mental power are shown not only in hybrids, but also in pure species. By removing their eggs when laid, the birds can be overworked in reproductive activity, with a corresponding decrease in energy of the offspring. The result is more females and a shorter term of life. Even in normal reproduction there is found to be a gradual diminution in developmental power of the germs throughout the season.

This idea of relative and varying germinal weakness and strength runs through all the work, and will be found difficult to controvert. It is probably but the beginning of a theory of evolution founded primarily, not on morphological, but on energy conceptions.

(6) Another important relationship which was studied in great detail is that between fertility and sex. The problems involved are too many-sided to discuss here. It was found, for example, that while in crosses between closely related species the sexes appear in equal numbers, in inter-family crosses only or chiefly males are produced. In wide crosses the development may only begin, or it may stop at any stage between hatching and maturity, resulting in short-lived birds. All these and many other results are interpreted in terms of developmental energy, the difference between the sexes being regarded as essentially a difference in metabolic level. This view is in accord with the classical theory of sex of Geddes and Thomson. Some means must be found of harmonising it with the chromosome theory.

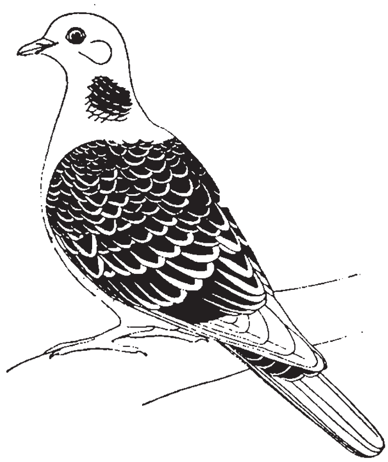

FIG. 5.—The Japanese turtle-dove, *Turtur orientalis*. Believed to represent the primitive colour pattern in pigeons, from which the chequers of *C. livia* were developed by the disappearance of pigment along shaft of feather.

(7) The study of voice, instincts, and behaviour in pigeons has added much to the value of the whole work. Whitman's intimate knowledge of pigeons from this side frequently furnishes corroborative evidence of relationships. It also made possible his singular success in crossing many species which had never been crossed before. The differences in the instincts of the reproductive cycle are often surprisingly marked and definite in different species. In a discussion of instinct in relation to intelligence, the author's view is that as instincts become more complex and plastic the possibility of choice finally enters, so that without any added brain structure the organism is encouraged or constrained by circumstances to *learn* to use its privilege of choice.

These notable volumes, two of which are sumptuously illustrated with coloured plates by Japanese artists, will doubtless arouse much discussion. It is to be regretted that an index has not been added, to make their contents more readily available. R. R. G.

THE NITROGEN PROBLEM.[1]

II.

BEFORE the war the United Kingdom produced and exported large quantities of ammonia nitrogen, upwards of 70 per cent. of the home production being, in fact, exported. Indeed, the British export trade in ammonium sulphate was larger than that of any other country. On the other hand, she was entirely dependent upon the Chile product for her nitric nitrogen. Agriculture accounted for the major portion of the home consumption of fixed nitrogen, but this only represented 23·5 per cent. of the total home production and importation. Indeed, in proportion to the total area under cultivation, the United Kingdom uses less artificial nitrogenous fertilisers than any other progressive agricultural country.

The war has had a serious effect upon the home industry. Whereas the estimated output of by-product ammonia in America and of by-product and synthetic ammonia in Germany in 1917 was more than double what it was in 1913, with us it declined in 1914 and 1915, slightly recovered in 1916, and in 1917 showed only an increase of 6 per cent. over the amount in 1913. Our export trade in ammonium sulphate practically ceased in 1917. Countries which formerly imported our sulphate of ammonia are now making their own by-product ammonia. This result is due to the action of the Government in controlling the export and price. As is well known, there has been a remarkable development in agriculture in this country during the last four years, and the home demand for nitrogenous fertilisers has been in excess of the supply. There can be no doubt that both the industrial and the agricultural demand for nitrogen products will continue to increase. The Committee estimates that on the assumption that the present scale of food production is at least maintained, the demand in the near future will probably represent a quadrupling of the average pre-war requirements. Our export trade in ammonia fertilisers will have in future to reckon to a still greater extent with synthetic products. It can only successfully compete by this country itself manufacturing such products. No doubt economies and improvements in existing by-product processes are conceivable and possible, but

[1] "Ministry of Munitions of War. Munitions Inventions Department. Nitrogen Products Committee. Final Report." Pp. vi+357. (London: H.M. Stationery Office, 1919.) Cmd. 482. Price 4s. net. Continued from p. 535.

it is unlikely that low-temperature carbonisation will have any considerable influence on the main result, and attempts to utilise peat and sewage afford no certain promise of success. Although our existing processes have admittedly shown themselves to be a national asset of the greatest value in times of war, they need to be supplemented, in a time of national emergency, by methods which will render this country independent of external supplies of nitrates.

The cost of power is, of course, a vital factor in connection with the establishment of any synthetic process of nitrogen fixation, and to this question the Committee necessarily devoted great attention and with special regard to the conditions of the United Kingdom. It has considered such water-power schemes as appeared practicable, and the cost of obtaining electrical energy from coal. The comparison is complicated by the many complex factors involved, and especially by the uncertainty concerning the future cost of coal and labour. At the same time, it offers an estimate of the cost of a particular water-power scheme which it has investigated, but of which it gives no details, and it is of opinion that for a power of more than 28,000 continuous kilowatts the running cost, under post-war conditions, would be 3·93*l*. per full kilowatt-year, inclusive of capital charges. The only possible chance of obtaining electrical energy from coal at a cost which would compare with this would be by direct firing at a power station operating on a very large scale. This with coal at 10*s*. per ton and an annual load factor of 97·5 per cent. works out at about 4·5*l*. per kilowatt-year of 8540 hours.

After careful consideration of the main features of the various nitrogen fixation processes and of the ammonia oxidation process, in the light of British conditions and requirements, the Committee concludes that (*a*) the *arc* process, in spite of certain disadvantages, viz. its large power requirements, its low electro-chemical efficiency, and the costly character of its chemical plant, would compete with the retort process of obtaining nitric acid so long as the cost of electrical energy was below 9*l*. per kilowatt-year. (*b*) The *calcium cyanamide* process affords a cheaper marketable form of combined nitrogen, so long as electrical energy is below 5*l*. per kilowatt-year, than any other established fixation process, and gives a solid nitrogenous fertiliser as a primary product. The manufacture may be combined with that of calcium carbide and crude cyanides, and, as the raw materials are cheap and abundant in this country, there is good ground for assuming that it would be successful with us, in spite of the relatively high cost of electrical energy. The Committee is of opinion that a steam-power station of 30,000-kw. maximum load is the minimum size that would be justifiable under British conditions. (*c*) The *Haber* process, with pure hydrogen at 2*s*. 6*d*. per 1000 cu. ft., is capable of producing ammonia at a cost below that of any ammonia process as yet established. The Committee, of course, had no opportunity of inquiring into the Claude process, the details of which have only recently become known. Both these processes are the most promising of all the synthetic methods of making ammonia and ammonium sulphate. It is too soon to express any definite opinion as to their relative merits as commercial processes, but it is certain that both of them have a great future.

The *ammonia oxidation* process for making nitric acid, although probably not in its final form, can even now furnish concentrated acid at a lower cost than the retort process from Chile nitrate, and ammonia oxidation converters are well adapted for use in the chamber process of making oil of vitriol. It is not unlikely that such converters will soon supersede the wasteful system of nitre-pots.

It should be stated, however, that the last word has not been said in favour of existing by-product processes. It is pointed out that improvements in the metallurgical coke industry, such as the more rapid replacement of beehive ovens by recovery ovens, and improvements in the existing practice in gasworks, both large and small, would do much to augment the yield and recovery of by-product ammonia, and the Committee was unanimously of opinion that energetic measures should be taken to ensure that industries making such a large annual demand upon our coal reserves should be made to utilise them to the maximum advantage, and it indicates in outline what these measures should be. The waste that has hitherto taken place in the potentiality of coal, as regards both its energy and its products, is a national scandal that ought no longer to be tolerated. Its continuance would be the strongest argument that the advocates of nationalisation could adduce.

Considerations of space prevent any attempt to deal with many other points which have engaged the attention of the Committee, and are set out in detail in its voluminous report, such as the question of the nitrogen problem as it affects other parts of the Empire. The Dominions beyond the seas are rich in latent resources in coal and other raw materials, and some of them possess exceptional water-power facilities, accessible to the seaboard and capable of easy development. Nor have we been able to devote much space to the question as it affects national defence. It must be evident, however, from past experience that, notwithstanding our maritime supremacy, the military situation has been, as the Committee states, fundamentally changed. We must no longer be dependent upon Chile nitrate for the manufacture of explosives. We agree with the Committee that a wise policy in regard to defence can well go hand in hand with a sound economic policy.

The Committee recommends that:—

1. The calcium cyanamide process should be established in Great Britain without delay, either by private enterprise (supported, if necessary, by the Government) or as a public work, and that the scale of manufacture should be sufficient to produce 60,000 tons of cyanamide per annum,

equivalent to about one-eighth of the present home production of ammonium sulphate, the necessary water-power being obtained in Scotland, or from a large steam-power station.

2. That the synthetic ammonia (Haber) process should be established forthwith on a commercial unit scale and extended as rapidly as possible, as a post-war measure up to a minimum manufacturing scale of 10,000 tons of ammonia (equivalent to 40,000 tons of ammonium sulphate) per annum; and it suggests that the factory at Billingham-on-Tees, which the Government, in 1918, decided to erect, mainly for the manufacture of ammonium nitrate, might be utilised for the purpose.

3. That an ammonia oxidation plant should be established in conjunction with the synthetic ammonia factory on a scale sufficient to produce 10,000 tons of 95 per cent. nitric acid, or its equivalent in nitrates, and that the plant should be designed to utilise either synthetic or by-product ammonia.

4. That steps should be taken with the view of conserving and increasing the output of combined nitrogen from existing by-product ammonia industries, of securing the better utilisation of the national resources in coal, and of reducing the consumption of *raw* coal as fuel. (The various steps which it is suggested should be taken to secure these ends are set forth.)

5. The Committee further recommends that certain nitrogen fixation processes—*e.g.* the Häusser process, certain cyanide processes, and sulphate recovery processes—should be systematically investigated on a small works scale. It understands that the question of low-temperature carbonisation of coal is being investigated by the Fuel Research Board. It suggests that the researches on the nitrogen problem initiated during the war should be continued under the auspices of the Government for the general benefit of the country; and that the results of the researches carried on up to the present should be edited, and published at the earliest possible moment, subject to such reservations as may be considered necessary by the Government, members of the Research Staff of the Munitions Inventions Department being allowed to communicate to scientific societies the details of their work, subject to such reservations as may be considered necessary by the Government.

The Committee concludes its report with a recommendation that a co-ordinated policy should be framed by an Imperial authority for safeguarding the future nitrogen requirements of the Empire. It points out that, so far as the United Kingdom is concerned, nitrogen fixation and allied industries will constitute a new "key" industry. The Committee is of opinion that the initiation and development of the industry will require the active support of the Government.

It is not to be anticipated, in the present state of the political position, and in view of the large arrears in its programme of reconstruction with which the Government is faced, that any immediate consideration will be given by it to the Committee's recommendations, or that any practical steps will be taken to give effect to them beyond attempting to dispose of the Billingham-on-Tees property, and possibly permitting the Research Section of the Munitions Inventions Department to continue its investigations. We understand that negotiations on behalf of an important group of firms are in progress for the purchase of the Billingham works. But whether the Haber process or the American modification of it will be carried on there remains to be seen. Within the last few days it has been announced that an influential financial syndicate is about to establish a factory in the neighbourhood of Maryport, West Cumberland, to work the Georges Claude process, which is already in operation at Montereau, near Fontainebleau, by which it is claimed that the production of ammonia is increased fourfold as compared with the Haber process, as worked by the Badische Anilin & Soda-Fabrik at Oppau, near Ludwigshafen. The first unit of the synthetic plant will be of sufficient size to produce the equivalent of 50,000 tons of sulphate of ammonia per annum. If this consummation is reached it will go far to solve the problem which the Nitrogen Products Committee has been considering with such thoroughness and care during the last three or four years.

EXPLORATION IN TIBET AND NEIGHBOURING REGIONS.[1]

COL. LENOX CONYNGHAM has done right good service to the science of geography by compiling in one comprehensive volume the complete story of the early exploration of the great Tibetan uplands before that land of mystery and romance became attractive to European geographers, who evolved the map of Tibet as we now know it on a more scientific basis. It would indeed have been useful if the brief preface to the volume had included a somewhat more detailed explanation of the means and the methods employed by these early native surveyors in those amazing journeys which gave us the first (and sometimes the last) outlines of Tibetan geography, and laid the foundations for subsequent map superstructure. The narratives of the individual explorers are given in chronological order, commencing with the journey of Pandit Nain Singh, in 1865, from Nepal to Lhasa, and terminating with that of Atma Ram, who accompanied our first adventurer, Capt. (now Sir Hamilton) Bower, when he traversed Tibet from Kashmir to China in 1891–2, following a route which was not very far removed from that of Nain Singh in earlier days. Then for the first time were the eyes, not only of geographers, but also of archæologists, opened to the immense wealth of scientific and historical knowledge which was to be gathered in that remote part of Asia.

[1] "Records of the Survey of India." Vol. viii. (in two parts). Part i., "Exploration in Tibet and Neighbouring Regions, 1865–79." Pp. xi+213+charts. Part ii., "1879–92." Pp. xi+215–411+charts. (Dehra Dun: Office of the Trigonometrical Survey, 1915.) Price 4 rupees or 5*s*. 4*d*. each part.