going diploidisation, each member of a pair of conjugate nuclei retains its identity, so that one member of a pair can divide independently of the other member of the pair whenever such a division is able to promote the diploidisation of another haploid mycelium or of an adjacent haploid cell.

The sexual process (fertilisation or conjugation) of animals and most plants is relatively simple in that two *unicellular* and *uninucleate* gametes fuse to form a unicellular and uninuclear zygote. On the other hand, in the Hymenomycetes the sexual process is more complicated, because it takes place between *multicellular* and *multinucleate* mycelia and results in the diploidisation of all the growing cells of each mycelium. It is the non-fusion of nuclei of opposite sex and the establishment of conjugate pairs of nuclei which makes this diploidisation possible.

The development of a haploid hypha (*ab*) or (*AB*), which has just become diploidised owing to the entry into it of nuclei derived from either a haploid mycelium of opposite sex or from a diploid mycelium (*AB*) + (*ab*), is shown in Fig. 7, where it will be seen that, as the cells grow in length or branch, conjugate nuclear division takes place, and that each conjugate nuclear division is accom-

panied by the formation of a clamp-connexion. When, in a dung-ball, a diploid mycelium of *Coprinus lagopus*, like that shown in Fig. 7, stage 3, meets a haploid mycelium (*AB*) or (*ab*) of the same species (cf. Fig. 2) the diploid and the haploid mycelia doubtless fuse hyphally and the diploid mycelium diploidises the haploid mycelium (cf. Fig. 6), thus increasing the chances that one or more vigorous diploid fruit-bodies developing all the possible sexual kinds of spores (*AB*), (*ab*), (*Ab*), and (*aB*) will be produced rather than one or more relatively feeble haploid fruit-bodies developing only one of the four possible sexual kinds of spores. There can be no doubt that, in *Coprinus lagopus* and in other similar Hymenomycetes, the diploidisation of haploid mycelia by appropriate diploid mycelia is a distinct aid to reproduction.⁴

In conclusion, the author desires to acknowledge a grant in aid of the work made by the Research Council of Canada and valuable assistance in making the experiments given by Miss Ruth Macrae.

¹ W. F. Hanna, "The Problem of Sex in *Coprinus lagopus*", *Annals of Botany*, vol. 39, pp. 431-457; 1925.

² Dorothy Newton, "The Distribution of Spores of Diverse Sex on the Hymenium of *Coprinus lagopus*", *ibid.*, vol. 40, pp. 891-917; 1926.

³ W. Leffeldt, "Über die Entstehung des Paarmycels bei heterothallischen Basidiomyceten", *Hedwigia*, Bd. 64, pp. 30-51; 1922.

⁴ A fuller discussion of conjugate nuclei has been prepared for vol. 4 of the author's "Researches on Fungi".

Recent Hydro-Electric Developments in Switzerland.

By Dr. BRYSSON CUNNINGHAM.

FROM the report for 1929 of the Swiss Service des Eaux, it is to be gathered that developments of hydro-electric energy have been prosecuted during recent years with unabated enterprise and zeal. There was merely a slight falling-off during 1929 in the productive capacity of the power stations, due essentially to the intense cold in the early part of the year and to depletion of the water supplies in the autumn. The returns show a total of 4178 million k.w.h. as compared with 4410 million k.w.h. and 4350 million k.w.h. in the two years immediately preceding. The adverse conditions necessitated recourse in a large measure to the supplies of water stored in the lakes, and the deficit was only made good towards the end of the year.

The most important installation put into operation during 1929 was the power station at Handeck, in connexion with the river Aar, an undertaking of the Forces Motrices de l'Oberhasli S.A., Innertkirchen. This has a present capacity of 60,000 horse power, with an ultimate possibility of 120,000 horse power. Among projects still in course of construction at the end of the year may be mentioned an installation on the Dixence in the Canton of Valais, of 175,000 horse power, and another of 50,000 horse power at Monte Piottino in the Canton of Ticino. An installation of 140,000 horse power at Ryburg-Schwörstadt on the Rhine will be partially Swiss.

It is computed that, on Jan. 1 last, the power stations in Switzerland, either in operation or in course of construction, aggregated a total capacity of about 2,700,000 horse power. Some of these

stations are of considerable individual capacity, among them being those of Vernayaz (Canton Valais) for the Swiss Federal Railway, 108,000 horse power; Wäggital (Zurich), 90,000 horse power; Löntsch (Glarus), 66,000 horse power; and Laufenburg (Rhine), 65,000 horse power.

A recent visit to the Engadine brought me into close proximity with a number of hydro-electric installations which have materialised during the past quarter of a century. The district is particularly rich in sites affording scope for power development and some of these have now been exploited almost to the full extent of their capacity. One of the most striking examples, which I had an opportunity of inspecting, is the undertaking of the Brusio Power Company, which has its headquarters at Poschiavo in the extreme south of the Canton of the Grisons and within a short distance of the Swiss-Italian frontier.

The series of stages by which the Brusio Power Company develops the hydraulic capacity of the southern slopes of the Bernina Range and the Poschiavo Valley commences at the summit level of the Bernina Pass, where there are two sheets of water forming a natural reservoir for impounding purposes at a level of 2200 metres above the sea. The two sheets of water, more or less frozen, of course, during a considerable part of the year, are Lago Bianco (White Lake) and Lago della Scala (the precise signification of which between 'staircase', 'scale', 'succession', and 'landing-place' is not easy to determine). The former is much the larger of the two, but they are so closely adjacent within a common depression as essentially to form

a single basin, which has been adapted so as to provide a supply of 15 million cubic metres of water | lying at a level of 964 metres above the sea and having a superficies of 1.96 square kilometres. It

FIG. 1.—The Bernina Lakes reservoir at the summit level of the Bernina Pass. View looking south. By courtesy of Die Kraftwerke Brusio.

is utilised to the extent of providing 14 million cubic metres of water for a power station below. For this purpose a retaining dam has been constructed across the bed of the Poschiavino at the point of exit from the lake and provided with an intake which is suitable for taking the discharge consequent upon lowering the lake level by $8\frac{1}{2}$ metres. The lake is replenished in due course during the season of melting snow. After leaving the lake at Meschino, the Poschiavino descends 433 metres in a horizontal distance of 5 kilometres to the Swiss-Italian frontier at Campocologno. Beyond this station there is one further stage of development at the junction with the river Adda near Madonna di Tirano.

for power purposes. To this end, the two lakes have been connected and by means of dams at each extremity of the basin the water level has been raised 5.5 metres, bringing the surface up to 2236.16 metres above sea level over an area of 1.36 square kilometres. Under normal working conditions, the water level can be lowered to 2226 metres, which is the state of affairs shown in the photographic view of the basin reproduced as Fig. 1. In order to augment still further the available resources, a set of three pumps has been installed for drawing water from the deeper portion of Lake Bianco, by means of which the level may be reduced to 2210.16 metres above the sea, the maximum difference in level between the fully impounded and the most depleted condition being thus increased to 26 metres.

The Bernina Lakes reservoir is fed by an average annual precipitation of 1500 mm. in the catchment basin and by summer seasonal meltings from the Cambrena glacier.

From the snow and ice of the Bernina ridges two main valleys descend towards the south and eventually merge into one another in the Poschiavo plain. One of these, the Val Pila, receives the natural overflow from the two lakes described above and also the discharge from the Palü glacier at the foot of Piz Palü on the ledge overlooking Cavaglia, where it gives rise to the torrent Cavagliasco; the other, the Val Lagoné, receives the flow of the upper Poschiavino, fed in turn by the streams from the Val di Campo. The Poschiavino, united with these tributaries at Robbia, passes through the valley of Poschiavo, having by this time attained an appreciable amplitude of flow, so far as Lake Poschiavo. This is an extensive natural basin

lying at a level of 964 metres above the sea and having a superficies of 1.96 square kilometres. It is utilised to the extent of providing 14 million cubic metres of water for a power station below. For this purpose a retaining dam has been constructed across the bed of the Poschiavino at the point of exit from the lake and provided with an intake which is suitable for taking the discharge consequent upon lowering the lake level by $8\frac{1}{2}$ metres. The lake is replenished in due course during the season of melting snow. After leaving the lake at Meschino, the Poschiavino descends 433 metres in a horizontal distance of 5 kilometres to the Swiss-Italian frontier at Campocologno. Beyond this station there is one further stage of development at the junction with the river Adda near Madonna di Tirano.

In all, the series of progressive developments consists of five power stations, situated in sequence at Palü, Cavaglia, Robbia, Campocologno, and Poschiavino. The

FIG. 2.—Power station at Robbia. By courtesy of Die Kraftwerke Brusio.

first of these, which receives its supply direct from the Bernina Lakes and the Palü glacier, has

a capacity of 15,200 horse power; Cavaglia power station, at a height of 1709 metres above sea level, develops 10,000 horse power; Robbia (Fig. 2), at a height of 1082 metres, develops 16,000 horse power; Campocologno (Fig. 3), at the level of 531 metres, develops 45,000 horse power, making a total within Swiss territory of 86,000 horse power, to which is to be added the 14,000 horse power of the Poschiavino station, bringing the total up to 100,000 horse power.

Nor is this the full tale of possible exploitation. The storage capacity of the Bernina Lakes and of that at the foot of the Palü glacier are susceptible of further artificial developments. The waters of the upper reaches of the Poschiavino in the Val Lagoné and of its influents from the Val di Campo are capable of being brought into use, as well as those of the Cavagliasco, the Bernina, and the Palü.

The record as it stands at present, however, is a most interesting example of the detailed, step-by-step utilisation of the full resources of an Alpine watercourse from its source in the glaciers of the summit to its final absorption in the comparatively low-lying and slow-moving river in the valley below—a descent which amounts to nearly 6000 feet. The conditions, of course, cannot be paralleled in Great Britain, but they are of interest as indicating how vast resources of power in mountainous regions, which for lack of knowledge and need of incitement have been ignored or neglected in the past, are now being brought into effective service. The works in question have been executed during the period of a quarter of a century commencing in 1903, the first installation at Campocologno having materialised in 1906, and the stations at Palü and Cavaglia having been put into operation at the close of 1927. A tribute is due to the initiative and foresight of the progenitors of the undertaking, as well as to the skill and enterprise with which the various sections of the work have been designed and carried out. I must also take the opportunity of expressing my acknowledgments to the Brusio Power Company, and in particular to the director, Herr Rickenbach, for the facilities which were courteously afforded me for inspecting the whole series of stations and for the information and photographs which have been kindly supplied at my request.

The electric current which is generated at the respective stations is transmitted between them by three principal lines of alternating current, three-phase, 23,000 volts, 55,000 volts, and 140,000 volts. The joint supply is transmitted northwards for utilisation in Switzerland by the Bernina Railway, the Rhaetian Railway, and by various local centres in the Engadine and even so far as Zurich; south-

wards, it is exported into Italy, where it is linked up with the system of the Lombardy Company serving the province of that name.

Had time permitted, it would have been interesting to inspect the series of power stations belonging to the A. G. Bündner Kraftwerke and located in the valley of Prättigau in the Lower Engadine. These have been in operation since 1922–23 and comprise installations of 14,000 horse power at Küblis, of 10,000 horse power at Klosters, and of 7500 horse power at Schlappin. Ultimately, the aggregate of the capacities is to be increased to 55,000 horse power.

Also, alongside the track of the Rhaetian Railway from Bevers to Chur, there is a power station at Thusis at the entrance to the Via Mala Gorge which

FIG. 3.—Power station at Campocologno. By courtesy of Die Kraftwerke Brusio.

utilises the water of the Hinter Rhine and develops energy to the extent of 13,500 horse power, which is supplied for the use of the railway system. The Albula station not far distant, of 26,600 horse power, should also be mentioned: it supplies current to the municipality of Zurich, as also does the Heidsee station of 13,000 horse power. Other sites are in course of exploitation.

Sufficient, however, has been enumerated to show that, even on a quite casual and very cursory survey, there is impressive evidence of notable activity in the realisation to the fullest possible extent of the wonderful hydraulic resources of the numerous mountain chains which form the predominant and characteristic feature of the country. That this development has been and is of the greatest economic benefit to the Swiss community cannot be doubted for a moment. Natural hydraulic power is an asset of the highest importance, self-replenishing, and, unlike coal deposits, not subject to exhaustion.

Impressive and inspiring as is the solemn

grandeur of the crests and pinnacles of massive rock and ice which tower to the heavens in stately solitude, great mountain ranges have a further claim to distinction in an age of pressing utilitarian needs. The Alpine panorama with its multitudin-

ous snowfields, glaciers, torrents, lakes, and rivers is no less wonderful as an example of how Nature contrives to compensate a country for its economic deficiencies in one respect by benefits of equivalent value, though of another kind.

Obituary.

DR. LEWIS EVANS.

IN the Lewis Evans Collection of Historic Scientific Instruments is a small jointed rule of ivory, inset with a compass needle, and engraved as a portable sundial. It was a special favourite of Dr. Lewis Evans, whose death occurred on Sept. 25 last, because it bears the inscription, "Registered 1853", which by a happy chance was the year of his birth, on Feb. 15. Twenty years later Francis Galton might well have included the Evans family among those English men of science whose hereditary influences and education he described at the Royal Institution, for at least four generations have achieved scientific distinction. The Rev. Lewis Evans, vicar of Froxfield, 1788-1827, was an accomplished mechanic and astronomer, who ground his own specula, recorded observations, and continued to 1864 the calculations on Ferguson's Astronomical Instrument and Rotula, published in 1817. He had been educated at Merton College, Oxford, was instructor in mathematics at the Royal Academy at Woolwich, and became a fellow of the Royal Society in 1823. He was in the habit of communicating mathematical notes to the *Reading Mercury* under the *nom de plume* of 'Felix Ford' (anagram of Froxfield), some of which are preserved with his lecture MSS. in the Lewis Evans collection. One of his sons, Thomas Simpson Evans, LL.D., became an assistant at Greenwich and, later, mathematical instructor at Woolwich. His grandson, Sir John Evans, K.C.B., for many years treasurer of the Royal Society, attained to special eminence as an antiquary, a branch of study which has been materially extended by both his sons—Arthur, who has also the scientific blue-ribbon of F.R.S., and Lewis, the subject of this notice, who died on Sept. 25. On the distaff side, two ancestors had also achieved similar distinction, namely, John Dickinson, F.R.S., F.S.A., and George Dionysius Ehret, F.R.S., the inimitable flower painter, who was born at Erfurt in 1708, and died at Chelsea in 1770.

Owing to the great demands made upon his time and energy by the needs of a great manufacturing business, Lewis Evans was more than forty years of age before he published his first paper, "On Pocket Sundials", a modest article illustrated by neatly executed cuts of the author's own drawing. This was followed by a fuller contribution upon the same subject to Mrs. Alfred Gatty's standard "Book of Sundials", 1900. His knowledge was largely based upon his own rapidly expanding collection of scientific instruments, in which a perfect Roman portable dial of about A.D. 300 was then one of the greatest treasures. In 1901 there appeared in *Archæologia* the account of another of his discoveries—the original dial of

gilt brass made for Cardinal Wolsey by Nicholas Kratzer, who at the time was "reading Astronomy in the University by the command of King Henry VIII. and soon after made by Cardinal Wolsey his Mathematical Reader when he first settled his lecture there". Kratzer was made a fellow of Corpus by Richard Fox in A.D. 1517.

From this time on, many writers at home and abroad drew upon the experience of Dr. Evans, notably Dr. Joseph Drecker of Dorsten, and with the dispersal of other collections his own collection grew. It was many years before he could obtain an astrolabe, but "nothing succeeds like success", and the first he acquired was soon followed by some three score others, the most important of which he figured and described in "Some European and Oriental Astrolabes", in the *Archæological Journal* in 1911. In 1922 he offered the whole of his unique collection of dials and early scientific books and instruments to the University of Oxford. It is by far the most important collection of the kind that has ever been given to a university; and owing to peculiar circumstances, the present gift is a lasting memorial to the noble-minded generosity of the donor—for, like the Mensing collection, it might quite easily have been sold for a fortune to America, and thus have been lost to Europe. Incidentally it has served as a nucleus around which other benefactors, including many Oxford colleges, have deposited instruments and objects of value for illustrating the progress of scientific studies and research in the University. In the past five years the space needed for the proper exhibition of the collection has doubled in area, and apparatus of the very greatest importance has had to be refused, on the ground that the best exhibition space available in the Old Ashmolean Building is still being occupied by the staff and books of the English Dictionary, although that work was completed many months ago.

As was recently pointed out in *NATURE* in a letter signed by the president of the Institute of Physics and others, scientific instruments, often the landmarks of invention, are lost so long as they are hidden and not in the charge of someone who appreciates their scientific value. No one realised this more vividly than did Dr. Lewis Evans himself. Although an ardent admirer of art and craftsmanship, he felt that to place unique instruments of science among art objects in a gallery of art, as is the case in the British Museum and at South Kensington in London, or at the Ashmolean Museum in Oxford, or to group scientific apparatus among books and to catalogue it as 'manuscripts', as is now the practice in the Bodleian Library, is both derogatory to science and destructive to the proper study of its history. He therefore determined that