Science and Progress in Australia.¹

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AN underlying motive of all international conferences is to contribute something towards that mutual understanding—that sympathy—which alone can preserve the peace of nations; but each has also its own specific work to do. The task of the Pan-Pacific Science Congress is to discuss those scientific problems which are of special interest in the Pacific area, to direct attention to them and to lay plans for future research. It is hoped that all the participating countries may benefit; but I think there are two good reasons why Australia may look to profit most. In the first place it is here that the Congress meets and here, therefore, that its deliberations will attract most attention from the public and those higher authorities that have it in their power to aid or discourage any co-operative ventures for the public good. In the second place, Australia, in respect to scientific effort, has more to learn from the older and greater nations—from the Mother Country, from America, from Japan, from Holland—than they have to learn from her.

This island continent is as large as the United States but has a population only about one-twentieth as great. It is a continent of huge distances and vast empty spaces, held by a people of nearly pure British stock, who would not run two persons to the square mile if evenly distributed over its surface. Collected on and near its coastal fringe, they have done much to open up the resources of the land and have learnt much about its difficulties. To carry on the work towards complete development, overcoming obstacles and gradually increasing the area of settlement, is the proud ambition voiced in the nation's motto "Advance Australia." Progress, full utilisation of the great land we occupy, is a duty we owe to ourselves; but clearly our obligation is even more binding as trustees for the world, present and future.

Many things are needed to ensure successful progress—the triumphant fulfilment of Australia's destiny. Statesmanship of course; but as to that we may have faith and confidence. Man-power—a vast increase of population; and towards that end even now the efforts of our rulers here and in Britain are turned, utilising and directing hither the migration wave from an overcrowded land where food is scarce: a movement which has arisen since the War and recalls the greater hunger migrations that went to make history when the world was young. But apart from these there is a need as pressing, as fundamental, though I think it is not so generally recognised of the people. That is the need of science.

Science is nothing more nor less than the knowledge and understanding of Nature's laws. To a law of Nature there can be no exception. The apparently abnormal is seen to be normal when the laws at work are better understood. There is no happening in the Universe except in conformity with natural law. No human act can successfully run counter to it. Any such attempt is foredoomed to failure. Man cannot "fight Nature"; he can but utilise its law-governed

processes, profiting by the result. There is, indeed, no true distinction between what we call "artificial" (man-made) and "natural" (Nature-made). An artificial ruby is either not a ruby at all, and therefore misnamed, or it is the outcome of Nature's edict that certain substances, raised to a certain temperature, will fuse, and, on cooling, will crystallise in a certain manner. All that the artificer has done is to gather the right materials and to adjust the environment to the necessary temperatures; and, for this last purpose, he has but utilised Nature's infallible laws of chemical combination and of energy. His ruby is, in truth, as much a natural product as those man finds ready-made in the earth. Let me cite a more important case. Sir Ernest Rutherford is commonly said to have *caused* the *artificial* disintegration of certain of the lighter atoms, such as those of nitrogen, and their partial transmutation into hydrogen atoms. He is said to have done this by bombarding them with swiftly moving alpha-particles emitted by radio-active material. The facts are true, but the common mode of stating them is misleading. Not Rutherford, but Nature, did the work; not Rutherford, but Nature, caused the result. Neither the work nor the result was new. What Rutherford did was to arrange the environment so as to render detection of the phenomena possible; then to observe and then to interpret Nature's deeds. Radium and other radio-active matter have been shooting out swift-moving alpha-particles, and these have been bombarding other atoms and causing occasional transmutations, since time was young; only we did not know of it until recently. Rutherford's discovery is one of the most important events in the history of science, and none but a man with genius such as his for searching Nature's secrets could have made it. We owe to him many other discoveries of first-rate importance and surpassing interest; but even he can do no more than study Nature, follow out her processes, and elucidate her laws.

In more obviously utilitarian fields the same story must be told. The sheep-breeder who gradually and patiently improves the quality or the quantity of his wool and thus raises the value of his flock is not the main agent in the process. He merely acts as Nature's henchman and her immutable laws of heredity do the rest. So it is with the cultivator of improved varieties of wheat—rust-resisting or what not—or of varieties of beet that provide a greatly enhanced yield of sugar.

Is all this a mere truism? I think not; for there are many signs that mankind at large does not yet realise that everything that happens in this universe is the result of the working of natural laws and that the best that man can do is to study them and turn the knowledge of them to his profit. One is tempted here to ask the old question: how many utterly futile man-made laws have been passed by parliaments, foredoomed to become dead letters or to be rescinded, because they tried to run counter to the complex and incompletely understood natural laws of economics or social science?

But, if the principle I have enunciated be a truism,

¹ From the presidential address delivered to the Second Pan-Pacific Science Congress at Melbourne on August 13.

so much the better ; for so much the more readily will it be conceded that a nation's progress is dependent on its *understanding* of Nature's laws. This is science ; and so much more readily will Australia realise that science is as essential as statesmanship and man-power if she is to achieve greatness.

Science, of course, is too vast a study for any but those who give their lives to it to make much headway, and even these rarely can specialise in more than one of its many branches. Nature, it is true, is one and indivisible, but her work is infinite. The more we learn of her the more we realise her unity, but the more we are forced for our own sakes to subdivide and classify science. The most learned in any branch are at best but amateurs in any other. A nation, therefore, needing science, must make liberal provision for the highest training in all its branches, and must, moreover, see to it that the resulting skill and knowledge are fully utilised for the public good.

Nature being infinite, it stands to reason that what man already knows of her—the science of to-day—is but a fraction of what man may come to know—the science of the future. Yet this small fraction is in itself stupendous. In modern times, since man learnt how best to seek new knowledge, all the great nations of the earth have contributed, and as science grew its rate of growth became accelerated. Now not a day passes without additions to every branch. Scientific education, then, must be equipped to deal adequately with all this accumulated mass of knowledge ; but the universities, if equipped to do no more, will fail in their task of training competent men of science to serve their country's needs, and that country will fail in its duty to the world—the duty of contributing by research to the growth of natural knowledge. The science of to-day cannot be divorced from the science of to-morrow ; the power to make new knowledge is both the final test and the reward of a scientific education.

The familiar distinction between “pure research” and “applied research” is justified in this—that, while there is no real difference in the methods employed and one may require as much skill and knowledge as the other, the aims from first to last are essentially different. The aim of any pure research is nothing more nor less than to add something new to natural knowledge in a chosen field. The investigator's reward is the joy of discovery. The aim of any applied research is to solve a particular problem, the successful solution of which promises results of direct utility to man and is therefore of marketable value. It may be that the investigator himself does not reap this tangible reward ; it may even be that he is content to let it go to others ; but in any case his task is that of the treasure-seeker. If he find that the expected treasure does not lie where he hoped to find it, he may follow up any other likely clue to its whereabouts, but may not turn aside tempted by mere glimpses of an unknown land. It is true that exploration there might possibly lead to valuable discoveries, but that is mere conjecture : his immediate task is to unearth the treasure he went out to seek.

Such definitely utilitarian research should require but little advocacy, for it should appeal strongly, even to the unscientific. Any one can understand something of the valuable results that would follow from the

discovery of a new and successful treatment of a disease rife among men or flocks and herds, of a method of eradicating a vegetable pest or a parasite destructive of cultivated crops, of an improved process of ore treatment or of metallurgical work, or of the utilisation of some waste product of a manufacture. But not everybody can realise that all such discoveries have their foundation in pure research, that the successful quest of the obviously useful is merely the last stage of an intricate series of scientific investigations, to which many workers have contributed—mostly working with the sole object of adding something to natural knowledge. Those acquainted with the history of scientific discovery and invention know that this is true. They know, moreover, that no genuine new knowledge can properly be stigmatised as useless or “merely academic,” however remote from utility it may at first appear ; for, sooner or later, it will be found as an essential link in the chain of truths that leads to a valuable conclusion.

When, in 1895, Sir William Ramsay separated small quantities of a gas from the rare mineral cleveite and identified its spectrum with that of Lockyer and Frankland's constituent of the sun's atmosphere, helium, the discovery was full of academic interest but certainly did not promise to be useful. On the purely scientific side the expectations have been far more than realised, for this helium element, since its discovery in terrestrial matter, has been linked up with all that earlier and later knowledge that has culminated in the proof of the electrical constitution of material atoms, or the fundamental identity of matter and electricity—probably the most far-reaching scientific advance within our memory. But, on the utilitarian side, what could offer less promise of practical application than a gaseous element, not only scarce and costly but also absolutely inert and incapable of forming chemical compounds ? Yet it was this very inactivity that soon found for it an important use and market value. For, next to hydrogen, helium is by far the lightest of all gases ; and, being inert and therefore totally combustible, it is a safe gas with which to inflate balloons and airships, while hydrogen emphatically is not. The scarcity of supply was overcome when research showed it to be present in small proportions in several natural gas springs in America, and methods were devised for separating it from its companion gases in a pure state. In parenthesis it may be said that the solution of this problem of its separation, were we to follow it out in detail, would itself be seen to have been rendered possible by a chain of earlier pure researches on the physics of the gaseous state. When war ended in 1918, large quantities of pure helium, compressed in drums, were ready in America for shipment to Europe, to be used in war balloons and air-ships. This was but twenty-three years after Ramsay's “academic” discovery of the apparently useless element in terrestrial minerals and half a century after the first observation of it as a line in the spectrum of the sun's chromosphere. The armistice came too soon for it to play its destined part in war ; but the ideal inflater of lighter-than-air vessels still meets a want in times of peace, and helium is now being prepared and stored in quantity in the United States, where I understand the use of any other gas for this purpose is prohibited by law.

Such examples of the complete dependence of practical science on pure research, and of the utter falseness of the idea that any genuine contribution to natural knowledge can be inherently and permanently devoid of utility, could be multiplied indefinitely. Any nation, therefore, which aims at progress must for its own sake foster to the utmost of its ability scientific education and both pure and applied research. If further reason and, perhaps, a higher reason be wanted, no civilised nation stands alone: each owes a duty to the others to do its share in the work that is essential for the world's intellectual and material—aye, and moral—progress—the making of new knowledge of Nature's eternal truths. Nothing but extreme poverty or youthful irresponsibility could excuse a nation which, shirking this sacred duty, elected selfishly to profit only by foreign-made science; and nothing is more certain than that it would profit not at all, for it would fail through sheer inability to understand.

That, of course, is far from being the case with Australia. Young though our nation is, it is not so very poor and it certainly is not irresponsible. To make progress for itself and for the world is Australia's just ambition, and it has done much already to prove that it does partly recognise the importance and the power of science. Each State has its University, and each University seeks, within its somewhat narrow means, to excel on its science side. We have our Royal Societies and others of more specialised type, our more popular Australasian Association for the Advancement of Science, and, of more recent birth but, we hope, with a great future before it, the Australian National Research Council, with important international connexions. Each State Government maintains its own scientific activities, particularly in connexion with agriculture and mining. The Government of the Commonwealth does much for public health and for meteorology; and quite recently it has undertaken to build, equip, and maintain a Solar Physics Observatory—a very important contribution to international research. Our Governments, indeed, both Federal and State, have given many proofs that they appreciate the value of international co-operation in scientific work. But democratic governments can never go very far ahead of public opinion; and our Australian people have given no sign as yet of a general understanding of what science can do for them or of an urgent desire to put it to the test.

Here, as elsewhere, there was some war-time awakening to the potency of applied research. It resulted, in 1915, in the adoption by the Commonwealth Government of an ambitious scheme for the formation of an Institute of Science and Industry, with a statutory constitution and with ample means for carrying out investigations over the wide field of Australia's primary and secondary industries. Pending the passing of the necessary Act of Parliament, the scheme was nursed for some four years by a body of voluntary workers, who tried to make up in enthusiasm what they lacked in financial means to success. That Institute now has its statutory constitution, its powers, its director and its office staff, but it has never yet been given the promised means to build the laboratories or appoint the skilled investigators essential to its proper work.

War-time awakening was but temporary. It happens that I have a personal knowledge of the history of that adventure and of the difficulties put in its way by unlooked-for opposition and growing indifference in Parliament and elsewhere. That experience has convinced me that the Australian public is still largely blind to its own interests and its duty. Time and education will bring improvement. All that has yet been done is but a beginning, holding out hope of greater achievement in the future. For real progress, Australia needs a great deal more science, even as she needs more men and women.

Let me cite briefly a few of those typical scientific problems of a practical kind which have interested the Commonwealth Institute. Few of them are peculiar to Australia. Most have their counterpart in other countries, and there is none in which we cannot benefit from the experience of one or more of the countries in the Pacific area.

The settlement of people on the land, the spread of pastoral industry and of agriculture, are seriously hampered by the aggressive character of many vegetable pests of foreign origin. One of these, the prickly pear, is estimated to be now in occupation of some 24 million acres of Australian soil, mainly in Queensland, and to be spreading at the rate of one million acres a year. Australia, indeed, owns a much larger area under prickly pear than its total area under cultivation; and there are parts of Queensland so densely covered with this pest that surveys wanted for a railway extension scheme could not be carried through it. Destruction by mechanical means or by poisons has been found too costly for general use; but the biological method of attack holds out more hope. This is based on the fact that the prickly pear, as well as other pests, has been introduced without those natural enemies, insect or fungoid, which keep it in check in its native haunts. By importing them we might eventually re-establish the balance of Nature. Obviously, no such action can be taken without proof that it is free from risk to crops or pasture; and this means prolonged research by experts. Some definite progress has already been made in this direction, but much more work is wanted.

The cattle industry is beset by many ailments, which in the aggregate cost Australia millions of pounds per annum. The cattle tick, with the related tick-fever, is responsible for untold damage, direct and indirect. Similarly, in sheep country the blow-fly pest causes enormous loss, especially in some seasons. All these and many other ills are, or should be, curable; and real success with any one of them would recoup Australia for all it is likely to spend on science; but nothing can be hoped for without extensive and systematically organised research.

In quite another field large progress has already been made, which, however, should but serve as a stimulus to further work. I refer to the increase of our harvests and the extension of the area available for cultivation by the selection and breeding of new varieties of plants better adapted to local conditions. Agricultural experts tell us that an increase of one bushel per acre in the average yield of wheat would represent a gain of 2,200,000*l.*, while any considerable extension of the wheat belt in average breadth by

the introduction of more drought-resistant varieties would enormously increase the nation's wealth.

Our forests, so uniquely Australian, offer problems which cry loudly for systematic scientific work, far too little attention having been paid to some of them in the past. The admirable pioneer labours of von Mueller and of Baker and Smith have opened up an almost limitless field in the investigation of the characters and the chemistry of our forest trees. Closely related is the practical problem of the development of forest-product industries. Those who have to do with the timber industry know how much remains to be done in the systematic study of the character of the timbers, their exact classification, and the methods of seasoning and of preservation. All this is apart from, though related to, the problem of forestry proper; that is, the development of a complete organisation, scientifically controlled, for the care and upkeep of the forests, which—though wantonly destroyed in the past—may still be one of the nation's great assets.

The thorough investigation of Australian clays, with the view of the development of a ceramic industry employing native material, is another example of what may be done by applied science in the future; and here again some noted advance has already been made by the Commonwealth Institute, though it has been compelled to restrict its field of work.

There are tasks ahead, however, of perhaps more fundamental importance than any of these in connexion with the development of our country's resources and the settlement of population—tasks, moreover, called for by our obligation to contribute in our own area to man's knowledge of the earth on which he lives. I refer to the need of much more extensive, detailed, and systematically organised topographical and geological surveys than any as yet provided for. Such work would seem to require a definite scheme of co-operation between the Federal and State Governments and the institution of permanent scientific services.

In Papua and still more in the Mandate Territory of New Guinea there is urgent need for systematic scientific work, both for utilitarian reasons and because the unknown, wherever it exists, cries loudly for intelligent investigation. There are not many parts of this earth's surface that remain to-day so unexplored as does much of the interior of New Guinea, or which hold out so much promise of reward to the topographer, the geologist, the chemist, the botanist, the zoologist, and the anthropologist. The services of all these are needed as regular adjuncts to the civil administration. The work should not be left to the casual efforts of individual enthusiasts or of occasional scientific expedi-

tions, often privately financed and undertaken more in the spirit of adventure than of true research. It needs highly trained men and systematic organisation. Most pressing of all is the need of skilled ethnological work—the study of the natives, their beliefs, thoughts, languages, customs, and mode of life, while yet it is possible; for it can be but a little while before they become sophisticated—I had almost said degraded—by contact with white man.

Australia has voluntarily undertaken a difficult task and a great responsibility in New Guinea and the adjacent islands. Its position there is that of a public trustee. Surely its most urgent duty is to make full provision for the scientific study of the land itself, its inhabitants and all that it contains. How else can it hope to succeed? How else to discharge its obligation fully to mankind? Pioneering work has been done in the past by specialists, some of them leaders of the highest repute; but the time has surely come for systematic, co-operative, and government-supported effort.

There is, then, reason to hope that the public demand for science in Australia will grow—that it has a great future before it. In building up that future on the foundations already laid, the Australian people must look for guidance and example to the greater and older nations of the earth. In this, as in all things, we turn first to that Mother Country which we still call Home. There the Royal Society, pioneer among national academies of science, has taught and practised the true gospel of the pursuit of natural knowledge for 260 years, and many younger research associations have gained world-wide repute. There also the cause of applied science has gained steadily in recent times, and is now represented by a powerful Department of Scientific and Industrial Research and by such highly endowed institutions as the National Physical Laboratory. We look also to America, where the organisation and endowment of scientific work are now on a scale that arouses universal admiration, not unmixed with envy. There Federal and State authorities, great manufacturing firms and wealthy citizens, seem to vie with one another in promoting education and research, knowing that thus the greatness of their country will be yet increased. We look to Japan—that wonderland which, in so short a span of years, has made for itself in science, as in all ways, an honoured place among the great nations. We look to Holland, ancient centre of learning and of maritime discovery, famous in the history of the Pacific, and to its splendid colonies in our tropic seas; for both Motherland and colonies are known throughout the world for what they have done and are doing for science.

Science and the Agricultural Crisis.¹

By Dr. CHARLES CROWTHER.

IT is generally recognised that the primary causes of the present difficulties of British agriculture are strictly economic in character, and not due to any gross and general failure to apply present-day scientific knowledge to the technique of farming, although the

great disparity which exists between the average production of the country and that secured by the more competent farmers on soils of the most diverse natural fertility suggests that with a higher general level of technique and education the intensity of the crisis might have been sensibly reduced. Whether it be a case of the "sick devil" or not, the agricultural com-

¹ From the presidential address delivered to Section M (Agriculture) of the British Association at Liverpool on September 13.