Nitrous Oxide.

In preliminary experiments the gas was prepared in the laboratory, at as low a temperature as possible, from nitrate of ammonia, or was drawn from the iron bottles in which it is commercially supplied. The purification was by passage over potash and phosphoric anhydride. Unless special precautions are taken the gas so obtained is ten or more milligrams too light, presumably from admixture with nitrogen. In the case of the commercial supply, a better result is obtained by placing the bottles in an inverted position so as to draw from the *liquid* rather than from the *gaseous* portion.

Higher and more consistent results were arrived at from gas which had been specially treated. In consequence of the high relative solubility of nitrous oxide in water, the gas held in solution after prolonged agitation of the liquid with impure gas from any supply, will contain a much diminished proportion of nitrogen. To carry out this method on the scale required, a large (11-litre) flask was mounted on an apparatus in connection with the lathe so that it could be vigorously shaken. After the dissolved air had been sufficiently expelled by preliminary passage of N_2O, the water was cooled to near 0° C. and violently shaken for a considerable time while the gas was passing in large excess. The nitrous oxide thus purified was expelled from solution by heat, and was used to fill the globe in the usual manner.

For comparison with the results so obtained, gas purified in another manner was also examined. A small iron bottle, fully charged with the commercial material, was cooled in salt and ice and allowed somewhat suddenly to blow off half its contents. The residue drawn from the bottle in one or other position was employed for the weighings.

Nitrous Oxide (1896).

Aug. 15	Expelled from water	3·6359
,, 17	... ...	3·6354
,, 19	From residue after blow off, valve downwards	3·6364
,, 21	,, ,, valve upwards ...	3·6358
,, 22	,, ,, valve downwards	3·6360
	Mean	3·6359

The mean value may be taken to represent the corrected weight of the gas which fills the globe at 0° C. and at the pressure of the gauge (at 15°), corresponding to 2·6276 for oxygen.

One of the objects which I had in view in determining the density of nitrous oxide was to obtain, if it were possible, evidence as to the atomic weight of nitrogen. It may be remembered that observations upon the density of pure nitrogen, as distinguished from the atmospheric mixture containing argon which, until recently, had been confounded with pure nitrogen, led [1] to the conclusion that the densities of oxygen and nitrogen were as 16 : 14·003, thus suggesting that the atomic weight of nitrogen might really be 14 in place of 14·05, as generally received. The chemical evidence upon which the latter number rests is very indirect, and it appeared that a direct comparison of the weight of nitrous oxide and of its contained nitrogen might be of value. A suitable vessel would be filled, under known conditions, with the nitrous oxide, which would then be submitted to the action of a spiral of copper or iron wire rendered incandescent by an electric current. When all the oxygen was removed, the residual nitrogen would be measured, from which the ratio of equivalents could readily be deduced. The fact that the residual nitrogen would possess nearly the same volume as the nitrous oxide from which it was derived would present certain experimental advantages. If, indeed, the atomic weights were really as 14 : 16, the ratio (x) of volumes, after and before operations, would be given by

$$\frac{2{\cdot}2996 \times x}{3{\cdot}6359 - 2{\cdot}2996 \times x} = \frac{14}{8},$$

whence

$$x = \frac{7 \times 3{\cdot}6359}{11 \times 2{\cdot}2996} = 1{\cdot}0061,$$

3·6359 and 2·2996 being the relative weights of nitrous oxide and of nitrogen which (at 0° C. and at the pressure of the gauge) occupy the same volume. The integral numbers for the atomic weights would thus correspond to an expansion, after chemical reduction, of about one-half per cent.

But in practical operation the method lost most of its apparent simplicity. It was found that copper became unmanageable at a temperature sufficiently high for the purpose, and recourse was had to iron. Coils of iron suitably prepared and supported could be adequately heated by the current from a dynamo without twisting hopelessly out of shape; but the use of iron leads to fresh difficulties. The emission of carbonic oxide from the iron heated in vacuum continues for a very long time, and the attempt to get rid of this gas by preliminary treatment had to be abandoned. By final addition of a small quantity of oxygen (obtained by heating some permanganate of potash sealed up in one of the leading tubes) the CO could be oxidised to CO_2, and thus, along with any H_2O, be absorbed by a lump of potash placed beforehand in the working vessel. To get rid of superfluous oxygen, a coil of incandescent copper had then to be invoked, and thus the apparatus became rather complicated.

It is believed that the difficulties thus far mentioned were overcome, but nevertheless a satisfactory concordance in the final numbers was not attained. In the present position of the question no results are of value which do not discriminate with certainty between 14·05 and 14·00. The obstacle appeared to lie in a tendency of the nitrogen to pass to higher degrees of oxidation. On more than one occasion, mercury (which formed the movable boundary of an overflow chamber) was observed to be attacked. Under these circumstances I do not think it worth while to enter into further detail regarding the experiments in question.

The following summary gives the densities of the various gases relatively to air, all obtained by the same apparatus.[1] The last figure is of little significance.

Air free from H_2O and CO_2	1·00000
Oxygen	1·10535
Nitrogen and argon (atmospheric) ...	0·97209
Nitrogen	0·96737
Argon	1·37752
Carbonic oxide	0·96716
Carbonic anhydride	1·52909
Nitrous oxide	1·52951

The value obtained for hydrogen upon the same scale was 0·06960; but the researches of M. Leduc and of Prof. Morley appear to show that this number is a little too high.

THE NORTHAM PEBBLE RIDGE.

THE pebble ridge at Northam is one of the most remarkable examples of littoral drift to be found anywhere round the coast of this country.

It is thus graphically described by Charles Kingsley in "Westward Ho!":—"On this pebble ridge the surges of the bay have defeated their own fury by rolling up in the course of ages a rampart of grey boulder stones, some two miles long, as cunningly curved and smoothed and fitted as if the work had been done by human hands, which protect from the high tides of spring and autumn a fertile sheet of smooth alluvial turf. . . . It was dead calm and yet the air was full of sound—a low deep roar which hovered over downs and broad, salt marsh and river, like the roll of a thousand wheels, the tramp of endless armies, or—what it was—the thunder of a mighty surge upon the boulders of the pebble ridge. . . . The spirit of the Atlantic storm had sent forward the token of his coming in the smooth ground swell which was heard inland two miles away. To-morrow the pebbles, which were now rattling down with each retreating wave, might be leaping to the ridge top and hurled like round shot far ashore upon the marsh by the force of the advancing wave fleeing before the wrath of the western hurricane."

The particulars contained in the following description of this ridge have been obtained during a recent inspection of this part of the coast of North Devon, and from information obtained from the coastguard and others living in the locality.

The boulders which compose the ridge have been derived from the cliffs which surmount the shore of Barnstaple Bay, from Hartland Point to Westward Ho, a distance along the coast of about thirteen miles. These cliffs rise to a height of 350 feet above the level of the sea between Hartland Point and Clovelly, the height then gradually diminishing towards Westward Ho, where they terminate. They are composed principally

[1] Rayleigh and Ramsay, *Phil. Trans.*, vol. clxxxvi. p. 190, 1895.

[1] *Roy. Soc. Proc.*, vol. liii. p. 148, 1893; vol. lv. p. 340, 1894; *Phil Trans.*, vol. clxxxvi. p. 189, 1895; *Roy. Soc. Proc.*, vol. lix. p. 201, 1896.

of hard carboniferous grit of a dark slate colour, except at the western end, where this rock is interspersed with red sandstone and shale and a few pockets of glacial drift. The beach between the foot of the cliffs and low water consists of rocks cut and furrowed by the action of the sea in perpetually rolling about the large boulders which lie along its surface.

Beyond Westward Ho the estuary of the Taw and the Torridge commences, consisting of a vast expanse of sand bounded by sand dunes.

Large fragments of rocks have in the course of ages been dislodged from the cliffs, the remains of which perpetually rolled about by the waves of the sea during high tides, which here rise to a height of 27 feet, have acted as instruments for grinding their fellows, and battering the cliffs, and so producing the rounded boulders which now strew the beach throughout its whole length for several miles, and a portion of which, drifted along the shore of the bay, have become finally heaped up in the Northam pebble ridge.

In some parts of the cliff indents of considerable size have been cut out, and across these the boulders have collected, and been thrown up into ridges and banks. At Abbotsham, about twelve miles from Hartland, there is such a bank, the top of which is 9 feet above high water of spring tides. This ridge or bank is about 160 feet wide, the boulders of which it is composed varying in size at the top from about 12 inches in length by 4 inches in diameter to pebbles 3 inches in diameter, the largest boulders weighing about 12 lbs., those at the foot reaching to a length of 2 feet and weighing about 70 lbs. Notwithstanding the large size of the boulders of which the bank is composed its sea face is shaped into a ridge and hollow, similar to other pebble ridges, the position of which varies according to the height of previous spring tides. The pebbles left on the shelf or hollow at the spring-tide level average a smaller size than those at the other part of the bank.

The boulders scattered along the beach all lie above the level of low water of neap tides. The general direction of movement is eastwards, but the boulders follow the line of the coast and the set of the flood tide. This direction varies round the bay from eastward to south-east, east again and then north-east, and finally south-east. The direction of the wind which drives the heaviest sea into the bay is from the north-west.

The Northam pebble ridge commences at the termination of the cliffs, and runs in a north north-easterly direction for upwards of two miles across a low flat plain which is below the level of high tides, until it falls into some hummocks of blown sand. It thus forms a natural embankment enclosing a tract of 900 acres of sandy and alluvial grass land which is used for grazing purposes, and also as golf links. After running along the foot of the sand hills for a short distance the pebble bank turns sharply to the south-east up the course of the outfall of the two rivers, the boulders diminishing in size to pebbles and coarse sand. There is an outlying bed of boulders, known as the Pulley, situated some distance from the bank, on the edge of the low-water channel of the river, but these appear to be a fixed deposit which neither increases nor diminishes in size.

The ridge is approximately 180 feet wide at the base and 20 feet high, the top being about 25 to 30 feet wide and 6 feet above high water of spring tides. The boulders on the top of the bank vary in size from about 12 inches in length by 6 inches in diameter to pebbles an inch in diameter, the average size being about 8 inches in length by 4 inches in diameter, the largest being about 12 inches long and weighing from 40 to 50 lbs. At the foot of the bank are to be found boulders measuring from 15 to 18 inches in length and weighing from 100 to 150 lbs. The size of the boulders does not vary much throughout the length of the bank. The greatest collection of small stones appears to be on the shelf or hollow at the level of spring tides, where the pebbles vary from about half an inch to four inches in diameter. Some of the larger boulders have been drifted quite to the far end of the bank.

The boulders consist entirely of the same description of slate-coloured carboniferous grit as the cliffs from Hartland to Abbotsham are composed of, and there can be no doubt that they have drifted from this part of the coast. At the commencement of the ridge there are fairly numerous samples of shale and red sandstone pebbles from the cliffs between Westward Ho and Abbotsham, but these gradually disappear further along the ridge, the softer rock of which they are composed evidently not being able to withstand the constant grinding process produced by the wave action of the tides and wind. From the foot of the bank to low water the beach is covered with sand, which dries from a third of a mile at the south end to three-quarters of a mile at the northern end.

There is a very slow but continuous drift or movement of the boulders along the bank northwards. The progress of the ridge being stopped by the sand hills, the bank has bifurcated at this point, a new or double bank now forming, a circumstance which has occurred within the knowledge of those who have known the bank all their lives.

The boulders composing the ridge are in perpetual motion during the time that the bank is covered by the sea at spring tides. Even in calm weather in summer the whole face of the bank is continually changing under the influence of the wave action of the flood and ebb tide, which is of sufficient force to cause the movement of even large boulders. Observers who have carefully watched this movement and marked individual stones find that they are never in the same place two tides running, and each spring tide leaves its impress in a hollow and ridge at high-water mark.

In heavy on-shore gales these ridges and hollows are obliterated, and the face of the bank is pulled down seaward, the extent to which this is carried depending on the force and duration of the gale. After the storm, and when the height and force of the waves have subsided, the pebbles begin to move back again ; the contour of the bank becomes more steep, and is soon restored to its normal condition.

During the winter at the end of 1896 there was a succession of westerly gales, culminating in a very heavy gale from the north-west. The bank was torn down and so lowered that the waves broke over it and inundated the enclosed land. Some of the largest boulders were thrown over the top of the ridge and hurled a considerable distance inland, where they now remain as a witness to the force of the gale. The disturbance of the boulders was so great under the action of the waves, that after the gale it was found that the base of the bank was moved ten yards inland, the clay bed on which it had rested previously being exposed. A somewhat similar movement took place during a gale about twenty years previously.

The peculiarity of this pebble ridge, and the way in which it differs from ordinary shingle banks, is in the large size of the boulders drifted along the coast, and heaped up by the action of the waves and tides. W. H. WHEELER.

RANDOM SELECTION.

THIS memoir[1] is the first of a series dealing with the problem of selection, namely the measurement of the changes in the characters of a race, when selection has acted upon any one, two, or more of them. The problem mathematically differs considerably according to the nature of the selection. But in all cases the general result is the same, the selection of any organ, whether by size, variability, or correlation with other organs, changes the sizes, variabilities, correlations of all other organs, whether directly correlated with the first organ, or only indirectly correlated with it owing to correlation with other organs which are correlated with the first organ. (A and C may have no correlation with each other, but both be correlated with B, *e.g.* two parents in the absence of sexual selection and their offspring.) The chief types of selection which have to be treated independently are :—

(i.) *Random Selection* or *Sample Selection.*—The isolation of a group out of a larger population. This will generally have characters divergent from those of the general population, but which form in themselves a correlated system of divergences.

(ii.) *Epidemic Selection.*—Selection which takes place so quickly that the growth or reproduction of the population may be neglected. For example, a severe winter or a pestilence.

(iii.) *Auxetic Selection*, or long-continued selection which allows during its action for growth, but not for reproduction. For example, diseases of childhood.

(iv.) *Gonimic Selection*, or long-continued selection which allows during its action for reproduction. For example, physical and mental qualities, pressure of other populations. These forms of

1 Contributions to the Mathematical Theory of Evolution. IV. On the Probable Errors of Frequency Constants, and on the Influence of Random Selection on Variation and Correlation, by Karl Pearson and L. N. G. Filon. (Royal Society, Nov. 25, 1897.)