1948
NEW ZEALAND

SCIENTIFIC MAN-POWER RESOURCES OF NEW ZEALAND

REPORT OF THE CONSULTATIVE COMMITTEE ON THE SCIENTIFIC MAN-POWER RESOURCES OF NEW ZEALAND APPOINTED BY THE HONOURABLE MINISTER IN CHARGE OF DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH IN FEBRUARY, 1947

Laid on the Table of the House of Representatives by Leave

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CONSTITUTION OF THE COMMITTEE

Mr. E. CARADUS, O.B.E. (Chairman).

Dr. J. C. ANDREWS, Challenge Phosphate Co., Ltd., Otahuhu.

Mr. F. R. CALLAGHAN, Department of Scientific and Industrial Research.

Dr. J. K. DIXON, New Zealand Public Service Association.

Dr. J. F. FILMER, Department of Agriculture.

Mr. H. HENDERSON, Education Department.

Mr. A. McGREGOR, Treasury Department.

Professor L. R. RICHARDSON, New Zealand Association of Scientific Workers.

Mr. A. H. WARD, New Zealand Dairy Board.

Mr. L. J. WILD, O.B.E., University of New Zealand.

Mr. N. S. WOODS, Department of Labour and Employment.

Secretary to the Committee: Mr. R. M. WAITE, Department of Scientific and Industrial Research.

Secretariat:—

Mr. J. H. ETHERINGTON, Department of Agriculture.

Mr. R. A. KREBS, Department of Labour and Employment.

Mr. A. B. THOMPSON, Education Department.

In the early stages the Chairman of the Committee was Mr. T. H. McCOMBS, M.P. (now Minister in Charge of the Department of Scientific and Industrial Research), and the following also were members:—

Committee: Dr. E. MARSDEN.

Secretariat: Mr. L. S. HEARNSHAW,
Mr. D. DOYLE.

Dr. Marsden was at that time Secretary of the Department of Scientific and Industrial Research; the other two also were members of that Department.

PREFACE

22nd October, 1948.

To the Hon. T. H. McCombs, M.P., Minister in Charge of Department of Scientific and Industrial Research.

SIR,—

We have the honour to present to you our report on the Dominion's scientific man-power resources, following the instructions of the late Hon. D. G. Sullivan, the Minister then in charge of the Department.

This Committee met for the first time on Wednesday, 26th March, 1947, and has met in all on fourteen days.

As Chairman of the Committee in the early stages, you will remember that the terms of reference required us—

to consider the policy which should govern the use and development of our scientific man-power resources during the next ten years, and to submit a programme on broad lines so as to facilitate forward planning in those fields which are dependent on the use of scientific man-power.

The Committee realized, with you, that research could reasonably be expected to give an accurate summary of the scientific man-power position as it exists at the present time, but that a forecast of the position at any great distance in advance would be subject to unknowable and uncontrollable events outside the scope of the investigation.

The Committee felt, however, that a forecast might be made with reasonable accuracy for a period of five years in advance, and has made its report and many of its recommendations on this basis.

Your Committee could not, of course, be representative of all organizations employing scientific workers. A Committee so constituted would be too unwieldy to function effectively. Its constitution was such, however, as to give representation to the University of New Zealand, the Department of Scientific and Industrial Research, the Department of Agriculture, the Education Department (the four organizations employing most scientific workers), the Department of Labour and Employment, the Treasury, the Public Service Association, the New Zealand Association of Scientific Workers, the Dairy Board, and to private scientific industry, while its Secretariat was composed of representatives of four of the five Government Departments represented on the Committee.

The Committee, during its deliberations, made contact by means of questionnaires with many prominent people and organizations concerned with the employment of scientific workers or likely to be able to assist in the solution of the problem, and its findings are based to a large degree upon the answers to these questionnaires. To these we should like to express our thanks. Without their assistance and co-operation our investigation would have been almost impossible.

Your Committee wishes to express its appreciation also of the valuable assistance rendered by the Department of Labour and Employment in connection with the statistical investigation of the employment of scientists in New Zealand and of the University training of scientists, and to thank its Secretariat for their sustained enthusiasm in and continued attention to the whole problem.

We have the honour to be, Sir,

Your obedient Servants,

E. CARADUS, Chairman.
J. C. ANDREWS.
F. R. CALLAGHAN.
J. K. DIXON.
J. F. FILMER.
H. HENDERSON.
A. MCGREGOR.
L. R. RICHARDSON.
A. H. WARD.
L. J. WILD.
N. S. WOODS.

I. INTRODUCTION

THE need for an inquiry into the adequacy or otherwise of scientific man-power has been realized for some years. During the recent war the need for scientists, both for work connected with the Armed Forces and for industry, led the Government to exempt from national service a fairly large number of University students taking science courses. For this and other reasons the past eight years have shown a remarkable increase in the proportion of University students specializing in science. The University, for its part, has therefore been concerned to know whether the number of scientists undergoing training is in excess of the demand. Industry, compelled to face new problems, and having to develop in new directions, has at times found difficulty in recruiting adequately trained people for key positions. Many Government Departments have had difficulty in filling important posts for which qualified scientists are required. Added to these facts is the common knowledge that many brilliant New Zealand students, after completing a course in science in New Zealand, proceed overseas for further training. Many do not return. It is not surprising, therefore, that the Senate of the University of New Zealand should have requested the Government to co-operate with it in an investigation of the supply of, and demand for, scientists generally and of the adequacy or otherwise of the training provided, nor that Government Departments, such as the Department of Scientific and Industrial Research, should have contemplated an inquiry of a similar kind. The present Committee was set up to report upon the whole situation and to make recommendations.

The general case for a regular and adequate supply of trained scientific workers requires little argument. Within a lifetime refrigeration, the internal-combustion engine, the aeroplane, radio and television, the harnessing of atomic energy have all become matters not of theoretical speculation, but of practical moment. The problem of feeding the population of the world is to-day a challenge to the trained intelligence. On the purely material level the supply of consumer goods, with its attendant problems of the search for raw materials, the discovery of cheaper and more efficient methods of production and distribution, requires on every hand the application of known scientific principles and the discovery of new ones.

The basic economy of New Zealand has already been profoundly influenced by the development of refrigeration. Our present and future position as a primary-producing country may be equally affected by the application of the scientific principles of genetics, by the correct nutrition of plants and animals, and by the study of bacteriology. Then, too, there is need for increased efficiency in those secondary industries in which we have to compete with much more highly industrialized countries.

As a Committee we have therefore attempted to assess the known demand for scientific workers and to estimate the probable future demand. Our order of reference, however, requires us to go still further. It is not sufficient to know that the number of posts likely to be available will be matched approximately by the number of persons who have undergone basic scientific training. Some branches of industry, research, and teaching require not only average ability, but ability of the very highest order. Indeed, the investigation of some scientific problems can be undertaken only if there is available a person adequately trained to direct research. A highly competent scientist backed by a well-balanced team of routine workers may find the answer to many obstinate questions. A team of routine workers without expert leadership may be little better than useless. It is therefore necessary in estimating the scientific man-power of the Dominion to think not only of crude numbers, but of the quality of the people available.

It may be pointed out that any forecast of the need for scientific man-power may be upset at short notice by unpredictable events. An economic recession, a change in Government policy, even rapid changes of population, either by way of natural increase or selected migration, may upset the most carefully prepared estimates. The recent development of secondary industries, the growth of which has been fostered by war shortages and post-war disturbance of normal economy, may not, in the opinion of some, be a permanent feature of New Zealand life. Any radical change in present conditions will, of course, affect the demand for scientific workers. On the other hand, even if some present avenues of scientific employment should no longer be available, the need for scientific workers generally will remain; but the direction in which scientific effort should be employed may be altered.

We stress at the outset the complexity of the problem in order to define the scope of the present inquiry. In an investigation there comes a time when the use of too fine a scale of measurement, or the attempt to combine in one equation too many variants, is wasteful of effort. The early stages of the present investigation were therefore given over to a search for the limits within which useful results could be obtained. We quickly came to the conclusion that only certain broad findings could be expected from the means at our disposal and the time allotted for the investigation.

The Committee gathered its information either from existing sources (in the case of numbers and categories of scientists in training) or from specially-designed questionnaires. We are aware of the limitations of the questionnaire method, and at every point care has been taken to see that an adequate coverage has been obtained. A definition of "qualified scientific worker" was arrived at after consulting a number of people who had given considerable thought to the New Zealand problem. The Department of Labour and Employment, at the request of the Committee, extracted from available records much of the basic data that has been used. Questionnaires were sent to Government Departments and to a comprehensive and representative group of industries and other bodies employing or likely to employ scientific workers. Full information was also obtained from University institutions and from the registered private secondary schools. In arriving at an estimate of the quality of the training available to scientists we were to some extent guided by a further questionnaire inviting opinions on the causes, and possible solutions, of major problems confronting us in the course of our investigations.

Our report does not attempt to be exhaustive, but we feel confident that within the limits of the inquiry we have been able to arrive at conclusions which will be useful in the formulation of policy.

II. THE BARLOW REPORT

In Great Britain in May, 1946, a Committee, under the chairmanship of Sir Alan Barlow, reported on the scientific man-power position in that country.*

The Barlow report affirms that in Great Britain "the demand for scientists† over the next few years will exceed the possible supply not only as a whole, but separately in each major branch of science" (*op. cit.*, page 4, paragraph 5). The need

* "Scientific Man-power": Report of a Committee appointed by the Lord President of the Council. CMD 6824, H.M.S.O., 1946.

† This report adopted the following definition of the term "qualified scientists": "persons holding degrees in the mathematical, physical, chemical, and biological sciences, together with the small number of men and women who, without being University graduates, are members of recognized scientific institutions with a membership status that is accepted as the equivalent of a University degree in these subjects."

for a prompt report on the scientific man-power position precluded a detailed investigation of the particular needs of the separate branches of scientific work. In this report on the New Zealand position an attempt has been made to assess these more detailed requirements.

It is estimated in the Barlow report that there will be by 1950 about 55,000 trained scientists against a requirement of 70,000. By 1955 the demand will have grown to 90,000, but the supply, on present plans, only to 64,000. Before the war British Universities were turning out about 2,500 scientists a year. The Barlow Committee propose that this rate should be increased to 5,000 a year. In Great Britain this target of 90,000 scientists would represent approximately 1·8 scientists to every thousand of population in 1955, or approximately 1·6 in 1952.

In dealing with the future supply of scientists, the Barlow report comments on the low percentage of the total population receiving a University education in comparison with other countries.

It is obvious that, with the differing conditions in the training and employment of scientists in Great Britain and this country, the findings of the Barlow report cannot be applied to New Zealand. The need for an inquiry based on local conditions is apparent.

III. THE PROBLEM IN NEW ZEALAND

The terms of reference required us "to consider the policy which should govern the use and development of our scientific man-power resources during the next ten years."

For the purposes of this report we have adopted the following definition of a "scientist": "A person holding a University degree or equivalent qualification in science, home science, or agriculture." This includes a member of a recognized scientific institution and a graduate in arts in the various scientific disciplines. We have excluded from this report consideration of graduates in medicine, veterinary science, and engineering.* This definition was adopted after considering views obtained from thirty-five leading scientists in New Zealand.

We felt that no satisfactory answer to this problem could be attempted without prior consideration of the following specific topics:—

1. What is the demand for scientists?
2. Is there a supply forthcoming sufficient in quantity and quality to meet the demand?
3. Having regard to New Zealand's economy, are there fields in which scientists are not at present employed, but in which use should be made of their services?
4. Is the present training of scientists adequate, both basically and in specialized fields?
5. Is a proper use being made of scientists?

IV. WHAT IS THE DEMAND FOR SCIENTISTS?

To obtain a satisfactory answer to this question it was necessary to know the trends in the employment of scientists during the last twenty years, the number of scientists employed in scientific work at present, the nature of their qualifications, the

* The question of the supply of medical graduates has been investigated by the Health Department; the Veterinary Services Committee has reported exhaustively on the supply of veterinarians, and a forthcoming report of another Committee will deal with the training and supply of engineers.

present number of vacant posts, and the probable requirements in five years' time. We of the opinion that no reliable estimate of requirements can be obtained for any longer period ahead.

SURVEY CONDUCTED

To obtain this information a questionnaire was circulated to present and likely future employers of scientists. Research associations, Government Departments, and firms likely to employ scientists in the following groups, together with various others, were approached :—

Adhesives.
Aerated waters and cordials.
Aircraft-manufacture.
Bacon-curing.
Battery-manufacture.
Biscuits and confectionery.
Bituminous products.
Breweries.
Building-materials.
Cawthron Institute.
Cement-manufacture.
Chemical-manufacture.
Compressed-yeast manufacture.
Concrete products.
Consulting chemists.
Cosmetics and toilet preparations.
Dairy products.
Disinfectants.
Electroplaters.
Essences, &c., manufacture.
Fertilizer-manufacture.
Foodstuffs-manufacture.
Freezing-works.
Fruit and vegetable canning.
Gas-production.
Gelatine-manufacture.
Glass-manufacture.
Government Departments—
  Air.
  Agriculture.
  Army.
  Broadcasting.
  Education.
  Health.
  Housing.
  Industries and Commerce.
  Internal Affairs.
  Internal Marketing.
  Lands and Survey.
  Marine.
  Mental Hospitals.
  Milk Marketing.
  Ministry of Works.
  National Film Unit.
  Navy.
  Patents Office.
  Police.
  Post and Telegraph
Government Departments—*continued.*
  Printing and Stationery.
  Railways.
  Scientific and Industrial Research.
  Standards Institute.
  State Advances.
  State Forests.
  State Hydro-electric.
  Transport.
  Valuation.
Hosiery-mills.
Ice-cream manufacture.
Insecticide-manufacture.
Ink-manufacture.
Lime processing.
Linseed-oil manufacture.
Local bodies.
Margarine-manufacture.
Mining.
Miscellaneous chemical products.
Motor-vehicle assembly.
Museums.
New Zealand Dairy Board.
New Zealand Wool Board.
Oil companies.
Oil-refineries.
Paint-manufacture.
Paper and pulp manufacture.
Pharmaceutical products.
Pickle, sauce, and jam manufacture.
Plastics-manufacture.
Plywood-manufacture.
Pottery and ceramics.
Private secondary schools.
Radio-manufacture.
Research associations.
Rope-manufacture.
Rubber manufacture.
Scientific-instrument manufacture.
Soap-manufacture.
Stock foods and sheep-dips.
Sugar-refining.
Tanneries.
Tobacco-manufacture.
Timber-treatments.
University of New Zealand.
Wallboard-manufacture.
Woollen and knitting mills.

The coverage of the survey was approximately 85 to 90 per cent. of the whole field. We consider that the number of scientists engaged by organizations not replying to the questionnaire would not exceed twenty-five.

EXPANSION IN SCIENTIFIC EMPLOYMENT

An examination of these questionnaire returns showed in a striking manner the growing demand for the services of scientists during the past twenty years.

Excluding scientists employed in State post-primary schools, the scientific labour force expanded from 162 to 1,040, an increase of 540 per cent. between 1927 and 1947. The figures also show a further 700 scientists will be required between 1948 and 1952, representing a further growth in demand of 67 per cent. on the 1947 figures. If State post-primary schools are included the increase is 766, a reduction in the over-all increase from 67 per cent. to 53 per cent.

New Zealand's requirement of 2,207 scientists in 1952 would represent approximately 1·2 scientists to every 1,000 of population. The corresponding figure for Great Britain is 1·6 (see page 6 of this report). This would indicate that the figure of 2,207 for New Zealand cannot be regarded as extravagant provision.

The use of scientists over these years is further shown by examination of the major subjects of their degrees as reported by employers and shown in Appendix I. For various reasons complete analysis was not possible—for example, in post-primary schools a graduate with a science degree may be instructing over a wide range of subjects and does not necessarily confine his teaching to his honour's subject.

DEMAND IN PRINCIPAL BRANCHES OF SCIENCE

The subject of the greatest numerical importance is chemistry, with a rate of increase of over 600 per cent. between 1927 and the present date. A more striking, if numerically smaller, increase is shown in botany. Rates of increase are shown in the following figures, in which index numbers (base 1927 = 1) are used (excluding State post-primary schools):—

Major Subject.	1927.	1947.	1952.
Agriculture	1 (9)	12	21
Botany	1 (5)	14	28
Chemistry	1 (56)	7	10
Forestry	1 (5)	4	13
Geology	1 (11)	4	5
Physics	1 (27)	7	11
Zoology	1 (13)	6	8

(Actual numbers of scientists in the base year are shown in brackets.)

The subjects mathematics and home science were omitted from the above table, as the number of people with those qualifications employed other than in post-primary schools is relatively small.

Further analysis of the requirements of the various employing authorities is shown in the tables in Appendices IIIA to IIIE. From these tables it is apparent that the demand from industrial concerns is almost exclusively for chemists and chemical engineers. No other group has such a pronounced emphasis on any single subject, although in teaching the preference for mathematics, home science, and chemistry is very marked.

In Government Departments and local authorities physics and chemistry take precedence in numbers, but the highest anticipated rates of increase are in home science, forestry, botany, mathematics, and agriculture.

THE MAIN EMPLOYERS OF SCIENTISTS

Of the 766 new scientists required by 1952, 286 are actually needed to fill present vacancies. The figure below shows the proportions as between the main employing bodies :—

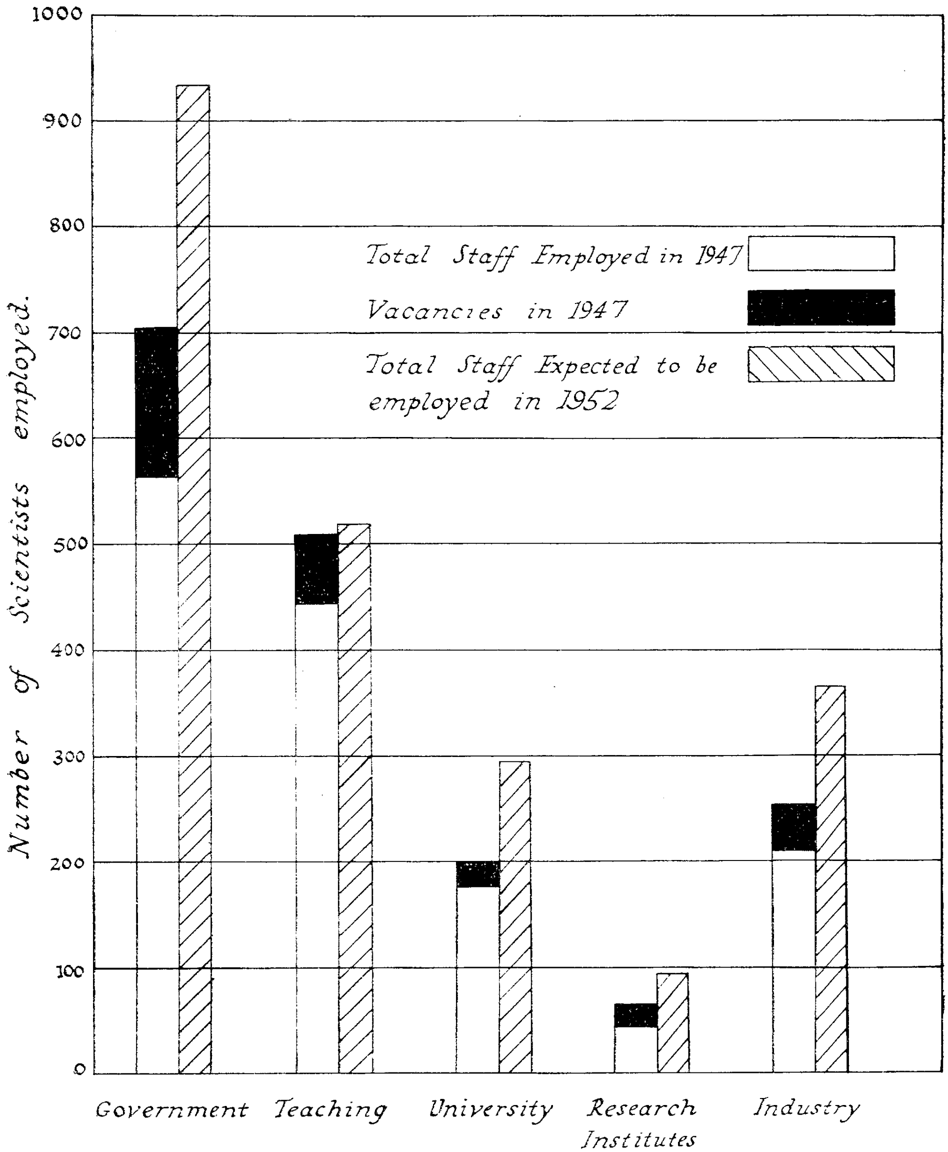

FIG. 1.—SCIENTISTS IN FIVE MAIN EMPLOYING GROUPS

The present total shortage of 286 for all groups is some 20 per cent. of the number at present employed.

The total staff requirements of each employing body in 1952 represent the following percentage increases over the staff at present engaged (vacancies ignored in each case): Government, 66 per cent.; teaching, 17 per cent.; Universities, 68 per cent.; research institutes, 94 per cent.; and industry, 74 per cent. The over-all increase for all groups is 53 per cent.

Details of the actual numbers now employed and likely to be required are shown in Appendix II.

WASTAGE IN SCIENTIFIC PERSONNEL

In order to determine the rate of engagement of scientists employers were asked to indicate the number of scientists engaged during 1947 (*a*) as replacements and (*b*) for new posts. Of the total of 265 scientists engaged, some 61 per cent, or 162, were for new posts and the balance of 103 were replacements. This replacement figure enables us to make an estimate of the likely annual wastage over the next few years arising from death, retirement, and transfer overseas or to other employment.

The wastage between 1948 and 1952 (515) has been taken to be five times the number of replacements engaged during 1947. Some allowance has to be made for a margin of error in this assumption. A proportion of persons engaged during 1947 would be replacements drawn from other positions within the existing pool of scientific workers, and of these some part would merely be replacing persons who had taken other positions but remained within the pool. Inclusion of these would tend to make the figure of 515 too high. Allowing for the annual turnover rate of male labour in clerical employment generally (some 16 per cent. to 18 per cent.)* and for the greater stability of professional workers, it is the considered view of the Committee that the error due to this cause could not be as great as 10 per cent. On the other hand, some retirements would not be replaced during the year, and exclusion of these would tend to make the figure of 515 too low. Again, after careful consideration, we are of the opinion that the error due to this cause would not amount to 10 per cent. The actual figure for wastage is therefore considered to lie between 464 and 566, the probability being that the two sources of error will largely cancel, leaving the figure very close to the assumed one of 515.

THE FUTURE DEMAND

To obtain the total additional number of scientists required over the next five years, therefore, it is necessary to add the figure for wastage (515) to the number estimated to be required by employers (766), giving a grand total of 1,281.

It is necessary, therefore, to consider next the possibility of this demand being met by the number of scientists trained in the University during that period.

V. IS THERE A SUPPLY FORTHCOMING SUFFICIENT TO MEET THE DEMAND?

In considering this problem the following questions were made the subject of statistical analysis:—

1. Number of students enrolling in science classes year by year between 1927 and 1947.
2. Ratio of students taking science courses to students in other faculties.

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* These figures were supplied by the Department of Labour and Employment from its *Half-yearly Survey of Employment*, published July, 1948.

3. Number of students obtaining degrees in science at the bachelor level during the same period.
4. Number of students obtaining degrees in science at the master level during the same period.
5. The future supply of science graduates.

This information was extracted by the Department of Labour and Employment from the tables of the annual reports of the Education Department (E–7) and the minutes of the Senate of the University of New Zealand. Because of changes in the University statutes, and for other reasons, considerable difficulty was experienced in obtaining comparable figures throughout the whole period. These unavoidable discrepancies do not, however, invalidate the main trends indicated by the figures.

THE NUMBER OF STUDENTS TAKING SCIENCE COURSES

In New Zealand the main organization concerned with the training of scientists is the University. The supply of scientists is, therefore, governed by the number of students enrolling in all courses, and, in particular, by the proportion of this total enrolling in science courses. Appendix IV sets out the number of students taking the various University courses between 1927 and 1947. This table shows a steep rise in the number of students to be found in specified science and allied courses. This trend is most graphically shown by the following table, in which index numbers (base: 1927=100) are used:—

TABLE A—INDEX NUMBERS OF STUDENTS TAKING COURSES (AT FIVE-YEARLY INTERVALS)

Course Taken.	1927.	1932.	1937.	1942.	1947.
Science	100 (383)	126	129	155	457
Agriculture	100 (26)	142	119	104	447
Home Science	100 (120)	87	83	155	142
Engineering	100 (236)	70	74	66	230
Mining	100 (19)	163	221	158	321
All others	100 (3,595)	105	107	85	241
Total	100 (4,379)	105	107	93	258

(Actual numbers of students in base year shown in brackets.)

RATIO OF SCIENCE STUDENTS TO TOTAL STUDENTS

The percentage of students taking a science course to students taking other definite courses ranged from 8·7 per cent. in 1927 to 15·5 per cent. in 1947. Figure 2 (page 12) shows these percentages for the years 1927 to 1947 inclusive.

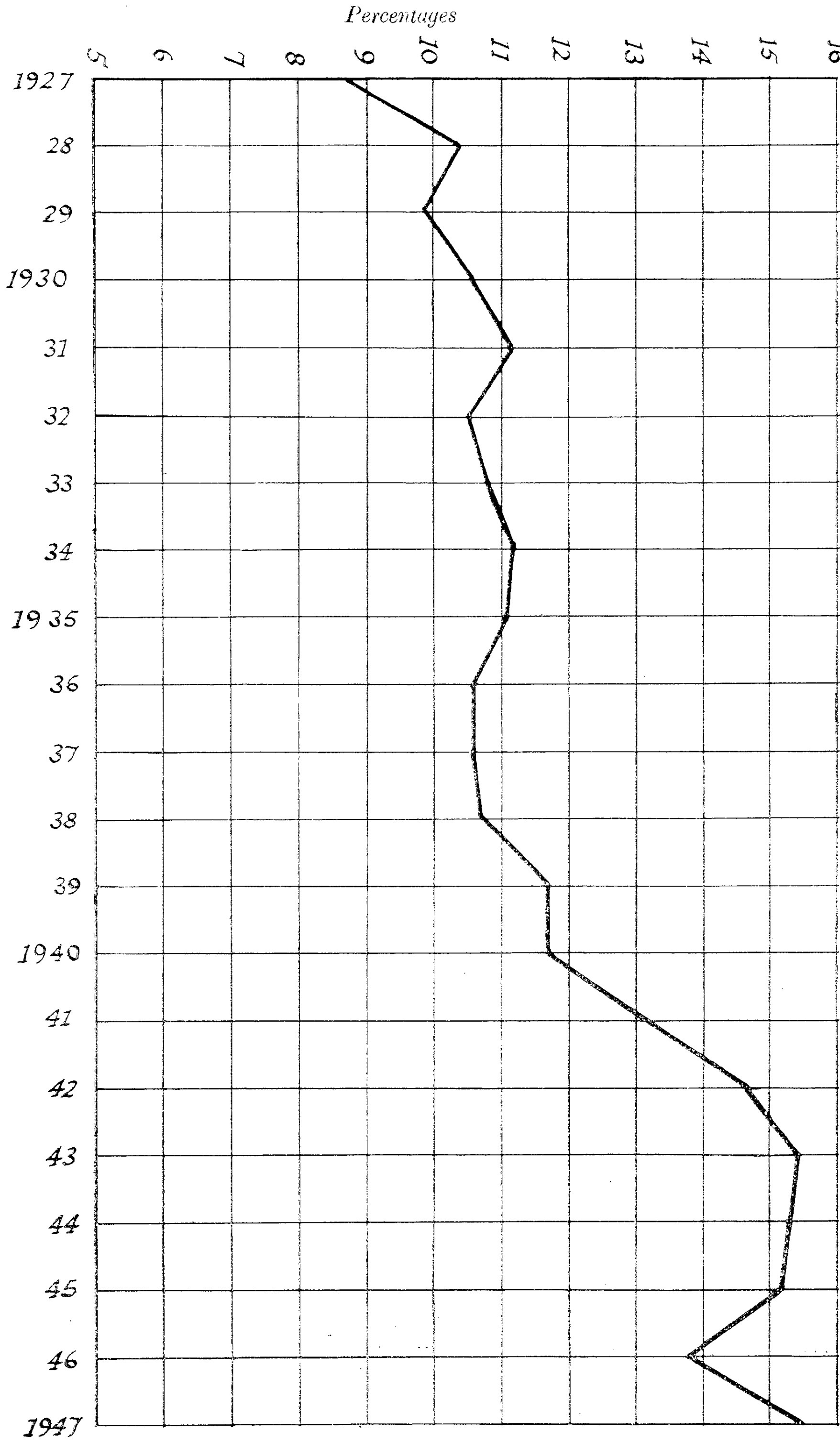

FIG. 2—PERCENTAGE OF SCIENCE STUDENTS TO ALL STUDENTS, 1927 TO 1947

THE NUMBER OF SCIENCE GRADUATES

Appendix V shows that the number of graduates in all courses rose from 531 in 1927 to 1,352 in 1947. Not only has the number of science graduates increased, but the proportion of science graduates has grown. Over the same period the percentage of bachelor science graduates in the foregoing figures increased from 10 per cent. to 16 per cent.

Using index numbers (base: 1927 = 100), the greater increase in the number of science graduates can be readily seen:—

TABLE B—INDEX NUMBERS OF UNIVERSITY GRADUATES, 1927 TO 1947

Graduating in—	1927.	1932.	1937.	1942.	1947.
Science	100 (77)	117	139	110	397
Agriculture	100 (2)	500	850	300	950
Home science	100 (7)	155	55	300	285
Others	100 (445)	100	109	69	227
Total	100 (531)	105	116	79	255

(Actual number of graduates in base year shown in brackets.)

In 1927 only 86 out of the 531 graduates in that year graduated in the science and allied groups, while in 1947, 345 of the 1,352 graduates were graduates in science and allied groups.

The number of masters of science included in the above figures similarly increased. In 1927, 22 masters' degrees were conferred, and in 1947 the number was 85. The percentage of those awarded honours to the number of bachelor graduates of the previous year is shown in Table C.

This table reveals no one-way trend in the percentage of honours graduates over the years 1927 to 1947, the percentages fluctuating widely from year to year. Too much emphasis should not be placed on fluctuations in particular years. For example, the 1944 figure (14·8 per cent.) is obviously due to the fact that only the most able students were allowed to proceed to a higher degree under the National Service Regulations in force during the war period.

TABLE C—SCIENCE GRADUATES: PERCENTAGE OF HONOURS GRADUATES TO BACHELOR GRADUATES ONE YEAR EARLIER

—	1927.	1928.	1929.	1930.	1931.	1932.	1933.
Honours (year shown) ..	18	20	15	19	19	20	31
Bachelors (previous year) ..	46	55	62	60	62	64	59
Percentage	39·1	36·3	24·1	31·7	30·6	31·2	52·5
—	1934.	1935.	1936.	1937.	1938.	1939.	1940.
Honours (year shown) ..	31	44	30	32	14	23	25
Bachelors (previous year) ..	90	83	78	86	62	59	56
Percentage	34·4	53·0	38·4	37·2	22·5	38·9	44·6
—	1941.	1942.	1943.	1944.	1945.	1946.	1947.
Honours (year shown) ..	21	20	13	12	37	61	70
Bachelors (previous year) ..	76	72	61	81	101	108	165
Percentage	27·6	27·7	21·3	14·8	36·6	56·5	42·5

NOTE.—This table includes first, second, and third class Honours, but not equivalent Honours or Pass M.Sc.

SUBJECTS TAKEN BY GRADUATES

The following table shows at two-yearly intervals the subjects for which the degree of M.Sc. was awarded for the period 1927 to 1947 :—

TABLE D—DISPERSAL OF M.SC. SUBJECTS OVER THE YEARS 1927 TO 1947

Subject.	1927.	1929.	1931.	1933.	1935.	1937.	1939.	1941.	1943.	1945.	1947.
Mathematics ..	8	7	3	5	11	5	6	3	1	5	10
Geology	2	0	2	1	1	1	3	0	3	1	6
Chemistry ..	8	11	15	15	26	24	12	13	10	19	37
Physics	2	1	4	10	9	11	5	3	1	8	14
Botany	2	2	2	1	5	2	5	3	0	6	8
Zoology	0	3	4	8	3	2	2	2	0	5	11

NOTE.—Figures relate to the year in which the examination was passed.

This table shows that on the whole chemistry has been the most favoured subject with physics and mathematics (in that order) retaining fairly steady preference from 1927 onwards. In 1947 the number of M.Sc. graduates showed a sharp increase in all subjects.

It is interesting to compare percentages of M.Sc. graduates for the year 1947 in each of the above subjects with—(*a*) percentages of the present scientific labour force with qualifications in each of these subjects, and (*b*) the percentages in the anticipated 1952 scientific labour force.

Subject.	M.Sc. Graduates, 1947.	Labour Force, 1947.	Vacancies, 1947.	Anticipated Labour Force, 1952.
Mathematics	12	18	20	17
Geology	7	4	4	4
Chemistry	43	41	32	40
Physics	16	20	21	21
Botany	9	9	14	11
Zoology	13	8	9	7
All above subjects ..	100	100	100	100

The figures for the scientific labour force in the respective subjects in 1947 and 1952 are extracted from Appendix I. Some allowance, however, should be made for the considerable number of cases where the subject has not been stated. This applies particularly in the anticipated labour force for 1952.

SUMMARY OF PRESENT POSITION IN UNIVERSITY TRAINING OF SCIENTISTS

From all this assembled information the following conclusions emerge :—

A. *Science*—

(1) The number of students in the science faculty in 1947 (1,750) was more than four and a half times the number in 1927.

(2) The percentage of students taking science to students taking other definite courses has increased from 8·7 per cent. in 1927 to 15·5 per cent. in 1947.

(3) The number of bachelor graduates in 1947 (221) was four times the number in 1927.

B. *Agriculture*—

(1) The number of students taking degree courses in agriculture in 1947 (116) was more than four times the number in 1927.

(2) The number of bachelor graduates in agriculture in 1947 (10) was five times the number in 1927.

C. *Home Science*—

(1) The number of students in the home-science faculty in 1947 (170) was nearly one and a half times the number in 1927.

(2) The number of bachelor graduates in home science in 1947 (19) was nearly three times the number in 1927.

THE FUTURE SUPPLY OF SCIENCE GRADUATES

From the information available as to the numbers of students taking science courses and the numbers who graduate we have attempted to estimate the numbers of graduates for the next five years, 1948 to 1952 inclusive.

As a basis for this estimate we have taken out the percentage of bachelor graduates to the number of students two years earlier, since a student beginning in, say, 1946 would normally graduate at the end of 1948. Over the five-year period 1943–47 we found that this percentage was approximately 16 per cent.

We have therefore made the following projections—

Science Students.		Bachelor Science Graduates.	
1946 ..	.. 1,516	1948, 16 per cent. of 1,516 =	242
1947 ..	.. 1,750	1949, 16 per cent. of 1,750 =	280
1948 ..	.. 1,750 (assumed)	1950	280
1949 ..	.. 1,750 (assumed)	1951	280
1950 ..	.. 1,750 (assumed)	1952	280
			1,362

All University colleges have not yet made a return of the number of their science students for 1948, but the figures to hand indicate that any decrease on 1947 figures will not be large.

It is reasonable to assume, therefore, that the total number of bachelor graduates between 1948 and 1952 inclusive will be in the vicinity of 1,362.

Similar projections for agriculture and home science indicate that the number of graduates in these fields between 1948 and 1952 inclusive will be 195 and 102 respectively.

MATCHING THE SUPPLY WITH THE DEMAND

Our questionnaires directed to employers of scientists have disclosed that employers estimate that an additional 661 scientists, 79 agricultural scientists, and 26 home scientists will be needed by 1952. To these numbers must be added the estimated wastage between 1948 and 1952 inclusive, an estimated total of 515 (see page 10 of this report). This estimate, it will be remembered, is based upon the 103 replacements during the year 1947, amounting to some 7 per cent. of the scientists actually employed in that year.

Before making any comparison of the anticipated demand by 1952 with the estimated number of students graduating between 1948 and 1952 an endeavour was made on the basis of past experience to ascertain what proportion of science graduates take up some form of scientific employment within New Zealand.

The line of reasoning is as follows :—

Scientific labour force (inclusive of post-primary schools) in 1927 ..	250
Scientific labour force (inclusive of post-primary schools) in 1947 ..	1,441
Increase in scientific labour force in twenty years.	1,191
* Wastage over twenty years at 7 per cent. per annum	900
Total number of graduates required	2,091
Actual number of bachelor graduates in science, agriculture, and home science, 1927–47	2,198
Apparent surplus	107

Apparently, therefore, some 5 per cent. of the total number of bachelor graduates are unaccounted for. This figure seems on the low side, but is, of course, dependent upon the estimated wastage figure of 7 per cent. per annum. If we consider as many as 10 per cent. of the total number of bachelor graduates not available for scientific employment Table E will show the apparent excess or deficit of scientists in 1952.

* This wastage was obtained separately for each five-year period.

TABLE E—THE SUPPLY AND DEMAND FOR SCIENTISTS

—	Estimated Additional Staff Required by 1952.	Estimated Wastage Between 1948 and 1952, Inclusive.	Estimated Total Additional Staff Required by 1952.	Estimated Number of Bachelor Graduates Between 1948 and 1952.	Estimated Number of Bachelor Graduates Between 1948 and 1952, Less 10 per Cent.	Apparent Excess or Deficit of Scientists.
Science ..	661	385	1,046	1,362	1,226	180+
Agriculture ..	79	30	109	195	176	67+
Home science ..	26	100	126	102	92	34—
Totals ..	766	515	1,281	1,659	1,494	213+

From the above figures it appears that we may be training too many science and agricultural graduates. It is important, therefore, to consider the accuracy and limitations of the data. In regard to *accuracy*, we consider first that the forecast of the numbers of students likely to graduate during the next five years is a very conservative one. This is confirmed to some extent by the application of the projection formula to the year 1947. Our projection gives the probable number of scientist graduates as 188, whereas actually the number who graduated was 221. Even if 1947 was an exceptional year the difference in figures indicates that our formula is unlikely to exaggerate the number of students who will graduate in future years.

The only other factors in the above table in which any error could lie are—

(*a*) Additional staff required by employers.

(*b*) Wastage of scientists between 1948 and 1952.

(*c*) Number of graduates not available for scientific employment.

The additional staff required by employers is based entirely on figures furnished by employers themselves. Appendix I gives the scientific labour force at five-yearly intervals, together with anticipated staff in 1952. In the form of index numbers (1927 = 1) the increase in the scientific labour force, excluding State post-primary schools but including existing vacancies (286), is as follows :—

1927.	1947.	1952.
1	8·2	10·7

The scientific labour force took twenty years to increase 7·2 points, and an increase of 2·5 points is estimated to take place during the next five years. This increase probably indicates a somewhat wider demand for the services of scientists in the future, and cannot be regarded as disproportionate.

The second factor, wastage, has been dealt with on page 10 and it is considered that the wastage as estimated in the table is reasonably accurate.

The estimate of the total number of graduates not available for scientific employment is dependent largely upon the 7 per cent. replacement which took place during 1947. The same figure was used in estimating wastage between 1948 and 1952. There is certainly a loss of graduates overseas and to non-scientific employment. The latter is probably not a serious factor, but the former demands some attention. In an attempt to answer this question we sought the opinion of a number of prominent scientists by questionnaire. From the views expressed by these gentlemen (see Section XI) we are of the opinion that the net excess of outflows over inflows is not serious numerically. The qualitative aspect of this loss is discussed in Section XI.

We think that the allowance of 10 per cent. made in Table E for graduates who do not find their way into the scientific labour force is not likely to be exceeded, and that the apparent excess of scientists and agricultural scientists as disclosed in Table E may be actually greater than the figures indicate.

After a careful study of the whole question of the supply and demand for scientists we conclude that—

(*a*) By the year 1952 the supply of scientists and agricultural scientists will be sufficient to meet the Dominion's known requirement at that date.

(*b*) Trends in home science indicate that the present shortage of graduates is likely to continue.

The Committee considers, however, in view of the importance of this question to the country as a whole, that a Scientific Man-power Standing Committee should be set up in order that the matter may be kept constantly under review. This is particularly necessary in view of the heavy enrolments in University classes over the past few years and the need for watching future trends in demand and supply. It must be remembered that it takes many years to train men for work at the highest levels of research, and that long-term planning is therefore the more necessary.

VI. THE QUALITY OF SCIENCE STUDENTS

One of the most difficult tasks confronting the Committee was that of obtaining a satisfactory measure of the quality of science students when compared with students in other faculties. After many attempts, we found two ways of obtaining a partial answer to our problem; the answer cannot, unfortunately, be complete. We considered first the available information on the quality of students entering on science courses, and then proceeded to compare the success of science students in their University examination with that of students presenting themselves for examination in other faculties. It is admitted quite frankly, for reasons that will appear later in this section, that neither of these methods, using available data, is entirely satisfactory. Taken together, however, our results point, we think, to the direction in which the correct answer may reasonably be expected to lie.

There is unfortunately, no common standard whereby the quality or ability of students entering University for the first time may be judged. University colleges do not make use of standardized tests of intelligence or even of such tests of general attainment. It is generally admitted, however, that winners of University Entrance Scholarships are, by and large, the ablest students from our post-primary schools. An analysis of the courses taken by such scholarship winners shows that a reasonable proportion of them takes up a science course. An examination of the year by year records yielded the following results :—

TABLE F—DISPERSAL OVER COURSES OF ENTRANCE SCHOLARSHIP WINNERS LISTED

Courses Taken.	1936.	1937.	1938.	1939.	1940.	1941.	1942.	1943.	1944.	1945.	1946.
Science	7	8	3	7	9	14	5	7	10	6	9
Arts	15	14	17	15	12	9	10	4	11	11	13
Medicine and dentistry	5	2	6	5	7	5	6	7	4	6	3
Engineering	1	5	3	3	2	1	4	6	5	5	1
Law	..	..	1	..	..	..	1	4	..	1	4
Architecture	..	..	..	..	..	..	..	1	..	1	..
Home science	2	1	..	..	..	..	..	..	..	..	..
Commerce	..	..	..	..	..	..	..	1	..	..	..
Scholarship declined*	1	6	3	4	..	6	10	9	5	8	8
Ineligible	..	..	..	..	..	1	..	..	1	..	..

* Declined outright or to re-sit in following year.

The above figures enable a comparison to be made between the numbers of scholarship winners entering upon the various courses in relationship to the total numbers in these courses. The comparison is more clearly seen in the following table, where the numbers of scholarship winners are expressed at rates per 10,000 of students in the courses :—

TABLE G—RELATIONSHIP OF SCHOLARSHIP WINNERS TO TOTAL STUDENTS

Course.	Total Number of Students Taking Course Between 1936 and 1946, Inclusive.	Total Number of Scholarship Winners Taking Course Between 1936 and 1946, Inclusive.	Number of Scholarship Winners per 10,000 Students in Course.
Engineering	2,873	36	125
Science	8,342	85	102
Medicine and dentistry	8,805	56	64
Arts	24,289	131	54
Law	3,425	11	32
Architecture	911	2	22
Commerce	9,105	1	1

NOTE.—The figures given for "total students taking course" represent the cumulative total of students at all stages in each of the eleven years.

It is apparent that science attracts a satisfactory proportion of University Entrance Scholarship winners. It must not be overlooked also that many post-primary school pupils intending to pursue science courses at the University do not enter for the Entrance

Scholarship Examination, but instead undertake a specialized science course in the sixth form. The proportion of able students who select science and medicine is thus probably even higher than the figure for Entrance Scholarship winners would indicate.

The Education Department awards a number of " special bursaries " for students studying pure or applied science. At first sight it might seem that an analysis of bursary awards would provide a means of comparing " science " students with students entering, for example, courses in " architecture and engineering." The distinction between special bursaries and ordinary bursaries, however, lies in the allowance for board and lodging included in the former. It is evident, therefore, that pupils in the University cities (which contain over 41 per cent. of New Zealand's population) intending to take science would be unlikely to enter for special bursaries. It was found here that the highest quality of students applying for special bursaries occurred among those seeking entrance to the special schools of architecture and engineering. For our purposes, however, there is little significance in this fact, when it is remembered that the schools, being attached to particular University colleges, have a fairly large number of students living away from home. On the other hand, candidates for bursaries in agriculture and home science were among the weakest of the applicants for special bursaries. We were therefore precluded from using the special bursaries as a basis for comparison in quality of students entering the University in the different faculties.

Our second approach to the problem was to compare the wastage of students from science courses with the wastage from all courses. Table H shows the number of students in all University degree and diploma courses and the percentage of failure at the annual examinations. The table also shows the number of students in the science course, together with the percentage of failures.

TABLE H—EXAMINATION WASTAGE

——	1945.	1946.	1947.
Candidates entering for all University examinations	10,428	14,455	15,957
Successful candidates	6,782	9,464	10,394
Percentage unsuccessful	35	35	35
Candidates entering for all science degree examinations	1,147	1,533	1,561
Candidates successful	815	1,178	1,194
Percentage unsuccessful	29	23	24

It is noticeable in the above table that the percentages of failures in science courses are considerably lower than the percentages of failures in all courses.

For a further appraisal of the quality of science students we sought the opinion of the Professors of Chemistry. As Stage I chemistry is common to the B.Sc. and the medical intermediate courses, we asked the Professors for an assessment of the relative quality of students in the two groups.

The opinions expressed noted the higher accomplishment of medical students in chemistry since the introduction of competitive entry to the Medical School. Prior to this there would seem to have been equality in the two groups. Figures were quoted showing that the attainment of B.Sc. and medical intermediate students was similar. It was pointed out, however, that only those medical students who were at the top of their group were accepted for the medical course, so that it is the less able medical students who transfer to science.

As a generalization, then, we can say that we have no evidence to show that science students are less able than students in other faculties, and there are indications that science students are, if anything, "above average."

VII. THE QUALITY OF SCIENCE PERSONNEL IN NEW ZEALAND

Although the number of graduates may be sufficient to fill all posts this will be of little value unless the quality is satisfactory. Scientific workers are required for both routine and original work, and, while an average level of technical competence will suffice for many positions, it is essential that the University colleges, research institutions, and extension services have on their staffs men of the highest capacity. The assessment of the quality of scientific workers in New Zealand presents some difficulty, and we have made use of the considered opinions of leading scientists within New Zealand, together with evidence of the standing of New Zealand workers overseas, in arriving at our opinion.

In the previous section we considered the quality of science students and the effect of the inducements to students to study elsewhere than in the science faculty. The differing value of bursaries is partly responsible for drawing into medicine and dentistry some students who would otherwise have excelled in a pure science course. This drawing-off of science students is limited, however, both by the natural inclination of those students who prefer pure to applied science and by the fact that the bursary system itself is successful only to a limited extent in selecting the very best talent. Generally speaking, it may be accepted that the standard of science courses in the University of New Zealand is a high one by international standards, such evidence as is available showing us that in the main New-Zealand-trained workers are at no disadvantage overseas. Not all those entering upon a science course complete it, but those who do graduate are of a satisfactory standard. Nevertheless, the average quality of scientific workers in New Zealand is one that gives no cause for complacency.

We have discussed previously the existing shortage of scientists, which has hindered the conduct of work both in industry and research establishments, but a more potent cause of anxiety to employers of scientists is the calibre of the workers available. There is widespread agreement that most positions calling for graduates of average ability can be filled, but that some positions calling for graduates of more than average ability must either be left empty or filled by men who are not especially suitable. This is the case particularly in research institutions which experience considerable difficulty in obtaining suitable staff, either at the graduate stage or later. It is apparent that unless the scientific workers in New Zealand include a large number of the best men the work undertaken will suffer and indeed in many cases unless a first-class leader is available for a research team the work of the rest of the group will be seriously handicapped.

On examining the work undertaken by M.Sc. graduates some very disturbing facts are apparent. As a working hypothesis it may be accepted that the holders of M.Sc. with first-class honours represent our more capable graduates and the majority of our future scientific leaders, and an examination of a sample of these over the last twenty years shows that approximately 50 per cent. of first-class honours graduates find employment overseas. Of all honours graduates, approximately 33 per cent. go overseas. For example, the following are the figures for honours graduates in chemistry from Canterbury University College since 1930 (M.Sc. and Honours in Chemistry (C.U.C.)):—

——	Total.	In New Zealand.	Overseas.
First-class honours ..	26	11=42 per cent.	15=58 per cent.
Second-class honours ..	52	41=79 per cent.	11=21 per cent.
Third-class honours ..	11	9=82 per cent.	2=18 per cent.
Pass	26	21=81 per cent.	5=19 per cent.
Fail	7	6=86 per cent.	1=14 per cent.
	122	88=72 per cent.	34=28 per cent.

It would thus appear that the post-graduate training made available through the various overseas scholarships makes it easier for our best science graduates to obtain positions outside New Zealand, and an investigation shows that about half of the holders of travelling scholarships do not return to New Zealand.

This drain from the pool of scientific workers arises from various causes, and the same reasons which lead New Zealand workers to remain overseas restrain scientists outside New Zealand from applying for positions here. New Zealand students must at times proceed overseas to acquire training and experience in certain specialized fields, and there is no reason why the loss of New Zealand scientists in this way should cause alarm if suitable replacements were obtained.

There are fields in New Zealand in which there are opportunities unexcelled elsewhere for original work and where facilities for work are first class, yet in spite of this there is a regular loss not only of average, but in particular of the superior talents in New-Zealand-trained scientists. Scientists in New Zealand, both New Zealanders and those from overseas, have been offered positions elsewhere—many have left the country already and others undoubtedly will unless means are found to retain them. The questions of losses of scientists through emigration and the factors affecting recruitment are discussed in the following sections, where we suggest methods of overcoming this problem. At this stage we wish to record our belief that the permanent loss of any large proportion of the best of our science graduates must affect the whole quality of scientific work, especially in research institutions, and that these men must be retained here (or men of similar calibre obtained elsewhere) if the standard of scientific endeavour in New Zealand is to be maintained even at the present level.

VIII. FIELDS IN WHICH NO SCIENTISTS ARE AT PRESENT EMPLOYED OR FOR WHICH AN INADEQUATE SUPPLY OF SCIENTISTS IS AVAILABLE

We gave consideration to the question of whether there are services and industries in which scientists are not at present employed, but in which they should or could be employed. We invited experienced scientists to express their opinions in this matter. These opinions lacked unanimity ; some stated that no scope existed for the profitable engagement of additional scientists, while others felt that there were still many fields in which scientists could with advantage be engaged.

This whole question must be linked up with the stated requirements of employers as expressed in their replies to the first questionnaire. The results of the survey are tabulated in Appendix I. By converting the total numbers of scientists employed (excluding State post-primary schools) into a graph, the rate of expansion in the scientific labour force is readily seen. A notable feature is the higher rate of expansion expected to take place between 1947 and 1952.

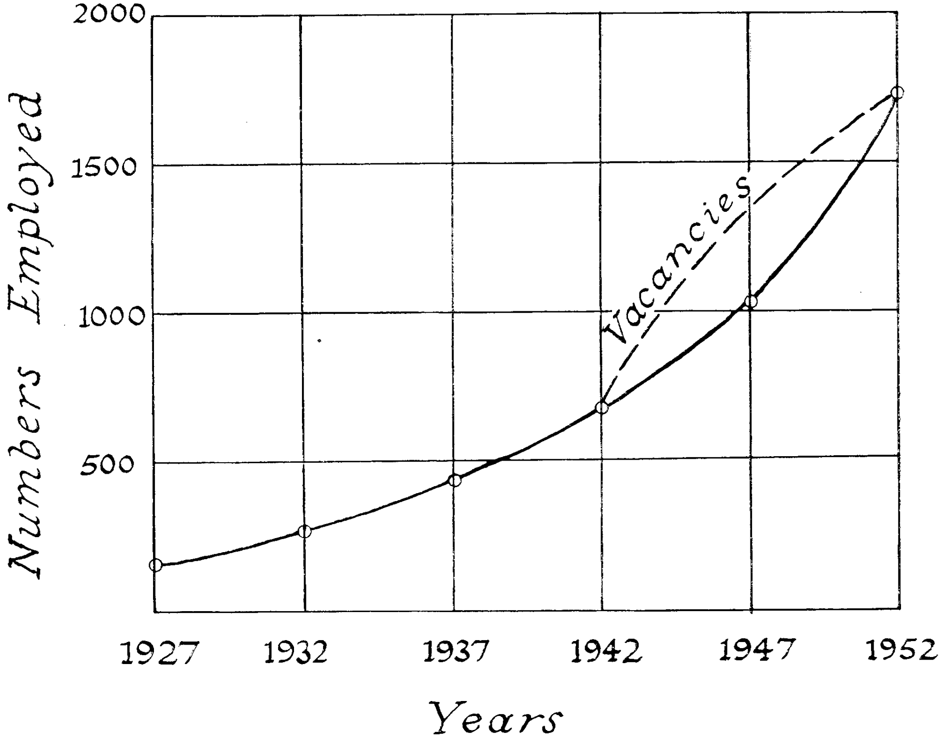

FIG. 3—GROWTH OF SCIENTIFIC LABOUR FORCE

The dotted line on the graph indicates what the scientific labour force would be if all current vacancies were filled.

Many of the openings suggested by scientists approached are already included in the current vacancy total as indicated by employers and in the anticipated staff in 1952. On the other hand, many are not so recorded by the employers concerned. Either employers do not confirm the need for scientists in these spheres, or they do not realize the value of scientific assistance in them. In either case it is evident that no early expansion in such directions is regarded as a practical possibility.

The average size of industrial units in New Zealand is small, and while the larger units in certain categories might profitably set up laboratories, smaller units could not economically do so. These smaller concerns, and many of the larger ones also, rely for expert advice on public consultants and on the formation of research associations.

There is another matter which must not be overlooked when considering the question of the scope for the engagement of additional scientists. All forecasts and opinions have been made and expressed at a time of general prosperity and of high taxation on company profits. These two factors could lead to optimism in the forecasts of both employers and scientists themselves.

After examining all the information on this subject we are of the opinion that there are many further directions in which scientists could be usefully employed. It is not easy to present an over-all picture of the situation, but it is obvious that we are faced with two distinct problems. Future developments will require limited numbers of scientists with highly specialized training in very restricted fields. The demand exists for small numbers of scientists trained to handle work in animal statistics, animal physiology, biochemistry, various branches of soil science, oceanography, marine biology, and other lines of work, in each of which for some time to come only two or three specialists are needed to collect local data, carry out routine investigations, or particular researches as required.

There are other researches in which the demand for scientists may be greater, though still limited. Scientists will be required for the development of food technology and building industry research in all their branches—metallurgy, wood-utilization, entomology, plant-diseases and wild-life researches. Here again, for the greater part, the demand is for specialists.

The two groups above have in common the demand for specialist personnel, a demand which cannot be satisfied by the import of such personnel, who are unavailable under present conditions and for some years to come other than from Central Europe, but probably must be met by the training of New Zealanders. This brings us to the problem of whether our educational system can be economically developed to train the bulk of these specialists, or whether our scientists are to be sent abroad for training. The decision must be made with consideration of the losses in the best talent which occur when our scientists are exported.

There are other opportunities for the employment of relatively larger numbers of scientists in such work as farm mechanization, station and farm management, geophysics, botanical, zoological and general geological researches, as well as the introduction of scientists into various Government Departments as field supervisors, field inspectors, and into district high schools as instructors.

We have not attempted to be exhaustive in this summary, but merely indicate the general features of the future situation to show that consideration must be given to the training available in this country, and to the diversification which is required to meet present and future needs.

IX. TRAINING AVAILABLE WITHIN NEW ZEALAND FOR SCIENTISTS

Basic training for pure science is provided in the post-primary schools and the four University colleges. The two agricultural colleges and the special University Schools of Dentistry, Engineering, Home Science, Medicine, and Mines cover many of the essential fields of applied science. As there are few barriers to attendance at post-primary schools and University colleges in this country, it is fair to say that, on the whole, opportunities for the study of science are good.

1. Post-primary Schools

Some introduction to science is provided for every pupil as part of the minimum required curriculum during the first three or four years of his post-primary schooling. Specialization in science, however, is not encouraged until the Sixth Form stage is reached. In general we agree with this policy. We believe that for future University students, and probably also for all pupils, the function of the secondary school is to provide a broad cultural foundation for later specialized knowledge. While we welcome the opportunities provided in the Sixth Forms of better secondary schools for selected pupils to concentrate on mathematics and science, we feel that this specialization should not be taken too far, and that nothing should be allowed to stand in the way of the development of the adolescent as a person.

We received little general criticism of the aims of the post-primary schools so far as science was concerned. Most of those submitting their opinions considered that the standard of Sixth Form work in science was reasonably satisfactory. Critics were mainly concerned at the size of some science classes, the shortage of fully qualified science teachers, and the difficulties arising, particularly in small schools, from lack of equipment and from staffing conditions which compel a teacher to deal with branches of science lying outside his own special training. Some of these difficulties can be remedied only when a greater number of qualified teachers is available and when the present shortage of buildings has been overtaken. We were assured that the Education Department was aware of the present difficulties and we note that the recently instituted post-primary school teachers' bursaries provide a means of encouraging well-qualified men and women to enter the teaching profession. Specialization to the extent we have already considered desirable, and with the safeguards we have mentioned, can be properly provided only when there is a regular flow into our schools of teachers equipped for the task they set out to do.

To examine fully the courses available in post-primary schools would take us outside our order of reference. We note, however, that there is still room for expansion of biological science in boys' schools, and in some girls' schools there is need for the inclusion of physics as an optional subject. We agree whole-heartedly with those who maintain that pupils intending to study science at the University should spend two years in Sixth Form work.

We gave some attention to the question of whether more pupils should be encouraged to specialize in science at the Sixth Form stage. While we would urge that a reasonable proportion of pupils of first-class ability should be attracted to the study of science, we do not consider that, on the whole, any urgent action is at present called for. Pupils choose their subjects in Form VI for a variety of reasons—among others, because of the options offered in the school, because a particular subject has fired their imaginations, and because of their proposed future career. We think that the schools would be unwise to encourage a too romantic approach to science and to hold out too much hope of a career in scientific research. Only a small proportion of pupils studying science are capable of becoming first-class research workers on completion of a University course, and too much stress on the possibility of such work, particularly in the early stages, may lead only to disappointment. There are, nevertheless, many kinds of employment where average ability in science may be exercised, and we were more than once reminded of the need for a better supply of technicians. We are far from suggesting, however, that science teaching in post-primary schools should be regarded as a narrow technical training. We would, indeed, go so far as to say that any tendency in this direction should be discouraged.

2. University Colleges

We have adopted the view that the function of the University in the preparation of scientists is to provide a general education and a training in the principles of science. Those who expressed opinions agreed that the training at present provided was by and large satisfactory for the ordinary or average student. They were less unanimous about the opportunities offered to the student of superior ability. We have shown elsewhere that in certain branches of science the shortages of graduates are more acute than in others. With certain exceptions, however, the shortages are not due to lack of facilities for training.

The problems of the University colleges have been great in the post-war years, and accommodation and staffing have been far below reasonable requirements. Recent increases in the Government grant should enable the worst of these difficulties to be alleviated within the next few years. It would, however, be surprising if, under the present overcrowded conditions, the standard of teaching has been all that University teachers themselves desire.

In view of the fact that for the initial training of scientists we depend entirely on the University we cannot too strongly urge the necessity for meeting the reasonable needs of the colleges. It is, of course, axiomatic that proper opportunities for research within the University cannot be provided until adequate conditions of staffing, buildings, and equipment have been attained.

Our comments on the University science courses themselves must necessarily be general in character; they concern the transition from post-primary school to University, the length of the courses, the research training received by students, and the subjects in which advanced courses are offered.

First-year science courses at a University college normally assume that a student will have had some preliminary training. We have already stressed the need for a sound preparation at the Sixth Form level for students proposing to specialize in science. Few schools, however, can provide a course, extending over a period of years, in all branches of science that a student may wish to study during his University course. In such circumstances it cannot be uncommon for a first-year University class to include two kinds of students—those who have concentrated on the subject for at least two Sixth Form years, and those who are commencing its study with only a meagre fund of experience. Such classes must be difficult to teach. Opinions on this situation probably range all the way from acceptance of the fact as unavoidable to preference for the rigid enforcement of prerequisites. The very able student can probably cope with the difficulty; but we believe that other students may suffer some strain and run risk of discouragement, in trying to reach a reasonable standard of work in the short time at their disposal. How to meet this situation and how to deal with such other problems as the introduction of some studies of a general kind into science courses and the lengthening of the B.Sc. course to four years to permit either preliminary courses at the early stage or greater specialization and some training in research at the later stage, are matters that we mention as significant without offering a solution. One of these difficulties might be overcome by the introduction of preliminary courses either at selected post-primary schools or at the University colleges. It would, of course, be necessary for the Education Department and the University to work out the details of any such proposal.

The danger of concentrating too narrowly on scientific studies, to the exclusion of the "humanities" has received the attention of University authorities in Britain and the United States, but the exploration of a "liberal education" hardly comes within our terms of reference.

The University has traditionally the responsibility of disseminating and extending knowledge. A University-trained scientist, therefore, should be introduced to the methods of research. We do not mean to suggest that the graduate should be ready to take up scientific work without "on the job" training. On this point we join issue with some of those who placed their views before us. We are, however, of the opinion (and in this we believe we have the support of University teachers) that the student reading for his master's degree should, during his course at the University, acquire the basic research techniques, and should be equipped by the University with the fundamental methodology of research in his particular subject.

There are spheres of research in which New Zealand could secure world-wide recognition at the highest levels. These include both research work which can be accomplished only within New Zealand and projects which, while they may be carried out elsewhere, can best be carried out in New Zealand. We feel it most necessary for New Zealand to build up research foundations at an internationally recognized level of excellence within its own special fields. Moreover, only if its research has international standing, can New Zealand hope to attract and retain men of the highest calibre. We think that New Zealand should concentrate its efforts largely (though not entirely) in those directions where pre-eminence is possible.

This brings us to the general question of concentration of research. For each University college to provide all the facilities necessary for higher research in all specialized branches of science would, of course, be wasteful, and we think that advanced research courses at least might be given different direction in the various colleges. Even when this rationalization has been achieved, there will still remain some fields of inquiry where the college may not possess facilities equal to those of highly specialized branches of industry and some research organizations. While we appreciate the desire of University authorities to ensure that work submitted for a University degree should be the work of the student himself and should be carried out under University supervision, we consider that this is not incompatible with the judicious use of the facilities of research institutions. We think that it is sound practice to encourage students to "cut their teeth" on suitable research projects connected with the welfare of our basic industries.

To achieve this object we envisage a kind of two-way traffic between the University and the research organizations. We recommend that the University should devise a way of enabling research work in specialized branches to be concentrated in the colleges according to facilities available and of enabling specialized research institutions, including those of Government Departments and industry, to be used, with proper safeguards, for the training of senior students. To this end a system of honorary lectureships might be introduced. We also recommend that research institutions be encouraged to "contract out" suitable research projects to the University colleges. These recommendations, if accepted, may do much to bring the University into closer touch with scientific problems outside the University and may indirectly serve to encourage students to return to New Zealand after a period of advanced study overseas.

For somewhat similar reasons we think that selected students should be encouraged to accept vacation work in industry or in the scientific branches of Government Departments. Here they would learn to apply the principles studied in the University and would be assisted in discovering fields of research and possible future employment. Money spent by Government Departments in engaging such students as temporary staff would in the long run return a dividend.

Concerning the content of courses for the degree of master of science, we wish to make two suggestions. The first is that provision should be made for an honours degree in a group of sciences, or in say, mathematics and physics. While more intense specialization may be desirable for the graduate entering industry or some special branch of scientific work, post-primary teaching often calls for the graduate with high qualifications in more than one branch of science.

Our second suggestion is that physiology, bacteriology, and bio-chemistry should be added to the subjects which a student may offer for the degree of master of science. All three subjects are of increasing importance, and there is at present a shortage of good research workers in these fields.

We were informed that there was a danger that University courses might grow out of touch with the scientific needs of industry and the research organizations. We consider that there should be adequate provision for representatives of the teaching institutions and the "working" institutions to meet together frequently to discuss their problems. We therefore suggest the setting-up of some standing body such as a Council of Scientific Education.

3. Technological Training

There are some kinds of scientific training that do not naturally come within the sphere of the University, and up to the present little attention has been paid to them. The development of secondary industries calls, however, for the supply of technicians as well as research workers in a number of advanced branches of applied science. Among these may be mentioned textiles, ceramics, printing, food technology, refrigeration, leather processing, paint-manufacture, laundry and dry cleaning, fertilizers and certain other chemical industries, plastics, and the utilization of forest products. These and other developments of our secondary industries call for the establishment of teaching and research institutions both to train technicians and to carry out research into problems of production.

We feel that provision for such training and research could best be made by transforming the main technical schools into institutes of technology and applied science, and that these schools should abandon their present function as post-primary schools and concentrate, in their higher branches, on special tasks. We believe, however, that the efforts of the institutes we envisage should not be dissipated in an attempt by each to cover too many activities, but that a specific field—for example, textile technology—should be concentrated in one institute, which would act as a national school.

Because no such centre of training has as yet been established in New Zealand there is an excellent opportunity for sound planning and for economic and efficient use of national resources. We believe that the need is great at present and that it will increase with the expansion of industy and of population. At present technicians have either to be imported or to learn by trial and error.

X. FACTORS AFFECTING RECRUITMENT OF SCIENTISTS

In our questionnaire to scientists we invited opinions on the adequacy or inadequacy of the present inducements to enter upon a scientific career. Comments were requested also on whether the present recruitment of scientists is being adversely affected by initial salaries, salary and promotion prospects, or other specific causes.

Reference is made by some scientists to the fact that the opportunity of performing work which is both interesting and socially useful is a strong attraction for the student with inclination and aptitidue for scientific studies. A keen interest in the work and personal satisfaction in achievement do operate as powerful inducements to taking up a career in science.

On the whole, however, opinion was directed more towards the improvement of the material incentives, and the removal of differences in the conditions of recruitment which apply within a number of the scientific fields.

These points will be noted under the following headings :—

A. Bursary schemes and guaranteed positions.
B. Senior posts.
C. Salaries.

A. Bursary Schemes and Guaranteed Positions

Some of our informants drew attention both to the inadequate number of bursaries and the low monetary value of some of them. The first concern, however, was with the inadequate value rather than the number. Stress was laid on the need for bringing the value of bursaries in the different subjects more into line, as otherwise too great a proportion of the able students are drawn into some fields to the detriment of others.

A further dissimilarity occurs in that some bursaries offer an opportunity for permanent employment—*e.g.*, the Education Department's bursaries for the post-primary teaching service.

Admittedly the bursar is required to enter into a bond to give a stated period of service following the completion of the University course as a condition under which the bursary is awarded. However, the opportunity of a permanent appointment, which is also implied, acts in many cases as an inducement.

The possibility was suggested also of early appointments being offered by Government Departments to graduates in science who have been awarded overseas scholarships. Some service in scientific work in New Zealand would give the scholar experience, acquaint him with local problems, and might well suggest lines of research for his post-graduate studies. The period between the awarding of scholarships at the end of the academic year and the departure of the scholar from New Zealand—that is, from approximately January to October—could be spent in this way. In some cases it might be advantageous to extend this period if the University would permit a postponement of the scholarship.

This scheme has an added advantage in that the post-graduate scholar wishing to return to New Zealand has a definite offer of employment, under conditions with which he is fully acquainted.

A further suggestion was that the number of overseas scholarships be increased. For instance, they could be granted to suitable candidates, in research institutions and Government Departments, who have served a period of several years in which they have proved their ability, with a bond for a stated period of service following the tenure of the scholarship. In such circumstances the value of the scholarship should be such as to meet all reasonable expenses.

The need for students to go overseas to obtain the benefit of research facilities not available in New Zealand is evident. At the same time the development of first-class research schools and institutes in New Zealand in selected subjects suitable for study in this country would encourage a two-way traffic in research students and would act as a further aid to recruitment.

We consider that there is need for a number of post-graduate scholarships tenable only in University colleges in New Zealand, and that graduates from overseas countries, as well as in New Zealand itself, should be eligible for the award of such scholarships.

B. Senior Posts

An important inducement for scientific work is the existence of senior appointments at which able scientists may aim. The presence of an able leader for a research team is a prerequisite for any research being undertaken in a particular field. Science must, therefore, offer the best conditions for the encouragement of the potential leader through the existence of positions of adequate status and remuneration.

To open up a new line of research it may be necessary in a Government Department to appoint a scientist from outside the Public Service to a senior position. It is considered that if this could be done expeditiously, and without prejudice to scientists already in the Public Service, scientific work would benefit.

C. Salaries

Much has been said on the subject of the inadequacy of salaries for scientists.

We have had stated to us specific cases where scientists of ability have received and accepted offers of employment overseas for comparable work at considerably higher salaries than those obtainable by them in New Zealand. This is a continuing problem.

While is has not been feasible for the Committee to undertake a detailed comparative study of salary and salary scales, we are satisfied that other measures for stimulating scientific man-power resources will be largely rendered ineffective by any failure to retain scientists of first-class ability against overseas competition for their services.

In this connection the attention of the Committee was drawn to the white-paper (Cmd. 6679) entitled "The Scientific Civil Service." This included the following provisions, which have been adopted by the British Government:—

(i) The scales and system of promotion of the scientific classes should ensure that the best scientific men should have equal prospects of pay and promotion with the best men in the administrative class, at least up to the top of the Principal grade. (Op. cit., page 15, para. 18 (i).)

(ii) The outstanding man should be able to reach the Principal Scientific Officer grade (£750–£1,020) in the early thirties. (Rates for London are £800–£1,100.) (Op. cit., page 15, para. 18 (v).)

(iii) The number of posts above the Principal Scientific Officer level to be increased to provide for the promotion of individual research scientists without expecting them to carry administrative responsibilities. (Summary of statement in op. cit., page 4, para 10.)

(We had evidence that appointments had been made to such posts in Great Britain at a salary of £1,200 to £1,400, and were informed that in New Zealand it is rare for a scientist to receive such a salary without taking over administrative duties.)

In 1947 the Australian Council for Scientific and Industrial Research adopted a scale of salaries for principal research officers and senior principal research officers which is almost identical with that implemented by the British Government.

In this connection the Committee realizes that it is admittedly difficult to compare the purchasing-value of salaries in Great Britain and New Zealand, and that a similar great disparity of salaries occurs in other branches of the Public Service, but there appears to be no doubt that there is a real difference, sufficiently great to have attracted a disturbing number of the most brilliant New Zealand graduates to both Australia and Great Britain.

It is pointed out, too, that there is a very real disparity between salaries paid to senior scientists in the New Zealand Public Service and those paid to scientists of similar status in other organizations largely financed by Government funds.

XI. LOSSES OF SCIENTISTS THROUGH EMIGRATION OR THROUGH ABSORPTION IN ADMINISTRATIVE OR NON-SCIENTIFIC WORK

The question of losses of scientific man-power through emigration has received brief notice earlier when the quality of scientists was considered. There is a very real loss of scientists overseas comprising approximately one-third of our honours graduates in science; this is to some extent countered by the selection of overseas scholars for posts in New Zealand, particularly in industry and the University and, to a lesser extent, in teaching and research institutions.

Accurate measurement of this is difficult. It would appear, however, that one-third of our honours graduates proceed overseas and do not return, and that approximately half this number are replaced by scientists from overseas.

We have not attempted to measure more exactly the number of scientists "imported and exported." We are of the opinion that there will always be a flow of scientific workers to and from New Zealand and that this is of considerable benefit to us. This opinion is supported by a majority of leading scientific workers and administrators in New Zealand. It is, however, desirable, particularly in respect of those sciences relating to animal, plant, and soil problems peculiar to New Zealand, that the staff be predominantly New Zealand trained. The honours graduate in science can familiarize himself with work undertaken in New Zealand while at the University and would be able, particularly in the applied sciences to appreciate fully the local problems in all their ramifications. If some means cannot be found of retaining the majority of the best graduates, the country must import its brains from overseas—a procedure accompanied by some difficulty at present as was shown in the previous section.

Emigration of scientists is not in itself undesirable, but the ultimate effect of the continuous export of many of the potential leaders of scientific thought in New Zealand will be to leave too many " average " scientists in the country. This is only part of a complex problem involving also such matters as training, salary, and status.

Even were salaries and working conditions made as attractive here as overseas there would probably still be a continuing flow from New Zealand of scientists for whom there are suitable positions locally.

Already the increase in the numbers of students at the M.Sc. level, the reintroduction of the Ph.D., the establishment of some post-graduate scholarships, and the increasing University staff, are all factors contributing to the rapid increase of research in the University. The situation in regard to research is rapidly changing from the condition of former years where the need for the export of young scientists for further training was almost essential. The current development has already brought some departments in the University to a level where they offer opportunities and facilities for graduate training at least equal to many available overseas. We can be confident that this will increase and that to-day and in the future the opportunities for many of the best students to be adequately trained in this country will mean that these students will remain to train here. Much of the problem of " export " is open to solution in this manner.

There is another significant loss of scientific workers through their absorption in administrative or non-scientific work. Very few scientists take up non-scientific work, but many, particularly in the Public Service, proceed to administrative positions. The nature of a scientific training is such that it should foster the qualities of mind needed for administration and scientific officers should be able to proceed to administration. In fact, scientific work, unless controlled by an administrator with scientific qualifications, will suffer both in respect to quality of work and morale of personnel.

In the State scientific services promotion inevitably leads to pre-occupation with administration and the highest-paid positions are remote from the laboratory or the field. It is not in the best interest of research institutions that the line of promotion should be only in the administrative field and we consider that positions of equal eminence should be available in science or in administration.

In general we consider that there is room for lessening the burden of administration on scientists in the University and the Government, and recommend that scientists should not concern themselves other than with the administration of scientific work, and that the University colleges and the Government Departments improve the clerical services given to their scientific administrative staff.

These considerations are not of the same moment in industry, as the scientist who shows any ability outside his specialized field will usually be called on to undertake executive work.

XII. LINES OF ACTION URGENTLY REQUIRED IN ORDER THAT AN ADEQUATE SUPPLY OF SCIENTISTS ADEQUATELY TRAINED MAY BE SECURED AND MAINTAINED IN ALL SUBJECTS AND AT ALL LEVELS

While we think that by 1952 the present shortage of scientists will be overcome by the anticipated supply of science graduates from the University colleges, we do not think that, even then, the desired standard would be reached in all subjects and at all levels, and means of improving the position at as early a date as possible are listed below under the headings (i) recruitment, (ii) reduction of net losses, (iii) increase in the proportion of experienced scientists, (iv) more effective use of existing personnel, (v) improvements in training facilities, (vi) salaries, and (vii) constant review.

(i) RECRUITMENT

(a) Better Bursaries

At the present time the Education Department awards a number of special bursaries in agriculture, architecture, art, engineering, home science, and science. In agriculture, home science, and science respectively there have been fifteen, twenty, and twenty awards in each of the last few years. The average calibre of the applicants for these three classes of bursaries, however, has not been high, probably owing in the main to the comparatively low value of the bursaries. For bursars who do not qualify for boarding-allowance—*i.e.*, who reside in a University town providing the desired course—the bursary is worth annually a maximum of £30 only, made up of a bursary allowance of £10, together with fees up to a maximum of £20. Those who qualify for a boarding-allowance receive in addition £40 boarding-allowance annually, making an annual maximum amount of £70 for the period of the bursary. The special bursaries are in competition with other bursaries awarded by the Health Department in medicine and in dentistry and by the Education Department for the post-primary teaching service. These three groups of bursaries are of an annual value of £70, plus £40 boarding-allowance in cases in which the bursar is eligible for it, while in some cases fees also are paid. The consequence of this is that there is much greater competition for medical, dental, and post-primary teachers' bursaries, and the average calibre of the bursars is higher than the average calibre of those to whom the Education Department's special bursaries are awarded. It is true that medical, dental, and post-primary teachers bursars are under bond to render service at the expiration of their course, but the Committee considers that similar conditions would be readily acceptable to those who were interested in a science career, and that an increase in the value of science bursaries with a similar bond would improve the average calibre of those entering upon science courses. The Committee is of the opinion, therefore, that the various bursary schemes should be brought more into line.

Recommendation—

That the various bursary schemes be brought more into line and that Treasury be asked to arrange for a conference of the Departments concerned in order that this may be done.

(b) Further Cadetships and Bursaries

Early in our deliberations we came to the conclusion that something should be done to facilitate recruitment for the Department of Scientific and Industrial Research and for the Department of Agriculture, both of which are experiencing difficulties in filling vacancies. We therefore suggest that bursaries be awarded to selected cadets who could then take up University studies which would fit them for scientific work in the Department in question. These bursaries, we consider, should be of the same value as medical, dental, and post-primary teachers' bursaries, and should entail full-time attendance at the University. The cadet would, of course, be under bond to serve his Department for a definite number of years at the termination of the bursary.

The Committee understand that the Public Service Commission has already agreed to appointments to these Departments on this basis.

Recommendation—

That one avenue of appointment to the Department of Scientific and Industrial Research and the Department of Agriculture be by means of bursaries of value equal to medical, dental, and post-primary teachers' bursaries.

(*c*) Appointment of Experienced Scientists to the Public Service

We gave much consideration to the possibility of appointing experienced scientists to the Public Service. We think that in scientific work at higher levels the most important factors are brilliance, experience, and ability to give fresh stimulus to scientific work rather than mere ability to carry on a particular job at the level at which it has been performed in the past. While the right of appeal should give priority to scientists of equal brilliance, experience, and initiative, already employed it should not protect mediocrity against outstanding ability or hamper the appointment of the best man on each occasion.

We think, too, that the appointment of overseas scientists of recognized ability in their particular fields to senior posts in the Public Service should be made easier than it is at present. There are, in our opinion, cases in which scientific appointments from outside the service should be made without hesitation.

(*d*) Improved Salaries

Salary scales obviously affect recruitment, and subsection (vi) below is devoted to this topic.

(ii) REDUCTION OF NET LOSSES

As indicated earlier in the report, we are satisfied that New Zealand is losing to overseas scientific employers, mainly within the British Commonwealth, more scientists than are returning or are coming to this country for the first time, and that the loss is in the main of the best of our scientists. We agree that New Zealand should make its full contribution to the British Commonwealth pool of scientific workers. With other parts of the Commonwealth, we benefit from scientific work done overseas. We think, however, that our contribution should not always be made by export, particularly when this is not balanced by a corresponding drawing-off from the pool. As we have indicated elsewhere, the development of scientific work of a very high standard in New Zealand may be expected to provide a field of work for first-class scientists both from New Zealand and other countries. The following steps should therefore be taken to recover a greater proportion of "exports" or, in other ways, reduce the margin between "exports" and "imports" of scientists.

(*a*) Continuous Contact with all New Zealand Scientists Overseas Through the Offices of the Various High Commissioners

In this way these scientists should be kept aware of suitable New Zealand vacancies. We are strongly of the opinion, however, that this action would be ineffective unless New Zealand conditions for scientists were improved (see paragraph (*e*) below).

Recommendation—

That arrangements be made through the various High Commissioners to inform New Zealand scientists overseas of suitable vacancies in New Zealand, and to inform New Zealand employers of scientific personnel concerning New Zealand scientists who are anxious to return.

(*b*) Provision of a Pool of Relieving Teachers in Post-primary Schools

The Education Department is continually receiving applications from teachers, often science teachers, in the United Kingdom who desire positions in New Zealand post-primary schools. There are vacancies in these schools, but, as is well known, all appointments to post-primary schools are made not by the Education Department, but by individual employing authorities. These bodies are not very ready to appoint a teacher quite unknown to them and unable to take up his position for possibly many months. On the other hand, scientists are not likely to undertake the long and costly removal to New Zealand unless they have a firm guarantee of suitable employment.

There are few instances, therefore, of post-primary teachers entering New Zealand from abroad. We think that more movement could be effected by providing a pool of relieving teachers for post-primary schools. Every Education Board has such a pool at present for its primary schools, but there is no corresponding pool for post-primary schools and only the Education Department could establish such a pool effectively. The following action is therefore recommended—

RECOMMENDATION—

That the Education Department establish a pool of relieving teachers for post-primary schools whereby, say, ten overseas science teachers of ability and experience could be assured of a position for twelve months after arrival in New Zealand.

(*c*) APPOINTMENT OF EXPERIENCED SCIENTISTS TO THE PUBLIC SERVICE

We would repeat here what has been said above (see (i), paragraph (*c*), of this Section).

(*d*) THE LINKING-UP OF THE UNIVERSITY OF NEW ZEALAND WITH THE FEDERATED SUPERANNUATION SCHEME FOR UNIVERSITIES (GREAT BRITAIN)

If reciprocal arrangements were made between some New Zealand scheme and the Federated Superannuation Scheme for Universities, scientists employed in British Universities would be more ready to take up positions in the University colleges of New Zealand.

(*e*) IMPROVEMENT IN NEW ZEALAND CONDITIONS FOR SCIENTISTS

Apart from improved salaries, the necessity for which we would place first, we would list the following six ways in which improvement could be effected :—

1. Visits abroad.
2. Interchange of scientists.
3. Bursaries for Ph.D. students.
4. Post-graduate scholarships tenable only in New Zealand.
5. Postponement of overseas scholarships.
6. Further development of research in New Zealand.

The first three of these call for little comment. After finishing their University courses in New Zealand many young scientists proceed overseas, with or without assistance, both to undertake further training and to meet other scientists. It is from this group that so many are lost. If these young men had reasonable assurance that, if they entered a New Zealand Government Department, they would later on be assisted by their employing body in obtaining overseas experience, we have little doubt that the Departments in question would have fewer difficulties in filling vacancies, and the loss of scientists would also be reduced.

Post-graduate scholarships tenable only in New Zealand would offset the loss of scientists through overseas scholarships. These scholarships should be of an annual value of £300 and should be tenable for one year, with the possibility of extension for a second year. They should also be open to applicants from overseas.

We have also mentioned the postponement of overseas scholarships. It was brought to the notice of the Committee that many young New Zealand scientists proceeding overseas on the conclusion of their University course do so without any knowledge of New Zealand's particular research problems and in consequence may not always employ their time overseas in the best interests of New Zealand. The Committee felt that the Department of Scientific and Industrial Research, the Department of Agriculture, and other Departments would be well advised to get in touch with these men and endeavour to place them " on the strength " for a brief period before they go overseas. Such action could not fail to be to the advantage of the Department in question and would increase the probability of the scientist's return to this country. Such a scheme would depend largely on the co-operation of the University authorities.

Further development of research in New Zealand is also important. One prominent New Zealand scientist informed the Committee that he was depressed by the tendency of many New Zealanders to think that no significant contributions to science can be made in New Zealand, and he regarded this erroneous viewpoint as being an important factor in the "export" of scientists. He considered that the ultimate remedy was to build up departments of research which would rank at world level and which would serve to fertilize and foster research at a high level throughout New Zealand. With this view the Committee would fully agree, emphasizing that this research should, in the main, centre round our basic industries with their many problems peculiar to this country and of paramount importance to our national economy.

RECOMMENDATIONS—

1. *That there be further facilities in Government Departments for visits of scientists abroad and interchange of scientists.*

2. *That for employed scientists there be provision for post-graduate bursaries for overseas study.*

3. *That there be adequate provision for post-graduate scholarships tenable only in New Zealand, and open both to New Zealand and overseas applicants.*

4. *That young scientists who may be proceeding on overseas scholarships should be encouraged to seek employment in Government scientific departments and other institutions before their departure.*

5. *That research in matters affecting our basic industries be developed to the fullest possible extent.*

(iii) INCREASE IN THE PROPORTION OF EXPERIENCED SCIENTISTS

Much of the evidence submitted indicated clearly that the shortage of experienced scientists was more pronounced than shortages at a lower level, and the recommendations made are directed towards securing an increase in the proportion of experienced men.

Of these steps those recommended under subsection (iv) below are regarded by the Committee as the most important.

(iv) MORE EFFECTIVE USE OF EXISTING PERSONNEL

The following are the steps which we consider necessary to make a more effective use of existing personnel:—

(*a*) ADEQUATE CLERICAL ASSISTANCE FOR SCIENTIFIC PERSONNEL

The Committee has reason to believe that a good deal of valuable time is in some cases being wasted because scientific personnel are not provided with adequate clerical assistance. We consider that the provision of such adequate assistance is an important factor in making the most effective use of existing personnel, particularly when in administrative positions. In such cases it is important that the administrator should still have a close personal interest in the practical problems of research, and this is impossible if an administrator is preoccupied with clerical work.

RECOMMENDATION—

That scientific personnel be provided with adequate clerical assistance in order that their time may be used to the best advantage.

(*b*) CORRELATION OF UNIVERSITY RESEARCH WORK WITH THAT OF OTHER RESEARCH INSTITUTIONS

We regard this as important and suggest that in this connection a Council of Scientific Education recommended in subsection (v), paragraph (*d*) below, might be helpful.

RECOMMENDATION—

That there should be correlation of University research work with that of other research institutions.

(c) Co-ordination of Research Work

A review of scientific activities in New Zealand shows that there is no over-all authority, other than Cabinet itself, either to consider projects or to direct personnel or to apportion expenditure. The Council of Scientific and Industrial Research is not such an authority; its powers are advisory only. The Committee discussed this question at some length. There was general agreement that full collaboration among scientific workers and co-ordination of scientific work would mean an economy of man-power and would enable the best work to be done.

Recommendation—

That while the best means of achieving co-ordination of research work is by the encouragement of active collaboration between investigators and institutions, some co-ordinating body is necessary.

(v) IMPROVEMENTS IN TRAINING FACILITIES

In Section IX of this report reference is made to the training available for scientists within New Zealand and to the suitability of that training.

(a) Provision of Further Courses

In activities in which only small numbers require training the Committee did not feel disposed to recommend the provision of further courses. In these cases, as in veterinary science, bursaries to enable the necessary training to be obtained overseas would be more economical. The Committee considers, however, that courses should be made available either at the University or at higher technological institutions in, for example, forestry, exotic forest utilization, meteorology, and textiles. In none of these are any courses available at the present time.

Recommendation—

That further courses in applied science be made available either at the University Colleges or at higher Technological Institutes.

(b) Modification of Some Existing Courses

In this connection the Committee makes the following recommendations in regard to courses to be followed by students intending to enter upon a science career:—

Recommendations—

1. *At the post-primary stage there should be no specialization whatsoever until the completion of the school certificate year.*
2. *In the Sixth Form specialization is desirable, but such specialization should not exclude study of cultural subjects.*
3. *The B.Sc course should be extended to four years.*
4. *That it be made possible for a student to secure an M.Sc. degree in physiology, bacteriology, or biochemistry,* and also in a group of sciences or in mathematics and physics, as well as in a single subject.*

Evidence was submitted that for teaching both of these modifications would be helpful, while many physicists felt the need of a higher standard in mathematics.

(c) Research and Honorary Lectureships

Recommendation—

That the University should devise a way of enabling specialist research work to be concentrated in the colleges according to facilities available, and of enabling specialist research institutions to be used, with proper safeguards, for the training of senior students, and that to this end a system of honorary lectureships be developed.

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* Since this report was drafted it has come to our knowledge that the master's degree may in future be taken in biochemistry and physiology at the University of Otago.

(d) Council of Scientific Education

The primary function of this Council would be to make recommendations to the Senate of the University of New Zealand in regard to scientific education. It would also serve the purpose of bringing the Services, Government Departments, and scientific industry into intimate contact with the University.

Recommendation—

That consideration should be given to the establishment of a Council of Scientific Education representative of the University of New Zealand, Government Departments, and scientific industry to make recommendations to the University Senate in regard to scientific education.

We suggest the following minimum representation:—

Four members to be appointed by the University of New Zealand;
One member to be appointed by the Education Department;
One member to be appointed by the Department of Scientific and Industrial Research;
One member to be appointed by the Department of Agriculture;
Two members to be appointed by the Minister of Education to represent other scientific interests.

(e) Improvements in Accommodation, Equipment, and Staffing at University Colleges

These will be necessary in connection with the recommendations in paragraph (c) of this subsection.

(f) Special Courses in Industrial Subjects for Non-university Students

These are necessary in industrial chemistry and in pharmaceutical work in order that students who can attend only part time can secure instruction. The Committee realized, however, that provision for some of these could only be made effectively with the establishment of technological institutions, which it understands the Education Department envisages among its schemes for further educational development.

(vi) SALARIES

This question has already been considered in Section X of this report, which deals with the factors affecting the recruitment of scientists.

A satisfactory salary scale for scientific men should provide:—

(a) Satisfactory initial salaries.

(b) Satisfactory final salaries, more important even than satisfactory initial salaries.

(c) A reasonable number of senior positions.

(d) Good opportunities for promotion.

(e) Recognition of good men early in their career, and accelerated promotion for such men.

(f) Proper co-ordination of salaries, at least in all institutions financed from Government funds.

Recommendation—

That the present scales should be carefully examined in order to make certain that all these conditions are fulfilled.

(vii) CONSTANT REVIEW

The need for watching future trends in the demand for and the supply of scientists has been stated in the concluding paragraph of Section V of this report. We consider that a constant review of the position would be of benefit to scientific work in New Zealand.

RECOMMENDATION—

That, in view of the importance of scientific man-power to the country as a whole, a Scientific Man-power Standing Committee be set up in order that the matter may be kept constantly under review.

XIII. SUMMARY OF CONCLUSIONS OF THE CONSULTATIVE COMMITTEE

(1) That there is at present a shortage of scientific man-power amounting over all science subjects to some 20 per cent. of the number at present employed (Appendix I).

(2) That in the fields employing the greatest number of scientific workers the shortage exceeds this figure (20 per cent.) in agriculture, botany, forestry, geology, mathematics, physics, and zoology, and is below 20 per cent. in chemistry and home science (Appendix I).

(3) That there is an acute shortage of scientific workers of ability and experience to fill key positions (Section VII).

(4) That the loss of scientific personnel to overseas positions is undoubtedly considerably greater than the number returning to or entering New Zealand for the first time and that the loss is in the main of the more able scientists (Section XI).

(5) That the output of science graduates from the University colleges is such that by 1952 there should be a sufficient total number of science graduates to meet the Dominion's needs if there is no undue loss overseas, or to occupations outside scientific industry, and if there is no very marked unforeseen development of scientific activities (Section V).

(6) That this output will not remedy present weaknesses unless machinery is devised to increase the proportion of scientific workers of ability and experience (Section XII).

(7) That there are some spheres in which scientific workers should be employed and in which they are not at present employed or are employed on too limited a scale (Section VIII).

(8) That if there are large developments in new fields the total number of science graduates anticipated by 1952 may still be insufficient.

(9) That some of the present University science courses are not altogether suitable for the needs of Government Departments and of industry and could with advantage be modified.

XIV. RECOMMENDATIONS OF THE CONSULTATIVE COMMITTEE

(1) That the various bursary schemes be brought more into line and that Treasury be asked to arrange for a conference of the Departments concerned in order that this may be done (Sections X and XII).

(2) That one avenue of appointment to the Department of Scientific and Industrial Research and the Department of Agriculture be by means of bursaries of value equal to medical, dental, and post-primary teachers' bursaries (Sections X and XII).

(3) That arrangements be made through the various High Commissioners to inform New Zealand scientists overseas of suitable vacancies in New Zealand, and to inform New Zealand employers of scientific personnel concerning New Zealand scientists who are anxious to return (Section XII).

(4) That the Education Department establish a pool of relieving teachers for post-primary schools whereby, say, ten overseas science teachers of ability and experience could be assured of a position for twelve months after arrival in New Zealand (Section XII).

(5) That the University of New Zealand should, if possible, be linked up with the Federated Superannuation Scheme for Universities (Great Britain), (Section XII).

(6) That there be further facilities in Government Departments for visits of scientists abroad and interchange of scientists (Sections X, XI, and XII).

(7) That for employed scientists there be provision for post-graduate bursaries for overseas study (Sections X and XII).

(8) That there should be adequate provision for post-graduate scholarships, tenable only in New Zealand, and open both to New Zealand and overseas applicants (Sections X and XII).

(9) That young scientists who may be proceeding on overseas scholarships should be encouraged to seek employment in Government Departments and other institutions before their departure (Sections IX, X, and XII).

(10) That research in matters affecting our basic industries be developed to the fullest possible extent (Sections IX, XII).

(11) That scientific personnel be provided with adequate clerical assistance in order that their time may be used to the best advantage (Sections XI and XII).

(12) That provision be made for the promotion of brilliant research workers in Government Departments to the highest grade without their being asked to accept administrative responsibility (Sections XI and XII).

(13) That salary scales for scientists in all Government Departments and institutions subsidized by Government funds should be examined with a view to revision. (Without satisfactory salary scales the other recommendations of this Committee are likely to be largely ineffective), (Sections X and XII).

(14) That there should be correlation of University research with that of other research institutions (Section XII).

(15) That while the best means of achieving co-ordination of research work is by the encouragement of active collaboration between investigators and institutions, some co-ordinating body is necessary (Section XII).

(16) That consideration should be given to the establishment of technological institutes (Section IX).

(17) That further courses in applied science should be made available either at the University colleges or at higher technological institutes (Sections IX and XII).

(18) That the B.Sc. course be extended to four years (Section IX).

(19) That it be made possible for a student to secure an M.Sc. degree in physiology, bacteriology, or biochemistry,* and also in a group of sciences or in mathematics and physics, as well as in a single subject (Section IX).

(20) That the University devise a way of enabling specialist research work to be concentrated in the colleges according to facilities available, and of enabling specialist research institutions to be used, with proper safeguards, for the training of senior students; and that, to this end, a system of honorary lectureships be developed with the object of bringing the science teaching in the Universities into closer touch with the outside world (Section IX).

(21) That consideration should be given to the establishment of a Council of Scientific Education representative of the University of New Zealand, Government Departments, and scientific industry to make recommendations to the University Senate in regard to scientific education (Sections IX and XII).

(22) That statistics of university training of scientists be reviewed to ensure that they will in future enable trends to be analyzed and studied, and that such statistics and the general position regarding employment of scientists be regularly reviewed (Sections V and XII).

(23) That in view of the importance of scientific man-power to the country as a whole, a Scientific Man-power Standing Committee be set up in order that the matter may be kept constantly under review (Section V).

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* Since this report was drafted it has come to our knowledge that the master's degree may in future be taken in biochemistry and physiology at the University of Otago.

XV. APPENDICES

Appendix I—Dominion Scientific Labour Force at Five-yearly Intervals: Classified According to Major Subjects

Major Subject.	Totals Exclusive of State Post-primary Schools.						Totals Inclusive of State Post-primary Schools.		Vacancies, 1947-48.
	1927.	1932.	1937.	1942.	1947–48.	1952–53.	1947–48.	1952–53.	
Agriculture	9	10	33	58	111	189	130	208	29
Anthropology	..	1	2	2	3	2	3	2	..
Bacteriology	..	2	3	3	8	3	8	3	1
Botany	5	12	21	32	72	142	98	168	31
Chemistry and chemical engineering	56	97	161	251	387	553	450	616	74
Forestry	5	6	5	14	21	65	21	65	12
Geology	11	10	15	24	39	56	46	63	10
Home science ..	2	14	18	26	38	64	143	169	6
Mathematics	9	13	21	50	71	137	206	272	47
Physics	27	56	89	139	203	308	223	328	49
Psychology	..	..	1	2	2	4	2	4	..
Zoology	13	15	23	37	75	101	89	115	20
Subject not stated ..	25	44	51	49	10	116	22	194	7
Totals ..	162	280	443	687	1,040	1,740	1,441	2,207	286

Appendix II—Scientific Man-power Requirements of Government Departments, Teaching, University Colleges, Research Institutes, and Industrial Concerns

—	Staff, 1947–48.	Anticipated Staff in 1953.	Excess of 1953 Staff over 1947–48 Staff.	Present Vacancies.
Government Departments and local authorities	564	935	371	138
Teaching	443	518	75	65
University colleges	176	295	119	24
Research institutes and museums	48	93	45	17
Industrial concerns ..	210	366	156	42
Totals	1,441	2,207	766	286

Note.—Research institutes whose staffs are directly employed by the Department of Scientific and Industrial Research have been included under Government Departments.

Appendix IIIA—Scientific Man-power Requirements of Government Departments and Local Authorities According to Major Subjects

Major Subject.	Staff, 1947–48.	Anticipated Staff in 1953.	Excess of 1953 Staff over 1947–48 Staff.	Present Vacancies.
Agriculture	69	107	38	24
Bacteriology	2	2	..	..
Botany	44	95	51	12
Chemistry and chemical engineering	138	193	55	21
Forestry	21	65	44	12
Geology	29	40	11	8
Home science	11	35	24	5
Mathematics	46	89	43	18
Physics	165	236	71	28
Psychology	2	4	2	..
Zoology	35	46	11	9
Subject not stated	2	23	21	1
Totals	564	935	371	138

Appendix IIIB—Scientific Man-power Requirements of the Teaching Profession According to Major Subjects

Major Subject.	Staff, 1947–48.	Anticipated Staff in 1953.	Excess of 1953 Staff over 1947–48 Staff.	Present Vacancies.
Agriculture	20	20	..	..
Botany	31	30	−1	15
Chemistry	75	75	..	8
Geology	7	7	..	..
Home science	115	115	..	1
Mathematics	142	141	−1	24
Physics	22	25	3	15
Zoology	18	22	4	2
Subject not stated	13	83	70	..
Totals	443	518	75	65

Appendix IIIc—Scientific Man-power Requirements of University Colleges According to Major Subjects

Major Subject.	Staff, 1947–48.	Anticipated Staff in 1953.	Excess of 1953 Staff over 1947–48 Staff.	Present Vacancies.
Agriculture	36	67	31	4
Bacteriology	1	1	..	..
Botany	16	32	16	2
Chemistry	36	62	26	4
Geology	8	11	3	2
Home science	17	17	..	..
Mathematics	14	39	25	5
Physics	25	42	17	3
Zoology	23	24	1	4
Totals	176	295	119	24

Appendix IIId—Scientific Man-power Requirements of Research Institutes and Museums According to Major Subjects

Major Subject.	Staff, 1947–48.	Anticipated Staff in 1953.	Excess of 1953 Staff over 1947–48 Staff.	Present Vacancies.
Agriculture	4	10	6	1
Anthropology	3	2	−1	..
Botany	4	2	−2	1
Chemistry and chemical engineering	18	15	−3	8
Geology	..	1	1	..
Mathematics	1	3	2	..
Mycology and bacteriology ..	5	..	−5	1
Physics	..	4	4	1
Zoology	13	22	9	5
Subject not stated	..	34	34	..
Totals	48	93	45	17

Appendix IIIE—Scientific Man-power Requirements of Industrial Concerns According to Major Subjects

Major Subject.	Staff, 1947–48.	Anticipated Staff in 1953.	Excess of 1953 Staff over 1947–48 Staff.	Present Vacancies.
Agriculture	1	4	3	..
Botany	3	9	6	1
Chemistry and chemical engineering	183	271	88	33
Geology	2	4	2	..
Home science	..	2	2	..
Mathematics	3	..	−3	..
Physics	11	21	10	2
Zoology	..	1	1	..
Subject not stated	7	54	47	6
Totals	210	366	156	42

Appendix IV—Number of Students Taking Various University Courses From 1927 to 1948

Students Taking Definite Courses.	1927.	1928.	1929.	1930.	1931.	1932.	1933.	1934.	1935.	1936.	1937.
Science	383	412	407	468	492	481	488	503	503	475	494
Agriculture ..	26	23	24	24	38	37	28	26	19	32	31
Home science ..	120	119	115	109	106	105	93	83	103	95	100
Engineering ..	236	147	221	210	221	166	172	145	132	212	174
Mining	19	22	16	13	32	31	35	41	39	33	42
Others	3,595	3,221	3,332	3,594	3,491	3,780	3,710	3,673	3,715	3,636	3,834
Totals ..	4,379	3,944	4,115	4,418	4,380	4,600	4,526	4,471	4,511	4,483	4,675
Percentage of science students to total students	8·7	10·4	9·9	10·6	11·2	10·5	10·8	11·2	11·1	10·6	10·6

Students Taking Definite Courses.	1938.	1939.	1940.	1941.	1942.	1943.	1944.	1945.	1946.	1947.
Science	511	587	566	624	595	796	1,002	1,176	1,516	1,750
Agriculture	45	49	39	26	27	36	33	42	88	116
Home science	139	144	170	184	186	190	207	207	207	170
Engineering	154	184	163	181	157	235	309	399	705	549
Mining	38	45	41	40	30	42	35	38	63	61
Others	3,901	4,023	3,840	3,703	3,063	3,881	4,967	5,890	8,377	8,660
Totals	4,788	5,032	4,819	4,758	4,058	5,180	6,553	7,752	10,956	11,306
Percentage of science students to total students	10·7	11·7	11·7	13·1	14·7	15·4	15·3	15·2	13·8	15·5

Note.—The figures shown include all students taking definite courses, whether of degree or diploma standard. It has not been possible from the records available to isolate degree students except in the case of agriculture, where degree students only are given.

Appendix V—Numbers of Students Obtaining Degrees from 1927 to 1947

Students Obtaining Degrees.	1927.	1928.	1929.	1930.	1931.	1932.	1933.	1934.	1935.	1936.	1937.
Science, D. and M.Sc.	22	55	38	32	29	33	39	55	55	44	45
Science, B.Sc. ..	55	62	60	62	64	59	90	83	78	86	62
Agriculture, M. Agr.Sc.	..	6	3	2	2	4	3	7	4	2	1
Agriculture, B.Agr.Sc.	2	3	6	2	10	6	11	12	8	11	16
Home Science, M.H.S.	..	1	1	1	2	..	..	..	2	..	..
Home Science, B.H.S.	7	5	5	11	12	11	11	7	9	6	4
Others	445	476	410	411	461	443	492	512	549	513	488
Totals ..	531	608	523	521	580	556	646	676	705	662	616

Students Obtaining Degrees.	1938.	1939.	1940.	1941.	1942.	1943.	1944.	1945.	1946.	1947.
Science, D. and M.Sc. ..	22	36	39	25	24	15	14	45	70	85
Science, B.Sc.	59	56	76	72	61	81	101	108	165	221
Agriculture, M.Agr.Sc. ..	6	8	5	3	1	1	..	..	5	9
Agriculture, B.Agr.Sc. ..	5	9	14	7	5	5	10	11	12	10
Home Science, M.H.S. ..	..	..	..	..	..	2	4	3	5	1
Home Science, B.H.S. ..	10	13	10	15	21	16	29	16	25	19
Others	424	475	439	388	307	348	460	554	759	1,007
Totals	526	597	583	510	419	468	618	737	1,041	1,352

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