the editor of the publications of the institution, Dr. Frank F. Bunker, on "Cooperative Research, Its Conduct and Interpretation." As an example of the fruitful results that may be obtained by the functional integration of a closely cooperating group, the editor selects the story of the activities of the Division of Plant Biology, under direction of Dr. H. A. Spoehr, in research on photosynthesis from the year 1911 through twenty-eight years.

Dr. Bunker explains the success of scientific research in our times as due to the same principle of cooperation. He writes:

> Again, as never before, there is team work among investigators who recognize neither national nor group boundaries. Neither are there ''trade secrets'' in scientific research. Progress reports are continually being interchanged among the workers throughout the world and thus each shares what he has learned with all the others; so, also, each borrows from others and builds upon what he borrows.
>
> An army of investigators, then, trained for the tasks, relieved of economic worry, supplied with every facility required, and working in tacit cooperation, accounts for the epoch-creating achievements now being made in the various fields of scientific research.

In the Year Book of the Carnegie Institution for 1934 Dr. Merriam wrote:

> As yet comparatively little attention has been given to the idea that science may have made its most noteworthy contribution through influences which aid in determining attitudes of mind and objectives. In other words, we have been concerned more largely with discussion of the extent to which science affects our environmental conditions than with the possibility that it helps to give us new points of view and a bettered attitude toward life. The great significance of this difference becomes apparent when we consider that influences determining point of view and attitude furnish major sources of human initiative, and are among the most important guiding elements in life.

These sentences take on new and startling aspects when we consider to what extent diverse points of view and attitude have determined conflicting human initiative within the past few months.

Thousands of people have doubtless gained a wider perspective and "a bettered attitude toward life" both from Dr. Merriam's own writings and from the numerous scientific and educational activities that have been sponsored by the Carnegie Institution under his guidance. Meanwhile "Cooperation in Research" affords a small-scale model of a cooperating society of diverse groups working in harmony, toward which a war-torn Europe may yet turn.

WILLIAM K. GREGORY

REPORTS

WORK OF THE CANADIAN NATIONAL RESEARCH COUNCIL

THE twenty-first annual report of the National Research Council has been issued. The work of the council falls naturally into two main divisions: the research investigations carried out in the laboratories at Ottawa, and the activities of the numerous committees that have been organized by the council to investigate specific problems and sometimes to plan and direct research which may be carried on in the universities or other institutions having special facilities for studies in certain subjects.

Special mention is made in the current report of the formation of the Associate Committee on Medical Research under the chairmanship of Sir Frederick Banting, co-discoverer of insulin. The method of forming this committee may be considered as typical. Preliminary discussions by representatives of the Canadian Medical Association, Royal College of Physicians and Surgeons, the Department of Pensions and National Health and the National Research Council resulted in the calling of a conference for the consideration of all matters relating to medical research in Canada. At this conference a composite picture of medical research was presented when each institution represented at the meeting reported on the scope of the researches on which it was engaged. On the recommendation of the conference the Associate Committee on Medical Research was formed.

Since then the correlation of medical research in Canada has been fostered through interchange of visits by research workers and group-planning of investigations in many fields. A distinct contribution to the furtherance of organized research in the medical field has thus been made.

Similar committees function under the council in many fields: aeronautics, asbestos, coal classification and analysis, field crop diseases, fire hazard testing, forestry, gas research, laundry research, leather, magnesian products, market poultry, metallic magnesium, parasitology, plant hormones, potato research, radio, radiology, survey research, weeds and wool.

In the laboratories there are four main divisions: biology and agriculture; chemistry; mechanical engineering, including aeronautics and hydraulics; and physics and electrical engineering. Supplementing these are a section on codes and specifications and the research plans and publications section. In addition there are the general administrative services necessary to such an organization.

Direction of the National Research Laboratories is vested in the president and all matters of policy are decided upon by the National Research Council, a body of 15 men appointed on the recommendation of the Committee of the Privy Council for Scientific and Industrial Research, which in turn consists of seven members of the Dominion Cabinet, presided over by the Honorable W. D. Euler, Minister of Trade and Commerce.

In the Division of Biology and Agriculture, the development of equipment for malting tests and for cold storage purposes has occupied an important place. Development of special equipment has enabled the laboratories to provide improved service to breeders of malting barleys. Efforts are being made to combine high yield and disease resistance with the superior malting quality needed for enlarging the potential domestic and foreign market for Canadian barley.

The development of equipment to provide temperatures as low as $-40°$ F. in addition to ordinary storage equipment has simplified the study of cold storage of perishables. It is now possible to deal with produce by the quick-freezing method, instead of allowing it gradually to reach the temperature of storage. In cooperation with the industry a comprehensive study of the whole system of curing and pickling bacon is under way, with the object of improving the quality and uniformity of the Canadian output.

Plants elaborate certain substances which, in very minute amounts, have profound effects on plant growth. These have been referred to as "plant hormones." Efforts have been made to utilize these substances as aids to plant growth by treating seeds with them. A method has been developed in the laboratories in which the substance in very small amounts is applied as a dust. By this means root development of cuttings has been stimulated. Types of cuttings that foresters have found very difficult to root have responded well to this kind of treatment. Experiments also indicate that improved germination, root development and growth of leafy parts may be attained when the seed or small growing plants are treated with dust. The substance is cheap, very minute quantities are needed, and since farmers already use dust treatment for the control of fungi, the use of the hormone will involve little extra expenditure of money or labor.

The Division of Chemistry has organized relations for research with the laundry and dry cleaning industry, the asbestos industry, the leather industry and, to a less extent, with the wool manufacturing and sugar industries. Much other work has basic industrial importance, *e.g.*, work on paints, rubber and textiles.

One of the most striking pieces of work of the last few years relates to the utilization of waste natural gas. It has been found that by heat treatment in a furnace of a special but nevertheless simple design, the fraction of waste gas known as stabilizer gas can be made to yield three to four gallons of liquid motor fuel of the benzol type per 1,000 cubic feet of gas. The striking result has now been secured that the residual gas from such heat treatment will yield six to seven pounds of carbon black. This combination process seems to have attractive commercial possibilities.

A distillation column has been developed that is of great interest to the oil-refining, synthetic chemical and coal-tar industries, as well as to other industries using distillation as a process. Noteworthy results have been obtained in researches on starch. In the corrosion laboratory problems ranging from the corrosion of laundry hot water pipes to that of hydro-electric power dam gates are being investigated.

The work on magnesian products in the laboratories has been very profitable to Canada. The magnesian products laboratory has not only made available to the Canadian metal industry better refractories, and a greater range of them, but it has shown that these can be produced from Canadian materials. An investigation of various domestic barks as sources of tannin for the leather industry has been carried on in the leather laboratory. In the rubber laboratory much has been done on the bonding of rubber to metal, including particularly the application to the manufacture of automobile engine mountings of a bonding material previously developed in the laboratories.

In the Division of Mechanical Engineering there are available a wind tunnel for the testing of aeroplane models, streamlined locomotives and any other equipment in which air resistance is important, and a model-testing basin in which somewhat similar problems in regard to water may be investigated.

Five ship models have been tested during the year in the towing basin in connection with the design of private and government vessels. In two instances it was found possible to make major improvements in the propulsive characteristics. A one-hundredth scale model of a stop-log emergency dam was tested to ascertain the forces likely to be met in the operation of similar full-scale structures. Engines, aircraft instruments, gasoline and lubricating oils have been tested for various branches of the government service. Instruction is also given to members of the staff of the Royal Canadian Air Force in the testing, care and maintenance of the instruments used in their work.

In the division of Physics and Electrical Engineering, the normal fundamental phases of work on sound, light and heat, and the studies on electrical engineering are carried on concurrently with a steadily increasing amount of testing, examination and standardization of instruments. Advice has been given to a number of government departments in connection with such varied matters as the acoustical treatment of rooms and buildings, apparatus for depth-sounding purposes, forest fire hazards, collection of insects and methods of plotting results of aerial surveys. In the metrology laboratory, apparatus for the precise calibration of standard gauges for industry has been designed and built. A satisfactory heater for use in refrigerator cars in winter to prevent freezing has been developed and is being taken up commercially. New apparatus has been installed in the electrical engineering laboratory to provide high-voltage current, and progress has been made in the precise regulation of voltage. Thousands of aircraft castings are being examined by x-ray methods and a 600,000-volt apparatus has been constructed to permit expansion of this work and for standardization of equipment for hospital use. Type approval of meters is being continued. The cathode-ray compass and direction finder, detection of fires through haze, estimation of forest fire hazard, vibration in aircraft, ultrasonic generators for depth sounding, problems in camera design for air photography and spectroscopic analyses are some of the other matters under study.

Recent additions to equipment include an electric surge generator capable of developing a million volts for use in the testing of transmission line and other insulating material.

Radium preparations in large numbers are measured and certified in the radium laboratory. Recently a device for rapid testing of radium tubes for leakage was constructed and a method for measuring the radium content of barium-radium bromide preparations was developed.

SPECIAL ARTICLES

EFFECT OF ULTRA-SHORT RADIO WAVES ON PLANT GROWTH

A NUMBER of papers were published during the last few years on the effect of radio waves on plant growth. The results obtained were not quite clear, but in a few cases a definite stimulation of plant growth was observed after seeds or plants were radiated with ultra-short radio waves.[1]

The present article summarizes some of the results of our investigation of the effect of radiation of young corn seedlings with radio waves 2.5 m long.

The waves used were generated by a magnetron oscillator of about 25 watts of power, with a GE type FH 11 split anode magnetron in a conventional circuit.[2] The tube was operated with a DC plate voltage of 1,500 volts in an air solenoid with a magnetic field strength of about 750 gauss. The heating of the filament was such that the plate current was equal to 50 mA. The tank circuit consisted of a single loop of two parallel thin-walled copper tubings 3 mm in diameter and 32 cm long. These tubings were placed vertically 3.5 cm apart. Their lower ends were connected to the plate terminals of the magnetron, and their upper ends were short-circuited. At a distance of 3 cm above the plate terminals a condenser was connected to the tubings. It was made of two 1/16 inch copper strips 3 by 5.5 cm bent to form a split cylindrical condenser about 3.5 cm in diameter. The wave-length was determined with a Lecher system loosely coupled with the oscillator.

The following experimental procedure was followed. Corn seeds were germinated in moist sand in a physiological darkroom at 25° C and 90 per cent. humidity. After 2½ to 3 days the seedlings were dug out for treatment in a room illuminated with white light of moderate intensity. Radiation of the seedlings was accomplished by placing the shoot (excluding the seed and roots) between the plates of the condenser on a strip (7 mm wide and 2 mm thick) of "Victron," a material which shows a very slight absorption of the waves used. The controls were treated exactly like the experimental plants, with the exception of the exposure to the short waves. After radiation the seedlings were planted in moist sand and put back in the darkroom, where they were kept for the duration of the experiment.

Various exposures were tried. Those of 60 seconds and longer usually destroyed the upper part of the mesocotyl, which became limp immediately after treatment and the seedlings died. Exposures of about 10 seconds turned out to be too short to produce any appreciable effect. Therefore the exposures of between 20 and 30 seconds were used in the experiments.

The results of these experiments did not demonstrate any stimulation of growth. To the contrary we found that the waves used produced, at least as far as corn seedlings were concerned, a markedly reduced growth of the first internode,[3] whereas the growth of the coleoptile was far less affected.

It was discovered a few years ago by one of us[4] that

[1] G. Murray McKinley, "Biological Effects of Radiation," pp. 541–558. McGraw-Hill, 1936; K. v. Oettingen, *Strahlentherapie*, 41: 251–285, 1931; S. Sasada, *Nippon Elect. Comm. Engin.*, 7: 295–297, 1937; A. Denier, *Proc. Intern. Congress for Short Waves*, Vienna, 1937: 320–322.

[2] Complete description in General Electric pamphlet GEJ-239A; see also E. D. McArthur and E. E. Spitzer, *Proc.* IRE.,19: 1971–1982, 1931.

[3] The shoot of the seedlings of grasses consists of the first internode or mesocotyl and above it the coleoptile which envelops the primary leaf.

[4] J. van Overbeek, *Rec. trav. bot. neerl.*, 33: 333–340, 1936.