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Résumé de l'article

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THE NATIONAL RESEARCH COUNCIL AND SEVENTY-FIVE YEARS OF AGRICULTURAL RESEARCH IN CANADA

Ralph H. Estey[1]

Abstract

Various aspects of the agricultural research that has been supported or carried out by the National Research Council of Canada during its first 75 years are reviewed. This research has ranged from such practical problems as: how to improve the edibility of oils from oilseed crops; how to improve the keeping quality of farm produce in storage; and how to control diseases and pests of farm animals and plants, to genetic engineering; the creation of new trans-genic plants and custom-designed enzymes for the benefit of agriculture.

Résumé

Divers aspects de la recherche agricole encouragée ou accomplie par le Conseil national de recherches du Canada pendant ses premiers 75 ans sont révisés. Cette recherche variée comprend des problèmes pratiques tels que l'amélioration de la comestibilité des huiles de cultures oléagineuses, l'amelioration de la qualité de conservation des produits de la ferme en entreposage, la lutte contre les maladies et les pestes chez les animaux de la ferme et des cultures, jusqu'au génie génétique; le développement de nouvelles plantes transgénétiques et les enzymes synthétique pour le bénefice de l'agriculture.

In 1916, when an Honorary Advisory Council for Scientific and Industrial Research, the precursor of the National Research Council of Canada (NRC), was constituted, the Dominion Department of Agriculture had been doing practical agricultural research for more than thirty years. However, that Department had only two people on its staff, other than administrators, with earned university degrees higher than a masters, and most of the twenty-four Superintendents of its branch farms and stations were completely lacking in university degrees. Only four of them had a degree higher than a BSc. With the possible exception of one person, nobody within the Department of Agriculture could make a proper sta-

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tistical analysis of the results of agricultural experiments.[2] Although those agriculturists had done some very useful work, little of it resulted from truly scientific experimentation.

In contrast to this, the Council, with a cadre of highly trained personnel that included two University Presidents, a Dean of Science, and university professors of chemistry and physics, soon became the only organization in Canada, other than one or two universities, capable of performing or sponsoring scientific agricultural research. Nevertheless, due to a lack of funds, and because it didn't want to alienate some of its supporters in the federal government who were also staunch supporters of the Dominion Department of Agriculture, the NRC did not rush into agricultural research.[3]

The first duty of the first Council, as set out in the Order in Council that established it, was to 'ascertain and tabulate the various agencies in Canada, which are now carrying on scientific and industrial research,' and 'to coordinate these agencies so as to prevent overlapping of effort.' It was also required 'to make a scientific study of our common unused resources, the waste and by-products of our farms, forests, fisheries and industries, with a view to their utilization in new or subsidiary processes.'[4]

One of the agricultural 'wastes' that received early attention was wheat straw, because approximately twenty million tons of straw was being burned on prairie farms each year just to get rid of it. In the first year of its operation the Council gave financial support to Prof. R.D. MacLaurin of the University of Saskatchewan to study ways of using straw for the production of gas to heat and light farm homes, and O.J. Walker was granted a Fellowship to study, in the Chemistry Laboratories of that University, products of the destructive distillation of straw, and the uses of the residue as fertilizer or fuel.[5]

Although the research on ways to make commercial use of wheat straw was interrupted by the exigencies of two world wars it continued, intermittently, and in

2 A list of employees and their degrees is in **The Organization, Achievements and Present Work of the Dominion Experimental Farms** (Ottawa, c 1925), 5.

3 The relations between the federal government, its department of agriculture and the NRC are described by Mel Thistle, **The Inner Ring. The Early History of the National Research Council of Canada** (Toronto 1966), 332-33.

4 **Report of the Administrative Chairman of the Honorary Advisory Council for Scientific and Industrial Research for the year ending March 31, 1918** (Ottawa 1918), 7-8.

5 Ibid. 7, 29, 30, 37.

1945 the NRC published abstracts on the use of straw, representing the culmination of several years' work, including references to 846 articles and 353 patents.[6]

Studies on the utilization of straw continued into the late 1950s when its potential for paper-making was investigated, and straw was used to manufacture insulating material, hardboards[7] and briquettes for fuel.[8]

Another agricultural waste that received early attention was that produced by tobacco farming and the manufacture of chewing and smoking tobacco. At the suggestion of Dr C. Gordon Hewitt, Dominion Entomologist, the Council investigated the economics of extracting nicotine sulphate, a powerful insecticide, from the tobacco wastes, and sponsored research along these lines by Arthur D. Hone, in the laboratories of the University of Toronto.[9]

One of the earliest inventions of the Council was the device and mechanism of the Associate Committee. The procedure was simple but very effective. When research on a subject of broad general interest was proposed, the Council frequently referred it to an Associate Committee composed of the leading authorities in Canada who were working in that particular field or who were otherwise qualified to offer advice. The committee members, unpaid except for expenses, were requested to review the state of knowledge on the problem, both inside and outside of Canada, and then to draft a specific research program for its solution and to suggest where and by whom the new research should be undertaken. The first two Committees to deal with matters directly related to agriculture were set up in 1917; one on Animal and Plant Diseases, and one on Flax Cultivation.[10]

The committee on animal and plant diseases concerned itself with investigations on swamp fever of horses in the prairie provinces,[11] and the rust disease of wheat. This latter was a direct response to the devastating losses due to rust in 1916 when the yield of wheat in western Canada was reduced by an estimated

6 **The National Research Council Review** (Ottawa 1951), 13. See also,'Abstracts on the Utilization of Straw,' NRC **Report 1242** (1945), and Report 3749 (1955).

7 G.D. Sinclair and H.R. Sallans, 'Insulating and Hardboard Mill of Prairie Fibreboard now Operating,' **Pulp and Paper Magazine of Canada** (December 1958). See also, Chemistry in Canada (December 1957).

8 J.E. Stone, 'The Briquetting of Straw,' **Canadian Journal of Technology** 29 (1951), 98-110.

9 A.D. Hone, 'Nicotine and Tobacco Waste,' NRC **Report 4** (1919).

10 **Report of the Administrative Chairman of the Honorary Advisory Council for Scientific and Industrial Research for the Year ending March 31, 1918** (Ottawa 1918), 10.

11 Ibid., 12.

ten million bushels. That great loss prompted the Council to give financial aid to Walter P. Thompson, Professor of Biology, University of Saskatchewan, in his attempt to produce an early ripening, rust-resistant variety of wheat.[12]

The committee on flax cultivation recommended that every effort be made to increase the cultivation of flax in both eastern and western Canada. The flax grown in Saskatchewan and Alberta at that time was for seed only and its straw was disposed of by burning. In response to the wartime shortage of linen, the Committee encouraged research into methods of using the straw for making the twine and linen fibres that were needed in the manufacture of aeroplanes.[13]

In 1919 a number of Prince Edward Island farmers were experiencing so many problems in their attempts to breed and raise silver foxes that they appealed to the Council for help. In response to their plea, the NRC created an Associate Committee on Fox-breeding and gave it $5000.00 to initiate an investigation of the various factors that were unfavourably affecting the fox-breeding industry. This initiative by the Council, plus the cooperation of the Health of Animals Branch of the Dominion Department of Agriculture, eventually enabled 'fox-farming' to become as well managed and almost as predictable as the rearing of other animals on Canadian farms. Some of the problems of the fox raising industry were discussed by Andrew Hunter in *NRC Bulletin No. 8*, in 1920, and G. Ennis Smith published on food for foxes, in *NRC Report No. 9*, in 1921.

Until 1923, when the NRC, in cooperation with the Dominion Department of Agriculture, set up an Associate Committee on Accurate Plot Work, it had been virtually impossible to make accurate comparisons of the yields of varieties of grain grown in test plots in different parts of the country. At first, the recommendations of that committee brought uniformity to only eight test plots from Alberta to Prince Edward Island, but the need for accuracy became so obvious that its principal recommendations were soon applied to test plot work throughout Canada.[14]

Because of a succession of dry years following the 1916 disaster, wheat rust was not a major problem in western Canada until 1923, when it was almost as devastating as it had been in 1916. Responding to urgent appeals for assistance from the affected farmers and from organizations directly related to or dependent

12 Ibid., 29.

13 Ibid., 10.

14 **First Report of the President National Research Council of Canada 1924-1925** (Ottawa 1925), 33.

upon agriculture, the federal government revised the Act that had established the NRC and expanded its clauses, in 1924. Under the terms of that revision the Council was specifically empowered to conduct research, 'the object of which is to improve conditions in agriculture.' As if in preparation for that revision, H.M. Tory, President of the young University of Alberta, had been persuaded to become a member of the Council in 1923, and its Honorary Chairman by the end of that year. Although Tory was not an agriculturist he promptly responded to the Council's renewed and augmented mandate by urging the immediate drafting of a rust research program. To do this, the Council created an Associate Committee on Cereal Grain Rust Research in 1924, and allocated funds to assist in getting its work under way. At Torey's initiative, and with the cooperation of the federal Minister of Agriculture, the Council first arranged for a general conference of rust experts from the United States and Canada, to be held immediately before the first meeting of the Associate Committee. That conference, in Winnipeg on 9 and 10 September 1924, discussed various aspects of the rust problem and then delegated a small special committee, chaired by E.C. Stakman, the leading authority on grain rust diseases in the United States, to propose an international program for the control of the disease. Immediately following that general conference, the Associate Committee on Cereal Grain Rust held its first meeting to discuss the recommendations of the International Committee. A second meeting was held on 26 January 1925, during which a programme for cereal grain rust research in Canada was adopted.[15]

Recommendations from those meetings, and the ones held a year earlier, were largely responsible for the lines of research on grain diseases carried on by the scientists of the Dominion Department of Agriculture in the newly constructed Rust Research Laboratory on the campus of the University of Manitoba, and in the prairie Universities, several of whose staff members received financial assistance from the NRC. One of the most noteworthy of these latter was Robert Newton, Professor of Field Crops and Biochemistry at the University of Alberta. He was the first director of the NRC's Division of Biology and Agriculture and, by chance, the senior author of the first paper published in the *Canadian Journal of Research*; a journal sponsored by the NRC. That paper, titled 'Studies on the nature of rust resistance in wheat,' described his own work and that of his graduate students, and provided an outline of several other projects funded by the NRC. Three other professors of western universities who received financial assistance to study grain diseases around that time were W.T.G. Weiner, at the Manitoba Agricultural College; H.F. Roberts, University of Manitoba; and J.B

15 Ibid., 22-23.

Harrington, University of Saskatchewan, each of whom received a grant in 1925.[16] From that year, and throughout the 1930s, grain research, with emphasis on wheat and barley, was a major feature of the agricultural work of the Council. The combined research efforts, largely coordinated by the NRC, eventually led to a spectacular reduction in the damage due to the cereal grain rusts and other grain diseases in Canada.[17]

During the first decade of the twentieth century there was a growing conviction that sufficient attention was not being paid to the control of tuberculosis in farm animals or in humans. Recognizing the importance of this problem and the need for coordinated research on it, the NRC appointed an Associate Committee on Tuberculosis Research that included representatives from all organizations known to be actively working on, or which were directly interested in, the control of that disease in Canada. A.C. Rankin, Dean, Faculty of Medicine and Professor of Bacteriology and Hygiene, University of Alberta, played a leading role in that cooperative study, which included veterinarians who had been recognized for their work on tuberculosis of cattle.[18]

In August 1926, the Department of Natural Resources of the province of Nova Scotia requested the NRC to investigate the storage of apples in the warehouses of that province, with the object of determining the conditions of storage which would reduce the considerable losses normally experienced, and improve the quality of the apples being marketed. An Associate Committee on Fruit Storage was promptly appointed by the Council and numerous experiments were carried out, in fruit-growers warehouses. The most useful results of that research were published by S.G. Lipsitt, in 1928, as *NRC Report No. 23.*

In the 1920s the inferior quality of the wool being marketed by Canadian sheep farmers prompted the Canadian Woollen and Knit Goods Manufacturers Association to request the NRC to recommend ways of improving the situation. Following a preliminary investigation, the Council established an Associate Committee on Wool, with members representing all aspects of the sheep breeding and woollen industry, including a representative from the Wool Industries Research Association of Great Britain. The recommendations from that committee, which became a Joint Associate Committee of the NRC and the Domin-

16 Ibid., 23.

17 A referenced account of this accomplishment has been provided by Thorvaldur Johnson, **Rust Research in Canada,** Canada Department of Agriculture Pub. No. 1098 (Ottawa 1961).

18 A.C. Rankin, 'Vaccination against tuberculosis with Bacillus calmette-guerin,' **Canadian Journal Research** 1 (1929), 48-56.

ion Department of Agriculture, in 1934, and its action as a sort of watchdog on the industry for twenty years, resulted in significant improvements in the quality of Canadian woollen goods with consequent benefits to sheep farmers as well as the manufacturers and exporters of their product.[19]

In 1928, the widespread occurrence of frost-injured grain containing varying percentages of immature and green kernels provided an opportunity for a study of the influence of this type of damage on milling and baking qualities of the affected wheat. An extensive investigation of different phases of this problem was undertaken by the Associate Committee on Grain Research that had been set up in 1926 to coordinate fundamental and applied research on grains relating to their quality for food and other traditional uses. The interests and activities of that committee ranged from cereal chemistry to agronomic practices. J.G. Malloch, the Committee's Research Assistant, in collaboration with W.F. Geddes, Professor of Agricultural Chemistry, University of Manitoba, and R.K. Larmour, Professor of Chemistry, University of Saskatchewan, carried out the initial investigation. They expanded their studies to include the relative milling and baking quality of wheat varieties and other factors contributing to variability in experimental baking.[20] After Malloch transferred to the Ottawa laboratories of the NRC, where H.R. Sallans and J.A. Anderson were investigating varietal differences in barleys and malts,[21] he continued his studies on factors that contribute to the quality of bread.[22]

The realization that diseases such as the smuts and root rots could not be ignored in the development of rust-resistant varieties of grain led to the formation of an Associate Committee on Field Crop Diseases in 1928. That Committee, composed of representatives from the Board of Grain Commissioners for Canada and the Universities of Alberta, Manitoba and Saskatchewan, absorbed the Associate Committee on Cereal Rust Research by making it a sub-committee in 1931. Plant breeding activities were monitored by a sub-committee which, in 1945, became an Associate Committee on Plant Breeding.

19 **National Research Council Report of the President 1926-1927** (Ottawa 1927), 10. Also, Ibid., 1934-35, 88-89.

20 W.F. Geddes, J.G. Malloch and R.K. Larmour, 'The milling and baking quality of frosted wheat of the 1928 crop,' **Canadian Journal of Research** 6 (1932), 119-55. See also 255-64 and 333-61.

21 H.R. Sallans and J.A. Anderson, 'Varietal differences in barleys and malts. X Correlations of carbohydrates with nitrogen fractions and with malt extract, steeping time and malting loss,' Ibid. 18 (1940), 219-29.

22 J.G. Malloch, 'Control of dough temperature during fermentation,' **Cereal Chemistry** 17 (1940), 73-78.

The Associate Committee on Field Crop Diseases was reorganized in 1946 and renamed the Associate Committee on Plant Diseases the following year. In the spring of 1928 the NRC was advised by the government of Nova Scotia that serious losses were being suffered by the apple growers of that province because their shipments of apples failed to reach England in a good marketable condition. The most serious trouble appeared to be due to the loose packing of the apples in barrels, which resulted in much bruising during transit, and their consequent sale at reduced prices. The Council appointed an Associate Committee on Apple Slacks, under the chairmanship of J.H. Grisdale, then Deputy Minister of Agriculture in the federal government, with representation from the Province of Nova Scotia.[23] Apparently the solution to that problem was so obvious that the committee became inactive within two years.

Complying with requests received from different honey producers' organizations, the NRC, in cooperation with the Dominion Department of Agriculture, the Manitoba Agricultural College and the Montreal District Beekeepers Association, appointed an Associate Committee on Honey, which held its first meeting in Ottawa in August 1929. The most important single problem with Canadian honey appeared to be that of fermentation, from which serious losses were being suffered. The committee also considered other problems, such as crystallization, bleaching of beeswax, and bee diseases. Miss H.D. Chateway, in the NRC's Division of Chemistry, found the moisture content of honey to be of great importance in regard to spoilage by fermentation.[24] This was also the time when the NRC sponsored research, directed by Dr F.J. Snell at Macdonald College of McGill University, the objective of which was to develop methods that would enable producers to put Canadian maple sugar and maple syrup on the market as standardized products.[25]

Weeds had long been responsible for a variety of losses to agriculturists in the prairie provinces but weeds were almost the last of the agricultural pests to be seriously investigated by scientists. There was no body of knowledge about weeds comparable to those concerning animal and plant diseases and insects. Because of its early interest in biological control of agricultural pests, including weeds, the Council gave financial support to A.W. Henry, University of Alberta, for his 1929 study of plant parasites of weeds.[26] In the fall of that year, a confer-

23 **Eleventh Annual Report of the NRC, 1927-1928** (Ottawa, 1928), 27.

24 **Thirteenth Annual Report of the NRC, 1929-1930** (Ottawa 1930), 39.

25 Ibid., 85-86.

26 Ibid., 14.

ence on the destruction of weeds by means of chemicals was called in Edmonton. That conference requested the NRC to undertake a study of weed control that was not to be limited to chemical repression. The Council responded to that request by appointing an Associate Committee on Weed Control, with a Subcommittee on Chemical Experiments. Financial assistance was given to G.P. McRostie, Professor of Agronomy, University of Manitoba; G. Godel, Weed Investigator for Saskatchewan; and W.G. Smith, Weed Investigator for Alberta. They worked with the Dominion Agrostologist L.E. Kirk and J.M. Manson, the Council's own weed investigator, and published 'Weeds and their Control,' as *NRC Report No. 27*, in 1932. The first nineteen papers by scientists supported by that committee, comprising some 437 pages, were published as *NRC Publication No. 763*, in 1937; three years after it had become known as the Associate Committee on Weeds of the Dominion Department of Agriculture and the NRC, and included an eastern section with representatives from the provinces east of Manitoba.

Insect control had been a concern of the NRC ever since the European corn borer was discovered in Canada late in the summer of 1920. Because its increase and spread was phenomenal, due to the lack of native parasites, corn (maize) growers appealed to federal and provincial departments of agriculture and to the NRC for assistance in controlling its spread. Although no special or associate committee was formed to coordinate insect research, Harold J. Fox, at the University of Western Ontario, was sponsored by the NRC in a study of the life history of a parasite of the corn borer as a first step in the biological control of the pest. His account of that work was published as *NRC Report No. 21*, in 1927.

In 1931, officials of the Canadian Cooperative Wheat Producers Ltd., the central selling agency of the wheat pools in the prairie provinces, appealed to the NRC for authoritative information on the feeding values of various grains, especially barley, a home-grown product, versus corn, a product that was largely imported. The Council granted funds to Earl W. Crampton, Associate Professor of Animal Nutrition, Macdonald College of McGill University, for such a study. Within a remarkably short time, Crampton published reliable information on the comparative feeding values for livestock of barley, oats, wheat, rye and corn, as *NRC Report No. 28*, in 1933. Three years later he published *Report No. 29*, which provided a review and an analysis of published data regarding the feeding values of those grains for poultry. There was no Associate Committee on Animal Nutrition until one was established in 1951.

In 1932-33 the NRC became more closely linked with Canadian agricultural scientists through the creation of an Associate Committee on Agriculture. It was composed of the deans of all the university agricultural faculties and agricultural colleges, the Chairman of the Research Committee of the Canadian Society of Technical Agriculturists (the forerunner of the Agricultural Institute of Canada), and three representatives of the Dominion Department of Agriculture. That committee served in an advisory capacity to the NRC and in this respect differed from the committees that were directing active research in their field. It was dissolved when the Dominion Department of Agriculture formed a National Advisory Committee on Agriculture in 1935-36.

Beginning with the early research on swamp fever of horses and tuberculosis of cattle, scientists of the NRC, or ones sponsored by the Council, have intermittently searched for methods to control pests and diseases of farm animals and poultry. This aspect of their work was highlighted when an Institute of Parasitology, a laboratory designed to serve a specialized field of biology rather than a geographical region, was established on the Macdonald Campus of McGill University in 1931, through the cooperation of the Québec Government, McGill University, the Empire Marketing Board, the Dominion Department of Agriculture, and the NRC. The three storey building, with library, laboratories and animal accommodations, was erected out of moneys received from the Québec Department of Agriculture. Equipment and salaries of the staff were provided jointly by the Empire Marketing Board and the NRC, of which H.M. Tory was then President. When the Marketing board went out of existence the Institute was, for many years, operated by McGill University in collaboration with the NRC and the Dominion Department of Agriculture.[27] Thomas M.W. Cameron, senior lecturer of helminthology at Edinburgh, became the first Director of the Institute in 1932. Scientists in that new facility, the first one of its kind in the world, worked in close cooperation with veterinarians in the Division of Animal Pathology, Canada Department of Agriculture. They developed control measures for intestinal worms of horses and sheep, worms and coccidiosis of domestic chickens, roundworms in pigs, and blackhead in turkeys, to mention only a few of their projects that pertained directly to Canadian agriculture, and which received financial assistance from the NRC, and coordinating advice from its Associate Committee on Parasitology, formed in 1932.[28]

As the federal Department of Agriculture increased its studies on diseases of farm livestock those of the Institute of Parasitology became less agriculturally oriented and more concerned with diseases and pests of wild animals, birds and fish, in Canada and other parts of the world.

27 **Sixteenth Annual Report of the NRC, 1932-1933** (Ottawa, 1933), 57.

28 C.E. Tanner, 'The Institute of Parasitology,' **The Macdonald Journal** (Dec. 1974), 3-4. Also, N.T. Gridgeman, **Biological Sciences at the National Research Council: The Early Years to 1952** (Ottawa 1978), 25.

In 1934 the NRC convened a Cold Storage Conference in Ottawa for a discussion of refrigerated railway and ocean transport, and the cold storage of meat, fruits and vegetables. At that conference it was decided that the NRC should begin a study of the storage of meat and the Dominion Department of Agriculture would study storage of fruits and vegetables. However, those lines of demarcation soon became blurred because the Québec Federal-Provincial Committee on Cold Storage requested the NRC to study conditions in the celery cold storage rooms in some Montreal warehouses.[29]

In 1935 it was decided to enlarge the scope of the committee and name it the Joint Associate Committee on Storage and Transport of Food of the NRC and the Dominion Department of Agriculture.[30] The second world war diversified the activities of the Committee and it became known as the Canadian Committee on Food Preservation, the history of which was compiled by M.W. Thistle.[31] By 1945 more than 200 scientific papers had been published in that Committee's numbered series.[32]

Although research on apple storage, by the NRC, was interrupted by the second world war studies on the cold storage of fruits and vegetables were revived after the war, with C.P. Lentz being one of the principal investigators. He was the author or co-author of more than a dozen papers on the effects of frozen storage on poultry meat[33] and the rate of moisture loss of fresh fruit and vegetables stored under refrigeration.[34] He and his colleagues also researched and published on the design of a jacketed vegetable storage system that was widely emulated.[35]

Shortly after the first world war there was an effort to find foreign markets for Canadian butter. This was difficult because of a lack of uniformity in the quality

29 **Annual Report of the NRC 1931-1932** (Ottawa 1932), 63.

30 Ibid., 1934-1935 (Ottawa 1935), 85.

31 M.W. Thistle, Compiler, 'History and work of the Canadian Committee on Food Preservation,' **Food in Canada** 9 (1949), 11-13; 34-36; 26, 28, 30, 32.

32 Ibid., 12.

33 C.P. Lentz and E.A. Rooke, 'Temperatures in frozen poultry, fruit and vegetables shipped by road in refrigerated trailers,' **Food in Canada** 21 (1961), 38-41.

34 C.P. Lentz and E.A. Rooke, 'Rate of moisture loss of apples under refrigerated storage conditions,' **Food Technology** 18 (1964), 119-21. Also, Ibid. 20 (1966), 201-4.

35 C.P. Lentz, L. Van den Berg, E.G. Jorgensen and R. Sawler, 'The design of jacketed vegetable storage,' **Canadian Institute Food Technology** 4 (1971), 19-23.

of the butter from different parts of the country. Being aware of this, the NRC granted funds to W. Sadler of the Department of Dairying, University of British Columbia, in 1919 and for several subsequent years, to study the relation of bacteria to the quality of graded butter. An account of that study was published as *NRC Report No. 16*, in 1926. In 1929 Sadler received an additional grant from the NRC to study the relation of bacteria to feed flavours and stable odours in milk.[36]

Butter and butter-making were topics of intermittent research for several years. After the second world war J.A. Pearce, Dyson Rose, and H. Tessier made an assessment of the German-made Fritz continuous butter-making machine for Canadian use,[37] and, with NRC support, two improved butter-making processes were developed. The ultimate result of this research was less costly butter that could be spread at refrigerator temperature, thus making it more competitive with butter substitutes. NRC research also led to the development of dairy and non-dairy foods with a shelf life of over three months without refrigeration.[38]

In the 1920s many farmsteads in Canada were relatively isolated, and getting electricity to them by conventional means was costly. To alleviate this situation, the NRC sponsored research, at the University of Saskatchewan, on the development of a satisfactory windmill unit for generating farm electricity.[39]

J. Ansel Anderson, Cerealist in the Council's Ottawa laboratories from 1930 to 1939, studied some of the biochemical aspects of grain rust, while his colleague, Frank H. Peto, Geneticist in those laboratories from 1932 until 1940, took the genetic approach. Peto's first project was a study of the effects of aging and temperature on the chromosomal mutation rates in barley and corn.[40] By germinating barley at abnormally high temperatures, he obtained a plant with double the usual number of chromosomes. He also obtained doubling through the use of the chemical compound known as colchicine. Peto's ultimate objective was the development of a perennial, rust-resistant grain plant. To accomplish

36 W. Sadler and M.L. Irwin, 'Feed flavor or stable odor in milk,' **Canadian Journal Research** 3 (1930), 200-04.

37 J.A. Pearce, Dyson Rose and H. Tessier, 'Assessment of the Fritz continuous butter-making machine for Canadian use,' **Canadian Journal Food Technology** 30 (1952), 167-77.

38 Anonymous, **A Practical Perspective. The NRC Plan 1986-1990** (Ottawa 1985), 39.

39 G.J. Klein, 'A small windmill-generator used for charging a 6-volt storage battery,' (Ottawa c1939) **NRC Report 813**. Also, **NRC Report for 1928-1929**, 40.

40 F.H. Peto, 'The effect of aging on the chromosomal mutation rate in maize and barley,' **Canadian Journal Research** 9 (1933), 261-4.

this, he experimented on the hybridization of wheat and closely related wild perennial grasses, and succeeded in crossing an emmer type wheat with the grass *Agropyron glaucum* to produce a vigorous, leafy perennial, but not one that yielded useful grain.[41] L.P.V. Johnson, of the then Division of Biology and Agriculture in the NRC, had a similar objective when he and his colleague H.A. McLennan, attempted to hybridize oats and perennial *Avena* species.[42]

Incidentally, Peto played a key role in the development of fast growing, disease-resistant, hybrid Poplar trees for prairie farm shelterbelts,[43] and he investigated the cause of bolting, (the abnormal production of flowers and seed the first year), in Swede turnips.[44]

Before Anderson left the Council to become Director of the Grain Research Laboratory in Winnipeg he studied varietal differences in barleys, with regard to malting, and on ways of improving the malting process.[45]

All too often farmers would watch a good crop of grain reach maturity and then be unable to harvest it in a dry state because of rainy weather. Council specialists, or ones sponsored by the Council, experimented with different methods of drying wheat, and the milling and baking quality of the resulting dried grain. William H. Cook, then a Junior Research Biologist with the NRC, was one of the leading figures in that work. His first task was to choose a method or an instrument that could accurately measure the amount of moisture in grain before he could devise methods for drying the grain that was found to be too wet for storage or milling. He and his colleagues also investigated the milling and baking qualities of the new cultivars of wheat as they were developed by plant breeders.[46]

41 F.H. Peto, 'Hybridization of Triticum and Agropyron. V Doubling chromosome number in T. vulgare and F1 of T. vulgare x A. glaucum by temperature treatments,' **Canadian Journal Research** C 16 (1938), 516-29.

42 L.P.V. Johnson and H.A. McLennan, 'An attempt to hybridize annual and perennial Avena species,' Ibid., 17 (1939), 35-7.

43 J.L. Farrar, 'Some historical notes on forest tree breeding in Canada,' **The Forestry Chronicle** 45 (1969), 393.

44 F.H. Peto, 'The cause of bolting in Swede turnips (Brassica napus var napobrassica [L.] Peterm.),' **Canadian Journal Research** 11 (1934), 733-50.

45 J.A. Anderson and W.O.S. Meredith, 'Laboratory malting. iii Steeping temperature and method,' **Cereal Chemistry** 17 (1940), 66-72.

46 Anonymous, **The Drying of Wheat, NRC Report No. 24** (Ottawa, 1929), pp 122. Also, Ibid., **Report No. 25** (Ottawa, 1932).

The fact that agricultural research had a prominent place in the activities of the NRC became more manifest in 1929 when the Division of Biology became the Division of Economic Botany and Agriculture, which, one year later, changed its name to the Division of Biology and Agriculture. However, those name changes came at a time when the Dominion Department of Agriculture was developing a cadre of well-trained scientists, several of whom were envious of the role the NRC was playing in agricultural research.[47] W.H. Cook, who became director of the Division of Biology and Agriculture in 1941, was well aware of this envy and its potential for non-cooperation, so he requested that the name of his division be changed to that of Applied Biology, without the word Agriculture. Consequently a Division of Applied Biology, within the NRC, came into being later that year. It retained that name until 1963 when it became the Division of Biosciences, and, in 1968, the Division of Biology.

Cooperation with the federal Department of Agriculture had been a feature of NRC activities, as they related to agriculture, almost from its inception. To make this cooperation more obvious the names of several Associate Committees became Joint Associate Committees of the NRC and the Dominion Department of Agriculture, in 1934-35. An example of this is the Associate Committee on Field Crop Diseases (Plant Diseases, after 1948) of the NRC and the Dominion Department of Agriculture.

W.H. Cook was a very versatile scientist. In 1937 he published a series of papers on chemical weed killers,[48] and as a Biologist in the NRC laboratories in Ottawa, he cooperated with his colleague, J.W. Hopkins, Statistician, and W.F. Geddes, Chemist in charge of the Grain Research Laboratory of the Board of Grain Commissioners of Canada, Winnipeg, in continuing research on methods of determining moisture in grain.[49] He held a prominent place in the Council's early work on cold storage research,[50] and was co-author of several papers in the series of twenty-two that were devoted to Canadian Wiltshire bacon and published in the *Canadian Journal of Research* in 1940-41; a series that was initiated by N.E. Gibbons, C.A. Winkler and W.H. White, when they provided an outline of

47 Thistle, 332-33.

48 W.H. Cook, 'Chemical weed killers. V Relative toxicity of selected chemicals to plants grown in culture solution, and the use of relative growth rate as a criterion of toxicity,' **Canadian Journal Research** C 15 (1937), 520-37.

49 W.H. Cook, J.W. Hopkins and W.F. Geddes, 'Rapid determination of moisture in grain,' **Cereal Chemistry** 12 (1935), 230-43.

50 W.H. Cook, 'Food preservation,' **Proceedings Royal Canadian Institute** 3 (1938), 41-50.

the study and their methods.[51] Cook went to Germany shortly after the end of the second world war to learn about German food technology, and he published his views on that general topic each month for seven months in *Food in Canada*, beginning in March 1946.

Because Britons had acquired a taste for what they referred to as Wiltshire bacon, and because, by comparison, they considered the bacon from Canada to be of inferior quality, NRC scientists C.A. Winkler and J.W. Hopkins, researched ways of improving the quality of Canadian bacon landed in Britain.[52] Winkler had devised a method of estimating the relation between the pH of meat and its colour, and the effect of desiccation on the colour of cured pork. Those studies led him to develop a recording apparatus to measure the tenderness of meat.[53] N.E. Gibbons, who, with Dyson Rose, showed that the anti-mortum treatment of pigs had a direct bearing on the quality of Wiltshire bacon,[54] made quantitative bacteriological studies of the meat[55] and was joined by H.H. White in a study of the colour quality of pork after frozen storage and its conversion to bacon.[56] In a related study, D.S. Clark, who had studied methods of estimating the bacterial population on surfaces, worked with L.A. Roth in studies on the bacteria of vacuum-packaged fresh beef.[57]

While the Council's research was directed toward the improvement of the quality of bacon and other pork products for sale to Britain, methods of improving the quality and preservation of dressed poultry, eggs and egg powder were also studied. For example, Mycologist F.T. Rosser studied the relationship between surface contaminants and the spoilage of eggs in storage. He, and his colleagues

51 W.H. Cook, N.E. Gibbons, C.A. Winkler and W.H. White, 'Canadian Wiltshire bacon. i Outline of investigations and methods,' **Canadian Journal Research** D 18 (1940), 123-34. See also, Ibid., 19 (1941), 233-39.

52 C.A. Winkler and J.W. Hopkins, 'Canadian Wiltshire bacon. xiii Tenderness of bacon and the effect of heat treatment on tenderness,' Ibid., 18 (1940), 300-04. Also, Ibid., 19 (1941), 22-7.

53 C.A. Winkler, 'Tenderness of meat. i A recording apparatus for its estimation and relation between pH and tenderness,' Ibid., 17 (1939), 8-14.

54 N.E. Gibbons and D. Rose, 'Effect of anti-mortum treatment of pigs on the quality of Wiltshire bacon,' **Canadian Journal Research** F 28 (1950), 438-50.

55 N.E. Gibbons, 'Canadian Wiltshire bacon. vi Quantitative bacteriological studies on the product,' **Canadian Journal Research** D 18 (1940), 202-10.

56 N.E. Gibbons and W.H. White, 'Canadian Wiltshire bacon. xvi Colour and colour stability of pork after frozen storage and conversion to bacon,' Ibid., 19 (1941), 85-95. See also 104-11.

57 L.A. Roth and D.S. Clark, 'Studies on the bacterial flora of vacuum-packaged fresh beef,' **Canadian Journal Microbiology** 18 (1972), 1761-66. See also 321-26.

also assessed the value of sealing agents against the entrance of microorganisms into the eggs.[58] That work was greatly accelerated after the supply of eggs and bacon to Britain from Denmark was interrupted by the second world war. Those studies continued for several years after the end of that war when Bacteriologist N.E. Gibbons investigated the effect of the age of eggs and the time of oiling on their keeping quality,[59] and Biochemist J.A. Pearce wrote, or was co-author of several papers on both dried eggs and liquid frozen eggs.[60] A.W. Khan included a study of biochemical changes in poultry muscle in his general investigation into the cryochemistry of animal tissue,[61] and was joined by L. Van den Berg in a study of quality changes in poultry meat during the freezing process.[62] Dyson Rose and C.P. Lentz had shown that short chilling periods cause toughness in frozen turkeys.[63]

Dyson Rose was heavily involved in a long-term study of frozen milk and of why some of the milk solids were so unstable during the freezing and thawing processes.[64] He also studied variations in the composition of milk from individual cows, and the relation between micellar and serum caseine in cow's milk.[65]

The NRC's investigations, during the second world war, of better methods for the canning of poultry meat had nothing to do with feeding the British who, because of an acute lack of refrigerated shipping space early in the war, decided that dressed poultry was something they could do without. This resulted in a quick build-up of poultry meat in Canada. Canning the meat was a possible solu-

58 F.T. Rosser, 'Preservation of eggs. ii Surface contamination of egg-shell in relation to spoilage,' **Canadian Journal Research D** 20 (1942), 291-6. See also 297-305, and 306-19.

59 N.E. Gibbons, 'Preservation of eggs. vii Effect of age and carbon dioxide content at time of oiling on keeping quality,' **Canadian Journal Research F** 28 (1950), 118-27. See also 101-6, and 107-17.

60 J.A. Pearce and M.W. Thistle, 'Dried whole egg powder. xxviii Reproducibility and interrelation of methods of assessing quality. Ibid., 27 (1949), 73-97. See also 231-40.

61 A.W. Khan, 'Cryochemistry of animal tissue: Biochemical changes in poultry muscle during freezing and storage,' **Chryobiology** 3 (1966), 224-9.

62 A.W. Khan and L. Van den Berg, 'Biochemical and quality changes occurring during freezing of poultry meat,' **Journal Food Science** 32 (1967), 148-50.

63 Dyson Rose and C.P. Lentz, 'Short chilling periods cause toughness in frozen turkeys,' **Canadian Poultry Review** 80 (1956), 39.

64 Dyson Rose, 'Influence of sugars and glycerol on casein precipitation in frozen milk,' **Canadian Journal Technology** 34 (1956), 145-51. See also 211-12.

65 Dyson Rose, 'Relation between micellar and serum casein in bovine milk,' **Journal Dairy Science** 51 (1968), 1897-1902. See also Ibid., 52 (1969), 8-11.

tion to the problem, because canned meat would not need refrigeration for shipment overseas.

When war in the Pacific cut off the traditional supply of the gelatinous agar used in bacteriological laboratories, and in the meat-canning process, there was an acute need for a substitute material. The NRC's biochemist E.J. Reedman, of the Division of Applied Biology, chose Irish moss (*Chondrus crispus*) as a candidate plant from which to obtain the agar substitute. The jellies that he and his laboratory assistant, Leonard Buckby, extracted from the Irish moss were found to be stronger than those of agar, and a taste test panel found no significant difference between agar and Irish moss jellies when used for canning meat.[66] Harvesting Irish moss became a lucrative part-time job for many farmers in Prince Edward Island, and one that continued long after the urgent war-time need for an agar substitute had passed.[67] Attempts were also made to propagate the moss vegetatively in a series of greenhouse experiments. Eventually seaweed research was largely taken over by the NRC's Atlantic Research Laboratory, from which A.C. Neish and C.H. Fox wrote about the vegetative propagation of Irish moss in undated *Technical Report No. 12.*

Although the British had, of necessity, stopped importing frozen poultry meat during the war, studies of methods to retain the high quality of dressed poultry during the freezing process, and its subsequent thawing, continued into the 1970s.[68]

When the NRC was established, Canada had been having a perennial surplus of wheat and it was popularly thought that the chemists of the NRC, or those supported by it, could solve this problem by devising uses for wheat other than bread making. Thus 'chemurgy,' a name coined in the USA in the 1920s to cover industrial usage of farm products, became a research theme within the Council. An early lead in this work was taken by G. Aleck Ledingham, a mycologist who had joined the NRC in 1933 as editor of the biological section of the *Canadian Journal of Research*, then transferred to the NRC's Division of Biology and Agriculture in 1934 to study the fermentation of agricultural wastes, with emphasis on

66 E.J. Reedman and L. Buckby, 'Investigations on the use of Irish moss in canning meat,' **Canadian Journal Research** D 21 (1943), 348-57.

67 E. Conway and E.G. Young, 'Seaweed research,' Nature 208 (1965), 840-1. Also, Science 151 (1966), 358-59.

68 A.W. Khan and R. Nakamura, 'Quality and biochemical changes during frozen storage of meat from epinephrine-treated and untreated chickens,' **Journal Food Science** 37 (1971), 145-7.

wheat straw.[69] The work of Ledingham was the foundation of what was to become an important feature of that Division's work for many years.

Part of the program of finding things to do with surplus wheat centred around its use in the production of starch and of industrial alcohol, both of which were in short supply during the second world war.[70]

A wartime induced shortage of vegetable oils prompted the NRC to open a modest oilseeds laboratory in the chemistry department of the University of Saskatchewan. The research there, headed by H.K. Sallans, was financed by the Grain Research Committee. Sallans' task was to cooperate with plant breeders in an evaluation of the seeds of flax, sunflower, rape and other likely candidates for the economic production of edible and industrial oils.

Emphasis was soon put on rape seed (now usually spelled rapeseed) because imported rapeseed oil was being used in Canada as a high quality lubricant for steam locomotives and marine engines. Soon after the steam locomotive was developed engineers learned that rapeseed oil was the oil that would best cling to metal and not be washed off by hot water and steam. Because almost all of the rapeseed oil being used by Canadians had been imported from Europe and Asia its supply was in jeopardy when war broke out.

C.D. Howe, the Canadian Minister of Munitions and Supply was so alarmed over the possibility of being unable to obtain sufficient quantities of this vital oil that he induced western farmers to grow rape for its seed by setting up a price structure that virtually guaranteed they would not lose money by growing rape of the recommended varieties.

The Forage Crops Division of the Dominion Department of Agriculture had been growing several kinds of rape, a near relative of the turnip, on experimental farms across Canada since the mid-1930s, so it was not an unknown crop. When the wartime demand for rapeseed oil became crucial many farmers responded by sowing some rape and less wheat. Soon there was such a shortage of rapeseed, and the price was so high that by 1943 that crop generated a higher dollar return per hectare than did any of the cereal crops. Western farmers needed no further inducement to produce rapeseed. When the war ended and the traditional sources of oils for industry and for food became available, and steam engines were rapidly being replaced by diesel and gasoline powered motors, the

69 J.G. Rempel, 'George Aleck Ledingham 1903-1962,' **Proceedings & Transactions Royal Society of Canada** 4th Series, 1 (1963), 91. Also, Gridgeman, 27-28.

70 Anonymous, **History of the Wartime Activities of the Division of Applied Biology, National Research Council** (Ottawa 1948), Mimeograph, CISTI No. Q21 N21b6.

need for the oil from rapeseed diminished and the price fell so low that it was no longer a profitable crop to grow. Nevertheless, there were a few people who saw a potential in an improved edible rapeseed oil as a substitute or replacement for imported vegetable oils.

At the Division of Applied Biology of the NRC, Ottawa, Biochemists N.H. Grace and H.J. Lips, together with taste panel supervisor Elinor Hamilton, investigated the edible uses of rapeseed and mustardseed oils,[71] and B.M. Craig, Biochemist at the Prairie Regional Laboratories of the NRC studied varietal and environmental effects on rapeseed and the composition of its oil.[72] Scientists in the Canada Department of Agriculture, and in Universities, conducted related studies which were coordinated, or supported financially, by the NRC.

The use of rapeseed oil for edible use was encouraged by the Associate Committee on Grain Research of the NRC, and as a result of its recommendation Canada Packers Limited intensified their research, in cooperation with the Saskatchewan Wheat Pool and the new Prairie Regional Laboratory.[73]

Prairie Regional Laboratory

In retrospect, one can see that the tiny oilseeds laboratory of the NRC, in the Chemistry Department of the University of Saskatchewan, was a precursor of what was to become the largest single research laboratory west of the Great Lakes, the Prairie Regional Laboratory (PRL), a branch of the Division of Applied Biology in Ottawa. Construction began, on the campus of the University of Saskatchewan, in the fall of 1945 but the building was not officially opened until 8 June 1948.

Problems of the prairie region that were being studied in the NRC's Ottawa laboratories were transferred to the PRL where, by 1949, a corps of thirteen professionals were in the new building working in three main areas or subdivisions: Oil

71 H.J. Lips, N.H. Grace and Elinor Hamilton, 'Canadian erucic acid oils. ii Edible use of rape and mustard seed oils,' **Canadian Journal Research** F 26 (1948), 360-5. See also **Canadian Food Industry** 21 (1950), 21-5.

72 B.M. Craig, 'Varietal and environmental effects on rapeseed. iii Fatty acid composition of 1958 trials,' **Canadian Journal Plant Science** 41 (1961), 204-10.

73 Details of the early developments in rapeseed production have been provided by A.D. McLeod, **The Story of Rapeseed in Western Canada** (Regina 1974), and by John K.G Kramer, Frank D. Sauer and Wallace J. Pigden, Editors, **High and Low Erucic Acid Oils** (Toronto 1983).

Seeds; Fermentation Chemistry and Microbiology; and Agricultural Residues. The work there was largely coordinated and monitored by a Coordinating Committee on Western Crop Investigations that had been established by the NRC in 1944 to control funding for the committees on crop diseases, grain research, and weed investigations at the University of Saskatchewan. That committee was superseded, in 1949, by a Prairie Regional Committee which, when disbanded in 1962, was replaced by a Special Western Agricultural Committee.[74]

The research on oilseeds was an extension of the work that had been initiated by H.R. Sallans and which soon became centred around the oils that could be extracted from rape seeds. As a result of cooperative research by the NRC, Canada Department of Agriculture, the prairie Universities, and several commercial establishments, Canada became the world's largest producer and exporter of rapeseed, and Canadian improved rapeseed oil for human consumption became known as Canola. This remarkable achievement was accomplished within about 30 years after the first rapeseed was grown on the Canadian prairies.[75]

Early in the 1950s there was concern in the western world over the purchases, by the USSR, of the ergot bodies of *Claviceps purpurea*, the fungus that produces the ergot disease of grain, and the knowledge that alkaloids from the ergot bodies were the source of hallucinogenic drugs and the so-called truth serums. It was rumoured that some farmers in France earned more from the sale of ergot bodies than from the grain grown on a given area of land. These facts and rumours prompted scientists at the PRL to study the ergot in Canadian grain; to culture the fungus on a variety of media and attempt to extract desirable alkaloids from it. L.C. Vining, was a leading investigator in those studies.[76]

Recurring surpluses of wheat continued to be the major economic problem facing western agriculture after the second world war. A partial solution was thought to be found in the processing of wheat, rather than imported corn, to satisfy part of the Canadian needs for starch, dextrose and syrup. Biochemist K.A. Clendenning and colleagues studied the production of syrups from wheat and other cereal starches and compared them with starches and syrups from other sources.[77] The economic extraction of starch from wheat, which had been

74 D.J.C. Phillipson, **Associate Committees of the National Research Council of Canada, 1917-1975.** (Ottawa 1983), 80.

75 Kramer, et al., 79.

76 L.C. Vining, 'Studies on the biosynthesis of ergot alkaloids,' **Canadian Journal Microbiology** 9 (1963), 291-302. See also, Ibid., 5 (1959), 441-51.

77 K.A. Clendenning and D.E. Wright, 'Production of syrups from wheat, potato, tapioca and

an urgent wartime project, continued to occupy the attention of PRL scientists for several years.[78]

Although it was common knowledge that the natural waxes on the leaves of plants affected water retention and the wetability of herbicide and pesticide sprays, their chemical composition had never been accurately determined. A.P. Tulloch of the PRL attempted to correct that deficiency in our knowledge and in doing so became internationally recognized as an authority on the chemistry of all kinds of wax; especially the waxes of various agricultural plants. While determining their composition, Tulloch also searched for economically useful components of leaf waxes and their potential use in plant taxonomy.[79]

Soon after it became known how to isolate plant protoplasts from leaves or from cultured cells by enzymatic removal of cell walls, scientists at the PRL used and improved upon those methods to produce any desired quantity of protoplasts. In addition to studies on various uses of the protoplasts, they investigated the fate of intact viruses that entered them.[80] Research workers in the NRC's Ottawa laboratories also studied plant viruses and in doing so learned that the potato spindle-tuber virus occurs in multiple forms and that each form is capable of causing infection on its own.[81]

A research program on the use of field peas as a source of plant protein for both animal feeds and human food was initiated at the PRL in 1968, and within a decade significant progress had been made in advancing field peas as a viable legume protein crop in the prairie provinces.[82]

For a few years in the 1970s an effort was made by Council scientists to transfer the nitrogen-fixing capabilities of leguminous plants to grasses, especially those that produce grain. It was in relation to that end that T.A. Larue, W.G.W. Kurz

waxy cereal starches,' **Canadian Journal Research** F 26 (1948), 284-96.

78 G.A. Adams, 'Separation of starch from gluten. vi Starch recovery and purification,' **Canadian Journal Technology** 29 (1951), 217-31. Also Gridgeman, 62.

79 A.P. Tulloch, 'Composition of epicuticular waxes from 28 genera of Gramineae; Differences between subfamilies,' **Canadian Journal Botany** 59 (1981), 1213-21.

80 O.L. Gamborg and R.A. Miller, 'Isolation, culture, and uses of plant protoplasts,' Ibid., 51 (1973), 1795-99.

81 R.P. Singh, J.J. Michniewicz and S.A. Narang, 'Multiple forms of potato spindle-tuber metavirus ribonucleic acid,' **Canadian Journal Biochemistry** 52 (1974), 809-12.

82 **Report of the NRC for 1978-1979** (Ottawa 1979), 6.

and J.J. Child studied methods of growing nitrogen-fixing bacteria separated from plant cells.[83]

When the PRL became the Plant Biotechnology Institute (PBI), in 1983, its interests broadened somewhat but remained focused on western Canada's important agricultural produce - cereals, oilseeds, seed and forage legumes.

All of the agriculturally related projects of the PRL or the PBI cannot be mentioned in this short history, but the advances made in the method of freeze preservation of plant meristems with its potential for the elimination of viruses from plants and its effective means of germplasm preservation and storage, is an example of the outstanding work that has been done there.[84] A Legume Biotechnology Project was established in 1988 with the objective of improving the performance of crop legumes through the application of biotechnology. Examples of this work include F.P. Chalifour and L.M. Nelson's study of enzyme activity in faba beans and peas,[85] and S.L.A. Hobbs, J.A. Jackson and J.D. Mahon's research on various aspects of the susceptibility of peas to gall-forming bacteria.[86]

PBI scientists, in cooperation with the University of Saskatchewan, developed a group of synthetic plant growth regulators that promote rapid seed germination and emergence, thus shortening the growing time of crops, - a real bonus to an agriculture that is expanding northward where there are fewer frost-free days in the growing season.[87]

Since the opening of the Institute's trans-genic plant centre during 1989-90, PBI scientists have studied proteins found in fish that function as antifreeze. The incorporation of such a protein into plant tissues should lower their freezing temperature and thus add extra protection during late spring and early fall frosts.[88]

83 T.A. Larue, W.G.W. Kurz and J.J. Child, 'Methods for growing nitrogen-fixing bacteria separated from plant cells,' **Canadian Journal Microbiology** 21 (1975), 1844-86.

84 For papers that lead to further information about freeze preservation of plant meristems see: K.K. Kartha, N.L. Leung and K. Pahl, 'Cryopreservation of strawberry meristems and mass propagation of plantlets,' **Journal American Society Horticultural Science** 105 (1980), 481-84, and R.H. Haskins and K.K. Kartha, 'Freeze preservation of pea meristems: cell survival.' **Canadian Journal Botany** 58 (1980), 833-40. See also, Ibid. 59 (1981), 1671-79.

85 F.-P. Chalifour and L.M. Nelson, 'Short-term effects of nitrate reductase activity and symbiotic dinitrogen fixation in faba bean and pea,' **Canadian Journal Botany** 66 (1988), 1639-45.

86 S.L.A. Hobbs, J.A. Jackson and J.D. Mahon, 'Specificity of strain and genotype in the susceptibility of pea to Agrobacterium tumefaciens,' **Plant Cell Reporter** 8 (1989), 274-77.

87 **Report of the NRC for 1988-1989** (Ottawa 1989), 11.

Atlantic Research Laboratory

The NRC's Maritime Regional Laboratory, which soon became the Atlantic Regional Laboratory, and later, the Atlantic Research Laboratory (ARL), located on the campus of Dalhousie University, Halifax, was established in 1952 to perform research in areas of special importance to the Maritime Provinces and Newfoundland. At first, the main thrust of that laboratory's research was in three areas: marine plants, particularly the algae; microbiology, with emphasis on the effects of soil microbes on farm animals and plants; and high temperature chemistry.

A project of the ARL directly related to agriculture was an investigation to determine why apparently healthy sheep and cattle in the Atlantic region stopped growing in mid-summer when pastures were still relatively good. This condition was referred to as 'ill-thrift' by Nova Scotia farmers, who had been aware of it for many years. Agriculture Canada scientists, who were cooperators in the project, had shown that it was not due to nutritional deficiencies, or to any of the known parasites of the animals. Mycologist D. Brewer was the author or co-author of several papers on the production of toxic metabolites by organisms that may have been at least partly responsible for the ill-thrift.[89]

A related study was carried on by Paul R. Gorham of the Division of Applied Biology, Ottawa, who investigated the alleged production of toxic substances by blue-green algae. For many years those algae, which are common in farm ponds, streams and other sources of drinking water for man and animals, had been suspected of causing sickness or death of animals, and dermatitis and gastrointestinal disorders in man, especially rural people. Gorham's research indicated that at least one species of blue-green algae could, under certain circumstances, be poisonous.[90] G.A. Grant and E.O. Hughes had studied the development of toxicity in algae.[91]

88 **National Research Council Canada Annual Report 89.90** (Ottawa 1990), 21.

89 D. Brewer, A. Taylor and M.M. Hoehn, 'Ovine ill-thrift in Nova Scotia. ii The production of antibiotics by fungi isolated from forest and marshland soil,' **Journal Agricultural Science** 78 (1972), 259-64. See also **Canadian Journal Microbiology** 24 (1978), 1082-86.

90 P.R. Gorham, 'Toxic water blooms of blue-green algae,' **Canadian Veterinary Journal** 1 (1960), 235-45.

91 G.A. Grant and E.O. Hughes, 'Development of toxicity in blue-green algae,' **Canadian Journal Public Health** 44 (1953), 334-39.

Several NRC scientists researched ways of improving the quality of potato chips and French fried potatoes. W.W. Hawkins of the ARL was heavily involved in this work. He, together with Margaret Black and Carol Marie Dicks investigated some biochemical changes in stored potatoes from Prince Edward Island and their relation to chip quality,[92] while he, Verna G. Leonard and Joan E. Armstrong, studied the effectiveness of ascorbic acid in preventing the darkening of oil-blanched French-fried potatoes.[93]

Because potatoes cannot be stored for more than a few months the perennial surplus of potatoes in eastern Canada poses more of a problem to their growers than does the surplus of wheat to western farmers. The NRC had long been aware of this and had appointed an Associate Committee on Potato Research, under the joint chairmanship of H.T. Güssow, Dominion Botanist, Department of Agriculture, and G.S. Whitby, Director of NRC's Division of Chemistry, as early as March 1935. Whitby had visited England, France, Germany and Holland, investigating the possibilities of using potatoes for the manufacture of starch and other products. That Committee prepared a program of research which included experiments in feeding potatoes to livestock and poultry; a literature survey for the nutritional value of potatoes; potato breeding experiments; chemical research on the utilization of potato starch; and, the dehydration of potatoes.[94]

In searching for ways to use surplus apples or apples that were not good enough for the fresh fruit trade, scientists at the ARL experimented with various blends of apple juices fermented with cultures of special yeasts, and the conditions under which an improved hard cider could be produced.[95]

Mariculture, the farming of marine plants, is not yet an important feature of Canadian agriculture but it may well become one of humanity's key sources of nutrition. Scientists at ARL, who initiated studies on the application of scientific agriculture to the cultivation of seaweeds in the 1960s, are using this expertise in a wide-ranging study of water clean-up methods for aquaculture, and otherwise

92 W.W. Hawkins, Margaret Black, and Carol Marie Dicks, 'Some biochemical changes on storage in potatoes from Prince Edward Island and their relation to the quality of chips,' **Canadian Journal Plant Science** 38 (1958), 457-463.

93 W.W. Hawkins, V.G. Leonard and J.E. Armstrong, 'Effectiveness of ascorbic acid in protecting the darkening of oil-blanched French-fried potatoes,' **Food Technology** 15 (1961), 410.

94 **Nineteenth Annual Report of the NRC 1935-36** (Ottawa, 1937), 90-91.

95 **Thirty-eighth Annual Report of the National Research Council of Canada 1954-1955** (Ottawa 1955), 12.

ensuring that Canada will not be a laggard in research on this aspect of future farming.[96]

In a different form of assistance to agriculture, the NRC, in cooperation with the Experimental Farm Service of Canada Agriculture, sponsored a National Committee on Agricultural Engineering which, in 1945, organized a Farm Buildings Sub-Committee. That Sub-Committee and its successors were largely responsible for the development of a Canadian Farm Building Code, and a Canadian Farm Building Plan Service which, in 1973, became the Canada Plan Service; a service that has been of inestimable value to farmers all across the country.[97]

In 1967 the NRC initiated a Negotiated Grants Program to assist Universities in the development of new research programs or facilities. Some of those grants had a direct bearing on Canadian agriculture. For example, the University of Saskatchewan was awarded one such grant to study the application of engineering principles to automation in agriculture. A negotiated grant enabled Simon Fraser University to establish a Pestology Centre in which staff and students are continuing to study nematodes, insects and other agricultural pests, and how best to control them.[98]

Similarly, some of the research partially financed by the NRC's Industrial Assistance Program has been of benefit to Canadian agriculture. For example, assistance to Uniroyal Ltd. of Guelph, Ontario, resulted in the discovery of systemic fungicides that provided a new and effective way to control smut and rust of grain crops.[99]

Scientists in the Biotechnology Research Institute of the NRC, which opened its own facilities in Montreal in 1990, have been researching the development and production of vaccines that may be useful to veterinarians.[100] Earlier research in the Division of Biological Sciences had resulted in the licensing and patenting of a diagnostic test for Brucellosis, a disease that can cause abortions in farm animals and remittent fever in man.[101]

96 **National Research Council Canada Annual Report 89.90** (Ottawa 1990), 23.

97 Anonymous,'Canadian code for farm buildings (Farm Building Standards) 1970,' **NRC Report 11065, and Report 15564.** See also, C.H. Kenny, 'Canada Plan Service 25 Anniversary.' Agriculture Canada and Ontario Ministry of Agriculture and Food, (1978), **History Series No. 12.**

98 **National Research Council of Canada. Report of the President 1972-1973** (Ottawa 1973), 36, 40, 90.

99 **National Research Council of Canada Presidents Report 1975-76** (Ottawa 1976), 36.

100 **NRC Annual Report 1987/1988** (Ottawa 1989), 12. 101 Ibid. 1984-1985 (Ottawa 1985), 14.

When the National Research Council Act of 1967 established a broadened mandate for the NRC, it still included: 'researches, the object of which is to improve conditions in agriculture,' and 'the utilization of the natural resources of Canada.' Nevertheless, from around the end of the second world war there has been a diminution of what may be regarded as practical agricultural research performed or supported by the NRC. This gradual change in emphasis was accompanied by a corresponding increase in fundamental research on problems directly or indirectly related to agriculture. More and more agricultural research that had been initiated or sponsored by the NRC was taken over by Canada Department of Agriculture. That became very apparent in April 1969 when a group of agricultural committees that had long historical connections with the NRC, including committees that were originally named Grain Research, Plant Breeding, Plant Diseases, and Plant Nutrition, were transferred to the Canada Department of Agriculture.[102]

The trend away from agricultural research became still more pronounced when the Natural Sciences and Engineering Research Council (NSERC) was established on 1 May 1978, 'to promote and assist research in the natural sciences and engineering other than the health sciences.' NSERC was also given the responsibility for the management and administration of the program of scholarships and grants in aid of research, that had been the responsibility of the NRC.[103] By 1990 the number of Associate Committees of the NRC that dealt directly with agriculture had been reduced to one; the Associate Committee on Agricultural and Forestry Aviation that was set up in 1965 to provide a forum for communication between specialists in agriculture, forestry, medical and aeronautical sciences.

The NRC is still committed to research toward the development of new and better agricultural products, especially through its PBI laboratories, but the scientists there recognize that plants and microorganisms are nature's chemists, transforming the basic elements into countless different forms of life. Consequently, much of the agriculturally related research is directed toward a better understanding of how these complex natural products are made, and of how the microbes, in turn, break them down again. In doing this they are learning how to build new organic molecules and, through genetic engineering, to create new

101 Ibid. 1984-1985 (Ottawa 1985), 14.

102 D.J.C. Phillipson, **Associate Committees of the National Research Council of Canada 1917-1975.** (Ottawa,1983), 39.

103 G.M. McNabb, **Report of the President The Natural Sciences and Engineering Research Council 1978-79** (Ottawa, 1979).

plant forms. Thus, scientists in the NRC are laying a firm foundation of fundamental research that will be of benefit to the future of Canadian agriculture.