who have produced sound workman-like diagrams, labour quite needlessly to improve them and attain some incredible standard of excellence in the finished work. It is all to little purpose, for the time would generally be much more profitably spent in sketching more specimens or in doing some reading or, perhaps, in relaxation from work altogether! After all, the notebooks are *laboratory* notebooks. They should contain neat and accurate impressions of practical work with the essential minimum of labelling—they are not meant to be finished artistic productions and time spent in an endeavour to make them so is being wasted.

Failure to make the best use of their practical work shows up in many candidates' answers over all grades. In 1933 many Intermediate candidates were quite unable to draw a reasonably accurate Liliaceous stamen or pistil. At the other end of the scale, many honours candidates who, making really beautiful drawings of the Tristanea shoot supplied, omitted to interpret the morphological features that were shown by their drawings with the accuray and diagrammatic effect of a first-class textmook figure.

The above are general comments. Detailed comments on the examination papers and suggestions for interpretation of the syllabus have been given for some years past in the examiners' reports.—T.G.B.O.

NOTES ON THE LIFE OF A GREAT AUSTRALIAN SCIENTIST.

THE following article is contributed by Professor L. A. Cotton, M.A., D.Sc., and by Assistant Professor W. R. Browne, D.Sc. It represents an outline of the scientific life of that great scientist and gentleman, Professor Sir T. W. Edgeworth David, K.B.E., C.M.G., F.R.S., M.A., D.Sc., who died in Sydney on August 28. It is the summary of a brief address to the Royal Society of New South Wales, given by those two of his colleagues, at the first general monthly meeting of the Society held after his death; and is, as the title shows, but a collection of notes on a few aspects of the life of an eminent scientist who has inspired and will continue to inspire many younger men.

Professor Cotton said:

When, on the invitation of the Council of this Society Professor Browne and I agreed to say a few words this evening about the scientific work of the late Professor Sir Edgeworth David, we decided that I should deal with the pre-war period and Professor Browne with the later years.

It was not the intention of your Council that these talks should cover the whole of Professor David's activities, for that obviously could not be done in such time as is available. You will understand, therefore, that any biographical references must be brief.

Nevertheless, no clear vision of Professor David's scientific work can be gained without an understanding of the man himself. As the son of a clergyman, he was nurtured in the atmosphere of the church, and these early influences determined his whole outlook on life, which was that of service. He gave everything he possessed, talents, time, unstinted effort and those lesser gifts of material things, to his fellow men, always himself feeling that he was a privileged person when his help was accepted. With a woman's tenderness, insight and sympathy, he combined the strength, courage and resolution of the heroes of all the ages.

His life's work was the search of truth—in particular truth as revealed in the records of the rocks. To this work he brought to bear extraordinary qualities of intellect, among which was an astonishing memory. His studies became part of himself, and after the lapse of many years he still retained the most detailed particulars of his early observations, and those of others. His enthusiasm kindled that of his students, and from his earliest days as Professor of Geology at the University of Sydney he attracted to his school bands of young men and women eager to follow him wherever he might lead.

At the age of twenty-seven he married her to whom our sympathies now go out for her recent bereavement. More than once Professor David has publicly acknowledged how much his work owed to the inspiration and help of his wife, and many of us here to-night know how true that was to the last.

The chief aspects of Professor David's work upon which I shall speak to-night may be considered under three heads. The first is his work as an officer of the

Geological Survey of this State, the second relates to his great work on the study of coral reefs, and the third to his researches in the Antarctic region.

After graduating with distinction in classics at Oxford, where he had also studied some geology, he took up further studies with Professor Judd at the Royal School of Mines in London. After completing this course he was appointed in 1882 to the Geological Survey of New South Wales. His first great piece of work in this position was the study of the tin-deposits of the New England District, and the results of this work were published in a large memoir in 1887. As one who has since worked for about two years in this district, I can pay a tribute to the great value of Professor David's memoir in guiding the subsequent mining operations of this field, from which more than ten million pounds' worth of tin have been won.

Shortly after completing his work in New England Professor David began his great survey on the Hunter River District.

The coastal areas about Newcastle provided him with the materials for working out the history of the coal measures in the lower part of the Hunter Valley, but to the west of Maitland the work was both difficult and arduous, for in those days, nearly half a century ago, there were but few excavations to show the nature and structure of the rocks.

Eventually he found the key to the structure of this district in a stratum known as the Muree Rock, and on making a map of this, he was able subsequently to trace out the whole succession of strata in the field. Amongst these was the Greta Coal seam, which has for many years yielded the best steam coal in Australia. Although this was concealed beneath the surface, in places to depths of more than a thousand feet, he was able to predict where it could be found, and the whole development of this coal has been guided by his great work. It is difficult to obtain an estimate of the value of the coal won from this field, but it certainly must exceed £50,000,000.

Out of this work on the study of the coal measures many problems of purely scientific interest arose, which were followed up by Professor David in later years. These will be mentioned later.

In the year 1891, Professor David was appointed to the Chair of Geology at the University of Sydney and here he found great scope for his talents as a teacher. Even in the early years of his teaching, when the number of students was small, he quickly gathered about him an enthusiastic band of young men who have since attained distinction as geologists: Mr. E. C. Andrews, Dr. W. G. Woolnough and Dr. L. K. Ward were among these. Later came Sir Douglas Mawson and Professor Griffith Taylor.

In the year 1897 Professor David was asked to assist in organising a second expedition to the coral islands of Funafuti. The first expedition had taken place a year before, but had been unsuccessful. After much difficulty the necessary funds were raised, and the second expedition set out under the command of Professor David. The object of the expedition was to sink a bore through the coral rock to a depth of about 600 feet, in order to test the theory of Darwin that coral reefs were built about, or upon, islands which were slowly sinking beneath the ocean.

In carrying out the work extraordinary and unforeseen difficulties were encountered, and nothing but the greatest determination and unceasing effort on the part of Professor David brought it to a successful conclusion. The bore had reached a depth of 698 feet when operations ceased.

A year later Professor David organised a third expedition under the leadership of Mr. A. E. Finkh, who succeeded in deepening Professor David's bore to 1,114 feet. At the same time two bores were put down in the lagoon under the supervision of Mr. G. H. Halligan, the deeper of these being 144 feet.

When the results of the expedition were forwarded to the Royal Society of London, which had supported the work, Professor David was made a Fellow of the Royal Society in recognition of its great importance.

In the years which followed his completion of his Funafuti work, Professor David resumed his researches on the geology of the Hunter River area. He had discovered during the course of his work the relics of an ancient Ice Age during which glaciers moved northwards over this district. This study of glacial geology was perhaps his greatest interest throughout life. He had first become interested in these problems while an undergraduate at Oxford, and it was a great joy to him to find later such relics of ancient glaciers in the Hunter River District.

It was while he was actively engaged in this work that the First Shackleton Expedition to the Antarctic set out from England. Upon its arrival in Australia Shackleton invited Professor David to visit the Antarctic for the summer. He also, upon Professor David's recommendation, agreed to take Sir Douglas Mawson and myself. As the vessel was overcrowded upon leaving England the addition of three more passengers raised great problems in the matter of accommodation in a ship of about two hundred and fifty tons burden.

Within a fortnight of sailing from Lyttelton on the first of January, 1908, Shackleton had made up his mind that at all costs he must have Professor David with him throughout the expedition. The Professor consented to remain, and as Mawson had, before leaving Australia, contracted to spend the winter in the Antarctic, the expedition was singularly well equipped for geological work. During the passage south fierce gales were encountered, and the *Nimrod* survived many perilous situations before being brought safely to anchor at Cape Royds. Here Shackleton made his base and laid his plans for polar exploration.

Before the winter set in an expedition under the leadership of Professor David was organised for the ascent of Mt. Erebus. This was successful in the face of great dangers and hardships.

After the long winter had passed, active preparations were made for the conquest of the two poles. These were the South Geographical Pole, which was Shackleton's own objective, and the South Magnetic Pole, for which Shackleton selected Professor David, Mawson and Dr. Mackay.

As all the effective means of transport, including motor-sledges, ponies, and dogs, were required for the South Pole venture, the Magnetic Pole party had to rely solely upon man power.

On the 5th October, 1908, the David party set out for the South Magnetic Pole.

The party set out with two sledges and a load of more than half a ton. As it was not possible for one man to drag a sledge, a great part of the journey had to be made in relays. This method had to be used until the Drygalski Glacier was reached and crossed.

The whole journey was one of extraordinary hardship and danger, and on numerous occasions the whole party nearly succumbed. The first part of the route was over the sea ice along the western shores of the Ross Sea. Long before the Drygalski Glacier was reached the screw pack ice was encountered and its jagged surface made the sledging heart-breaking work. Worse still was the risk of the ice becoming broken up by a blizzard, in which case the party would have drifted northward until the ice melted. This danger became greater as the summer advanced, and as the party moved northward. Even when the Drygalski Glacier was reached and this dread lifted, new dangers and difficulties arose. The great glacier had to be crossed, and it was found to be heavily crevassed. Although only twenty miles wide, it took a fortnight of precious time to cross this barrier. Now the party had to leave the sea and turn inland seeking the Magnetic Pole. The time was now all too short for this enterprise. A depôt was made of one sledge, to which a black flag was hoisted to attract the notice of the *Nimrod* when she should search for them six weeks later. Meanwhile 520 miles had to be travelled to and from the Pole, and this, too, on restricted rations. The sufferings of the party on this journey are well known. When nearing the Magnetic Pole it was discovered that the pole had wandered, and was farther off than had been reckoned. The last dash for twenty-four hours to the pole, leaving the sledge behind, risking a blizzard that would have ended all, shows the determination of that great leader of the party. The return journey, with provisions running short, delays through a blizzard, and a miraculous rescue crowned this great achievement.

After his return from the Antarctic in 1909 Professor David was for some years engaged in the task of working up the geological observations made on the Shackleton Expedition, and also in his Hunter River glacial studies.

In the year 1914 the British Association for the Advancement of Science held its meeting by invitation in Australia. Many distinguished geologists were among the visitors, including Professor Coleman, a world authority upon Ice Ages of the past.

A geological excursion led by Professor David was made to the Hunter River District for the purpose of examining the glacial evidence of that area. There was, however, missing up to that time, a very important piece of evidence which would have crowned the whole of Professor David's researches. It was therefore a dramatic movement when the Professor himself made this discovery in the company of the overseas geologists present.

Then, without warning, in the middle of the deliberations of this scientific congress, came the declaration of war on 4th August, 1914.

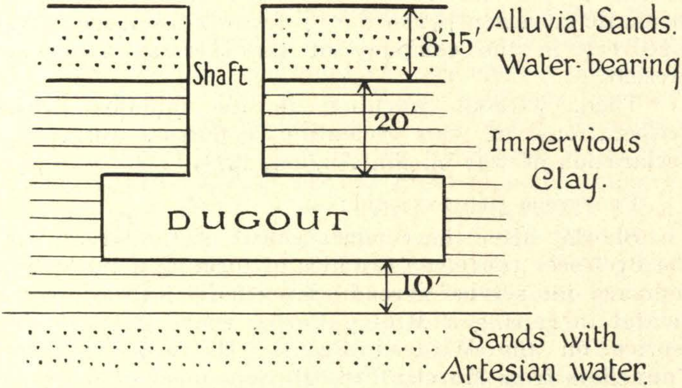
PROFESSOR BROWNE said:

Shortly after the commencement of the Great War the Professor conceived the idea of forming a tunnelling company for service abroad. Eventually he was instrumental in raising a Mining Corps, which did valuable service on the Western Front. He was with the Tunnellers from March, 1916, till September of the same year, when he met with a severe accident, falling some 70 feet down a shaft through the failure of a windlass. As he himself whimsically described his experience in a letter: "I suddenly realised that I was finding the value of g for that particular part of Europe." Providentially he was not killed, but there is little doubt that the injuries he received eventually hastened his end. After his recovery he was transferred to G.H.Q. to the office of the Inspector of Mines.

The work of geologists in the Great War was of a great many different kinds. There was, of course, the problem of water-supply, and there were the finding of rock-materials for roads and concrete, and the selection of sites for bridges and trenches, and, perhaps most important of all, for dugouts and mine-galleries. It was necessary, of course, that these should be dry, and the determination of suitable positions involved intensive study of the sedimentary strata, and much trial-boring to determine thicknesses of dry and water-bearing formations. Sometimes an impervious clay bed of sufficient thickness was utilised for excavations, even though it was overlain and underlain by porous water-bearing sands, as illustrated (Fig. I). The artesian water in the lower strata was under great pressure, and a sufficiency of cover beneath the floor of the dugout had to be left.

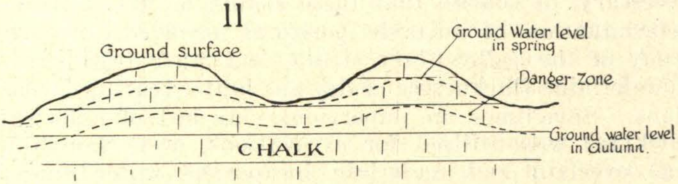
Again, in the chalk country the study of the seasonal water-table fluctuations was of vital importance. Above the surface, in the chalk, of the underground water

I



horizon, excavations could be made with safety, but any hole made beneath that level was immediately filled with water (Fig. II). It was desirable that all dugouts and mine-galleries should be as low as possible in the dry layer, but it was found necessary also to allow for the fact that owing to seasonal variation in rainfall and evaporation the level of the water-table reached a maximum height in spring and fell to a minimum late in autumn. A careful examination of records enabled the geologists to predict accurately the height to which the water would rise in the chalk, and much useless work was in this way avoided. On one occasion when galleries were being driven under a hill in connexion with dugouts for headquarters staff it was found that one tunnel

II

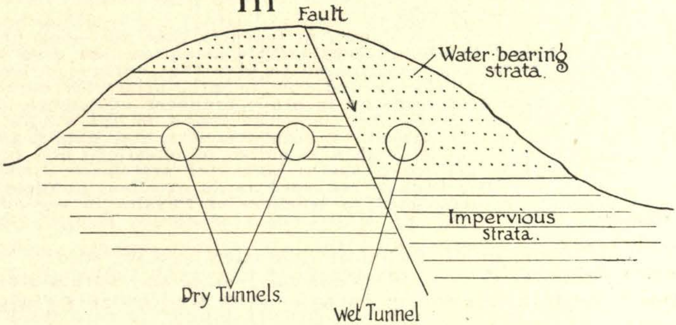


SECTION SHOWING SEASONAL FLUCTUATION OF WATER-TABLE (UPPER SURFACE OF GROUND WATER ZONE) IN CHALK.

was perfectly dry, while another at the same level was wet. The problem was referred to Colonel David, who discovered that a fault had let down water-bearing beds against impervious strata, and recommended a new site for the second tunnel. This proved quite satisfactory (see Fig. III).

Such were a few of the problems with which the geologists had to cope. Needless to say, they were kept exceedingly busy both in field-work and in preparing the necessary maps and sections. Actually three geologists were doing for the British armies work for which the Germans employed more than twenty, and prob-

III



ably as many as forty men. The Professor urged strongly that the number of geologists should be increased, but the High Command considered such an increase unjustifiable.

The feeling of his comrades-in-arms towards the Professor were voiced in 1919 by General Liddell, Chief Engineer of one of the British Armies, who said: "We regarded him always with the most affectionate admiration. He was one of the finest characters we have ever met."

In 1925, after his retirement from the Chair of Geology, the Professor made plans for the preparation of a book, which was intended to embody the results of his forty years of observation and study of the various aspects of the geology of Australia and New Guinea. For this stupendous work there was no one half so well equipped in every way as himself. He had visited most of the States, had discussed on the spot points of geological interest with colleagues in other States, and

had given much time and thought to the question of correlation or linking up of the formations which had been encountered in various States. For the most part the geologists of Australia have of necessity kept rigidly within the boundaries of their own particular States, and much remains to be done to join up and tie together the loose ends of their discoveries. This was a work for which the Professor was particularly fitted. He did not, however, regard himself as omniscient, and so he enlisted the co-operation of a number of his colleagues to contribute information on aspects of the geology with which they were specially familiar, while he set himself the task of co-ordinating and welding into a homogeneous whole the data available from the various States, as well as writing up from his own knowledge special sections which involved an acquaintance with interstate geology. The conception was a mighty one—that of reducing our knowledge of the geology of a continent to its essentials and producing a connected account of it. One of the main difficulties of such a scheme arises from the fact that our continent is very large and the number of geological workers very small, so that there are great areas whose geology is only imperfectly known, while the detailed data which would enable correlation between one State and another, and even between different parts of the same State, have in many cases not yet been worked out. To one less conscientious or thorough it would have been a comparatively simple matter perhaps to set down what was known, ignore or minimize the difficulties and present a readable account which would probably have been true so far as it went, but would certainly not have been the whole truth. This course did not commend itself to the Professor, and to bridge the gaps in knowledge he travelled extensively in characteristic endeavour to solve the difficulties by his own efforts. It was a task before which the stoutest heart might well have quailed, but he attacked it with vigour, though as the work progressed he was heard to express regret that he had not started it ten years earlier. The gathering of material was carried on for some time in Australia, but he was always in demand for some service or another—and through his life he never learnt to say "No"—and for this and other reasons he determined to pursue his labours in England, where he worked in 1926 and 1927 mostly in London and Cambridge. It was possibly at this time that he decided that the book would have to be a three-volume one. Circumstances arose which compelled him to return to Australia in 1927, and there the work was continued. In 1931 the first-fruits of his research appeared in the form of a New Geological Map of the Commonwealth embodying recent data provided by the various Geological Surveys as well as the results of much of his own work. This was accompanied by a volume, modestly named Explanatory Notes, which was really an epitome of the Geology of the Commonwealth, the first systematic and authoritative summary of its kind. The value of both of these publications in the geological world is proved by the frequency with which one finds them referred to in literature.

Even though at this time he was beginning to suffer acute physical pain, his mind still retained its pristine freshness and vigour, and the final chapter of the Explanatory Notes, in which he gives a picturesque and comprehensive survey of the Geological History of the Commonwealth, is a masterpiece, full of exhilaration and literary charm.

As time went on increasing physical weakness made it more and more difficult for him to concentrate on the book. Nevertheless with heroic courage he carried on and forced himself to work when he was really far from fit. Naturally the members of the staff of the Geology Department gave him all the help in their power, but unfortunately, though much had been accomplished, he was not spared to bring his great work to a conclusion.

One is frequently asked what is the position with regard to the book. As a matter of fact nobody knew the precise position except the Professor himself, for, naturally enough, he retained direction of affairs, and those who helped him were in the position of assistants for special portions. It can be stated definitely that some important sections of the work are practically completed. In regard to much of the rest, particularly of the portion dealing with the historical geology, some is certainly complete, and the Professor had accumulated great quantities of material, but how far he had advanced in the task of co-ordinating his information and reducing it to reasonable dimensions will be known only when his MSS. are examined. He himself said more than once that he felt the end of the work was in sight, and doubtless had he enjoyed reasonable health it would have been well-nigh completed by now. The preparation of the book for the press must be regarded as a sacred duty by his geological colleagues, both for his own sake, and because the failure to make known the fruits of his unique experience would be a tremendous loss to geological science in Australia and in the world generally.

A word should be said about the discovery, about six years ago, of traces of fossils in the pre-Cambrian Adelaide Series of South Australia. The Professor had long believed that this thick series of ancient sediments would ultimately reveal signs of contemporaneous animal life, and he was pardonably elated when at last he discovered traces of what he confidently regarded as organic remains, the oldest known fossil animals, by far, allied to the eurypterids, annelids, phyllocarids and other types.

While many of his fellow scientists are convinced of the truly organic nature of the remains, others, especially in Great Britain, have adopted a conservative attitude. Nevertheless the Royal Society and the Geological Society of London showed their sense of the importance of the discovery by voting grants of money to enable further material to be quarried out. The Professor worked early and late, as opportunity offered, at this new material, but the book had first call on his energies and the work on the fossils was never completed.

We are, perhaps, as yet too close to this discovery to appreciate its importance and significance to the full. The Professor himself considered it to be his greatest contribution to science, and it may well be that to future generations of scientific workers he will be best known as the man whose researches definitely placed the dawn of animal life far back in the dim remoteness of geological antiquity.

One could say much, did time permit, about his inspiration as a teacher, and about his labours for science and association with scientific societies. One could dilate, too, on his lovable nature, so loyal and unselfish, his gracious charm of manner, his power of oratory, his sense of humour which did not desert him even upon his death-bed, his scholarship, his strong sense of duty, his humility; but all these characteristics and a great many more are known to most of you.

A few months ago he happened to read some lines from Tennyson's "Ulysses", and he remarked that it was his favourite poem. It tells, you remember, how the weather-beaten warrior and explorer refused in his old age to live in idleness and honoured ease, but must be up and doing again with his old comrades.

"How dull it is to pause, to make an end,
To rest unburnish'd, not to shine in use!

. . . .

Old age hath yet his honour and his toil;
Death closes all: but something ere the end,
Some work of noble note, may yet be done,
Not unbecoming men that strove with Gods."

We can understand how such lines appealed to him, especially in his later years, for he was through all his life and to the end a worker and a fighter. Of him it may be truly said that he died in harness, not the harness of one who toils beneath a heavy load, but that of a brave and gentle, a fearless and blameless knight, who spent his life in the practice and the pursuit of truth and honour and goodness. We mourn—and it is natural we should—we mourn the loss of one whose like we may not hope to look upon again, but we can rejoice in his life so full of high endeavour and noble achievement; we can thank God for him whose every action was an inspiration and an example to us all—David, the well-beloved.

THE CHEMISTRY OF EUCALYPTUS OILS.

By A. R. Penfold, F.A.C.I., F.C.S.,
Curator and Economic Chemist, Sydney Technological Museum.

In the last issue of Environment I gave a brief popular description of the commercially valuable Eucalypts and the important essential oils obtained from their leaves and terminal branchlets. I also discussed how these oils could be obtained and the many and varied uses to which they could be applied. The valuable uses and properties of Eucalyptus Oils—a typically Australian product—have not been appreciated to the extent they merit, probably due to lack of publicity. It is confidently anticipated that considerable interest will have