gamic Lycopod, and the other a Gymnospermous Sigillaria. The remarkable peculiarities characterising the central axis of these specimens make it absolutely certain that they all belong to one species of plant.

The typical *Lepidodendron Harcourtii* is then examined in a similar manner. In the details of its organisation it differs materially from *L. Selaginoides;* nevertheless, as its growth progresses, it displays typically similar changes. It attains to much larger dimensions than the latter plant does before developing its exogenous zone, corresponding in this respect with the Arran plant. Its earlier changes are chiefly seen in the rapid development of the bast or prosenchymatous layer of the outer bark and in the increase in the size and number of the vessels constituting its vasculo-medullary cylinder or medullary sheath—the "*étui medullaire*" of Brongniart; but in more advanced specimens a cylindrical zone of centrifugally developed vascular wedges begins to make its appearance in a quasi-cambian zone of the cells of the inner bark, these cells being arranged in more or less regular radiating lines. In this state the rudimentary vascular zone corresponds very closely to what is seen in young stems and roots of Cycads.

The author shows that, contrary to the views of M. Renault, very marked changes take place in the development of the vascular bundles destined for the secondary branches of the plant. In the first instance, each of these is but a concavo-convex segment of the entire vasculo-medullary cylinder, whose detachment leaves a large gap in the continuity of that cylinder, which, however, soon becomes closed again by the convergence of the disconnected ends of the broken vascular circle. The concavo-convex detached segment undergoes a similar change. Its two extremities meet, and before it escapes from the outermost bark it has assumed the cylindrical form of its parent stem.

The rootlets of *Stigmaria ficoides*, now well known to belong alike to Lepidodendron and to Sigillaria, present some peculiarities of structure which are only found in the Lycopodiaceæ and the Ophioglossæ, amongst living plants.

The vascular bundle in the interior of each Stigmarian rootlet is inclosed within a very regularly circular cylinder, composed of the cells of the innermost bark; but the position of the bundle in relation to the cylinder is always, unless accidentally disturbed, an eccentric one. This position has not escaped notice, but it was regarded as accidental; it now, however, proves to be a normal one. The bundle begins to appear in very young roots, as one or two very small vessels developed in close union with the innermost cells of one side of the cylinder within which it is located; newer and larger vessels are gradually added centripetally, until the bundle occupies a considerable portion of the area inclosed by the inner bark cylinder. The remaining space is usually empty, but occasionally specimens are found in which it is filled with small delicate cells that have escaped destruction. These represent what in the living Lycopods are liber-cells. The outer cortical layer of the root, composed of well-preserved and rather thick-walled cells, is usually separated from the inner cylinder by a similar lacuna; but in a few specimens the cells of this usually destroyed middle bark are retained in good preservation. They consist of very delicate thin-walled parenchyma, separated by a sharp line of demarcation equally from the innermost and outermost cortical cylinders. The number of the vessels in each of the vascular bundles given off from any one section of a Stigmarian root is found to vary but little, but they steadily increase, both in number and size, with the size and age of the root. Young specimens of Stigmarian roots are described, the smallest of which is not more than one-fifth of an inch in diameter, and the vascular bundles of its small rootlets consist each of from three to five minute vessels. In the largest rootlets from old roots they number about forty, most of the additional ones being of larger size; intermediate examples exhibit a regular gradation on all these points.

The only living plants which possess rootlets with this structure being Lycopodiaceæ and Ophioglossæ, and it being sufficiently clear that the Lepidodendra belong to the former and not to the latter order of cryptogams, the existence of this Lycopodiaceous feature in the rootlets of Sigillaria is another indication of the Lycopodaceous affinities of these plants.

Many of the Diploxyloid forms of the Lycopodiaceous stems of the coal-measures have an abundant development of spiral or barred cells in their numerous medullary rays. Amongst living plants this characteristic seems to be almost, if not wholly, confined to the Gymnosperms.

Two important additional observations have been made in reference to the structure of the curious strobilus, *Calamostachys Binneyana*. The exact mode of the attachment of its sporangia to the Equisetiform sporangiophores has been ascertained; but what is still more important, it has also been discovered that it is provided with both micro- and macro-spores—an additional indication of its probable Lycopodiaceous affinities, already suggested by other features of the fruit.

The recently discovered Fungi of the coal measures are investigated, especially the *Pernosporites antiquiorum* of Mr. Worthington Smith. The author finds, in the specimens he has examined, including that described by Mr. Smith, no traces of septa in the hyphæ or of zoospores in the Oogonia. He concludes that its affinities are probably with the Saprolegniæ, and not with the Pernosporeæ.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

THE Professorship of Zoology in the Royal College of Science, Dublin, is vacant by the resignation of Prof. Bridge. The salary is 200*l*. a year, and at present the professor is only required to lecture during one term, commencing in February and ending in June.

THE University Court of St. Andrews have elected Mr. Arthur Stanley Butler, B.A., of Exeter College, Oxford, to the Chair of Natural Philosophy in the United College, St. Andrews, in the room of Dr. William Swan, resigned.

THE Calendar of the University College of Wales for 1879-80 shows that that institution is fairly well equipped in its various departments, science occupying a prominent place in its curriculum.

AT the end of the Legislative Session the French Chamber of Deputies voted a law establishing free primary education. It must go through the Upper House before becoming a definitive Law of the State.

SCIENTIFIC SERIALS

THE *American Naturalist*, June.—A. E. Brown and J. D. Caton, the domestication of certain ruminants and aquatic birds. J. S. Lippincott, the critics of evolution (concluded).—C. E. Bessey, the supposed dimorphism of *Lithospermum longiflorum* (the large flowers appear from April to May, the cleistogamous flowers from then until the autumn frosts).—Dr. J. Leidy, on some aquatic worms of the family Naides (describes and figures *Dero limosa*, perhaps = *D. digitata*, Oken; *Aulophorus vagus*, this forms a tube of the statoblasts of a species of Plumatella, and *Pristina flagellum*).—W. H. Dall, American work in the department of recent mollusca during 1879.

July.—G. Brown Goode, the use of agricultural fertilisers by the American Indians and the early English colonists (contains some interesting facts about fish manures).—C. S. Minot, sketch of comparative embryology (The Sponges).—O. B. Johnson, the birds of the Willamette Valley, Oregon.—J. F. James, a botanist in Southern California.—J. S. Kingsley, American carcinology in 1879.—A. S. Packard, jun., the structure of the eye of trilobites, with figures; concludes that the hard parts of the eye of the trilobites and of Limulus are throughout identical, while the nature of the soft parts of the former must ever remain problematical. There is good evidence that the retinal mass was like that of the king-crab; if so these forms as to their eye-structure will stand near each other and far apart from all other arthropods.

THE *Journal of the Royal Microscopical Society*, June, contains: Prof. Duncan, on a parasitic sponge of the order Calcarea (Plate 10), *Mobiusispongia parasitica*, growing within *Carpenteria raphidodendron*, from the reefs of Mauritius.—Dr. Cooke, on the genus Ravenelia (Plate 11).—Dr. H. Gibbes, on double and treble staining. An excellent suggestion is incidentally made by Dr. Gibbes, that the covering glasses used by microscopists should be of a known thickness. We would even go further, and advise that a fixed scale of thickness might be adopted. Dr. Gibbes uses two thicknesses, ·006 and ·004.—Dr. A. Grunow, on some new species of Nitzschia (Plates 12 and 13).—James Smith, on the illumination of objects under the higher powers of the microscope.—The most useful record of current researches relating to invertebrates, cryptogams, &c., is continued as usual.

THE *Revue des Sciences Naturelles*, June 15, contains: M. Hesse, description of two new crustacea, male and female, of the genus Dinemoura (*D. mustela lævis*) (Plate 1). The figures are coloured from living specimens; the species lives not in the interior of the shark, but on its skin, and its mode of fixation is minutely described.—M. Duval-Jouve, on the species of Vulpia to be found in France.—D. A. Godron, on the giant maize (*Zea caragua*).—M. Rietsch, on Bobretzki's studies on the formation of the blastoderm and germinal lamellæ in insects.—A. Villot, the synchronism of the marls and clays with lignite of Hauterives with the group of St. Ariès.—M. S. Jourdain, on a very simple form of the group of worms *Prothelminthus hessi* (S. J.) = ? *Inthosia leptolanæ*, Giard (Plate 2).—Scientific review of recent French writings on zoology, botany, and geology.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, June 17.—"On the Spectrum of the Flame of Hydrogen," by William Huggins, D.C.L., F.R.S.

Messrs. Liveing and Dewar state, in a paper read before the Royal Society on June 10, that they have obtained a photograph of the ultra-violet part of the spectrum of coal gas burning in oxygen, and in a note dated June 8 they add that they have reason to believe that this remarkable spectrum is not due to any carbon compound but to water.

Under these circumstances I think that it is desirable that I should give an account of some experiments which I made on this subject some months since without waiting until the investigation is more complete.

On December 27, 1879, I took a photograph of the flame of hydrogen burning in air. As is well known, the flame of hydrogen possesses but little luminosity, and shows no lines or bands in the visible part of the spectrum, except that due to sodium as an impurity.

Prof. Stokes, in his paper "On the Change of Refrangibility of Light,"[1] had stated that "the flame of hydrogen produces a very strong effect. The invisible rays in which it so much abounds, taken as a whole, appear to be even more refrangible than those which come from the flame of a spirit lamp." I was not, however, prepared for the strong group of lines in the ultra-violet which, after an exposure of one minute and a half, came out upon the plate.

Two or three weeks later, about the middle of January, 1880, I showed this spectrum to Prof. Stokes, and we considered it probable that this remarkable group was the spectrum of water. Prof. Stokes permits me to mention that, in a letter addressed to me on January 30, he speaks of "this novel and interesting result," and makes some suggestions as to the disputed question of the carbon spectrum.

I have since that date taken a large number of photographs of the spectra of different flames, in the hope of being able to present the results to the Royal Society, when the research was more complete. I think now that it is desirable that I should describe the spectrum of the flame of hydrogen, but I shall reserve for the present the experiments which relate to the presence of carbon and its compounds.

The spectrum of the flame of hydrogen burning in air is represented in the diagram. It consists of a group of lines which terminates at the more refrangible limit in a pair of strong lines, λ 3062 and λ 3068. At a short distance in the less refrangible direction, what may perhaps be regarded as the group proper commences with a strong line, λ 3090. Between the strong line λ 3068 and the line λ 3090 there is a line less bright, λ 3080. Less refrangible than the line λ 3090 are finer lines at about equal distances. The lines are then fine and near each other, and appear to be arranged in very close pairs. There is a pair of fine, but very distinct lines, λ 3171 and λ 3167. In this photograph the group can be traced to about λ 3290. This group constitutes the whole spectrum, which is due probably to the vapour of water.

I then introduced oxygen into the flame, leaving a small excess of hydrogen. A spectrum in all respects similar came out upon the plate. I repeated the experiment, taking both spectra on the same plate. Through one-half of the slit the spectrum of the oxyhydrogen flame was taken. This flame was about 7 inches long, and the spectrum taken of a part of the flame 2 inches from the jet. The oxygen was then turned off, and the quantity of hydrogen allowed to remain unaltered. A second spectrum with an exposure of the same duration was then taken through the second half of the slit. On the plate the two spectra are in every respect similar, and have so exactly the same intensity that they appear as one broad spectrum.

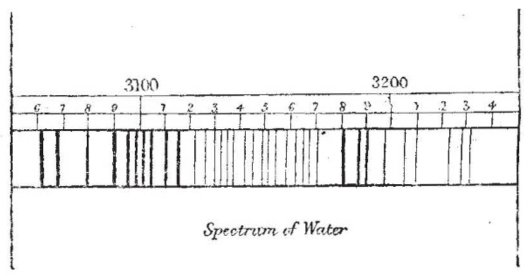
In all these experiments a platinum jet which had been carefully cleaned was used.

In these experiments the two gases met within the blowpipe and issued in a mixed state.

The jet was removed, and a flame of hydrogen was surrounded with oxygen. This spectrum shows some additional lines. In this case the jet was brass, and in this or some other way impurities may have been introduced; and I should at present incline to the view that the additional lines about λ 3429 and λ 3473, and the groups more refrangible than λ 3062, do not belong to the water spectrum, but to impurities.

Coal-gas was substituted for hydrogen in the oxyhydrogen blowpipe, and oxygen admitted in as large a proportion as possible. The inner blue flame rising about 2 inches above the jet showed in the visible part of the spectrum the usual "five-fingered spectrum." The light from this part of the flame was projected upon the slit. The spectrum contains the water group already described, and in addition a very strong line close to G, and two lines, λ 3872 and λ 3890; this latter line is seen to be the more refrangible limit of a group of fine lines shading off towards K.

The ultra-violet group, when carefully compared with the group in the spectrum of pure hydrogen, shows several small



Spectrum of Water

differences. I am inclined to believe that there is the supposition of a second fainter group. There is strong evidence of this in some spectra of hydrogen taken under other conditions. There is also a broad band less refrangible than the strong line at G, and the light extends from this line on its more refrangible side.

A double Bunsen burner (Fletcher's form) with a strong blast of air was then fitted up. The spectrum was taken of the intense blue flame. It resembles the one last described. All the distinctive features are intensified, and a continuous spectrum and groupings of very fine lines fill up all the intervals between the groups already described, so that there is an unbroken strong spectrum throughout the whole region which falls upon the plate.

A spirit lamp was arranged before the slit. The spectrum is essentially the same as when coal-gas is burned, but as it is less intense only the strongest lines are seen. The water group, the strong line at G, and the pair of lines rather more refrangible than K, are seen. Probably with a longer exposure the finer lines would also show themselves.

The distinctive features of the spectra of coal-gas and of alcohol appear to be connected with the presence of carbon.

Table of Wave-lengths of the Principal Lines of the Spectrum of Water. No. 1.

3062	3095	3135	3171	3217·5
3068	3099	3139	3175	3223
3073	3102	3142·5	3180	3228
3074	3105	3145	3184	3232
3077·5	3111	3149·5	3189	3242·5
3080	3117	3152·5	3192·5	3252·5
3082	3122·5	3156	3198	3256
3085	3127	3159·5	3201	3262
3090	3130	3163	3207·5	3266
3094	3133	3167	3211	3276

[1] *Phil. Trans.*, 1852, p. 539.