level. The reason why no one has succeeded until now in inducing these reactions to take place is because no one has hitherto been able to supply the large energy increment necessary.

I believe that we find in this the key which unlocks the door of vital chemistry, and that the chemistry of all life is one of high energy, our laboratory experience being confined to the chemistry of low energy. From this viewpoint I see a wondrous vista unfold itself, wherein new understanding, new hopes, and new possibilities reveal themselves. Health and vitality must essentially depend on the high energy level being maintained; any lowering of that level will lead to poor health and weak vitality. Knowledge comes to us of the means whereby the high level may be kept unimpaired. The most important sources from which we can absorb high energy are fresh food and ultra-violet light. From one we learn the necessity of the rapid distribution of our food supply before its high energy is lost;

from the other we gain a real understanding of the benefits of ultra-violet light therapy, and, more important still, of the dangers of its misuse. We gain an insight into the chemistry of vitamins, which in the light of our new knowledge reveal themselves as stores of high energy, which yield their energy to restore and maintain the vitality of decadent tissues.

A vision thus comes to us of a new chemistry with limits far flung beyond those which constrain our knowledge of to-day, a chemistry which will embrace and co-ordinate not only the properties of inanimate matter upon this earth, not only the wondrous mechanism of the life of man in health and in disease, but in addition the stupendous marvels of the birth and growth of the worlds outside our own. From those who would decry this as a mere speculation I beg forgiveness, and plead that speculation based on sure experimental fact is the life-blood of true scientific research.

Industry and Research.¹

By Sir RICHARD THRELFALL, G.B.E., F.R.S.

ONE of the things that strikes a chemist or physicist when approaching the biological sciences is the narrow range of temperature within which alone the phenomena of life occur. A chemist's attention might also be directed to the fact that his medical adviser has to carry a thermometer graduated to fifths of a Fahrenheit degree, with a range of, say, fifteen or ten degrees, in order to investigate the state of health of his patients, whether he practises in Greenland or Ceylon, and only requires one thermometer wherever he is. Human beings can and do exist over a range of, external temperature of more than one hundred Fahrenheit degrees, that is to say, over a range of, say, one hundred times the roughly permissible body temperature variation. How is this possible? It is only possible because man himself has invented means of narrowing the range so as to get within the limits of his own temperature regulation; in other words, he has invented fire, clothing, and housing. Moreover, human beings require food, and they can find it in some form, directly or indirectly, wherever the sun shines on earth and moisture, but not always in a form in which they can assimilate it, so that in effect the supply is limited and competition for it ensues. This has most probably led to human creatures occupying areas where food is available, though climatic conditions are very unfavourable.

It is at least a plausible view that man's struggle with Nature is due to his being driven or tempted to follow the food supply, and by intelligence leading to invention, has devised means of overcoming climatic difficulties, particularly in the supply of heat to his body and its conservation therein. The aspect of the matter which interests us now is the supply of heat by oxidation of carbon

and hydrogen in the neighbourhood of the body—not within it—together with the supply of light by which mankind's working life is increased.

Inventions such as the use of fire were made before records were kept, but we have copious records of later inventions, and very likely the earlier ones came about in a fundamentally similar way, as assumed and put forward by Charles Lamb in his "Dissertation upon Roast Pig." First comes the chance observation by an individual gifted enough to seek for its implications; then the endeavour to reproduce the phenomena by copying the original apparatus; then the attempt to distinguish essential from unessential parts of the process leading to a working theory; and finally, the improvement and simplification of the operation under guidance of the theory, which itself is subject to continual extension and improvement. These remarks apply to a fundamental invention, not to productions of improvements which rest on the successive observations and thought of many individuals. I cannot think of any discovery made in my time that does not rest to a greater or less extent on previous work.

Both academic and technical progress has been made throughout the ages, and indeed until within the last twenty years or so, by the efforts of individuals who were usually engaged in, and were paid for, quite other matters than the making of discoveries. Indeed, I remember the time—not so very long ago—when research was looked upon by the majority of quite educated people as a sort of hobby to be indulged in by those whose means permitted them sufficient leisure. So far as I know, the Royal Institution was one of the first places where physical and chemical research was looked upon as the primary duty of the professor, though, of course, the endowment of learning, that is, the careful investigation of what much earlier people had written or said, is a very old idea.

¹ From an address delivered on the occasion of the opening of the new research laboratories of the Gas Light and Coke Co., Fulham, London, on July 26.

Looking back over the history of civilisation, it seems amazing that so much thought and time should have been spent over the study of the opinions of people whose sources of information were so meagre however acute their intellects may have been, while the whole vast subject of the study of the phenomena of the habitable world was left severely alone. No doubt an explanation can be thought of, but the history serves as a warning of how difficult it is to overthrow a false standard of intellectual activity after it has once become established, and particularly after it has attained the dignity of being a 'vested interest.'

Let us turn to the history of our own art, that of carbonising coal. Passing over previous limited attempts, I direct attention to the fact that Boulton and Watt's factory near Birmingham was illuminated by gas—presumably as a demonstration—by Murdoch at the celebration for the Peace of Amiens in 1802. In Thorpe's "Dictionary of Applied Chemistry," 117 years later, Dr. Harold G. Colman, a recognised authority, writes as follows: "Up to within the last few years the method of manufacture of coal gas has remained in its general principles almost identical with that employed by Murdoch and his immediate successors (prominent among the latter being Samuel Clegg, senior, and his son, Samuel Clegg, junior), although in detail and in the magnitude of the operations great change has taken place."

Whatever the reason may be, the fact remains that during the prosperous days of the nineteenth century the gas industry, like many others, did not devote much time or money to 'work for the future,' the term by which a chairman of the old Edison Co. in U.S.A. denoted research. Meanwhile—I need not repeat the well-worn tale—Germany had fought its way into competing with England's foreign trade by proceeding in what they would call a 'rational' manner, alike financially, commercially, and technically, and especially by 'working for the future' they improved the present in all directions. During the War, this process, long appreciated by the few, penetrated even into political circles, and there was some searching of heart as to why industry in Great Britain had not also 'worked for the future.' In view of the fact that several millions a day were being spent on the War, those in authority decided that some moderate sum might be spent in an endeavour to put the position of research in scientific, and particularly technical, matters on a better basis. After a time, during which the ground was surveyed, the policy settled down to creating institutions devoted to the study of matters supposed to be beyond the scope of individual effort, and encouraging the members of various industries to combine for research purposes, a sum of one million pounds being devoted to the assistance of the latter. The new venture, born in the Education Department, was placed under the Lord President of the Council for administrative purposes, with Sir William McCormick as executive chairman and Sir Frank Heath as secretary, and an advisory council of scientific men and industrialists.

As one who has had a continuous but small part in its development, I may say that, subject to the strict but sympathetic attitude of the Treasury, its own frugality, and the interest shown in it by successive Lord Presidents, whatsoever success the Department may have attained has been mainly due to the wisdom and work of the chairman and secretary.

The activities of the Department of Scientific and Industrial Research are, of course, adequately described in the annual reports, but there are one or two points to which I might refer. In the first place, the guiding principle has always been rather to induce the industries to do things for themselves than to attempt to do scientific work for them. The idea was that if only those who conduct manufacturing operations could be brought to value doing work for the future by investigation, they would willingly continue such work without external pressure. The difficulty would lie in creating initially a receptive state of mind, a difficulty so great that it could only be overcome by actual demonstration. From this it was hoped there would arise in time such a body of enlightened opinion that nobody would dream of conducting a manufacture without the assistance of systematic research. There is scarcely any industrial operation, perhaps no such operation at all, which would not benefit if it were systematically investigated. For example, to take the gas industry, which has been in existence now for something like a century and a quarter, one of the surprises of my life was to find that it was the opinion of the leaders of the technical side of the industry that research was required into the working of ordinary horizontal gas retorts, and I noticed some two years ago that the chairman of Imperial Chemical Industries stated in his annual address that research was still needed in relation to the ammonia-soda process.

Another matter which was forced upon the Department's attention at a very early date was the difficulty of finding properly equipped young men to carry on the investigations it was proposed to set going. It always used to be said that the rapid progress made in the dye industry in Germany was largely due to the fact that their system of education produced many more young men capable of scientific employment than were available in England. Very likely there is some truth in this. At all events, when the Department began to seek for workers, it was faced with a very great difficulty in finding them. Accordingly, and with the consent of the Board of Education, a system was instituted by which promising young graduates were assisted to continue their training for two or three years, during which time they underwent a sort of apprenticeship in research work under their own teachers. Great care was exercised both in the selection of the candidates and in watching their careers, as much as £50,000 a year being spent on this activity at one time. The results, I may say, have on the whole been entirely satisfactory, but I have always felt that the pursuit of science, either pure or applied, could not become a reason-

able profession until a sufficient number of reasonably good openings was assured.

In the course of my life, particularly as a fisherman, I have noticed what great observational powers are possessed by many people who would not describe themselves as in the least scientific, and I have gradually come to the conclusion that there is plenty of raw material among the young men and women of Great Britain, which only needs reasonable encouragement to form the personnel of a large research army. In short, parents must be assured that science as a profession is worth following from the financial point of view before their sons and daughters will be allowed to embrace a scientific career.

In establishing new laboratories there are two things to be considered—equipment and personnel. Of these, incomparably the more important is personnel, for the best equipment differs from the worst only in saving time for those who are using it. During recent visits to America I have taken the opportunity of conferring with the heads of many large industrial laboratories in that country, with the view of ascertaining the lines on which such laboratories are best conducted. I may say that I had very decided views of my own on the subject after spending something over half a century as a laboratory worker, and I was pleased to find that these views were entirely corroborated. In a word, it amounts to this, that everything turns on the

personality of those at the head of the laboratory; that is to say, it depends on qualities with which the chief was endowed by Nature and not upon the knowledge he may have acquired. Of these qualities, enthusiasm for the work is the most important. Service should be looked at before remuneration. There should be personal contact between the director and the worker, and I personally, if forced to choose, would select an enthusiastic director rather than a distinguished exponent of the science he professes.

I have heard a good deal about team work of late years, but I have never understood exactly in detail what this term is held to mean. Of course, a large number of people may be employed to study different aspects of any particular phenomenon. Does team work mean that they are to exchange their ideas freely?—if so, it can do nothing but good. On the other hand, does it mean that workers are expected to conceal their identity in the presentation of results?—if so, I think that one great incentive to every worker is withdrawn. I propose as a more effective alternative to the elimination of the man whose attitude is, "I said it first," that all workers should make it a point of honour, and I speak to senior workers more particularly, to make a habit of giving, if anything, more credit rather than less to those who work under or with them, for any advance that may be made by their conjoint efforts.

Obituary.

PROF. S. S. NEUSTRUEV.

IN the sudden and unexpected death of Prof. S. S. Neustruev, of the University of Leningrad, on May 24, whilst on an expedition to Kirgizia, soil science has suffered another severe loss. Neustruev, like Glinka, who predeceased him by only a few months, was one of the greatest representatives of the school of Dokuchaiev, a school which is responsible for most of the modern views on soil genesis and classification.

Neustruev was born in Murom in 1874, and graduated in the physico-mathematical department of the University of Moscow in 1898. He was then appointed to the staff of the soil department of the Zemstvo in Samara, where he worked until 1906, and whilst there he published several papers dealing with the soils of Samara, particularly from the geological point of view.

During 1906 and 1907, Neustruev was investigating questions of soil structure, and from 1908 to 1914 he was a member of the botanical and soil expeditions sent by the Emigration Department and the Dokuchaiev Committee to Turkestan. His time spent in Turkestan was very fruitful, and he published numerous monographs and articles. For his first report he received an award from the Royal Geographical Society.

From 1915 to 1918, Neustruev was the leader of the Orenburg soil expedition of the Dokuchaiev Committee, and then for some time worked in western Siberia. In 1922 he became secretary of the Dokuchaiev Soil Committee and editor of its

Bulletin. Under his supervision classes in geography were started, which later developed into the geographical faculty of the University of Leningrad. In recent years he led two important expeditions for the Academy of Sciences to Kasakstan and Bashkiria. In 1924–25 he took part in a detailed soil geological survey of the neighbourhood of Leningrad, and in 1924 he also conducted investigations in the northern Caucasus.

Neustruev was one of the Russian delegates to the International Congress of Soil Science in Washington in 1927, and those who took part in the excursion across America will never forget his unfailing courtesy and the painstaking care with which he explained the Russian views on the field study of soils. At this Congress he was chosen to edit the International Soil Map of Asia.

In April 1928 he was elected chairman of the Leningrad organising committee and vice-president of the general committee for the second International Soil Congress which is to be held in Russia in 1930, and of which he was to be chairman of the committee on the genesis and classification of soils.

Neustruev was a man of high culture, an accomplished linguist, and altogether a most attractive personality. He has left a scientific legacy of about 100 publications. Many of these deal particularly with south-eastern Russia and Turkestan, but he has also left a number of papers of more general interest, such as his essay on the "Classification of the Processes of Soil Formation"