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Some Scientific Investigations affecting Queensland

BY

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[Delivered before the Royal Society of Queensland, 27th March, 1939.]

THREE years ago, on my return from over a year abroad, during which time many research institutions were visited and many scientific investigators were met, I addressed this Society on the part it had played and should continue to play in matters pertaining to research.

Some of you will remember my reminding you that when this Royal Society was founded—over fifty years ago—those responsible decided very wisely that the objects should be:—

> "The leading objects for which this Society is established are the encouragement of scientific research and the study of new applications and laws."

Since that reminder to you I have thought much about the matter, as it has been my good fortune to be associated very closely with many research activities, both within the State and beyond it.

Events of world-wide importance move rapidly these days, and the necessity for this Society to do what it can in furtherance of its "leading objectives" was never more urgent than now.

You do not need to be told of the changes which have come over the world's methods of trading, and you are all well-informed as to the influence of these as far as the Empire is concerned, and Australia in particular. Things have changed very decidedly, and we need to use to the very best advantage all our resources—material, research, and human.

The time has not long passed when those who knew the value—economic and otherwise—of research had to implore those whom it would most benefit as to the wisdom of supporting research investigation both financially and in kind.

It is one of the most hopeful features of our outlook to-day that there is an ever-widening appreciation of the value of these research inquiries.

When times are bad—as they were in Australia in 1929 onwards—everybody turns to the economist and to the research scientist, but there is still a very human tendency to forget about the scientist when times of prosperity return, and then in times of adversity to cast the blame on him for not doing something to prevent these unfortunate circumstances.

Perhaps the best, but also the most unfair, tribute paid to the scientist is the blame cast upon him for the development to-day of tremendous methods of destruction of structures and of mankind.

Presumably there are those who think that the progress of science may be halted. It cannot be halted, nor should it be. Man himself should develop, and in his own way keep pace with this development. This matter is an extremely serious one, but, I fear, a fruitless one for me to pursue this evening. May I, however, take up with you the question of aiding and abetting the conduct of pure research investigations?

The Commonwealth Government is an enlightened one as far as research investigations are concerned, especially those relating to the application of science to industry. Through the Council for Scientific and Industrial Research, we now spend about a quarter of a million pounds yearly on research investigations. These are nearly all affecting the primary industries, and as time goes on, with our mandate to engage in the research investigations relating to secondary industries, this figure must, of course, increase. The State Governments—especially that of Queensland—also are very enlightened in this respect, and they are working in the closest co-operation with the Commonwealth.

What this Society, along with its sisters and universities, needs to do is to safeguard the position of pure research, because applied research of an economic and industrial nature can yield only results in accordance with the development of pure research.

"Research for its own sake" is a slogan that every one of us should paste in his hat. Governments now have learned the wisdom of finding money for the applied researches; while years ago they may have prospered without organised industrial research, to-day they know they will fail without it. But they seldom realise how fundamental to these applied researches is the encouragement and development of pure research investigations. On Royal Societies and universities there are very heavy responsibilities in this matter. It is well to remember that the teachers of advanced science must engage actively in research investigations if they hope to inspire their students. They must attempt to advance the frontiers of knowledge, or the frontiers will leave them rapidly behind.*

Mention should be made of the important scientific investigations mainly in the nature of pure research which have been going on in regard to the Great Barrier Reef over a period of sixteen years. This work was initiated within Queensland, and is not only administered from here but has also been carried out mainly by Queensland investigators, with the exception of the work of an expedition of British Scientists in 1928-29, which was organised by the Great Barrier Reef Committee.

The results of these investigations, both by the members of the expedition and by the local workers, are published from time to time and are known to those scientists throughout the world who are concerned in coral reef investigations. This work is continuing year in and year out, and is a good illustration of solid, quiet, pure research along a programme carefully worked out and pursued in an unostentatious fashion.

Associated with the pure researches are certain applied researches of industrial importance, but it may be said definitely that the value of these latter investigations is based completely upon the pure research. The use in the cement making industry to-day in Brisbane of the coralline deposit at Mud Island in Moreton Bay instead of the limestone material

* Soviet Science, J. G. Crowther, page 20.

from Gore is an excellent illustration of the economic results, often of great importance, which follow upon pure research entered upon simply in the spirit of "research for its own sake."

May I appeal to every member of this Society to help in the encouragement of pure research, and, as a reminder of its absolute necessity in the proper development of our country, may I furnish a few instances which, if necessary, you can use when you are "passing on the torch"?

As pointed out by Sir Frank E. Smith,* it was Roger Bacon who first urged the experimental method in gaining knowledge, and 300 years later Gilbert became famous for his experimental work, especially that on magnetism. Galileo, a contemporary of Gilbert, also, as you know, favoured, in spite of tremendous opposition. the experimental method. The first great revolution in industry which resulted from the work of Black, James Watts, and others on the nature of steam followed upon the results of experiments.

Who would have thought that the experimental work of twenty-five years ago which resulted in the then laboratory toy we now know as the *photo-electric cell* was producing something that to-day is a vital link in the "talkies," is used as a burglar alarm, operates in large stores to switch lights on or off, with variation in daylight illumination, groups electric lamps according to their candle-power, arranges cigarettes in rows with the imprinted name uppermost, selects cigars by the colour of the outside leaf, controls the magnitude of electric currents, is used in television, and furnishes a completely unbiassed decision as to the order in which racehorses finish?

Unquestionably, in the past there has been a considerable amount of capital (pure research discoveries) accumulated, and we have been living on that capital. It must be supplemented, however, and the need for constant replenishment must be appreciated far more widely than is the case to-day, and especially by Governments. One may say that nearly every fundamental discovery has originated in the laboratory devoted to pure science when no regard was being paid to its possible practical application.

Faraday's discoveries, in which lay the germ of all our dynamos and electrical power units, were believed originally to be of no practical importance. Pasteur's researches, which led him to study fermentation problems and, later on, the control of disease, were originally conducted as pure scientific investigations. It took over twenty years from the time that Clerk Maxwell mathematically proved the existence of electro-magnetic waves for them to be actually produced and recognised, and on this we have based to-day the great system of wireless and radio as we know it. Mendel's discoveries in heredity and cross-breeding, which have meant millions and millions of pounds to us in Australia in connection with the development of our modern varieties of wheat, originally had no industrial application.

In spite of the above, one of the main difficulties to be overcome in Australia is the recognition of the importance of scientific research and the creation of an atmosphere which will encourage research in all departments of knowledge.

* Norman Lockyer's Lecture, 1932, page 6.

Were it not for the capacity to float off separately the lead sulphide and the zinc sulphide from the Mount Isa ore, we should not have had the big industrial development at Mount Isa which has already seen the expenditure of so many millions of money.

There has been a tremendous change during the last few years, and many who viewed the scientist with suspicion, and certainly would have none of him about their precincts, now come almost cap in hand to invoke his aid, and, as I could indicate to you from C.S.I.R. experience, they come now with hands full of money begging us to do the scientific work which they now realise is of such fundamental importance.

Referring to the co-ordinated research efforts so often talked of, the following remarks by Dr. F. P. Keppel, the President of the Carnegie Corporation of New York, are interesting*:—

"There are fashions in research, just as there are fashions in hats and gowns. To-day we have the endocrines, the cosmic rays, heavy hydrogen, the outer galaxies, pioneer belts. There are fashionable techniques—the bombardment of the atom, the partial correlation, the private life of the long-suffering banana fly, the photo-electric eye, linguistic atlases. For a while we are all excited about the possibility of deliberately planned co-operative research.

"We are not so sure to-day.

"It was, by the way, the degree of foundation support going to enterprises of this kind a few years ago which evoked the cry from my predecessor on this platform, Professor Zinsser, of Harvard:—

> "'Research Councils and foundations organise co-operative researches, thinking that the shy truth can be snared by the noisy advance of a well-drilled company of technicians, forgetting that discovery was ever a solitary task, in which co-operation must be spontaneous, asked as the need arises by one lonely seeker from another.'"

In support of the view that it is absolutely essential to have pure research fostered and encouraged, let us see what our very practical friends in U.S.A. think about it.

Dr. Keppel estimated that in 1927 some £43,000,000 was spent in U.S.A. and about 90 per cent. of the funds came from industrial and commercial bodies. Much of it was necessarily routine and utilitarian research or investigation, but there are many shining examples to the contrary—e.g., Langmuir's work in the realm of pure physics is known the world over—he is on the pay-sheet of the General Electric Company. Other instances are contributions by scientists on the staff of the American Telephone and Telegraph Co.—one on endocrinology, another on the physics of light and the chemistry of pigments, and another on personal analysis. None of these has anything much to do with telephones or telegraphs.

Of course, we need scientific workers of the very best calibre, and, speaking generally, the best men for these research posts are our own trained graduates who are "topped off," if necessary, by carrying out post-graduate or research activities in carefully selected institutions abroad—in those places where they may receive the best inspirations and

* F. P. Keppel: Philanthropy and Learning, page 15.

where they may become acquainted with the right technique. Naturally, we will be well-advised to recruit to a limited extent our research services from time to time by carefully selected people from abroad, but we will find it increasingly harder to induce the old country to send us good men—it wants them all herself—but, fortunately, the local product, adequately trained and experienced, has already demonstrated a fitness to undertake the tasks the country asks of it.

The provision recently by the Commonwealth Government of £30,000 per annum to be used through C.S.I.R. in conjunction with the several universities in Australia in the stimulation of research and in the training of young graduates as research investigators was most wise. It has provided facilities which were sadly needed—in our own University especially—and now the way is clear for anyone who has a "flair" for research investigation to engage in such an activity. The provision of these facilities should be known as widely as possible, and the Commonwealth Government and the University would welcome into this scheme those qualified and competent to serve their country in this all-important matter of research.

While more details will be given of applied researches than of pure researches, it is hoped that the impression will not be left that pure researches, as such, have no sound establishment in Queensland and in Australia, for quite definitely they have.

Applied researches have prominence in this address because most of those who read it will be more concerned in that direction, and the necessity of applying the results of scientifically conducted experiments to our industrial activity is of such paramount importance.

As already indicated, applied researches can progress only on a sound basis of pure research. A long list of scientific research into physical, chemical, engineering, zoological, botanical, geological, and palæontological matters could be drawn up, but anyone especially interested is advised to consult the proceedings of the various State Royal Societies and of the Australian Institution of Engineers, also the Memoirs of the various State museums.

Let us now consider some of the research investigations which have taken place in the past, which are going on at the present day, and which will need to take place in the future. A purely cursory examination indicates that to-day a vast amount of research is taking place within Australia, and in Queensland, in particular, a very wide field indeed is being covered. This field has, generally speaking, been in the realm of primary industry, but we are on the eve of an enormous development on the secondary industrial side which will necessitate the application of a considerable amount of energy, time, and money.

With confidence one may review the past record of achievement and think particularly of the spectacular success which attended the subjugation of the prickly-pear problem by biological control. Let us realise that going on at the present time is this extremely interesting work on chilled beef which brings in its train the necessity for research investigations into the fattening of cattle on improved pastures in our coastal regions. The realisation that the base-metal mining and milling industry at Mount Isa was determined by the capacity to apply selective flotation methods to the various sulphides in turn brings home to one the part which such investigations play in the building-up of a country by the provision of raw materials for industrial activity.

It has been borne in upon us in a rather brutal manner these last few years that we must learn to stand upon our own legs and that competition in the world's markets to-day, as far as our primary products are concerned, is very keen indeed. Not only must we learn to produce the goods, but we have to transport them and market them, often under grave disadvantages as far as distance and time are concerned. In Great Britain a certain measure of preference to Empire-produced goods exists, but we have keen competition from our sister Dominions, especially Canada, South Africa, and New Zealand. While New Zealand and Australia together face the almost equal and great handicap of distance, South Africa, like the Argentine, our great competitor for so many products, has advantages over us.

In matters relating to foodstuffs, these disadvantages hit us rather severely, but, as a result of long, patient, and careful research investigations, the disabilities are becoming lessened day by day, but possibly will never be overcome completely in all circumstances. It is only by research investigations, however, that these disabilities can be reduced to what may be spoken of as a reasonable vanishing point.

The experiment made at the Low Temperature Research Station in the University of Cambridge some years ago as to length of time a piece of beef could be kept without decomposition was the basis on which our chilled beef export trade is built. It was found that by chilling and providing an atmosphere containing a certain percentage of carbon dioxide the sound life of beef could be much extended.

It is a far cry from that original experiment to the existing position, and it is pleasing to note that in Brisbane so much of the research on chilled beef has been done by C.S.I.R. officers provided with facilities by the Queensland Meat Board.

In Queensland we do well to remember that at present our primary products are of chief importance, and it is useful to recollect that about 80 per cent. of the value of what we send away is produced directly and indirectly from the land.

In connection with these primary products, we have some five considerations to bear in mind:—

(1) The preparation for the crop, whatever it may be;
(2) The production of the crop;
(3) The harvesting;
(4) Preparation for marketing;
(5) Transport to markets.

Speaking generally, our record is satisfactory in the first three.

Unseasonable factors over which at present we have no control at times have to be met, but we can take a fair degree of satisfaction in the knowledge that, relatively to other countries, we hold our own in these matters. Regarding (4)—the preparation for marketing—we cannot deny, avoid it as we would wish, that we are very remiss in many directions, and in respect to (5)—transport to markets—we have very grave disabilities to overcome, mainly owing to distance and time.

Research investigations are more applicable and fruitful of results in the matters relating to the preparation and the production of the crops than in the others, but transport difficulties are grave.

All the beneficial results from these research investigations will, however, be much depreciated if the preparation for marketing is not carried out properly, and I am afraid that we in Australia are very neglectful in this matter. People here refuse to believe this, I know, but the agents in Covent Garden markets have told me, and will tell you also; moreover, they will show you the evidence, which cannot be denied —seeing is believing!

In many cases the results of research in other countries may be lifted readily and applied out here with beneficial results. Unfortunately, this cannot always be done, and in this respect, perhaps, Queensland is at a greater disadvantage than some of her sister States, because the country is either sub-tropical or tropical, and because of the White Australia policy.

We can take much quiet satisfaction in the developments which have taken place, but we must accept the challenge in regard to the difficulties, and also appreciate the fact that these difficulties can be met in one way only, and that is by the application of the results of research investigations carried on relentlessly year in and year out.

Now let us turn to the dairying industry. In Queensland there has been a perfectly wonderful expansion, and to-day, under normal seasonal conditions, we produce something like five times as much butter and cheese as we did twenty years ago.

The industry is conducted right from the southern border of the State up to the Mossman area, about 1,000 miles further north (a range of latitude of some 12 degrees), and for some 400-500 miles within the tropics. This performance is unparalleled elsewhere, but it brings with it certain definite problems.

The results of all the research on butter and cheese cultures, on improved pastures, &c., in Denmark may be lifted, holus-bolus as it were, and be applied with great success in New Zealand, or, say, Victoria, because of similar climatic conditions. But you cannot do it for this State because of the different climatic and pasture conditions. We have to tackle our own problems and work them out ourselves if we are going to continue the success which has already attended this wonderfully expanding industry. Such things as the proper selection of cows, the use of good bulls, the need for milk-testing, and the necessity of proper hygienic conditions, of course, when more extensively and better applied, will do much, but the climatic conditions of the industry here and the peculiarity of our pastures have to be carefully studied, evaluated, and the results applied.

While one speaks eulogistically of this very great extension of an industry, one often wonders whether in the past the exploitation of certain resources, especially of the non-recurring mineral type, has been of as much benefit to the State as it might have been. The question of whether the State should allow non-recurring resources to be exploited until the fullest investigation as to their amount, quality, and character has been made is a very important one. While not bewailing the mining in the past of very important auriferous deposits in Charters Towers, Gympie, Croydon, and elsewhere, the fruits of which both directly and indirectly did so much to bring about the development of Queensland, I would like to draw your attention to the exploitation of the coal resources of the Ipswich area. Here we have closely adjacent to a big

city which in the future will be very much more important as a manufacturing centre than it is to-day material which, as marketed at present, must be rated as a relatively inferior coal product, especially for steam-producing purposes. The development of this field by a large number of small collieries has not lent itself suitably to the introduction of modern coal-washing plants, and so we find there is placed upon the market, at a relatively high cost, a dirty product with a high ash content not very acceptable to many who must use it.

This same coal has many virtues as a source of by-products important in industry, and perhaps in the not-too-distant future will have a value as a raw material for conversion into oil infinitely above its present steam-raising value.

Please don't misunderstand me. I don't suggest we should hold up the development of a country, or that we should advocate the non-use of this coal; but it may well be that it would have been a far better thing for Queensland over a long term of years if there had been a less active operation upon the relatively limited coal resources of this field. The application of research investigations to such material is of far-reaching importance in answering such questions as I have raised.

At Broken Hill many years ago there were evolved for the first time anywhere wet methods of concentrating the lead-sulphide content of unaltered ore-bodies. In the evolution of mechanical devices for harvesting crops and in the discovery of dry-farming methods—long before they were termed such in America—Australia has shown her inventiveness through her research investigations. The production of rice in the Leeton irrigation area of the Riverina by the application of wholesale methods of cultivation and harvesting, such as are used in wheat-farming, has been attended with great success, especially in regard to the cost of production.

In the past there has been evolved that wonderful Australian animal which we call the Australian Merino sheep. We cannot retrace the steps of its evolution to see exactly how this wonderful end-point as far as a wool-producer has been achieved, but of the results there is no doubt, as the whole world acclaims.

All of these achievements show the capacity of the people in this country to face up to their own problems and to apply research investigations with beneficial results.

With pride, Queensland may talk of the triumphal march of progress which has attended not only the production of sugar-cane tonnage per acre, but also the efficiency of the milling of that material by white men within the tropics.

Some ten years ago three University science graduates were sent abroad for a protracted period to study various aspects of sugar production. Subsequently they were placed in executive positions. The Bureau of Sugar Experiment Stations, as a result, has a strong and sound scientific leavening, and developments of great importance to the industry have taken place in both field and mill.

The following table and subsequent observations which have been furnished by the Director of the Bureau illustrate this clearly:—

	Average for Queensland— 1918-1927	1928-1937.
Tons cane per acre	16·51	18·53
Tons sugar per acre	2·17	2·66
Tons cane per ton sugar	7·62	6·97

The increased sugar yields per acre reflect both better farm work and improved milling performance. The yield figures for 1936 and 1937 are even more striking, as they show 21·1 and 20·6 tons of cane and 3·04 and 3·06 tons of sugar per acre, respectively, while the tons of cane required to make 1 ton of sugar were 6·94 and 6·73. The cane and sugar yields for 1938 are estimated to approximate closely to these values also.

Costs of sugar manufacture have been substantially reduced by milling research work; they are reflected in both accelerated crushing rates and improved sugar recoveries. Records for the past ten years only are available, but a comparison of the 1928 with the 1937 data show:—

	1928	1937
Average crushing rate, tons cane per hour ..	47 (1932)	59
Sugar extraction, per cent.	94·2	95·2
Boiling-house efficiency..	95·7	96·7
Tons of added fuel, B.T.U.'s per ton cane (millions)	2·8	2·4

As far as forests products are concerned, we find in Queensland especially a very active programme of research in the extension into the field of the results of scientific investigations. Seasoning, utilisation, chemistry, wood structure, timber physics, mechanical properties, preservation, plywood veneers and glueing, and the many uses of such products as gums, essential oils, tan barks, plastics, artificial silk, &c., are all subjects of keen investigation, and, speaking generally, the fundamental research in these matters is done primarily in the Forests Products Laboratory of C.S.I.R., while a certain amount is done also in University laboratories.

Silvicultural research in Queensland to-day is most vigorous and is certain to yield results of great practical importance. It is essential that we know the best means of perpetuating our forests, and, especially, how to do that while at the same time obtaining the maximum production of marketable timber.

In this State the work has been concentrated on those forest types which produce the bulk of the State's timber requirements.

In the making of roads which will last and render the service required, the old order has changed. To-day much testing of soils for stability under varying conditions, of gravels for soundness and binding properties, must be done. In this way only is it possible to build from the bed upwards a stable road, and the application of such research work is now made in most of the States, and it is pleasing to note that it is being done on really sound lines in Queensland.

Later on in this address the question of what dividends are paid by the capital invested in research investigations is considered on a broad basis, but at this stage let us consider whether or not wheat

research in Queensland has paid. I am indebted to the Under Secretary of Agriculture and Stock for the following:—

"In Queensland, prior to the year 1910, the area of wheat harvested did not exceed 100,000 acres, the average yield per acre received being comparatively low, owing to the lack of suitably prolific varieties capable of resisting rust, maturing sufficiently early, and withstanding the effect of moderate storm rains.

"The position is now entirely altered, as a steady expansion has taken place during the last twenty years, culminating in the recent record harvest, estimated to exceed 7,000,000 bushels from an area of over 400,000 acres.

"The wheat-improvement activities of the Department of Agriculture and Stock can claim responsibility for a large share of the expansion noted, especially in regard to average yields per acre, as over half the wheat acreage now consists of varieties evolved at the former Roma Experiment Farm under the direction of Mr. R. E. Soutter, wheat-breeder, and introduced into general cultivation through the medium of trial plots on the Darling Downs.

"Pioneering work was commenced at the Roma farm in the year 1906, with a view to the expansion of agriculture in the Maranoa.

"For the ten-year period 1916-1925, the average yield per acre in Queensland was 11·38 bushels—an average which advanced to 14·92 bushels per acre for the following decade (1926-35), being an increase of over 3 bushels per acre.

"With an acreage of 400,000, and regarding wheat as selling at 3s. 6d. per bushel, the increase represents a gain of £210,000 per annum to the State—a sum which more than compensates for the moderate outlay for wheat research during recent years.

"Naturally, due credit must be given to improved cultural methods, coupled with the introduction of tractors and improved farm machinery, particularly the combine-drill and header-harvester, but in this sphere the Department has also been assiduous in advocating early summer fallowing and the correct use of available machinery.

"At the former Roma Experiment Farm the average yield per acre in both field and experimental blocks considerably exceeded the low average yield for the Maranoa district, thereby demonstrating the value of timely and thorough cultural operations."

Perhaps the most spectacular success of all our great scientific research investigations has been in the biological control of prickly-pear. This, plus (and a very important plus) the administration provided by the State Prickly-pear Land Commission, brought out the wonderful results which are now so well known and which are so justifiably acclaimed.

Australia has during its 150 years of settlement exhibited a capacity to face up to and to solve most of the difficulties which it has met. The protective policy of the country, especially since Federation, no doubt has helped much, particularly in secondary industries and in the sugar-cane growing and milling industry. It is interesting, however, to compare the efficiency of industries such as the steel-manufacturing and sugar-cane growing and manufacturing industries, which have had such

solid protection, with corresponding ones in other parts of the world. If you make this comparison, you will be pleased to find the result is not by any means to the disadvantage of Australia—it is decidedly the other way.

Problems relating to the production of our animal products are very great and are due, like most of our troubles, to the introduction, accidental or otherwise, of organisms not indigenous to this country. The introduction of animals and plants from elsewhere, with the disturbance of the balance arrived at by nature over a long period of time, brings in its train a long list of problems which exercise to the full the energies and ingenuity of our scientists.

I have not the time to deal with the effect of cattle tick infestation, of buffalo fly attack, or of soil deficiencies as far as cattle are concerned, or of the troubles the sheepmen have in Western Queensland in keeping up their flocks by natural increase alone, or of the extremely serious results of the blowfly attack, &c. These matters, together with all the pest problems associated with the growth of crops such as tobacco, cotton, &c., are the subject of much experiment and research by Commonwealth and State.

Brilliant success has attended some of the investigations, such as overcoming prickly-pear and blue mould in tobacco, or in connection with pleuro-pneumonia in cattle; but the challenge offered by the tick, worm nodules, the blowfly, nut grass, and noogoora burr—just to name a very few—demands the best brains provided with all the facilities of training which modern civilisation can provide.

The dividends to be won by the investment of money in researches of this type are great, but there must not be too much impatience exhibited by the investor. The money put out must be regarded as "patient" money which sooner or later is likely to yield enormous dividends.

While most of the researches indicated in this address have been related to either the primary or secondary industries, we must not overlook those on diseases affecting man. The great work in Queensland by a past-president of this Society on filaria made him known throughout the world. I speak of the late Joseph Bancroft.* Several other medical members of this Society have carried out researches of far-reaching importance upon problems which affect man and his environment within this State.

Within the State Department of Health and Home Affairs work on Weil's disease and certain fevers is especially worthy of note.

Medical research of a scientific character will, no doubt, be carried out in Queensland in the future on more extensive lines than in the past now that we have a medical school within the University.

While one may take confidence out of our past performances, it is perfectly clear that our future existence and expansion are based more and more on the application of the results of scientific investigations. In the past we have shown we can produce the men. We certainly have the problems which are to be solved.

Enough has been said to indicate the worthwhileness of research and the necessity for its continuance in this country, but there are those

* Proc. Roy. Soc. Qld., Vol. 11, pages 73-76.

so-called hard-headed business people who ask for figures in support of the paying character of research. One hopes that already in a general way justification for this has been made, but if one must have figures, then let us see what has been the experience in the mother country of recent years.

Amounts spent on research and the results.

J. D. Bernal,* in a recent article on "A Policy for Scientific Research for Britain," discusses the question of what is the scale of benefits which science is capable of giving to industry, agriculture, and health, and he considers that they are not at all realised. He says that, compared with any other form of expenditure, science is capable of yielding a return incomparably greater.

There is, of course, difficulty in getting precise figures on matters of this kind, but figures have been provided by the Department of Scientific and Industrial Research of Great Britain, and they show that research conducted by the Department at a cost of a few thousand pounds "has in many cases saved the industries concerned hundreds of thousands of pounds per annum."

Some economies effected as a result of the researches carried out by D.S.I.R. in connection with six research associations—namely, Iron and Steel, Non-ferrous Metals, Electrical Industries, Refractories, Food Investigations Board, and Cotton—show that on an expenditure of not more than £400,000 economies have been yielded of not less than £3,200,000 per annum. That is to say, a return on the money invested in research has returned a dividend to the industries concerned of 800 per cent. per annum. That is the kind of thing that appeals to your business man!

One is prompted to inquire what amounts are spent on scientific research in different countries. Bernal has calculated that in Great Britain about £4,500,000 is found altogether by the Government, by universities, and by industry.

This sum represents about one-tenth of 1 per cent. of the national income. If this amount be compared with what is spent on advertising, it is not very large, and is even grotesquely small.

Great as this £4,500,000 spent in Great Britain seems to us, it does not show up too well in comparison with that found in some other countries. Bernal estimates that U.S.A. spends £40,000,000 per annum; that is three-tenths of 1 per cent. of the national income, and relatively is three times as much as Great Britain finds.

The Soviet Union, however, is the great spender in this respect, and it has been estimated to be just under 1 per cent. of its national income, while in Germany and Japan, Bernal considers "it probable that the proportional sum spent is between three and five times that of Great Britain."

There is every reason for believing that these estimates are soundly based, and, as far as U.S.A. is concerned, a relatively recent estimate by Dr. F. P. Keppel of the money spent indicated about £45,000,000 per annum, which is rather greater than Bernal's figures.

* Nineteenth Century and After, Jan., 1938, page 99 *et seq.*

Regarding the Soviet Union, Major-General A. G. L. McNaughton* indicates that there are 840 institutes engaged in research, and in 1934 there were 47,900 persons engaged in research work. Their annual expenditure now exceeds £100,000,000 sterling for a population of 186,000,000 people. General McNaughton indicates that the figures continue to increase just as fast as they produce trained workers. As this Canadian authority puts it, consideration should be given to the "cost of not doing it" by other countries.

Now, what of Australia? Here we have a population of less than 7,000,000 and a national income to-day of round about £800,000,000. We have funds for research coming from the Commonwealth and State Governments directly to Government departments and institutes, also indirectly to research organisations financed partly by endowments. Universities contribute materially in this matter; also there has been a marked increase of late from industry itself.

As a result of calculations made by the Information Bureau of C.S.I.R., it would appear that the estimated amount spent in 1938 in Australia from all sources on research investigations was about £1,025,000, or approximately 0·128 per cent. of the national income of £800,000,000. The comparison with that of Great Britain is really very favourable. The sum of something over £1,000,000 is estimated as follows:—

Organisation.	Estimated Sum for 1938. £
Commonwealth—	
C.S.I.R.	272,500
Miscellaneous	112,500
Waite Institute	35,700
Medical Institute	25,600
Universities	82,500
State Agriculture Departments	326,900
Other State Departments	42,500
Industries	128,000
	£1,026,000

= 0·128 per cent. of the national income of £800,000,000.

We have to ask ourselves: Is that enough? It is about all we can spend with our present available trained workers, but I have no doubt about the wisdom of the amount being increased as and when the trained workers become available.

Conclusion.

The purpose of this address has been to place before you the strong claim which the support of research—more particularly of pure research—has upon those of you who really wish to see our country progress.

It has not been my purpose to make the list of researches at all complete, because there is no necessity to do so.

* Address to Canadian Society of Cost Accountants and Industrial Engineers, Montreal, 29th September, 1937.

An endeavour has been made to see what is the business aspect of research, and one hopes that even the hardest-headed critic on that score has been satisfied.

Those who decided over fifty years ago what the objects of this Society should be were wise men, and I feel that to them we must pay a warm tribute.

Let us see that the Royal Society of Queensland in the future continues to live up to the objects for which it was founded!

DAVID WHYTE, Government Printer, Brisbane.