either be continuous with that on the tarsus or show stages in "breaks" at one or two of the joints (Fig. 3). These and other facts of a like character go to prove that the degenerative evolutionary processes in the ostrich are all *orthogenetic* in their nature, and that a retrogressive change set up in any one direction is likely to be continued until final elimination of the part in question. The continuity is probably more apparen

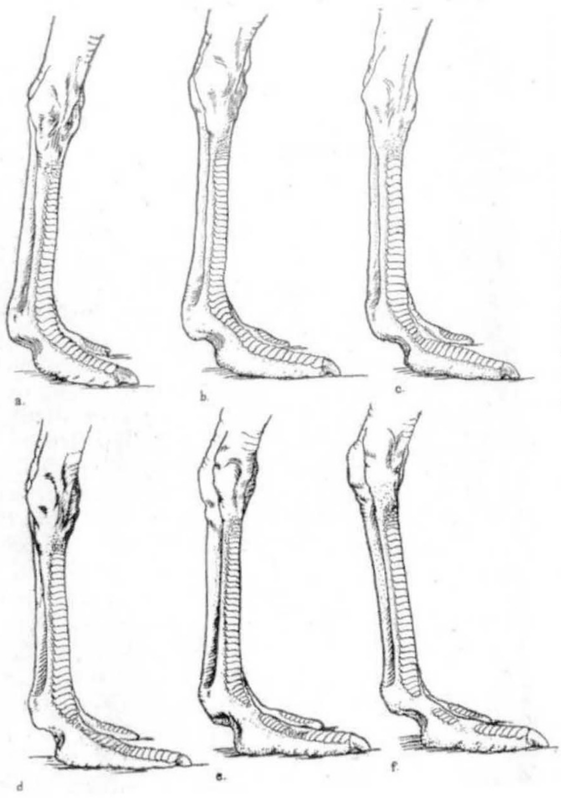

FIG. 3.—Series showing various stages in the loss of scales over the big toe.

than real; for if the somatic changes correspond with alterations in the germ plasm, it must be inferred that these are discrete in their origin, and apparent continuity is conferred mainly by intermixture and owing to the smallness of the changes. The stages must, however, be successional and represent a definite tendency in the germ plasm, in contrast to the haphazard nature of the mutations usually studied—a tendency which is held to be wholly apart from any considerations as to the welfare of the bird, as well as from environmental influences.

To the highly contentious question of the inheritance of acquired characters, the ostrich would appear to have a contribution to offer. Owing to the loss of its second toe, the crouching bird, for mechanical reasons, no longer makes use of the symmetrical axial callosity at the ankle, but develops an accessory one to the side. This is formed anew with each generation, and must have done so ever since the second toe disappeared, though presumably this happened thousands and thousands of generations ago. No hint of the accessory callosity occurs on the newly hatched chick; it is not inherited, but has to be acquired anew each time. On the other hand, the hereditary axial callosity, though unused for the same period, shows no signs of reduction; it has persisted through the ages, though non-functional. Further, the ostrich rests upon its sternal and pubic projections, and a strong callosity is developed over each. These would unquestionably form as a direct response of the skin to the pressure and friction involved in crouching, but are found to be hereditary, showing on the newly hatched chick. Hence we are presented with an hereditary structure which would also be formed independently as a result of the ordinary activities of the bird were it not already provided, strongly compelling us to suspect that the presence of the former is in some manner directly connected with the latter; in other words, that a character originally developed as a result of external stimuli has in time become so impressed upon the organism that it now makes its appearance apart from the primary stimuli.

The question of the origin of the three or four species of ostrich also makes some appeal to the evolutionist. No one intimately acquainted with the northern and southern ostrich would dispute their specific distinctness, but the East African and Somali species appear to be founded on intermediates of the two. Moreover, the northern and southern birds freely interbreed, and their offspring are fertile, some of the characters blending and others showing Mendelian segregation. Unquestionably all the representatives of the genus Struthio are a common stock, continental in their distribution, in which mutations have occurred in certain areas and not in others, but not of such a nature as to prevent free interbreeding.

The Conservation of Our Coal Supplies.[1]

By PROF. J. W. GREGORY, F.R.S.

COAL is the main material foundation of British industrial supremacy. The importance of coal is given by Mr. Justice Sankey as his first reason for its State ownership. The rapid British industrial progress at the end of the eighteenth century was due to our abundant coal. Modern coal mining began in Belgium earlier than in Britain, but British mines soon had the greatest output in the world. In 1800 they produced two-thirds of the world's coal, in 1860 the proportion was 60 per cent., and in 1913 the United States,

[1] Address to the Philosophical Society, Glasgow, on March 10.

Britain, and Germany together produced 87 per cent. of the world's coal. It was not until 1899 that the British output was surpassed by that of the United States; but, in spite of the ease of working of the American fields, our yield per unit of coal area is sixteen times as great as that of America. The British output of nearly 300 million tons is irrefutable evidence of the skilful organisation of the British coal industry and of the courage and capacity of the British miner.

This drain of 300 million tons a year inspires disquietude as to how long it can last. The first authoritative estimate of our coal resources was that of the Royal Commission of 1865, which estimated them as roughly 150,000 million tons. Later estimates have increased this amount to about 200,000 million tons, which would maintain the 1913 output for 600 years; the United States supplies would be maintained for 1500 years, those of Germany for more than 1500 years, while the coal fields of China would last for several millenniums. The world is in no immediate danger of a coal famine, but the British industrial position is threatened by the continued rise in the price of coal, which may hamper competition with countries with cheaper supplies. Jevons in 1865 issued a warning of this danger, and his main prediction has been amply justified, for during the seventy years from 1834 to 1904 the price of coal almost doubled, while that of general commodities fell by about a quarter. The increased cost of coal cannot, therefore, be explained by such influences as variations in currency.

The maintenance of the British output at a price which will enable British manufacturers to compete with those of foreign coal-producing countries depends on the increase of our coal reserves by the discovery of buried coal fields, such as doubtless occur under the younger rocks of eastern and southern England, while an extension of the Scottish coal fields may occur in north-eastern Ireland under the lava sheets of Antrim. The coal field of South Yorkshire and Nottinghamshire has been enlarged since 1905 by the discovery of 400 square miles of coal-bearing country, most of which is already being worked or developed. The eastward extension of this field is less than was expected by the Coal Commission of 1905, but its eastern and southern margins are still undetermined. The Kent coal field was found, in consequence of a geological prediction, during boring operations at Dover in connection with the Channel tunnel. Private bores for water have thrown light on the possible range of the coal in the south-east of England, but there are large areas which are unlikely to be tested by private enterprise. It is deplorable that they should be left unproved, as a few bores between the Nottinghamshire and Kent coal fields, and between London and Bristol, might lead to the discovery of very important additions to the national coal reserves. Such bores should be put down at the national expense, the cost, if successful, being charged to the area benefited.

As much light may be thrown on the distribution of concealed coal by private bores, the journals of all deep bores should be communicated to the Geological Survey and published either annually or, if desired by those who have paid for them, after an interval of ten years.

The national coal supplies will be increased by the working of deeper seams. The extreme limit of coal mining has been regarded as 4000 ft., but that depth has been greatly exceeded in metal mining, and 4900 ft. is the accepted Continental limit for coal mining.

The working of thinner seams is becoming practicable by the use of machinery and by working coal in conjunction with the adjacent clays; but the extension of thin-seam working would be hindered by a Government scheme for the nationalisation of coal. The nationalisation of all minerals, since clay and limestone often form the ground in large areas, would mean the nationalisation of the land. The nationalisation of coal alone would seriously hamper that combined working of coal with clay or limestone on which the development of thin-seam working is mainly dependent.

It may also pay the nation to arrange for the extraction of seams so thin that they cannot be worked at a profit, for if the labour be available the direct loss may be recompensed from the profits earned by the coal in other industries. It has often been suggested that to make our coal last longer the output should be restricted, but that policy, fortunately, appears now to have no advocates. The universal demand is for an increased output. Its restriction is opposed to the sound commercial principle, "Use an asset while you can." Unrestricted output is, however, justifiable only so long as coal is used economically. Great savings are possible. Sir George Beilby estimates that the average British consumption of coal per horse-power per hour is 5 lb., and that it should be no more than $1\frac{1}{2}$ lb., thus saving 56 million tons of coal a year. Greater saving appears possible by economy in the use of coal than from the numerous alternative sources of power, though resort to them will become necessary if coal prices rise.

Economy in coal is the most promising method of reducing the drain on our coal reserves. The country has used only about 6 per cent. of its total coal. Our coal supply would maintain the 1913 output for centuries, but if the annual output increases until, as some authorities expect, it is trebled, the handicap of high price may be on us in less than a century. By economy in coal consumption great industrial expansion is possible on the present output.

The essential factors with regard to the coal question are that no other source of power is available in this country on a large scale; coal is still indispensable, while it is limited in amount and irreplaceable; and, owing to the exhaustion of the more easily worked seams, a steady rise in price will continue, and probably at an accelerated rate. Ultimately the nation must enforce economy in the consumption of coal, prevent waste in mining, and be prepared to work seams at a direct financial loss. The coal industry can be conducted on those lines in accordance with three possible policies—nationalisation, one coal trust for all the British fields, or group working by a combine for each coal field, co-ordinated by national control. Which of these policies is best is not a geological question. The problem for geologists is whether one of these policies is necessary at once, owing to the diminution of our coal reserves. The recent rise in the price of coal has been due partly to a just increase in miners' wages, partly to the higher costs of supplies, and partly to some spontaneous hypertrophy of price in distribution. Compared with these influences, the contribution to the soaring of coal prices by the geological factors is trivial. The conditions of our coal supplies do not render immediately necessary any drastic action in the conduct of the industry. In countries such as India, where the total coal reserves relative to the area and population are small, nationalisation may be the soundest economic policy, but we are far from the time when the three great coal-producing countries—the United Kingdom, the United States, and Germany—will find nationalisation necessary owing to the approaching exhaustion of their coal supplies.

The direct issue before the nation at present is between national ownership of the minerals with centralised Government control of mining—which may give us the drawbacks of nationalisation without its advantages, and is repudiated by both the miners and the mine owners—and a scheme of nationalisation combined with local administration of the industry by those engaged in it. The issue between nationalisation and the pre-war system may not be put to the nation unless as a result of the conflict between the nationalisers who advocate central control and those who advocate local control. The pre-war system has no chance of permanence unless developed to give the miners better conditions and a share in the control and financial fluctuations of the industry, combined with regulations to enforce economy in the use of coal and to secure less waste in mining, and with the determination of the extent of the concealed coal fields on which the future of the country will ultimately depend.

Obituary.

PROF. CHARLES LAPWORTH, F.R.S.

THE work of Prof. Charles Lapworth (who died on Saturday, March 13) in the sciences of geology and geography will continue to influence and inspire the growth of these sciences for many years to come. At the moment we can but mourn the loss of one worthy to be classed with the greatest of the old masters.

Gifted with a vivid and flexible imagination which he kept in his most brilliant excursions well under the control of his data, with unwearied patience in the collection of fact by his own observation or that of others, with an active and most orderly mind for grouping and arranging ideas, with the moral courage to hold his hypotheses in test until the survivors of them became proved theories, with a perfect genius for stratigraphy, an instinct for geometry, and the hand of an artist, Lapworth had the qualities requisite to bring the study of the older palæozoic rocks to the level of an exact science, to throw new light on the mechanism of earth-movement, and to forge the links between geology, "the geography of the past," and the geography of the present.

In 1864 Lapworth grasped the opportunity of work in the Southern Uplands, the country redolent of Scott, his favourite author. Spending every leisure moment in walking over ground thus made sacred to him, and possessing the gift of close and accurate observation, he could not help becoming interested in the landscape and the rocks; and he soon found himself studying the geology of the region in company with his friend James Wilson.

It happened that the landscape of this area concealed under an aspect of simplicity, but revealed to the eye of genius, a rock-structure of extraordinary complexity, to which there was apparently no clue except a few obscure pen-like markings, called graptolites, in the Moffat shales; and these had been tried for the purpose, but "turned down" as useless. Lapworth, however, determined to give them a second chance, and, as a result of systematic collecting, a keen eye for a country, and a retentive memory for minute, but significant, lithological variation, accompanied by a more elaborate piece of geological mapping than his predecessors had ever attempted, succeeded in proving that they could be used to unravel a rock-succession, even though it was more crumpled, inverted, and tangled than any other then known.

The rock succession and tectonic structure thus made out were tested against the simpler succession and relations and the more normal fossils of the Girvan area, and proved correct. At the same time, the graptolite zones that Lapworth had established were tested by comparison with successions made out partly by others, but mainly by himself at home, and by workers in Scandinavia, Bohemia, etc., proving that he had successfully performed at Moffat the double feat of working out the succession by means of the structure, and the structure by the succession.

The correct reading of the Uplands having shown that an apparently simple upward succession might be altogether misleading, and that this region gave support, and not contradiction, to general laws previously established in the organic and