demand for such personnel in every field of war activity. In October, 1940, a special engineering training program was organized under the U. S. Office of Education and financed by Congressional appropriation. Later this program was extended to include also training in science and industrial management. It operates at both the collegiate and the technical school levels and its magnitude may be appreciated by the fact that, even in its first year of operation, it put through its specialized courses approximately ten times as many students as graduated in that year from the regularly established engineering colleges. Most but not all of the work was carried on in night schools, and the whole program has been decidedly helpful in relieving the technical manpower shortage.

*Army and Navy Technical Training Programs.* At the present time the Army and Navy are jointly establishing a very extensive program for the training of their own younger personnel in such fields as aeronautical engineering, naval architecture, electronics, communications, automotive engineering, etc., through contractual arrangements with several hundred of the nation's colleges and universities. Under these programs it is anticipated that approximately 250,000 selected young men in uniform will be detailed for this training at educational institutions during the coming year, the duration of such training to vary from field to field and individual to individual, in accordance with the needs of the situation and the performance of the individual. These special collegiate programs are intended to supplement, at the higher level, the very much larger technical training programs which the Army and Navy are conducting in their own establishments.

## CONCLUSION

I conclude this factual, over-long, but I hope usefully informative address on a note of faith and optimism which I am sure is shared by the allied scientists on both sides of the Atlantic. Each of us concerned with some phase of the war effort is aware of some very significant new applications of scientific research in the war. For most of us, this knowledge is largely restricted to the special fields in which we ourselves have been working. Of necessity, the general public knows only in a vague way about some of these things and nothing at all about most of them.

When victory has been won, and the whole story of these scientific accomplishments can be told, it will indeed be a thrillingly interesting recital. Out of it all will come, not only its important contribution to victory, but a number of exceedingly significant results of permanent peace-time value. It is already evident that many of these war-time developments will have very useful peace-time applications, whose contributions to our standards of living and general prosperity and comfort will help to compensate for the ravages wrought by the war. Scientists will have a renewed faith in the worth-whileness of their work, and will continue their intellectual and practical endeavors with the increased power that has come from the experience of "team-work" on war problems. The general public, and especially the governmental and industrial leaders, will have greater appreciation of the value of science and scientists, both pure and applied—and this should result in permanently increased support of scientific research in the universities, industries and governmental agencies. These, I trust, will be some of the long-term gains to which we may look forward as the result of the temporary concentration upon practical problems of survival and victory which the war has forced upon us.

With these words of optimism, I close with the hope that the next American Pilgrim Trust lecturer to address you may not feel obliged to discuss the war, but will be able to treat of some interesting aspect of the progress of science in accord with the original conception of Sir William Bragg and as a happy feature in the post-war forward march of science.

# THE BIOCHEMISTRY OF ANTHOCYANINS

By WILDER D. BANCROFT

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A GREAT deal of work has been done all over the world on the chemistry of plant pigments. Very little work has been done anywhere on the stages through which the pigment develops in the living plant. This should be called the biochemistry of the plant pigments and is temporarily a neglected field of science. My attention has been called by Professor Bruce of Cornell to a book entitled "The Chemistry of Natural Coloring Matters" by Mayer and Cook, published in 1943. I can not find in it any information as to the probable precursors of the carotenes, to take one instance. If somebody would rewrite this book, making an exhaustive presentation of the biochemical side, he would have a masterpiece.

The red pigments in leaves, fruits and flowers and the blue pigments in flowers and fruits are mostly due to anthocyanins, though the red in the tomato, the watermelon, the berry of the mountain ash, the grape haws and the pink-fleshed Texas grapefruit is due to a lycopene. It is now known that anthocyanins are formed in plants in at least two different ways, through reduction of flavones or flavonols by ultraviolet light,[1] or through hydrolysis of what are called leuco-anthocyanins.[2] The latter reaction is often, but apparently not necessarily, accompanied by oxidation. There may be other ways of developing anthocyanins in plants; but this has not yet been proved definitely for any anthocyanin in any leaf, flower or fruit.

Light will not reduce flavones in a test-tube; but it will in some plants at some times. Therefore there must be found in some plants, under as yet unknown conditions, some substance or substances which will make flavones photosensitive. We do not yet know what this sensitizer is in any case. Flavones can be reduced electrolytically to anthocyanins,[3] but it is necessary to have a cathodic over-voltage. Consequently the reduction in the plant is undoubtedly an enzyme reaction.[4]

One important biochemical question is to determine the substance from which the anthocyanin is formed, and this has not been done in a great many cases.

With leaves which turn red in the autumn it is a relatively simple matter to test the green and then the red one so as to determine the probable precursors of the anthocyanin. This was done by Rutzler[5] in some cases. Leuco-anthocyanin appears to be the precursor in 14 per cent. of the cases. The red autumn pigments of the leaves of the sumach, the dogwood and the barberry come from a flavone and those of the sugar maple, the Virginia creeper and the Seckel pear from a leuco-anthocyanin. The leaf of the Japanese creeper, when green, contains both flavone and leuco-anthocyanin. We do not yet know which gives rise to the anthocyanin or whether both do.

When the leaves come red before they turn green, another technique becomes necessary and one was apparently devised by Abbott[6] over thirty years ago. A small copper beech was kept partially covered in the spring, and the leaves under the sacking came green. When these green leaves were exposed to the sun, red could be detected inside of two days. Abbott of course did not test the green leaves for flavones or leuco-anthocyanins. Since light turns the leaves red quickly it seems probable that flavones were present. The development of enough acid to hydrolyze a leuco-anthocyanin would probably take longer.

We do not know whether the red leaves which appear as new leaves in the tropics could come green if the leaves were shaded, as Abbott did his. The botanists and the chemists have not yet got together on this point.

With red flowers one can not usually apply the leaf technique, because it is only in a few cases that we can examine the flower before and after it has turned red. Kuyper[7] reports that the flowers of *Hibiscus mutabilis* come out white at dawn and turn red during the day. Temperature is important in producing the color change. At temperatures under 16° C. there is practically no development of pink. This makes it probable that Kuyper was dealing with a leuco-anthocyanin.

Shibada, Nagai and Kishida[8] found that the flowers of *Diervilla grandiflora* S. and Z. bloom white; but turn rose color during the day. They did not test for

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