more with eloquent words to wish prosperity to literature, art, and science. And as if all this were not enough in the midst of his other busy official engagements, we found him just after breakfast at the unveiling of the Meissonier statue in the Louvre Gardens, where he made an admirable speech, summing up the characters of Meissonier's work.

An Englishman might be forgiven if he ventured to express openly his opinion that such things as these could not, or at least would not, be done in his own country. We suppose our Vice-President of the Council is the Minister who most nearly corresponds here to the Minister of Public Instruction in France. But when had we ever a Vice-President who thought it worth his while to show, outside of his official duties, so much active interest in the cause of science, art, and literature?

While this recognition from the State and its functionaries was extended to the Institute, the latter showed in several ways how well it realised its representative character as the outward symbol of the higher intellectual progress of France. One was especially impressed by the way this feeling was exhibited at the opening gathering in the great hall of the new Sorbonne. Behind the academicians and correspondants, the best seats in the building were allocated to representatives of education, law, justice, &c. The chief schools and colleges had places allotted to them, legibly marked out by large labels affixed to them. Lawyers, judges, and professors came in their robes to take part in the proceedings. Every section of the programme appeared to have been most carefully thought out. There was a well-trained orchestra, which began by playing a composition of the first composer who became a member of the Institute of France, and afterwards gave a fragment of *Mors et Vita*, by Gounod—the last composer who had passed away from the Academy of the Beaux-Arts. Good care, indeed, was taken in the celebrations to show that music and the drama were included within the range of the Institute's activities. An afternoon "gala" performance at the Théâtre Français included parts of Corneille's *Cid* and Molière's *École des Femmes* and *Femmes Savantes*, wherein the chief members of this incomparable company showed once more what perfect acting should be.

Lastly, a stranger could not but be pleased with the numerous facilities offered to him to meet his old friends, and to make new ones. At the evening receptions and dinners, at the daylight gatherings in the Institute buildings, and in the foyer of the Théâtre Français, but most of all in the excursion to Chantilly, and the rambles through the rooms and grounds of that princely chateau, he had opportunities of seeing everybody that he wished to converse with. No one who went to Chantilly will be likely to forget the success of that concluding day of the proceedings—the autumnal woods with their long vistas, the magnificent castle, the endless treasures of art and literature within the rooms, but above all, and as the centre and soul of the whole scene, the figure of the Duke d'Aumale, who has gifted all that estate to the Institute. Sitting in his bath-chair wrapped up in black velvet, hardly recovered from his last attack of gout, he showed himself the most vivacious talker in the company, shaking hands with his guests, discoursing to them of pictures, travel, and incidents of his life with the urbanity and dignity of the old *grand seigneur*.

There was one special source of gratification to English visitors in the remarkable band of men who went to represent Great Britain at the Centenary. The French members of the Institute seemed to feel the compliment paid to them by the attendance of so many illustrious men of science, literature and art. And the strength of the English contingent drew forth the admiration of visitors from other countries. It was pleasant, in these days of political rivalry, to see human culture linking men in a brotherhood which stands above nationality and politics, and more especially to note that nearly the whole of the Englishmen who have been so generously recognised by the Institute of France should have attended its Centenary.

THE GOLD MINES OF THE RAND.

The Gold Mines of the Rand; being a Description of the Mining Industry of Witwatersrand, South African Republic. By F. H. Hatch and J. A. Chalmers. (London: Macmillan and Co., 1895.)

AFRICA is proverbially a land of surprises. It is not likely, however, that more startling surprises can be in store than those witnessed by the present generation. We have seen a great city spring up, in what, before the discovery of gold in the Witwatersrand, was a desert, a city with over eighty mines, the workings of which extend east and west from Johannesburg for 45·8 miles. The mines have been worked with regularity, and the augmentation of dividends has attracted the attention of capitalists in all parts of the globe, resulting in the Russian Government commissioning Mr. Kitaëff to report on the gold-field, and in the Prussian Government despatching Mr. Schmeisser for the same purpose. The output of gold from the Witwatersrand has risen from 23,000 ozs. in 1887 to 2,023,198 ozs., valued at nearly £7,000,000, in 1894, whilst the return for the first nine months of the current year was 1,711,337 ozs. The Transvaal now produces one-fifth of the world's supply. It is calculated that at the present rate of progress the output of the Witwatersrand mines will have reached by the end of the century a value of £20,000,000.

To the already ample literature relating to the Transvaal gold mines, this handsome and profusely illustrated volume of three hundred large octavo pages is the most valuable contribution that has yet appeared. The authors possess special qualifications for the important task they have undertaken. Mr. J. A. Chalmers is an Associate of the Royal School of Mines, and his brilliant career as a student has been followed by many years successful practice as a mining engineer in South Africa; whilst Dr. F. H. Hatch's scientific attainments and literary skill are well known from his important petrographical researches carried out previously to his retirement in 1892 from the Geological Survey of England and Wales, and from his useful manuals on mineralogy and petrology.

The authors divide their subject-matter into twelve chapters. The first deals with the history of the gold discoveries and of the development of the mining industry, whilst the subsequent chapters deal respectively with the geology, the auriferous conglomerates, the

Witwatersrand deposits, the development and prospects of deep-levels, mining practice, surface equipments of the mines, the metallurgical treatment of the ore, economics, mining law and statistics.

Unfortunately for students of South African geology, much confusion results from the fact that beds of an identical character often receive different names in different localities. The inconvenience of this want of uniformity in the classification of the rock systems will now, it is hoped, be obviated, as the authors' clear exposition of South African stratigraphy cannot fail to be generally accepted. The geology of South Africa is, it may be noted, comparatively simple. The main subdivisions are (1) recent deposits; (2) the Karroo formation; (3) the Cape formation, and (5) the South African primary formation. The sedimentary deposits are underlain by granites, gneisses, and crystalline schists, which constitute the greater portion of the formation of north-west central Africa. This primary formation occurs largely in Mashonaland, Matabeleland, and the Mozambique, and predominates in the northern and eastern parts of the Transvaal. Lying unconformably on these beds are the shales, sandstones, conglomerates and limestones of the Cape formation, which extend over the southern, western, and middle parts of the Transvaal. They appear to be of an age corresponding with the Devonian and Lower Carboniferous periods of European classification. The Karroo formation, which may possibly be correlated with European Lower Mesozoic formations, has a widespread occurrence in Cape Colony, Natal, the southern Transvaal and the Orange Free State. It derives its importance for the Transvaal from the fact that it carries the coal-seams that have rendered such valuable aid to the development of the auriferous deposits. Lastly, the recent deposits comprise those of alluvial and æolian origin, together with the curious surface material to which the authors apply the somewhat misleading name of "laterite." This material is widely distributed throughout the Transvaal. The gold of the Witwatersrand is obtained entirely from beds of conglomerate, known as "banket," carried by the Cape formation. These are composed mainly of pebbles of white or grey quartz embedded in a matrix consisting originally of sand, but now completely cemented to an almost homogeneous material by a later deposition of quartz. The pebbles as a rule do not carry any gold, the mineralisation being confined to the matrix. The average total yield of the conglomerate stamped last year was 13·16 dwts. of fine gold per ton. With regard to the origin of the ore-bodies, the authors enumerate the various hypotheses without giving their support to any one of them. They have, however, been unable to find any evidence in favour of the idea locally prevalent that the dykes met with, have acted beneficially on the banket in their immediate neighbourhood in regard to gold contents. Petrologically the dykes belong to the group of dark-coloured greenstones, among which the authors have recognised the following types: diabase, olivine-diabase, bronzite-diabase, epidiorite, gabbro and olivine-norite.

One of the most interesting chapters in the book is that on the development and prospects of deep-levels. As the bedded character of the banket deposits became

known, and as the persistency in depth and the uniformity in the gold-contents became established by deep boreholes, companies were organised to work the deep-seated portions of the beds. In discussing the depth at which the main bed will be found, the authors bring forward evidence to show that a very important flattening of the bed takes place. They therefore take a more optimistic view of the future of the gold-mining industry than that taken by other writers. The most important problem that presents itself is to ascertain the limit in depth to which mining may profitably be carried. The limiting factors are increased temperature, excessive initial expenditure, and increase of working costs. The rise in temperature with increasing depth must, the authors think, be ascribed almost entirely to secular causes.

Unfortunately very few experiments have been made to gauge the rate of increase. Mr. Hamilton Smith in 1894 made some determinations of the water in the Rand Victoria borehole at a depth of 2500 feet, the results indicating an increase of 1° F. for every 82 feet. Some rough determinations, too, have been made by Mr. A. F. Crosse at the Ferreira and Crown Deep shafts. In view of the scientific interest and commercial importance of the matter, it is to be hoped that an accurate determination of the temperature will be made at the bottom of the borehole which is now being put down to intersect the main bed at a depth of 3500 feet. At present, experience in other countries is the only available guide, and it is to be regretted that such results collated by the authors are very incomplete. A table of temperatures in some deep European and American mines is given (p. 104), but this, being disfigured by gaps and misprints, such as St. Andre for St. Andreasberg, Prizebram for Przibram, Sanson for Samson, Lambert for Charleroi, does not carry much weight. Nor are the shafts of the Michigan copper mines fair illustrations to select, inasmuch as the coolness of the rock is undoubtedly due to the proximity of the cold waters of Lake Superior. The authors' statement that at the Calumet and Hecla shaft, Michigan, there is a rise of only 4° F. in a depth of 4400 feet, is certainly inaccurate. The temperature determination must have been influenced by the fact that compressed-air rock-drills are in use at that mine. The ice-cold exhaust would lead to erroneous results. The usual geothermic gradient is 50 to 55 feet for an increase of temperature of 1° F., and the lowest recorded is that of 100 feet to 1° F., at the Lake Superior copper mines. It would appear, therefore, that in assuming it to be somewhat less than this in the Rand, the authors are taking too optimistic a view, more especially as Mr. Crosse's determination (p. 103) of 66·7° F. at 825 feet, and 70·7° F. at 1030 feet indicate the normal gradient of 50 feet to 1° F. In the discussion of this important subject, the authors might have referred with advantage to Koebrich's 387 determinations of temperature in the Schladebach borehole. These are of special importance, as they were taken at fifty-eight points at equal distances of 30 metres down to the greatest depth yet attained of 1716 metres. The result of this investigation was that the gradient was found to be 46·09 metres for 1° R.

The chapters describing mining practice, surface equipment, and the metallurgical treatment of the ore, occupy more than a third of the volume. Admirably illustrated by

excellent drawings and photographs, they give a clear idea of the vigorous manner in which the work is carried on. Additional authority is given to them by the fact that they contain contributions by Mr. L. I. Seymour, Mr. C. Butters, and other leading engineering experts. The volume concludes with valuable information regarding material and supplies, labour, working costs, mine accounts, mining laws and regulations, production and dividends. A good index, eighty illustrations, fourteen photographic plates, and seven folding maps and plans, complete a volume of which the authors may justly be proud. With the exception of a geological map, which would have been a useful addition, the only omission appears to be a bibliography of the existing literature relating to the subject. The authors appear to be unacquainted with the geological work of Mr. C. J. Alford (London, 1891), and with the engineering descriptions of Mr. T. Reunert (London, 1893). Indeed they regard the published information relating to the nature of the ore deposits and to the extraction of the gold as meagre and inadequate. Yet Mr. W. Gibson in 1892 published a list of sixty-seven works on South African geology, sixteen of which bear directly upon the geology of the Transvaal. Mr. Schmeisser in 1894 gave the titles of fifty such works, and Dr. K. Futterer in 1895 gave 156 titles. With the rapid development of the mining industry, literary productions become antiquated with remarkable rapidity. When the writer of this review visited the Witwatersrand in 1892, there were 1907 stamps running. Now, according to Dr. Hatch and Mr. Chalmers, there are 2642 (June 1895). Since 1892 work has been pushed on more vigorously than ever before, and from the sixty mines near the outcrop of the main bed 5,000,000 tons of ore have been extracted in 1893 and 1894. Numerous deep boreholes have been put down to the dip of the bed, and several shafts have been sunk, encountering the auriferous conglomerates at depths of 600 to 1000 feet. Five years hence there will be 8000 stamps running. The present average stamping capacity is over four tons per stamp per day, and it is probable that, owing to technical improvements, the average will be five tons. With a total extraction of 10 dwts. of gold per ton, the output should be 6,500,000 ounces. The ore reserves are estimated at 170,000,000 tons, equal at 45s. per ton to £382,000,000. It seems unlikely that the average cost of mining and treating this ore will exceed the present cost of 30s. per ton. The authors think, therefore, that they may safely forecast a production from the Witwatersrand within the next half-century of £700,000,000, of which £200,000,000 will be profit.

BENNETT H. BROUGH.

STARCH.

Untersuchungen über die Stärkekörner. By Dr. A. Meyer. (Jena: Fischer, 1895.)

THOSE who are best acquainted with the laboured details of Naegeli's classical investigations into the nature and growth of starch-grains, and the controversy which followed regarding his astounding hypothesis, which so long dominated certain of our text-books under the name of the "intussusception theory," will best be prepared for another huge work of inquiry into the physical

and chemical nature, growth and solution, and significance to the plant generally of those curious structures. The full appreciation of the magnitude and value of Meyer's task will depend on the reader's acquaintance with the bearing of numerous discoveries which have been made since Naegeli's day, and turned to criticism and the final overthrow of his hypothesis; and among these stand prominently, on the biological side, Schimper's demonstration of the significance of the various plastids to the stratification of the starch-grain, Sachs' brilliant work on the rôle of the starch-grain in assimilation, and Strassburger's severe criticisms in his researches on the structure and growth of the cell-wall; and, on the physical and chemical side, Émil Fischer's work on the synthesis of carbohydrates, and the splendid work of our own countryman Horace Brown—the latter, indeed, as much physiological as chemical in its methods and results.

Meyer's book, which contains over 300 large pages of closely-printed German in the dryest of styles, which would be hard to forgive if the matter were not so good and the spirit so enthusiastic, covers the whole range of the enormous domain now centred around this formerly so insignificant a structure, the starch-grain; and it is embellished with nine tables and ninety-nine illustrations, good, bad, and indifferent, for the quality of the figures varies much, suggesting periods of different powers or methods of delineation during the fifteen years or so the author has been occupied with this monumental monograph.

For it is monumental, in the sense that it has evidently been gradually built up as a big structure, bit by bit, with morsels of hard evidence dug with great labour from the difficult quarry of facts, only to be worked with the best powers of the microscope, and the best methods which modern technique puts at the disposal of the investigator.

The work may be regarded as divided into five parts. The chemistry, physics, and biological properties of the starch-grain as an object of research, form the subject-matter of three of these parts; the fourth is occupied with some extremely ingenious and careful comparative studies of the changes undergone by the grain in the different organs of various selected plants, at stated seasons, and under experimentally varied conditions; while the fifth part may be taken as the critical survey of the investigations and views of others scattered through the body of the work, and the copious literature collected at the end.

It is, of course, impossible to traverse a work like this in a review, and the following short summary must suffice for a glimpse at Meyer's views and results, some of which he has already published in short papers from time to time.

He regards the typical starch-grain as consisting of two substances, one of which, *α-Amylose*, can be obtained separately in the crystalline form, whereas the other—*β-Amylose*—cannot be isolated in crystals. The relations of these two constituents to each other, and to other carbohydrates found in modified starch-grains, are considered in detail; they occur in the grain itself as acicular crystals (*trichites*) arranged more or less radially, and the starch-grain is in effect nothing but a complex, mixed sphere-crystal composed of radiating branch-systems of these *trichites*, in different proportions, and more crowded in the denser layers than in the softer ones.