PROCEEDINGS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

VOL. II.

MDCCCXLIV—MDCCCXLVIII.

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PLATES IN VOL. II.

ERRATUM.

Page 136, line 23, for *at neither*, read *out in their*.

PROCEEDINGS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

FORTY-THIRD SESSION.

6th November, 1844.—Dr. Thomas Thomson, *the* President, *in the Chair.*

Messrs. Dawson and Griffin were appointed to audit the Treasurer's accounts for last year. Dr. Watt stated that the Statistical Section had held a correspondence relative to an improvement in the Scottish system of registration, but as yet without any satisfactory result. The President laid on the table Mr. Graham Hutcheson's recent work "On the Nature and Cause of the Diurnal Oscillations of the Barometer," for which, on the motion of the President, the thanks of the Society were given. It was agreed that a Conversational Meeting should be held on the 13th instant.

The Vice-President having taken the chair, the President read a Biographical Notice of the late Professor Wallace of Edinburgh.

13th November, 1844.—*Conversational Meeting.*

This Meeting was held in the Assembly Rooms, and was attended by upwards of three hundred individuals. Various models and articles of manufacture were exhibited in various parts of the room. Models of the Atmospheric Railway and Air Gun made by Mr. James Laing, attracted particular attention. The following account of Lewis was then given:—

I.—*Notice of a Visit to the Island of Lewis, by* James Smith, Esq.

Mr. Smith stated, that Lewis was the most northerly of the western group, and, though it was generally spoken of as a distinct island, it was, nevertheless, connected with Harris by a narrow neck of land, from which circumstance they were sometimes called the Long Island. The rocks were of the primitive, or granitic formation, and the surface of the country had, altogether, a very peculiar aspect. It appeared that the peat moss had begun to be formed immediately upon the granite rock, for below the moss there is a rough gravel, mixed with small quantities of clay, and hardly such a thing as a distinct alluvial deposit. Generally speaking, the subsoil was a rich gravel, and there were no remains of trees, or coarse grass; nothing but mossy plants.

One might be led to suppose that the country was a dead flat, but it was not so; for in Lewis there were interspersed beautiful slopes and valleys, through the centre of which various rivulets made their way. The whole surface was covered with bog from two to ten feet, and in some places twenty feet in depth, although the general depth might be stated at about four feet. Upon the surface of this bog nothing was grown but bent grass and stunted heath, and on the whole it had a very dreary aspect. Not a tree was to be seen; all around there was the brown bent, and in the after part of the year, when it became decayed, the appearance was peculiarly bleak and desolate indeed. The island was not without its beauties, notwithstanding, for the sea lakes which indented the coast, and the fresh-water lochs in the interior, imparted to it rather an interesting effect.

The most remarkable thing connected with the island, however, was this,—that the slightest improvement did not appear to have gone on for a very long period, and the people were very much in the same position that the inhabitants of this country occupied a hundred years ago. They still use the ancient distaff (*figs.* 2 and 3), although it was a hundred years since it had been supplanted in this country by the Dutch wheel, and nothing amused him more than to have seen the women coming from Stornoway, carrying with them the spinning-wheels, to commence what they conceived to be a novel and vast improvement. He might mention that the advantages which the best machinery of the day possessed over the distaff, were as a thousand to one; yet, by means of the distaff, these people managed to manufacture their clothing, which, under the circumstances, was very comfortable.

Their cultivation of the soil was as primitive as their manufacture of cloth. Their holdings were very small; the island had been for fifty or sixty years in the possession of proprietors who had no money to improve, or with which to encourage the people; and to this he in a great degree attributed the primitive state in which he found them. He also attributed it partly to the fact, that the Gaelic language was almost universally spoken, and the inhabitants, therefore, could have very little intercourse with the low country. There was no such thing known as the young men going away from the island to push their fortune, and returning to it afterwards with wealth. From Stornoway, it was true, a number had gone out and distinguished themselves, but this was the exception. Still the inhabitants were not deficient by nature. They were a social people in their own way; they were kind to their children, kind to each other, and kind to their animals. He would say, that they were a people of intelligence; and when you entered upon any subject which they understood, it would be found that their intellects were as acute as those of other people. With regard to their habits of industry, they were a hard-working people, and ready to exert themselves when they had an opportunity of doing so; but, from the circumstances under which they were placed, they were not able to do so with advantage. Their possessions, as he had said, extended only to a few acres each, and the people were congregated in villages or little towns, instead of being dispersed in farms over the face of the country, as was the case elsewhere. They had, therefore, their little portions of land around for cultivation, and a right to grazings in the neighbourhood.

In regard to their houses, they did not live in dwellings such as were seen in the mainland, for they were more like huts than any thing else. The walls were from six to eight feet thick, composed of bog in the centre, and faced with stone inside and out. There was sometimes only one apartment, but generally two, and under the same roof the people lived and kept their cattle. There was this distinction, however, viz., a fall of eighteen inches from the apartment in which the family lived to the adjoining one in which the cattle were kept. This might seem to some to be rather an odd arrangement, but the people themselves considered that there were points in it which contributed to their comfort. The room in which the cattle were kept was the entrance one, and as the air passed through it, it came into the adjoining portion of the house appropriated to the family in a warm state. Where ponies were kept, an outer hall or shed, beyond the cattle apartment, was reared for their accommodation. Some of the better houses had a division wall, which separated the cow-house from the family apartment, but generally this was not the case. Most people would think it strange to live along with their cattle, but the people of Lewis had different notions on this subject, and when shut up in the long winter nights, they considered it comfortable to have the beasts in the next apartment, to hear them, and see their motions, and occasionally to supply them with food. One peculiarity in the building of their houses was, that the roof was within the wall, instead of projecting beyond it; and in this way he had seen something like a series of terraces, extending over half a town. One use of them was, that when the children became troublesome, or the mother was more than usually busy, the children were disposed of on these terraces, or high places, and it was quite amusing to see the little creatures looking down over the wall at what was going on below. The parents, however, did all this in the most kindly manner. They have done all they can to cultivate their little possessions in the best manner. Their cultivated portions are those from which the peat has been cut away; they then come to the gravel, and gather soil from one part to add to another. Two thirds are taken from one part and added to another third, and thus a soil is formed; but in winter a complete pool is formed between these ridges of soil. They have done nothing in the way of draining, they have never attempted to penetrate the hard subsoil, which is often steeped in water. They have no system of winter ploughing, but just move the land immediately before planting the potatoe crop, or sowing the seed, and the only preparation they made was that of sometimes pulling the weeds in the summer season.

He would now describe to them some of the implements in use amongst this primitive people. The Cascrome (*fig.* 1), is an instrument with a sole about fifteen or eighteen inches in length, thick behind, and sharp in front; the latter, being the part which first penetrates the soil, is shod with iron. It is pushed forward by means of a long handle fixed into it, and also by a pin attached to the heel of the sole or sock, for the foot of the labourer. A more unlikely implement to have the name of a plough, it is scarcely possible to conceive. The people lay the land over in furrows, by successive movements of hand and foot, but of course the line is not drawn in a continuous form. When two of the neighbours have a pony each, they occasionally use another kind of plough, with only one stilt, and the beam of which rests on the ground, *fig.* 4. The great difficulty in providing their implements was the scarcity of timber, of which none grew in the island, and they had consequently to send to the mainland for it. As a proof of its value, he might mention that the shaft or handle of the Cascrome (which is a piece of wood about the size of a broomstick) would cost 3s. 6d.

From the scantiness of the soil, they did not, of course, produce heavy crops; but here he would instance the ingenuity of the people in making the best of their position. He had seen as good produce of potatoes, barley—or rather bear or bigg—for the new kinds of barley were unknown to them—and oats, as in any part of the country, and they managed to produce these results by the skill with which they prepared the manure. It was efficacious, in the first instance, in the raising of potatoes, and afterwards it produced a fine barley crop. When the barley was ripe, they did not cut it as was the case elsewhere, but pulled it up by the roots, and tied the whole up in sheafs. When it was "won" and ready for the stack, the straw was then cut from the sheafs below the band, which had this advantage, that it enabled them to stow away the grain in small bulk—a matter of no small moment in a country exposed to so much wind and rain. After the grain itself had been thus preserved, they took the straw which had been cut from it, and placed it on the roofs of their houses. They

THE CASCROME.

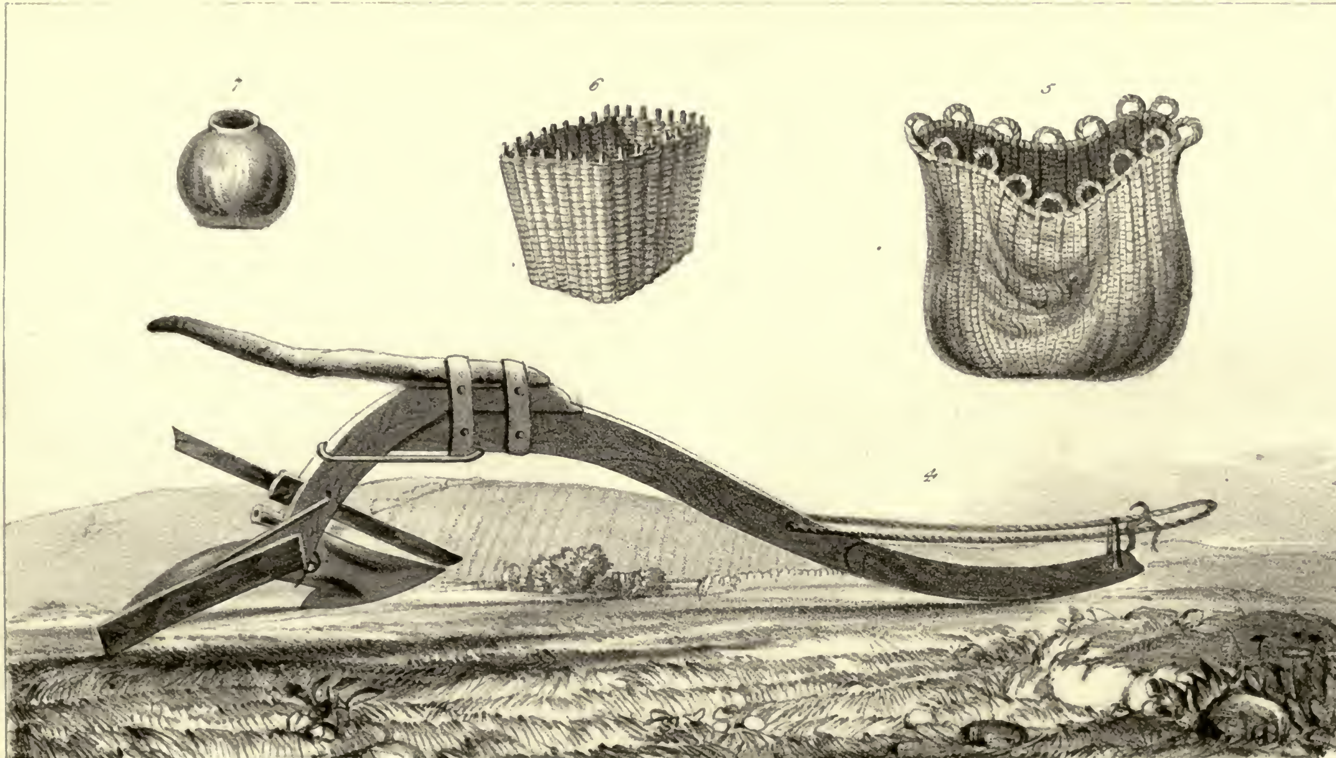
2

THE REEL

3

THE DISTAFF

G. Buchanan, Delt Maclure & Macdonald, Lith.



G. Buchanan Delt

Maclure & Macdonald, Lith.

LEWIS PONY PLOUGH.

laid it loosely on, just as the farmers here spread it over the top of a stack, and then tied it down with ropes spun from the heath. In this position it was exposed to the smoke of their peat fires. He might here mention, that the fire was placed in the middle of the room, and there were no chimnies; but instead of them, a number of holes were ranged all around the top of the side wall. When the smoke ascended, therefore, as it did by means of its lightness, and a portion of it was forced back, it escaped by means of these holes. A great deal of it, however, made its way up through the straw on the roof, and when approaching one of these little towns, he could compare its appearance to nothing more likely than that presented by the smoke rising from a cluster of heated grain stacks. This straw became very valuable, from the great condensation of ammonia and other products which took place in it. The people of Lewis planted their potatoes without any manure whatever; but when the plant had got up to the length of two or three inches, a general unroofing of the houses took place, and the straw which had been preparing there all the season was thrown upon the drills; it was rarely covered up, excepting in windy weather, when a slight sprinkling was put upon it to prevent its being blown away. This manure penetrates the soil immediately, and the potatoes forthwith come up with the greatest luxuriance. Indeed, if they were to scatter guano upon the soil, the effects would not be more rapid or complete than those produced by this prepared straw. This certainly evinced great ingenuity on the part of these people, who, from the difficulties of their position, were driven to it as the only means of preparing manure. He had no doubt, indeed, that it might lead to valuable results in the agricultural practice of more favoured districts. The people of Lewis, however, had another kind of manure than that described; they had the manure which was produced from their cows, and he might here mention that in their care of it they evinced a degree of intelligence superior to that of farmers of much higher pretensions, for they kept it constantly covered up, and each and all joined in the opinion that if it was exposed it lost, to a great extent, its efficacy. When the manure, therefore, was taken out of the house for one crop, they immediately commenced to accumulate for the next, and thus they kept adding to its bulk, till it was needed for the potatoes or barley. It might seem strange that the people should live in the next apartment to so much decaying matter; but the people feel no inconvenience from it. He might mention, however, that at the time the manure was taken out fever often prevailed amongst the people, which he could only attribute to this cause. Some of the best agriculturists were about to follow this plan of keeping the manure constantly covered up; he did not say that they should live in the same house with it, but it was of great moment that the manure should be constantly under cover.

In Lewis they followed a strict rotation of cropping. They had first potatoes, then barley or bigg, and then oats—constituting a three years' shift. According to this rotation they had grown their crops for 100 years, and one might naturally suppose that their lands would be worn out by it; but this was not the case, for they had generally good crops, and last year it was an extraordinary one. There had been inhospitable seasons, certainly, in which the crops entirely failed, and great distress followed; but generally speaking, their crops were excellent. The potatoes were good; and as to the barley, though dark in the straw, he never saw it in any country present in a more marked manner that golden appearance which indicated a healthy yield. He could not say so much for the oats; they had a fancy for the black oats, but in this country the white variety was considered preferable. On the whole, there was no doubt that if these people were properly directed in the best modes of cultivation, they would, with their habits of industry, make rapid progress. He trusted that happy days were yet awaiting them, for they had now got a gentleman connected with them who would devote his money to work out the improvement of their country, and otherwise promote their welfare; and though they were a hundred years behind their brethren on the mainland, they would advance with railway speed. On their shores there were millions of tons of shell-sand, which was so nicely pulverised that it could be at once applied to the soil. It would, no doubt, be much improved were it calcined or burned and mixed; but even taking it in its native state, great advantage would be derived from its application to the ground. There was no lime or coal, but the want of the former would be made up by this shell-sand if they could only get easily at it. It lay among the perpendicular rocks around the island; and as there were no roads, the difficulty of procuring and transporting it would be very great. When the Roads were made, however, means would be taken by which the inhabitants would avail themselves of these deposits, and they would form a material element in fertilising the soil. So much for the agriculture of Lewis.

As to their manufactures, he might state that they made their own dishes or vessels from the clay found amongst the granite gravel. They fashioned the vessel merely with the finger and thumb; and the strength and thinness with which they were made, proved the quality of their clay. They turned over the neck or mouth, and by putting a cord, or rather a leather thong, round it, they were enabled to carry them from place to place, containing water or milk; and they also stood the heat requisite to boil their contents when placed on the fire, *fig.* 7. They also made their creels for carrying out their manure, and for other uses; and when he showed one of them, the audience would be surprised to hear they were made of the stem of the dock, or "docken," *figs.* 5 and 6. So much was this plant prized amongst them, that when it grew between the possessions of two farmers, the docks were carefully divided between them. There was not a willow in the island; and the dock, therefore, was very much prized for its usefulness. They answered for the women when they went to market, as well as for carrying potatoes and manure. Another mode of the people of Lewis was that of feeding their cows on sea-ware. It was just the dulse or tangle, which they had often seen sold on the streets of Glasgow, and it was no unusual thing, when a woman went out to milk the cows, to take some of this dulse or tangle, which the animal consumed with great satisfaction when the process of milking was in progress. The cows often sought for it themselves on the sea-side, especially in seasons when grass was scarce. There were some seasons, indeed, when they almost entirely lived upon it.

At one time, as they would be aware, a large revenue was drawn from sea-weed, for converting into kelp; but from the various changes which he need not dwell upon, it had fallen in value from about £20 to £2 10s. per ton. It did not, therefore, now pay for the manufacture of kelp, and it was therefore better to apply it to the soil. Forty tons of sea-ware were equal to one ton of kelp, and twenty tons of this sea-ware was quite enough to manure an acre; this was 25s. for manuring an acre, and he had no doubt this sea-ware would come more and more into general use for the purposes of cultivation.

Mr. Smith then exhibited a large bag in use in Lewis, which was made of the stem of the bent grass, and spun in the long winter nights; they were used for keeping the corn in, and carrying such portions of it to market as they were able to spare for sale. He might state that there was only one distillery on the island, which took up all the surplus of the barley crop.

Mr. S. stated that the population extended to 17,000 souls, and there were 270,000 acres of land, which, if improved as it might be, would maintain twice the number of people in more comfort than they were at present. He hoped that the period of this improvement was not far distant, and that when they went to visit Lewis they would find it a green pastoral land, instead of a dreary waste.

20*th November*, 1844.—*The* President *in the Chair.*

On the motion of Mr. Liddell, seconded by Mr. Crum, the thanks of the Society was given to the following parties, not being members of the Society, who had contributed to the exhibition at the Conversational Meeting on the 13th:—Mr. Robert Thom, Her Majesty's Consul at Ningpo, the Committee of the Mechanics' Institution, Mr. John Findlay, Mr. James Brown, Mr. James Allan, sen., Dr. Smith of Crutherland, Mr. A. Burton, Mr. S. P. Cohen, and Mr. John Buchanan: and likewise to the Committee, for their very effective and satisfactory arrangements at the Meeting. The Treasurer then presented his accounts for the past year, which showed a balance in favour of the Society of £138 15s. 1½d.

The meeting then proceeded to the forty-third annual election of Office-Bearers, when the following were chosen:—

PRESIDENT.—PROFESSOR THOMAS THOMSON, M.D., F.R.S., L. & E., M.R.I.A., &c.

VICE-PRESIDENT, WALTER CRUM, F.R.S.	SECRETARY,.........ALEXANDER HASTIE.
TREASURER,........ANDREW LIDDELL.	LIBRARIAN,.........THOMAS DAWSON.

COUNCIL.

A. ANDERSON, M.D.	PROFESSOR GORDON.	WILLIAM MURRAY,
J. H. BALFOUR, M.D.	WILLIAM GOURLIE, JUN.	JOHN STENHOUSE.
A. BUCHANAN, M.D.	J. J. GRIFFIN.	R. D. THOMSON, M.D.
J. FINDLAY, M.D.	ALEX. HARVEY.	ALEX. WATT, LL.D.

Professor Gordon read a paper on the most economical use of steam, which has been printed in the form of a pamphlet; and Mr. Stenhouse exhibited a yellow substance from India, called Purree, from which Indian Yellow is prepared; likewise a specimen of glass silvered by the new process.

4th December, 1844.—*The* PRESIDENT *in the Chair.*

The following Members were admitted:—Messrs. Alex. Warren Buttery, James Allan, sen., George Thomson, Matthew Fairlie, S. P. Cohen, Dr. Henry Böttinger, William Gilmour, jun.

A minute of Council was read, recommending that £50 should be granted for the purchase of books, and the payment of periodicals for the current year. The following papers were communicated by Dr. R. D. Thomson:—

II.—*Experiments with Manures on Potatoes and Turnips.* BY LORD BLANTYRE.

EXPERIMENT I.—On Potatoes—Cow Park of Porton Farm—Soil poor and light—had been subsoiled previous autumn, after being drained and ploughed for oats from old grass in 1842. One drill, each plot for experiment, with each different rate of manure, being about one-thirtieth of an acre.

	Bolls.	Pecks.	
No. 1.—Dung at the rate of 30 tons per acre,	47	10	per acre.
2.—Nothing, ...	10	2	"
3.—3 cwt. Guano per acre, . . .	21	1	"
4.—4 cwt. " . . .	25	12	"
5.—6½ cwt. " . . .	34	6	"
6.—7½ cwt. " . . .	31	4	"
7.—8 cwt. " . . .	34	6	"
8.—Dung at the rate of 30 tons per acre,	43	12	"

N.B. The bolls are Renfrewshire bolls, of 5 cwt. per boll—there are 16 pecks in a boll.

N.B. The wheat of this year (1844) appears inferior on the portion of the field where the above experiments with Guano were tried.

EXPERIMENT II.—On Yellow Turnips—South-west field of Porton—Soil light. This field was not in very poor order, from having been in potatoes, dunged in 1841, wheat and barley in 1842. The other parts of the field not experimented on were dressed with bones, 30 bushels per acre, with 5 tons of ash dung. The crop was good.

	Tons.	Cwt.	Qrs.	
No. 1.—Bones and Dung as above, (30 bushels bones, 5 tons dung,) . . gave	23	17	0	per acre,
2.—3 cwt. Guano, ...	26	2	2	"
3.—4 cwt. "	27	6	2	"
4.—5 cwt. "	28	16	2	"
5.—6 cwt. "	29	8	0	"
6.—7 cwt. "	31	9	0	"
7.—8 cwt. "	27	6	2	"
8.—9 cwt. "	28	16	2	"
9.—10 cwt. "	31	0	0	"
10.—Calcined Bones, 30 bush. per acre, .	25	8	0	"
11.— " 45 bush. per acre, .	24	12	0	"
12.—Animal Charcoal, 30 bush. per acre,	25	0	0	"
13.— " 45 bush. per acre,	25	8	0	"

The calcined bones were the riddlings of bones used in a China Manufactory. The animal charcoal was got from some of the Sugar Refiners, called exhausted animal charcoal.

III.—*Analysis of Two Species of Epiphytes, or Air Plants.* By JOHN THOMSON, M.A.

I. *Commelina Skinneri.*—Until about four months prior to the time this plant was examined, it had roots in some earth; but about that time Mr. Murray, of the Glasgow Botanic Garden, cut them all off, and left it hanging on the wall to which it had been trained. I had only 353·05 grains of the young shoots to operate on, so that very great precision cannot be expected in the results. After exposing this quantity on a sand bath to a heat of about 280°, there remained 71·91 grains of the dried plant, so that the difference, which must have been almost wholly water, amounted to 281·14 grains. The dried portion was then burned, and it left a residue of 7·14 grains of ashes, which were now subjected to analysis.

After treating the ashes with water to separate the soluble from the insoluble part, and evaporating the two portions to dryness, there were obtained of matters insoluble in water 4·22 grains, and of soluble substances 3·05 grains, the whole amounting to 7·27 grains, there being thus an excess of ·13 grains.

Muriatic acid was next poured on the insoluble portion, when a violent effervescence took place, and only ·77 grains remained undissolved. By fusing this with carbonate of soda, and adding muriatic acid in the ordinary way, there were found to be ·60 grains of silica. The whole quantity dissolved in muriatic acid was now mixed, and ammonia was added. A precipitate fell, which was boiled with caustic soda to remove alumina. What remained was peroxide and phosph. of iron; it was dried, and found to weigh ·22 grains. The portion dissolved by the caustic soda was precipitated by the addition of muriatic acid, the excess of which was removed by adding carbonate of soda. There were thus found to be ·44 grains of alumina, or phosphate of alumina.

To the washings oxalate of ammonia was added, and after filtering and burning, the precipitate weighed 2·90, which was carbonate of lime.

The next point was to determine the composition of the salts soluble in water. By accident this part of the process was not completely executed. The only constituents which were determined were the sulphuric acid, the potash and the soda, the first of which was found, by precipitating with nitrate of barytes, to weigh ·92 grains. The potash and soda were separated by means of bichloride of platinum and found to weigh respectively ·24 grains and ·94 grains.

The following is a statement of the entire results:—

	grs.		grs.		grs.
Water,	281·14				
Organic Matter,	64·77				
Ashes,	7·14	Soluble in Water,	3·05	Sulph. Acid,	·92
				Potash,	·24
				Soda,	·94
				Chlorine, &c.	·95
		Insoluble in Water,	4·22	Silica,	·60
				Peroxide and Phos. of Iron,	·22
				Alumina, or Phosph. of Al.	·44
				Carb. of Lime,	2·90
Entire plant,	353·05		7·27		

100 parts of the plant would contain—

Water,	79·64
Organic Matter,	18·34
Ashes,	2·02
	100·00

100 parts of the ashes again would contain approximately—

Soluble Salts,	42·72		42·72
Insoluble,	59·10	Silica,	8·43
		Peroxide and Phos. of Iron,	3·08
		Alumina, or Phosph. of Al.,	6·16
		Carb. of Lime,	40·62
	101·82		101·01

II. *Vanilla planifolia.*—The following is the composition of a specimen of the Vanilla planifolia which I examined. Although called an epiphyte, it had roots in some of the pots. It is a very succulent plant, with a small round stem, and alternate petiolated, elliptico-lanceolate, polished leaves:—

Water,	89·06
Organic Matter,	9·84
Ashes,	1·10
	100·00

The ashes were similar in composition to those of the Commelina Skinneri. They contained no alumina, and had a perceptible quantity of phosphoric acid.

Mr. Johnston, of Greenock, described his oxyhydrogen engine.

18*th December*, 1844.—*The* PRESIDENT *in the Chair.*

The following members were admitted:—Messrs. Laurence Hill, jun., Thomas Watson, Alexander Wilson, and Oliver G. Adamson.

Professor Balfour exhibited and described various drawings and specimens of plants belonging to the Pandanaceae or screw-pine tribe.

8*th January*, 1845.—*The* PRESIDENT *in the Chair.*

The following members were admitted:—Dr. John A. Easton, Messrs. James Miller, William Brown, Thomas G. Buchanan, George S. Buchanan, and James Reid Stewart. Professor Gordon read a paper on the Economy of using Steam expansively. The Secretary was directed to acknowledge the following donations:—Dr. Watt's Report on the Vital Statistics of Glasgow; Professor Forbes, of Edinburgh, "On the Transparency of the Atmosphere, and the law of Extinction of the solar rays in passing through it."

22d January, 1845.—*The* PRESIDENT *in the Chair.*

Mr. Robert Barclay was elected a member of the Society. Mr. Johnston read a note on Steam Boilers. The following communication was read:—

IV.—*Abstract of "An Account of a Dredging Excursion in the Frith of Clyde.* By the REV. DAVID LANDSBOROUGH." Read *22d January*, 1845, by WILLIAM GOURLIE, JUN.

IN August, 1844, I had the pleasure of accompanying Mr. Smith of Jordanhill for a few days in a Dredging Excursion, in his yacht, the Raven. On the 13th August, we sailed up the Kyles of Bute. Opposite to Rue-Bodach, the dredge brought up hundreds of *Ophiuræ;* —*O. texturata; O. albida; O. rosularis; O. granulata, and O. Bellis.* There were also a few good specimens of *Emarginula fissura,* and two specimens of the rare *Trochus millegranus.*

That evening, and also next morning, we visited a newer Pliocene deposit discovered at Rue-Bodach and Balnacoolie some years ago, by Mr. Smith and Mr. Sowerby. The shells are deposited in thick clay. The shells found by us were, *Mya truncata, Venerupis virginea, Cyprina Islandica; Nucula rostrata; Pecten Islandicus; Tellina proxima;* and what we valued most, because very rare, *Panopæa Bironæ.*

On the morning of the 14th we visited a vitrified fort discovered some years ago by Mr. Smith, on one of the little islands in the Kyles.

The weather was delightful, but too calm for dredging. A little breeze having sprung up, we had a few hauls. We got a good specimen of *Laomedea dichotoma,* and of *Antennularia antennina* var. *ramosa.* We got, moreover, a fine large specimen of *Brissus lyrifer,* the fiddle-heart urchin, first discovered by Professor Forbes when dredging in the Kyles with Mr. Smith. It was 2½ inches in length, by 2 inches in breadth.

On the 15th we sailed for Lamlash. We had more than enough of wind next morning, but we were able to dredge a little. On *Laminaria saccharina* we got some good specimens of *Lepralia annulata,* first found by me in Britain; we got also *Goniaster Templetoni, Solaster papposa, Comatula rosacea, Uraster glacialis, Echinus sphæra, Echinus miliaris,* and *Echinocyamus pusillus.*

As the steamer in which I was to return home was beginning to send up volumes of smoke, we had time only for another haul. The dredge came up laden with shelly sand. We had not time to examine it, but fortunately I remembered that Mr. Bean of Scarborough had asked me to send him some shelly sand, and I wrapped up a little, which I sent him, reserving a handful of it for myself. As I was not well acquainted with microscopic shells, he has kindly, at my request, named those found in the sand by himself, and also those found by me

The number is very great to be got out of six or seven handfuls of sand. Mr. Bean said that it was the richest he had ever obtained, except from Germany.

Mr. Keddie read the following report from the Botanical Section:—

29th April, 1844.—Dr. Balfour presented specimens of ferns from the Caraccas, and of Fagus Antarctica and Fagus Forsteri (or Evergreen Beech) from Cape Horn; also several botanical publications. Dr. Balfour read an account of several trips in the neighbourhood of Glasgow, last summer, exhibiting specimens of the plants collected.

28th May, 1844.—Mr. Balloch read an account of a botanical excursion to Campsie Glen, on the 30th of April last. In that glen the party gathered Lathrea squamaria. Large quantities of the roots were dug up along with those of the elm, upon which the Lathrea seemed to grow, with the view of investigating into the alleged parasitical nature of this plant, but without enabling the party to arrive at a definite conclusion on the subject. The party thence proceeded to Fin Glen, in the neighbourhood, where they were successful in picking fertile specimens of Equisetum Drummondii. They also found Paris quadrifolia, although not in flower, besides a number of other plants of less note.

25th June, 1844.—Mr. Gourlie read papers communicated by the Rev. Mr. Landsborough, a corresponding member, on Gloiosiphonia capillaris, and Polysiphonia parasitica, for which thanks were voted to the author. Dr. Balfour presented specimens of plants gathered at Lochwinnoch, Muirshiel, Rothsay, Dunoon, and Toward, for the Herbarium.

30th July, 1844.—Dr. Balfour exhibited a number of plants from Ailsa Craig; also a specimen of the Bush rope of the West Indies, from Dr. W. H. Campbell, Demerara. Mr. Gourlie exhibited a ball of agglomerated leaves, from the hermitage near Killin. Mr. Keddie read an account of a Botanical Excursion to the Bass Rock, &c., in company with Professor Balfour, and a party of his summer class. The Section adjourned till the next session of the Society.

The Secretary was requested to acknowledge receipt of Vol. ii. Part 4, of Transactions of the Royal Society of Arts of Edinburgh.

5th February, 1845.—*The* President *in the Chair*.

The following gentlemen were elected members of the Society:—Messrs. Robert Fleming, Michael Scott, John S. Miller, James Caldwell, William Gardner. A paper was read—

V.—*On the Acid of the Stomach, and on the Digestion of Vegetable Albumen, Fat and Starch.* By ROBERT D. THOMSON, M.D.

THIS paper has been printed at length in the Philosophical Magazine for April and May, 1845. The object of the communication was to prove by experiment, 1. That when albumen and fat are used as articles of food, they can be detected, the former only in minute quantities, during a certain space of time in the circulation. 2. That when starch is swallowed, after having been boiled, it is first converted into dextrin or soluble starch, and then into sugar. 3. That sugar exists in the blood in considerable quantities when starch has been employed as an article of food. 4. That no free hydrochloric acid exists in the stomachs of animals during the digestion of starch. 5. That an acid exists in the stomachs of animals fed on starch, which corresponds more nearly with the lactic than with any other known acid.

Dr. Balfour exhibited a specimen of Ceradia furcata, a singular plant from the coast of Africa, opposite Ichaboe, presented to him by Mr. Alexander Bryson of Edinburgh. It is a shrub, having the appearance of coral, belonging to the natural order Compositæ, section Erecthiteæ of Decandolle, and allied in many respects to the genus Kleinia. The plant yields a resin possessing an odour resembling that of Olibanum.

VI.—*Analysis of Ceradia Resin.* By ROBERT D. THOMSON, M.D.

THE resin possesses an amber colour, and an odour similar to that of Olibanum. It partially dissolves in alcohol, and is precipitated by water. Caustic ammonia produces no precipitate in the alcoholic solution. The alcoholic solution possesses a slightly acid reaction, and is not precipitated by nitrate of silver. Specific gravity 1·197, determined by my pupil, Mr. Hugh B. Tennent.

Analysis gave the following results:—

19·9 grains lost by exposure to the temperature of 212° for some days 2·11 grains. During the whole of the period its peculiar odour was emitted. Previous to being subjected to this heat it was pulverized, but it speedily became soft, and collected into a mass. In this state—when burned with oxide of copper and chlorate of potash—

6·24 grains gave 18·33 grains CO_2.
and 5·50 " HO.

This amounts to per cent.

Carbon, . . .	80·113
Hydrogen, . . .	9·793
Oxygen, . . .	10·094
	100·000

Calculated according to the formula C_{10} H_7 O, or C_{40} H_{28} O_4, the result would be as follows:—

Carbon, . . .	80·00
Hydrogen, . . .	9·33
Oxygen, . . .	10·67
	100·00

After being heated in the water bath for some weeks, the resin still continued to emit an odour. It was then pulverized, and again heated somewhat higher, when it speedily gave out fumes, and lost its smell entirely. Its composition was then found to be as follows:—

6·52 grains gave, with Oxide of Copper and Chlorate of Potash,
15·89 Carbonic Acid.
5·02 Water.

which are equivalent to

Carbon, ...	66·46
Hydrogen, . . .	8·55
Oxygen, ...	24·99

Calculated according to the formula

$$C_{40}, H_{30}, O_{11}$$

its composition will be

Carbon, ...	67·03
Hydrogen, . . .	8·37
Oxygen, ...	24·60

Dr. Balfour exhibited the spatha of a palm called Manicaria saccifera, which he had received from Demarara. The laws of the Society, as amended by the Council, were read, and a copy laid on the table for the scrutiny of the members.

19*th February*, 1845.—*The* PRESIDENT *in the Chair.*

Messrs. James Stevenson and James P. Hamilton were elected members. The mortality bills of London for the last quarter of 1844 were presented, also the quarterly tables of mortality in 150 districts of England. The following report from the Botanical Section was read:—

January 13*th*, 1845.—The Section held its first meeting for the Session, PROFESSOR BALFOUR in the Chair. Dr. R. D. Thomson proposed that the Section should adopt measures for forming a Flora of Glasgow, and suggested as a model the lists prepared by the Berwickshire Naturalists' Club. The subject was remitted to a Committee, consisting of Mr. Gourlie, Mr. Lyon, Mr. Adamson, and Dr. Thomson, —Mr. Gourlie, Convener. Dr. Balfour read an account of a Botanical Excursion, last autumn, to the Mull of Kintyre, illustrated by plants collected in the district.

January 28th, 1845.—PROFESSOR BALFOUR in the Chair. The President was added to the Committee on the Flora of Glasgow. Dr. Balfour made some observations on the development of monocotyledonous and dicotyledonous plants, showing that the former have the tendency to produce univascular individuals, obeying an organogenic law, of which *three* is the type, while the latter have the tendency to produce bivascular individuals, according to an organogenic law, of which *five* is the type.

Dr. Balfour also noticed the recent remarks of Duchartre, on the order in which the different parts of the flower in the genus Primula are developed, and showed that in this way the opposition of the stamens to the petaloid segments might be explained. The development of the free central placenta in Primulaceæ was also mentioned as an argument in favour of the axile formation of that organ. Dr. Balfour concluded his remarks by noticing the opinion of Thuret and Decaisne, as to the reproductive organs in Fuci, and pointed out the analogy between these and similar organs in other cryptogamic plants. Dr. Balfour's observations were illustrated by drawings and specimens.

It was agreed that a Conversational Meeting should be held in the Merchants' Hall on the 12th March, at which will be exhibited a collection of works of art, purchased by the Government, at the Exposition in the Champs Elyseés at Paris, and sent down for a short time to the School of Design of this city.

Dr. Balfour made some observations relative to the reproductive organs of Fuci.

The following paper was read:—

VII—*On the Coagulation of the Blood and other Fibriniferous Liquids.* By ANDREW BUCHANAN, M.D., *Professor of the Institutes of Medicine in the University of Glasgow.*

DR. BUCHANAN showed some specimens of hydrocelic serum, the fibrin of which was coagulated by means of a few fragments of the *washed clot* of blood added to it sometime before. The coagulated masses were transparent and tremulous, like calf-foot jelly, and so firm as to admit of being inverted on a plane surface without altering their shape. Dr. Buchanan made the following observations in explanation of the phenomenon.

The experiment exhibited to the Society, and the analogous experiments mentioned below seem to me important, as serving to rectify some prevailing opinions as to the essential properties of Fibrin, and the part which it plays in the coagulation of the blood, and certain other physiological processes. They are still farther interesting to me, as enabling me to correct some erroneous views of the constitution of the blood which I entertained, and which having been made public in the first volume of the "Proceedings of the Society," I feel it a duty to rectify.

The opinions commonly entertained by physiologists and chemists, to which allusion has just been made, are, that fibrin has a spontaneous tendency to coagulate: that this spontaneous coagulability is a characteristic property of fibrin, by which it is distinguished from albumen and casein: and that the coagulation of the blood, and of various other animal fluids depends on the spontaneous coagulation of the fibrin which they contain. My experiments, on the other hand, show, that fibrin has not the least tendency to deposit itself spontaneously in the form of a coagulum: that, like albumen and casein, fibrin only coagulates under the influence of suitable reagents: and that the blood, and most other liquids of the body which appear to coagulate spontaneously, only do so, in consequence of their containing at once fibrin and substances capable of re-acting upon it, and so occasioning coagulation.

The liquid of hydrocele, and other dropsical liquids, are generally regarded by physiologists as identical with, or at least closely analogous to the "*liquor sanguinis*," or liquid part of the blood; which they suppose to be effused, both in health and in disease, from the capillary blood vessels into the serous cavities and cellular interstices of the body. I have elsewhere shown,* that of all these effused liquids that of hydrocele approaches most nearly in its qualities to the serum of healthy blood. In two cases in which the experiment was made, the specific gravity of hydrocelic serum and of the serum of blood drawn from the same individual on the same day, differed very little; and I have recently met with an instance of hydrocelic serum drawn from a very strong man having a specific gravity as high as 1·038, much higher therefore than the ordinary specific gravity of the serum of blood. I entertain no doubt, therefore, that the serum drawn off in cases of hydrocele, is, for the most part, identical with the liquid part of the blood. Such an opinion, however, can scarcely be held by those who believe the liquid part of the blood to be spontaneously coagulable; for, without controversy, the liquid of hydrocele possesses no such property, as I have ascertained by attentive observation in many hundred instances. If carefully drawn off, it may be kept till it putrifies without showing the slightest tendency to coagulate. If, again, as

* Med. Gazette, 1836.

frequently happens, a little blood has been accidentally mingled with it, coagulation may ensue, not spontaneously, but from the re-action of certain elements of the blood upon the dissolved fibrin. This, if we leave out of sight the propensity to make facts bend to theory, is the only explanation that can be given of the assertion frequently made, but so inconsistent with observation, that the fluid of hydrocele is spontaneously coagulable.

What are the elements of the blood that have the power of causing fibrin to coagulate? The washed clot of the blood is the most efficient. It is perhaps indeed the only element of the blood that has the property of coagulating fibrin. The washed clot is the substance which is usually, but very erroneously, named the *fibrin of the blood.* It is best obtained* by mixing one part of liquid blood with from six to ten of water, and stirring them carefully for five minutes, so as to prevent the blood from falling to the bottom and coagulating unmixed. After the mixture has stood from twelve to twenty-four hours, it is to be filtered through a coarse linen cloth, and the product washed with water. The mass thus obtained consists, chiefly, of the insoluble portion of the red corpuscles; next of the colourless granules and globules; and least in quantity of the precipitated fibrin, by which these main constituents of the coagulum are agglutinated together.

Let a small quantity of this substance be mixed with the liquid of hydrocele, reducing it to minute shreds, and diffusing it equably through the liquid. Coagulation will ensue in many cases as rapidly as in the liquid blood itself. The coagulum is often quite distinct in from five to ten minutes. It becomes gradually firmer, and in the course of a few hours admits of being passed without breaking from one vessel to another, and very much resembles the transparent tremulous substance of calf-foot jelly. The power which the washed clot has of coagulating fibrin is not less remarkable than that of rennet in coagulating milk, to which, indeed, it may be aptly compared. This experiment is well adapted to the lecture-room—the reagent being added to the liquid serum at the commencement of the lecture, and the coagulated mass shown at the end of it. A very complete illustration of the process by which the blood coagulates may be exhibited by adding to the liquid along with the reagent some pounded charcoal, the particles of which being diffused through the liquid, and getting entangled in the meshes of the nascent fibrin, there is formed a black clot, which, on the addition of a little water, swims in it, just as the blood-coagulum does in the liquid serum.

The washed coagulum retains its coagulating power for a long period —even after its odour indicates the commencement of the process of putrefaction. In preserving it as a reagent, however, I think it advisable to add to it a small quantity of spirits, and to keep it in a

* Med. Gazette, 1836.

stoppered phial. Thus kept, I have found it to retain for several months its power of coagulating fibrin. The serum of hydrocele is the more coagulable the fresher it is. It sometimes soon loses its coagulability on being kept, but more frequently retains it till putrefaction is far advanced. There is, therefore, no difficulty for any one repeating those experiments, and satisfying himself of their truth.

The experiment which I have described is very analogous to some experiments which I performed in the year 1831, and of which I afterwards published an account in the "London Medical Gazette," (April 9, 1836.) I then showed, that if the clot of blood reduced to the liquid state by kneading and expression through a linen cloth, be mixed with hydrocelic serum, the mixture recoagulates into a perfectly homogeneous solid mass, which, like the ordinary coagulum of blood, becomes florid on exposure to the air: and that if a portion of coagulum not so disintegrated be put into a vessel containing hydrocelic serum, a web of fibrin is gradually spun around the coagulum. I showed that these effects were not due to the colouring matter of the clot; but I did not try the effect of the washed clot, my attention having been called in a different direction, by finding that pure serum of blood and hydrocelic serum when mixed together underwent coagulation. On since discovering the efficacy of the washed clot in causing coagulation, I thought it probable that the minute solid particles, which the microscope never fails to detect in the serum of blood, were the agents to which the coagulation of the two kinds of serum when mixed together ought to be ascribed. This corresponded well with the observation which I had long before made, that the deeper the red tint of the blood-serum employed in the experiment, the better does it succeed. On the other hand, Dr. Anderson, in his paper "On the state in which fibrin exists in the blood,"* has shown that if the mixed liquids be carefully filtered, so that no solid particles can any longer be detected by the microscope, coagulation nevertheless ensues; thus rendering it probable that the coagulating principle exists in the serum of blood not as a solid but in a state of solution. It may, however, be objected to this experiment, that the blood-corpuscles pass through any filtering paper, however dense; and that it is impossible by filtration, to deprive turbid serum of the solid particles mechanically diffused through it.

In the summer of last year, after I had satisfied myself as to the power of the washed clot in causing coagulation, I tried the effect of the buffy coat of the blood, reduced to minute shreds, and diffused through the hydrocelic liquid, and found it, in numerous instances, to have a similar power. I even found, that the dried buffy coat from the blood of a horse, which I had kept for several months, on being pulverized and mixed with the liquid, induced coagulation. I found

* Proceedings of Phil. Soc. of Glasgow, vol. i. p. 201.

the effect of the colourless buffy coat to be much greater than that of the red clot. I also found the upper part of the red clot to have a stronger coagulating power than the lower part of it. These facts seemed to show that it was the colourless corpuscles of the blood in which the coagulant power was mainly seated. The colourless corpuscles rise to the surface on the blood being drawn, and, there exerting their coagulating power, render the upper part of the clot invariably much firmer than the lower part of it; and this is exactly what is seen in a more marked way, in inflamed blood, in which the colourless corpuscles are much more abundant, and rising by their levity to the surface, form a layer on the top of the red corpuscles; and thereafter, by their superior coagulating power, give rise to the firm crassamentum without redness which we name the buffy coat. As I knew the transparent coagulum, which we find on the surface of newly formed blisters, to consist chiefly of such colourless particles, I tried it as a coagulant, and found it to induce coagulation, although less powerfully than the washed clot of blood. The coagulum, formed artificially in hydrocelic serum by different reagents, seemed to have little coagulating power; as if the transparent granules of fibrin must not only be precipitated, but have acquired more or less of the organized vesicular shape which they have in the blood and in the blister-liquid, before they possess the power of coagulating. This power seemed, therefore, to be the result of organization, and analogous to the metabolic power which Schwann has ascribed to the elementary cellules. This view led me to think it probable, that all the tissues of the body might have a similar power of reacting upon the liquor sanguinis effused into their meshes, and thus contributing to their own development, by engendering there such vesicles as we meet with in the blister-liquid. My first trials made with the muscle and skin of beef well washed to free them of blood, did not succeed; but on trying the muscle of veal, I found it to produce coagulation. I afterwards recognized a similar coagulating power in the muscular substance of beef and veal, in white-fish, skin, and cellular membrane: but the effect produced was less remarkable than that of the washed clot, and required a longer time, generally from one to three days. The tissue which answered best was the spinal marrow, probably in part from its greater softness and diffusibility. On one occasion, I found the spinal marrow of a bullock to cause coagulation in half-an-hour, the coagulum formed being very firm and beautiful. The substance of the brain seemed to have less power, although no rigorous comparison of them was made. Last of all, I found that the corpuscles of mucus from the Schneiderian membrane and throat possessed a coagulating power, though tardy: and that even the globules of purulent matter, which are just altered primary cellules, retained their coagulant power; for when put into hydrocelic serum, instead of continuing diffusible through the liquid, they agglutinated themselves together by the intermedium of fibrin, forming a white solid mass, such as we often see of smaller size on inflamed membranes, and in the interior of the eye.

These various experiments fully satisfied me that the tissues possess the property of coagulating fibrin: and I was farther disposed to think, that this power was most energetic in the primary cells or vesicles; and less energetic as these cells passed into secondary forms, as in the red corpuscles of the blood, the pus globules, and the various tissues of the body. This corresponds well with the greater vigour of development in fœtal life and infancy, when the tissues have deviated little from their primary structure; and the gradual diminution of the activity of the function as life advances, and the tissues are more and more altered. The coagulation of the fibrin of the effused liquor sanguinis, under the influence of the primary cells and tissues, may probably, therefore, be regarded as the primary organizative act by which the assimilable matter dissolved in the nutritious liquid passes into the form of an organized solid. There are, however, two distinct forms under which this act presents itself to our observation. In the one, which is that which occurs in normal circumstances in the living body, the process takes place slowly, and the product consists of isolated granules, which are gradually developed into perfect cells: in the other, which occurs in the effused fibriniferous liquids, the process is sudden, and the product a gelatinous mass. It is to the latter that the name of *coagulation* peculiarly belongs, and it is to be regarded rather as a pathological action than as belonging to the domain of physiology. The two processes may be aptly compared to the depositions which take place from saline solutions; if the deposition take place slowly the product consists of regular crystals, but if rapidly, it is an amorphous mass.

It is scarcely necessary for me to add, that I am now satisfied, that the fibrin of the animal fluids exists in them in solution, previous to its appearing in a corpuscular form: and that the liquor sanguinis differs from the serum which separates from the blood-coagulum in this respect, that the former contains fibrin in solution, while the latter has been *defibrinized* by the action of the colourless blood-corpuscles upon it. I also think the theory of the production of cell-germs and cells by the reaction of the two kinds of serum upon each other, less probable than the theory of their formation stated above. The same theory may also be applied to explain the origin of the blood-corpuscles in the capillary lymphatics, and the production of the numerous less regular corpuscles which are formed in the capillary blood-vessels during inflammation, and which, after mingling with the circulating blood, rise to its surface when drawn, and reacting on the fibrin occasion the buffy coat of the blood. The opinion expressed by Dr. Anderson in his paper already quoted, that the blister-liquid contains fibrin which is precipitated during coagulation, I believe to be correct in many cases, as I have sometimes found that liquid, when acted upon by the washed clot, to deposit fibrin: in other cases again, I have found, on applying the same test to the blister-liquid, that it contained little or no fibrin; and in such cases, I believe the coagulum which forms in it, to result from the simple aggregation of the organized corpuscles which it contains, as observation with the microscope first suggested to me.

VIII.—*Account of a Botanical Excursion to the Mull of Cantyre or Kintyre and the Island of Islay, in August,* 1844. By J. H. Balfour, M.D., F.L.S., F.R.S.E., *Regius Professor of Botany in the University of Glasgow.*

In the present paper, I mean to introduce to the notice of the members the botany of that part of Argyleshire which extends in the form of a peninsula from Tarbet to the Mull of Cantyre, as well as that of the island of Islay.

A party, consisting of Mr. Babington, author of the Manual of British Botany, Dr. Parnell, author of the work on British Grasses, Mr. John Miller, jun., Mr. John Alexander, Mr. R. Holden, Mr. Risk, Mr. Craig, and myself, left Glasgow by the St. Kiaran steamboat, at 11 A.M. on Saturday, 10th August, 1844. There was a large party on board, returning from the Highland Society's Cattle Show. The day was remarkably fine, and we had an excellent view of the beautiful scenery on the shores of the Firth of Clyde. This in some measure compensated for the slow progress of our boat, which did not reach Campbelton till near 9 P.M.

Campbelton is prettily situated on an inlet of the sea, the opening of the bay being protected by an island, which, however, becomes a peninsula at low water. The island is composed of a porphyritic rock, which is sometimes used for making ornaments of various kinds. The climate is mild, and many of the more delicate plants stand the winter well. On visiting one of the gardens in the vicinity, under the guidance of Mr. Stewart, chamberlain to his Grace the Duke of Argyll, we found myrtles, hydrangeas, and other tender plants, thriving in the open air, and we observed a fine Fuchsia hedge, which was in full flower, and contributed in no small degree to ornament the garden.

On the 12th of August we left Campbelton early, and proceeded by the shore towards Kildalloig, and thence by the rocky and sandy shores of the Mull as far as Ballishear. The cliffs are not so precipitous as those on the Galloway coast, and did not produce many rare plants. The most interesting plants were found on the shore. Some of the party who went inland were by no means successful in their botanizing, but this may probably be attributed in some measure to their having spent a portion of their time with Mr. Stewart, enjoying the pleasure of grouse-shooting. The result of their sport was found to be by no means unacceptable at the end of the day's work.

Among the plants met with, I may notice Epilobium angustifolium, which grew in great profusion and beauty, Hypericum Androsæmum, a common plant in all our western counties, Hieracium umbellatum, Convolvulus Soldanella and sepium, Atriplex laciniata, rosea, and angustifolia, Sinapis monensis, Helosciadium nodiflorum both in a large erect and in a small creeping form, Cotyledon Umbilicus, Vicia sylvatica, Lolium temulentum, and Epilobium virgatum, distinguished from E. tetragonum by its leaves being truly decurrent, the scions from the lower part of the stem being very slender and filiform. It is a species of Fries, but it does not appear to me to be well marked. In salt marshes we picked Scirpus maritimus, Blysmus rufus, Œnanthe Lachenalii, a common plant in the West of Scotland, and usually mistaken for Œ. pimpinelloides, from which it is distinguished by its elongated, slender, fusiform, or subcylindrical tubers, gradually enlarging from the base of the stem, and having no distinct pedicle, as well as by its fruit being broader than the calyx, and contracted at the base.* Dr. MacDonald mentioned his having found Linnæa borealis near Kildalloig.

At Southend the shore and the inland party met, and the latter were so satisfied with their day's sport, and with the comfort of Mrs. MacKay's inn, as well as with the prospect of a good dinner, that they declined proceeding further for the night. The movement party was thus reduced to three, who visited the sandy shores in the neighbourhood, and walked on to the lighthouse at the Mull. On the sands at Southend, Convolvulus Soldanella, Raphanus maritimus, Sinapis monensis, Sagina maritima, and Reseda Luteola were found in profusion. The old church at Keill, and the ruins of the Castle of Dunlavader, attracted attention. Near an old churchyard on the roadside, Hyosciamus niger was met with, and near Carskay, Geranium pratense was picked. The rocks in the vicinity have been hollowed out into caves, some of them of great size and depth. Similar caves had been noticed in the rocks along the shore from Campbelton to Southend, and one of them is designated the cave of St. Kiaran, from some legend connected with that saint.

On reaching the lighthouse we were most hospitably entertained by Mr. Noble and Mr. King, the superintendents, and every thing was done to promote our comfort. The country around the lighthouse is bare and rocky, and produces no plants of any interest. The Mull is well described by Macculloch as a rude hilly tract, without beauty even on its sea shores. The only interest is connected with the caves in the rocks to which I have alluded. In the interior of the district little is to be seen, and it is chiefly on the shores that a botanist or geologist finds materials for research. At the point of the Mull the

* For an account of the British species of Œnanthe, see paper by Mr. H. C. Watson, in The Phytologist, vol. ii. p. 11.

tides flow with rapidity and turbulence, and it is by no means pleasant for one who is unpractised in a sea voyage to beat round the headland in a boat.

On the morning of the 13th we examined the peculiarly rugged and precipitous rocks near the lighthouse, some of them rising to several hundred feet above the level of the sea. Sedum Rhodiola was seen in abundance, but no other plants deserving notice. After breakfast we walked along the upper part of the cliffs towards Largybean, where fine caves and stalactites occur. The rocks, composed principally of micaceous slate, were comparatively unproductive, and it was chiefly in those parts where limestone occurred that our researches were rewarded by plants in any way rare. One of the most interesting plants was Dryas octopetala,* associated with Saxifraga aizoides, oppositifolia, and hypnoides, Spergula subulata, and a hairy variety of Hieracium sylvaticum. The day was very wet and misty, and not favourable for botanical pursuits. Nevertheless, we examined the rocks carefully, and reached Lossit, after being joined by the Southend party, about 3 P.M., and were kindly received at Mr. M'Neill's. We visited his garden, and saw a species of Passion-flower in full bloom, which stands the winter well, also Hydrangeas, attaining an enormous size, and covered with profusion of flowers, besides Fuchsias, Pelargoniums, Salvia patens, &c. Passing through the fishing village near Lossit House, we made the best of our way to our old quarters at Campbelton, traversing a flat country in some parts furnishing coal, which is conveyed by means of a canal to the eastern shore of Cantyre. On either side of the flat strath, which extends from Machrihanish bay to Campbelton, there is a hilly moorish district which has not yet been brought into cultivation.

August 14*th.*—Having procured a cart for our baggage, the most bulky portion of which consisted of paper and boards, we crossed the peninsula of Kintyre or Cantyre, towards Machrihanish bay, passing the old church of Kilchinzie. The shores at the bay are composed of immense hills of sand raised by the waves of the ocean which roll on the beach at times with enormous fury, causing their roar to be heard for many miles. The sands are kept together and prevented from being blown inland by Ammophila arenaria, Carex arenaria, Triticum junceum, and other plants commonly known as bent or marram, the stems and roots of which extending in all directions, and interlacing together form a sort of basket work, and thus give a certain degree of firmness to the loose soil.† Plants thus contribute in some measure to the solidity of the land, and prevent the inroads of the

* This plant is often found on limestone rocks, not far from the sea level, as at Assynt in Sutherlandshire.

† Besides the plants mentioned, Elymus arenarius, Triticum repens, Festuca rubra and arenaria, Galium verum and Trifolium repens are commonly found assisting in fixing the sand.

ocean. In Norfolk there are low hills of blown sand fifty or sixty feet high, bound together by means of grasses or sedges in the way I have mentioned. The maritime part of Lincolnshire which lies below the sea level, is protected in a similar manner from the invasion of the sea; and the great embankment in Holland owes its stability in no small degree to the plants which grow on it. The drifting of sands often causes great devastation,—covering thousands of acres of land, and destroying vegetation. This is seen in many parts of this country, as well as of France, Holland, and Russia. About the commencement of last century the French government took up the subject, and directed attention to the shifting sands in that part of France which lies near the bay of Biscay. A species of fir, Pinus maritima, was planted, which now covers the sandy desert, and has effectually checked the progress of the sand drift. Some interesting facts on this subject were lately given in the Gardener's Chronicle, where it is also stated, that on the estate of Lord Palmerston on the west coast of Ireland, between the towns of Ballyshannon and Sligo, nearly 1000 acres of land were covered with sand, in some cases to the depth of 100 feet or more. About eighteen years ago, the Ammophila arenaria or Bent, was planted in these lands in large quantities, and the Pinus maritima major, from Bordeaux and other places, was also introduced, and by this means a most striking improvement has taken place. About 800 imperial acres have been reclaimed and converted into productive pasture land.

Lint (Linum usitatissimum) is commonly cultivated in this district of Scotland, and in all the fields we observed abundance of Cuscuta Epilinum twining round the stems and destroying the crop. The cuscutas or dodders, of which three species are natives of Britain, are most troublesome weeds, which are not easily extirpated. Their seeds germinate in the soil, and the plants immediately twine themselves round others in their neighbourhood, becoming attached to them parasitically by means of suckers, and ultimately losing their connection with the soil. They are very destructive to crops, and different species are connected with different plants. A species lately imported into Britain has done much harm to the crops of clover. In the lint fields Camelina sativa was also present, probably imported along with the seed.

The party walked along the shores of Machrihanish bay, passing Ballochantuy Kirk, Barr House (Mr. M'Alister), Glenacardoch point, Linanmore Kirk, and Killian, and reached Taynlone in the evening. The rocks were chiefly micaceous and calcareous. At some places, as near Barr House, the limestone is quarried, and there are caves which extend to a great depth; we entered one, which extended about 150 feet. The road from Machrihanish bay northward, runs along the shore, and enables the traveller to have a fine view of the channel of Gigha, as well as of the islands of Jura and Islay. The Paps of

Jura form very conspicuous objects in the distance. In some places near Ballochantuy and Killian, where the road winds among broken detached rocks, the scenery is romantic and interesting. At Killian there is a curious old church in ruins, apparently referable to the Norman times, with round arches, coupled circular headed windows, and peculiar doors made with two side stones converging upwards, and a flat stone on the top, resembling, in some degree, what is seen in Egyptian architecture. Part of the old church is used as a burying ground by the MacDonalds of Largy. In the churchyard are many old inscriptions, and some curious carvings on stone. The ruins are prettily situated on the banks of a stream. There is a vitrified fort in the neighbourhood. At a little distance from the shore in this quarter, and parallel to it there runs a ridge of old red sandstone rocks, and the streams coming from the higher grounds, when descending over these rocks, give rise to numerous picturesque waterfalls. The plants gathered this day were,—Thalictrum minus, Convolvulus Soldanella, Sinapis monensis, Ranunculus sceleratus and Scirpus Savii in moist places, Crambe maritima, Ligusticum scoticum, Hypericum Androsæmum, Epilobium angustifolium, Vicia sylvatica in great quantity on the dry stony beach, Pulicaria dysenterica, Vicia sativa on sandy shores near Taynlone, Eryngium maritimum, Steenhammera maritima, or as it is often called in this country, the oyster plant, from the taste of its leaves,* Apium graveolens near Taynlone, Conium maculatum especially in churchyards, as at Killian, Anagallis tenella in all moist places, Schœnus nigricans, Atriplex erecta in fields near Barr, Fumaria capreolata, Cerastium atro-virens, Pyrethrum maritimum, and Catabrosa aquatica assuming a remarkably stunted and creeping appearance on moist sandy shores near Killian; the fruit of this grass is very sweet, having the taste of liquorice. Hieracium boreale was also picked near Linanmore Kirk and Barr, Tanacetum vulgare near Killian, Carex vulpina near Barr, Equisetum Telmateia in many places between Campbelton and Taynlone.

We reached the latter place between 5 and 6, P.M., and took up our quarters in a small inn, where we had considerable difficulty in getting accommodation; some of the party sleeping, or attempting to sleep, on the floor, and others on the tops of tables. In the neighbourhood of the village we saw Potamogeton pusillus, Alisma Plantago, Samolus Valerandi, Catabrosa aquatica and the maritime variety already alluded to, Hippuris vulgaris, Bidens cernua, Œnanthe Lachenalii, and Lolium temulentum or the poisonous Darnel-grass. This grass seems to be common in many parts of Cantyre. All along the shore, especially near Taynlone, we met with profusion of Algæ,

* In America, Tragopogon porrifolius, or salsafy, receives the same name. Its roots are used for soup, which is said to resemble oyster soup.

and after storms I have no doubt that many rare species might be gathered.

August 15*th.*—This day we intended to have crossed by a ferry-boat to the island of Gigha, but the weather was so stormy, and a north-west wind was blowing with such fury, that it was deemed advisable to proceed along the shore to the foot of Loch Tarbet, where the steamboat touches on its way to Islay. Accordingly, we proceeded to Clachan and Stewartfield, and thence to Porthullion. The shore was bare and unproductive. Helosciadium nodiflorum, Trollius europæus, Lycopus europæus, Bidens tripartita, and Papaver dubium, were the chief plants which we picked. Near Porthullion we were more successful, having gathered Radiola millegrana, Carum verticillatum, Pinguicula lusitanica, Salicornia herbacea, the procumbent variety, Schoberia maritima, Epilobium virgatum, Eleocharis pauciflora, Myrrhis odorata, Veronica scutellata, Habenaria viridis, and Sedum Telephium.

About 4 P.M., we joined the Maid of Islay steamboat, and, after encountering a heavy swell off the northern point of Gigha, to the no small discomfort of some of the party, we entered the sound of Islay, and reached Port Askaig about 9 P.M. Here, through the kindness of Mr. G. T. Chiene, factor for Mr. Campbell of Islay, we found a cart ready for our baggage, and a carriage and four to convey the party to Bridgend and Ealabus, our drive commencing in true Highland style with a bagpipe accompaniment. A comfortable inn at Bridgend received some of the party, and the remainder were kindly accommodated in Mr. Chiene's house at Ealabus.

Before considering the botany of Islay, I shall make a few remarks on the general features of Cantyre botany. The part of Cantyre examined by the party did not yield many rare plants. This may depend, in some measure, on the nature of the rocks, which are often of a hard non-disintegrating and dry micaceous nature. The most prevalent rock is mica slate. This, along with some chlorite slate, forms the greater part of Cantyre. The old red sandstone formation occurs on the shore between Campbelton and Ballyshear, and is also found on the island of Sanda. It likewise appears on the west coast, and can be traced from Campbelton by Kilchinzie to Machrihanish bay. I have already stated that it forms a range of cliffs at a short distance from the shore, near Killian. Primary limestone occurs to the north of Campbelton, and in several places near Killian and Taynlone, as well as in the Largybean district, not far from the point of the Mull. In the valley which extends from Campbelton to Lossit, we meet with the carboniferous series of rocks. The island of Gigha is composed of mica slate.

The crops, so far as we observed, were good, and the harvest was early. On the 13th of August, we saw some barley cut. Rye is cultivated in many places. We could not detect any ergot in it. Bere or Big (Hordeum hexastichon,) is also cultivated for the use of the distilleries, which are numerous in this part of the country. Potatoes were excellent in the sandy and peaty soil.

Much might be done to improve the agriculture of the country by proper drainage, the use of the new manures, and the introduction of some good grasses. Arrhenatherum avenaceum, or oat grass, is a common weed in Cantyre, and might be advantageously sown on waste lands, as a grass of which horses and cows are fond. Timothy grass (Phleum pratense) thrives well, and might be sown with benefit as a late grass, while Alopecurus pratensis might serve as an early one. These two last-named grasses are not common in Cantyre. Holcus lanatus or Yorkshire fog, is very common. It is a poor grass, and might be replaced by others of a more nutritious quality. Festuca elatior would do well in boggy places. Avena flavescens was not met with, but it is well fitted for dry lands. Italian Rye grass might be sown with advantage, as it thrives in a mild climate. We did not see this grass during our walk. Catabrosa aquatica is a very nutritious saccharine grass, which does well in wet lands where draining cannot be carried on easily. In Belgium, Dr. Parnell informed us, it is much used for fodder, and the cows there are said to give excellent milk and butter. Near Taynlone this grass occupies a great extent of the sea shore, and the seeds might easily be collected in large quantity. The poisonous Darnel-grass was met with among the crops in several places, although it did not occur in such quantity as to give rise to injurious effects so far as we could ascertain. It ought, however, to be extirpated, as cases of poisoning have occurred from using it in the preparation of bread.

Besides the part of Cantyre to which I have alluded, on our return from Islay, we also examined part of the shore of Loch Tarbet, near its northern extremity, and the neck of land between West and East Tarbet, which is not much more than a mile broad. Boats are sometimes carried across from one sea to the other, and there is a curious fable mentioned by Pennant, that Donald Bane ceded the Western Isles to Magnus on the condition of his receiving the aid of Norway against the family of Malcolm. By the contract Magnus was to have all the islands—the definition of an island being whatever could be circumnavigated. The Norwegian, it is said, caused his boat to be drawn across the isthmus between the two Lochs Tarbet, and thus included Cantyre in the bargain. This story is considered a mere fable by Macculloch.

The shores of Loch Tarbet are beautiful and picturesque, and the sail up the Loch in a fine day is very interesting. The country around has an undulated surface, with here and there some fine woods coming down to the water's edge, and surrounding cultivated spots of various extent. We made a few additions to the Flora of Cantyre on the shores of the loch, by picking Milium effusum, Circæa intermedia, and large specimens of Salix pentandra.

I now proceed to give an account of our excursion in the island of Islay, and in doing so I shall allude only to the more interesting Phanerogamous plants and ferns, inasmuch the mosses, lichens, and seaweeds observed by the party possessed no attraction as regards rarity.

Islay is one of the western islands of Scotland, and was at one time famous as the residence of MacDonald, one of the great Kings of the Isles. The holds or castles of the MacDonalds exist on islands in some of the fresh water lakes to which I shall afterwards allude, especially Loch Gurim and Loch Finlaggan. The extreme length of the island, from the Moile of Oe in the south, to Rumhail in the north, is about thirty miles; and its breadth, from the point of Ardmore on the east, to Sanig on the west, is upwards of twenty miles. The superficial extent is about 154,000 acres, and the extent of coast is nearly 200 miles. The form of the island is irregular, and it is deeply indented by an arm of the sea called Lochindal. It is chiefly composed of those hypogean rocks, termed by Lyell metamorphic, or altered rocks, in consequence of the supposed changes which have taken place in them since their deposition. These metamorphic rocks contain few or no organic remains, and are thus separated from the palæozoic stratified rocks. Clay-slate is looked upon as intermediate between the metamorphic and the fossiliferous strata. The transition, primary fossiliferous, and grauwacké of authors, are considered as belonging to the palæozoic series, being the strata which contain the fossil remains of the earliest formed animals. The principal part of the island of Islay consists of quartz rock, with beds of clay slate, grauwacké slate, and micaceous schist. Quartz forms the high grounds of the north, and the great mass of the Oe district. Gneiss occurs in some parts of the island, and limestone in others. Porphyritic and basaltic rocks and veins are met with in many places; the basalt being often of an amygdaloidal nature. Near Port Askaig a peculiar kind of conglomerate occurs. Lead and iron are found in the island, the former being mixed with copper and some silver. At Ballygrant the lead is worked, and the veins are tolerably productive. In the Rhins a vein of magnetic iron ore occurs, which, according to Mr. Campbell, contains a small per centage of titanium. A rich ore of iron is found on Lossit hill, and a vein of iron glance at Ballyneal. At Stramishmore, in the Oe, there is a vein of impure graphite, 200 or 300 feet wide. Mr. Campbell states that he has analysed this, and finds that the quantity of carbon varies from 9 to 64 per cent., and iron from 5 to 16 per cent. He also has detected manganese in small quantity. Dr. R. D. Thomson has examined two specimens of this impure graphite, and the following are the results he has obtained:—

Peroxide of Iron, with some Alumina, . .	20·79	20·00
Sesquioxide of Manganese, ...	7·33	2·44
Magnesia, and some Lime, ...	trace.	12·00
Plumbago, ...	13·67	3·60
Carbonate of Lime, ...	20·12	1·15
Insoluble matter, consisting of Silica and Alumina, &c.,	32·76	55·00
Water, ...	5·33	6·81
	100·00	101·00

Near Ealabus there is a chalybeate well.

Throughout the island monumental stones, forts, and other antiquities occur. The climate is similar to that of the other Western Islands, being mild and moist. Plants which will not stand the rigour of a continental climate succeed well. At Islay House many of the more delicate plants thrive in the open air. The garden, however, is more remarkable for its excellent culinary productions than for the rarity of the flowers. At Mr. Campbell's cottage, in the south-east of the island, many fine plants were observed. Rhododendrons there attained a very large size.

In Islay there is still a great extent of improveable peaty land, which might easily be brought into cultivation. Much has already been done in the way of improvement by the spirited and enlightened proprietor, Mr. Campbell, and he has been ably seconded in his efforts by Mr. Chiene, his intelligent, indefatigable, and, I may justly add, hospitable factor. By draining, burning, paring, and the application of lime, much moorish land has been rendered productive. We saw excellent crops of oats on land recently reclaimed. Mr. Campbell seems to be anxious to introduce all the improvements which have been suggested of late by agricultural chemists, and I believe that his zealous and well directed efforts will soon make a great change in the aspect of the island. The zeal and energy of his factor, too, are seen in the mode in which various improvements have been carried out in the neighbourhood of Islay House, and perhaps in none more than in the formation of a road through a wet peat moss, which is now in the course of being drained and brought under the action of the plough.

We commenced our excursion in Islay, on Friday the 16th of August, by starting after breakfast for Kilchoman, which is situated in the south-west of the island. We reached this place by the aid of conveyances provided by Mr. Chiene, and at once proceeded to examine the sandy shores in the neighbourhood. The sands here, as in Cantyre, are kept together by Ammophila arenaria, Carex arenaria, Triticum junceum, and other creeping grasses and sedges. Near Kilchoman we found Sinapis alba, Listera ovata, Habenaria viridis, and Gentiana Amarella both blue and white. In the churchyard of Kilchoman there are some curious grave-stones, and an old cross similar to one in the Main-Street of Campbelton. It is said, indeed, that the latter was originally taken from Islay. At Kilchoman our party separated into two divisions, one proceeding along the shore, and the other going inland to examine the marshy ground in the vicinity of Loch Gurim or Gurm. The shore party was upon the whole most successful, having picked Mentha rubra of Smith, Gentiana Amarella, Convolvulus Soldanella, Malva sylvestris, Conium maculatum, Epilobium virgatum already noticed in the Cantyre trip, and Equisetum Telmateia of Ehrhart. The latter plant is the E. fluviatile of Smith, Hooker, and Babington. The name is derived from τελματειος, growing in mud, but we found the plant growing in moist sand. Both fertile and barren stems were gathered, the former being unbranched and having numerous large deeply toothed sheaths, while the latter had whorled branches, were nearly smooth, and presented about thirty striæ on the stalk. A remarkable trailing variety of Juncus lamprocarpus, with regular rootings at the joints, covered the shores in profusion along with Agrostis alba, var. maritima of Babington, with a procumbent rooting stem, a creeping form of Eleocharis palustris, and the sea shore variety of Catabrosa aquatica, already noticed in Cantyre. This latter variety is the minor of Babington, and littoralis of Parnell. It is abundant on the west coast of Scotland on sandy shores within the influence of the tide. In some places it covers patches of at least half an acre. It is found in Bute in considerable quantity. It differs from Catabrosa aquatica in its smaller growth, and in the glumes having mostly only one floret. I may here remark that the tendency to a trailing habit was seen in many of the plants on the shore, especially at the points where rivulets joined the sea; and some of the species on this account presented an aspect very different from that which they assume in their usual localities.

On sandy ground in the vicinity of the shore numerous other plants were seen, such as Arabis hirsuta, Gymnadenia conopsea, with its odoriferous purple blossoms, Eryngium maritimum forming spiny tufts of great extent, the beautiful Anagallis arvensis and tenella, Pyrethrum maritimum, Ligusticum scoticum, Viola lutea with all its shades of purple and yellow, Thalictrum minus in a very dwarf state, Spergula nodosa, Arenaria serpyllifolia and marina, Pimpinella Saxifraga, and Erythræa Centaurium and linariifolia. One of the plants noticed attracted our attention particularly, inasmuch as in Scotland it is usually seen only in alpine districts, while here it was flourishing luxuriantly at the sea level. I allude to the Draba incana or twisted-podded Whitlow-grass. No doubt, in many instances, in the north of Scotland, we see alpine plants coming down to the level of the shore, as at Cape Wrath in Sutherlandshire; but the northern nature of the locality accounts in a great measure for this apparent anomaly. But in the case of Islay, the occurrence of alpine species so low cannot be accounted for in the same way. Mr. H. C. Watson says that Draba incana belongs to the alpine and upland regions of Scotland and

England. It is often found on alpine limestone rocks. It is met with near the summits of the mountains in Wales, Westmoreland, and Scotland. I have specimens from Raven-scar Walden, and from Teesdale in Yorkshire. In marshy spots near the shore we observed Hypericum elodes, Sparganium ramosum, Œnanthe Lachenalii, a common plant in the west, and Samolus Valerandi; while in fields Papaver dubium and Lamium intermedium were abundant. The only other plants of interest remarked in this locality were Radiola millegrana, Ononis arvensis, Atriplex laciniata and rosea, Cerastium atrovirens, Cakile maritima, Trifolium arvense, and Eleocharis pauciflora.

After a thorough examination of the sandy shore, the party proceeded towards some slaty rocks, where Sedum Rhodiola and Asplenium marinum were found. Here the two divisions were to have joined, but by some mistake no union was effected, and in our search for each other a still farther separation took place. Moreover, the day which had been gloomy now exhibited a pluvious tendency, and ere long rain descended in torrents so as to damp in some measure the ardour of the party, and in the course of the afternoon there was seen a solitary botanist wending his way through the marshes and bogs with his habiliments thoroughly saturated with moisture, and his fingers so benumbed as scarcely to be fit for the effort of pulling a plant; while parties of two and three, ignorant of their exact position, and anxious to get to comfortable quarters as soon as possible, proceeded by various devious paths to the nearest huts for information. All fortunately reached their destination in the course of the evening, —their arrivals occurring at various intervals, and their adventures being very much diversified.

The peat-bogs which were visited in the course of the day lie between Kilchoman and Loch Gruinart. They are very wet, and in many places quite impassable in rainy weather, so that it required considerable dexterity on the part of the traveller to avoid being immersed up to the shoulders. This is particularly the case with the boggy ground near the western extremity of Loch Gurim. In these localities Scirpus lacustris, Sparganium simplex, Ranunculus aquatilis, Peplis Portula, Schœnus nigricans, Drosera rotundifolia, anglica and longifolia, Utricularia minor, with its elegant vesicles, Rhynchospora alba, Hippuris vulgaris, Scirpus Savii and setaceus, and the delicate Pinguicula lusitanica were observed. Triglochin maritimum was picked along with Scirpus lacustris about two miles from the shore. A Salix resembling rosmarinifolius was also gathered. In all there were 320 Phanerogamous species noticed in the course of the day's walk.

The roads in this part of the island were upon the whole good, but they pass in some places over hilly districts. Potatoes seemed to thrive well, and the fields gave excellent crops of oats. Near Islay House there was a good field of wheat. The flax in the district was not infested with Cuscuta.

August 17th.—The morning was very showery and unpromising, and, in place of visiting Portnahaven as had been proposed, we proceeded along the shore to Bowmore, and thence round Laggan point as far as the mouth of the river Laggan, along the banks of which we botanized as far as the bridge. The piscatorial members of the party considered the day peculiarly favourable for enjoying the luxury of a nibble; but their success was not so greatas they anticipated, and, as usual, this was attributed to some fault on the part of the river and the fish. One of the party expatiated in glowing terms on the mode in which he hooked a salmon, described his excitement on the occasion, and all the emotions which arise in the bosom of one whose fly, for the first time in its existence, has been honoured by the grasp of so noble a visitor. But unfortunately this splendid animal preferred living in its native river, even with the appendage of a hook and a broken line, to the pleasure of contributing to the repast of a hungry botanical party. Some sea-trout, river-trout, and parr were taken, but even Parnell's prepared minnow, or *minnow-persuader*, as it was called, though wielded most dexterously by the Doctor himself, failed to procure a large supply, and we looked in vain for the salmon which he had promised for dinner.

On the shore near Bowmore we met with the usual maritime plants, as Aster Tripolium, Plantago maritima and Coronopus, Salicornia herbacea (the erect form), and Juncus compressus. Great quantities of Zostera marina had been thrown on shore by the waves, and were used as manure by the farmers, along with sea weeds. This plant has been employed for various purposes; among others, it has been recommended in a dry state as a stuffing for beds and cushions. At Laggan point fine cliffs occur, but they are not productive, being covered chiefly with Pyrethrum maritimum, Armeria maritima, Cochlearia officinalis, and some grasses. Beyond this point the shore becomes sandy, and is covered with bent. A little way inland, boggy ground occurs, in which the three species of Drosera, Rhynchospora alba, Utricularia minor, Menyanthes trifoliata, and other marshy plants are found. This boggy ground, like that near Kilchoman, was in many places very wet, and resembled, in that respect, the bogs which occur in Ireland, such as those of Cunnemara in Galway. The peat is of excellent quality, and is used extensively for fuel.

Much might be done to improve this peaty soil, by paring, burning, draining, and the admixture of sand, which is abundant in the neighbourhood. In cases where draining could not be easily accomplished at once from the nature of the level, the system of colmation, as pursued in Italy, might be practised, so as to deposit soil on the surface of the peat, and by thus raising its level enable draining to be afterwards undertaken with success. * The introduction of Dactylis cæspitosa

* Carte Idoauliche della Valle de Chiana, con un saggio sulla storia del suo bonifica-

or Tussack grass, might be successful in this situation, both from the nature of the climate and the proximity to the sea. Should this grass be introduced into the country, the peaty soil on the western islands of Scotland would probably be that best fitted for its growth. In this way the waste lands of these localities might be made, without preparation, to afford excellent pasture, as well as protection to cattle. This grass was noticed in the Falkland Islands during the recent antarctic expedition. A short account of it was published by Sir William Hooker, * and his son, Dr. Joseph D. Hooker, will give a full description of it in his admirable Antarctic Flora, part of which is already published under the patronage of Government. The plant is called Tussack or Tussac grass, from the lower part of its culms forming a tuft or *tussack.* The stems rise to the height of four to six feet, and the leaves hang down all around. It is perennial, and produces large leaves, and an enormous quantity of herbage, which is saccharine and nutritious. The cattle in the Falkland Islands are remarkably fond of it. The plant thrives best in a wet, peaty soil, in insular situations where the spray of the sea dashes over it. Judging from the soil and climate in which it grows, there is every reason to believe that it might be most advantageously sown in the western islands of Scotland. Seeds have been sent home to this country, but only a few of them have germinated. Those sent to the Glasgow garden have not sprouted. Besides the Tussac, Festuca Alopecurus of D'Urville or Arundo Alopecurus of Gaudichaud, also deserves to be noticed as an important Falkland Island grass found in peat-bogs.

The climate of Islay is well adapted for oats, and much of the peaty soil might be rendered highly productive. Wheat also thrives in some places, but this crop probably requires a warmer summer than occurs in the island in general.

On the sandy shores at Laggan we found Convolvulus Soldanella, and in the fields Lamium intermedium and Fumaria capreolata; while the banks of the river furnished luxuriant specimens of Hieracium umbellatum, sylvaticum and boreale. The last-mentioned species has been usually regarded as a form of H. sabaudum, and is figured as such in English botany. It is distinguished by its upper leaves being sessile, with a round base, not with a cordate-clasping base, as in sabaudum, involucral scales appressed in three regular rows, and uniform in colour.

In the woods near Ealabus and Islay House, which we examined

mento, et sul metodo con cui vi ci Esequiscono le Colmate, di G. A. Manetti. Firenze, 1823.

The system of Colmation was fully explained by Professor Gordon at one of our late Conversational Meetings, and its application to such localities as Lochar moss, near Dumfries, was pointed out in an interesting manner by Mr. Smith, late of Deanston.

* Hooker's Notes of the Botany of the Antarctic Expedition. See also Gardeners' Chronicle for March 4th, 1844; and London Journal of Botany, Vol. II., p. 247.

at different times, we found a number of plants which deserve attention, such as Aquilegia vulgaris, Hesperis matronalis, Valeriana pyrenaica, Campanula latifolia, Epilobium angustifolium, Polygonum Bistorta, Prunus Padus, Lysimachia nemorum, Ruscus aculeatus, Carex remota, and Scolopendrium vulgare. Some of these species, however, have undoubtedly escaped from the garden. Betula alba and glutinosa were also seen. The latter is looked upon by most botanists as a mere variety of the former, but Mr. Babington thinks that he has found a marked character in the stipules, which in B. glutinosa are rolled back, while in B. alba they are circinnate. The form of the fruit, he also thinks, is different in the two cases. In a pond near Ealabus grow Lycopus europæus, Potamogeton natans, and Nymphæa alba. On making a transverse section of the petiole of the Nymphæa, it was observed that the large tubes had hairs in their interior, which generally came off in threes. Again, in making a similar section of the peduncle, or flower-stalk, we noticed generally four or five large tubes in the centre, and smaller ones around, but in none of them could any hairs be detected. These tubes in the stalks of the flower and leaf appear to contain air for the purpose of floating the various parts of the plant.* Carex vesicaria and Equisetum limosum both in an unbranched and branched state, were picked at Loch Skiros.

On examining some of the Carices and grasses, it was found that the rule in regard to the solid stem in the former, and the hollow stem in the latter, was not universal. Thus Carex remota and ovalis had distinctly hollow stems, while Ammophila arenaria had a solid stem. This grass is said by Dr. Parnell to be the only British one with a stem always completely solid.† It also differs from other grasses in not having a striated stem. It may also be remarked here, that in the Umbelliferæ, the character founded on the fistular stem does not invariably hold good, for on the same root solid and fistulose stems will occasionally be found.

Many of the grasses in Islay displayed much of the ergot, or that disease which is common in rye, and which is an altered state of the ovary caused by the attack of a fungus, Ergotætia abortifaciens of Quekett. This plant produces sporules, which communicate the disease to healthy grain, either by being directly applied, or by being taken up from the soil. Mr. Quekett has produced the disease artifi-

* On examining the peduncle of Nymphæa alba lately in Bute, I detected hairs in its tubes as well as in those of the petiole. The same thing was seen in the peduncles and petioles of Nuphar lutea. In the latter plant the air-tubes in the petiole were larger than those in the peduncle, and displayed the hairs most distinctly.

† See Parnell's work on British Grasses. Bromus patulus, and some other foreign grasses, have also solid stems, and Mr. Gorrie has noticed the same occurrence in some varieties of wheat.

cially by watering healthy plants of rye with water containing the sporules. Proper draining will probably prevent the attack of ergot. Ergot injures the quality of the flour, and cases are detailed in which the use of diseased rye has caused dry gangrene. The disease is not, however, peculiar to rye. It occurs in many grasses. Professor Henslow has observed it in wheat in Suffolk; and in the district in which he saw it, it is stated that about a century ago several cases of poisoning occurred from diseased wheat. Our party observed ergot in considerable quantity on Anthoxanthum odoratum, and on Phalaris arundinacea. The former grass is very abundant in many parts of the island, and is well deserving of cultivation. Besides the ergot, we noticed the disease in oats, caused by a species of uredo, and commonly called smut. In many fields the disease was very prevalent. It is said to be prevented by steeping the grain in stale urine, and afterwards sifting lime on it. A solution of salt, and a weak solution of sulphate of copper, have also been employed.

August 19*th*.—The day was very unpromising, and thick mist and rain set in about seven o'clock A.M. Nevertheless, four of the party started in a conveyance for Portnahaven, while the rest went to Ballagrant Loch to fish. The south-western shores of the island, as far as Portnahaven or the Rhins, are low, gravelly, and occasionally rocky, and consist chiefly of clay-slate, with greywacke slate in alternate beds. Gneiss is met with in some parts of the shore, especially between Octafad and the point of the Rhins or Rinns. These shores produced few plants of interest. Geranium pratense was noticed near Port-Charlotte, and in a neglected garden at the same place we observed profusion of Papaver somniferum of a pink colour, with dark spots at the base of the petals, similar to what occurs in Papaver Argemone. The same variety was picked by Dr. Parnell at Ballagrant. At Portnahaven there is a lighthouse on an island close to the shore, and there are other islands in the neighbourhood. The tides in this quarter, more particularly at the point of the Rinns, are very violent and rapid, and it is interesting to notice the agitation which is caused even by a moderate degree of wind. On arriving at Portnahaven, the weather was so bad and the rain so heavy, that two of the party did not choose to quit the conveyance, and accordingly they proceeded directly to Kilchearan, and there enjoyed the hospitality of Mr. Ralston until the other two botanists met them.

Proceeding along the western shore of the Rinns from Portnahaven we encounter a very rugged and rocky coast, intersected by numerous indentations, and broken up by narrow ravines into which the sea enters with great violence. Fine caves and gigantic natural arches occur in many places. The prevailing rocks are clay-slate and greywacke, with occasional trap dykes of considerable extent. In some places, as at Losset Hill, we met with a peculiar kind of conglomerate. Near

Losset, which is a fishing village, the cliffs are remarkably fine, attaining a height of many hundred feet, and covered with innumerable sea-fowl. In this quarter there are the remains of a fort.

The most interesting plants seen on the cliffs were Sedum Rhodiola, Pyrethrum maritimum, in some cases with a singular flattened or fasciated stem, caused apparently by the union of several stalks, Ligusticum scoticum, Carex extensa, Spergula subulata, and Pulicaria dysenterica. The cliffs are now and then interrupted by sandy shores covered with bent, and there Convolvulus Soldanella, and Equisetum Telmateia were found, along with Galium verum curiously altered by the attacks of insects.

At Kilchearan, where a slate quarry is worked, we joined the rain-dreading botanists, whom we found comfortably accommodated in the house of Mr. Ralston, the tenant of the farm in this quarter, who kindly entertained the whole party. Mr. Ralston seems to be an intelligent farmer, and has contributed to the improvement of the agriculture of the district. He pointed out to us a field of from twenty to thirty acres bearing an excellent crop of wheat. He has introduced Cheviot sheep with profit, and in his dairy he has the Ayrshire breed of cows, to the excellence of the produce of which some of the party can bear testimony.

Returning by the shore to Ealabus we did not observe any plants of peculiar interest. On our return we had the pleasure of meeting Mr. Christison, who had been sent to this country by the Norwegian government for the purpose of getting information as to agriculture. Foreign governments, in the encouragement which they thus give to science, set an excellent example to Britain.

August 20th.—This day the botanical section proceeded first by the shore, and then across the island to Loch Gruinart, examining the southern shore of the loch, and going as far as Ardnave and the point of the Nave. The rest of the party indulged their fishing propensities by visiting the river Laggan. The day was showery, but upon the whole favourable.

In the salt marshes near Islay House, many common sea plants were found, as Salicornia herbacea, Glaux maritima, Aster Trïpolium, and Poa maritima. In a ditch near Gruinart, Rumex Hydrolapathum or great water-dock, was picked, a species well distinguished by its lanceolate acute leaves tapering below into a petiole which is flat above, and by the enlarged ovato-triangular divisions of its perianth nearly all with tubercles. It was formerly described by botanists as Rumex aquaticus, a distinct species with broader leaves, not tapering, and non-tubercled fruit, hence called grainless-dock. R. Hydrolapathum is rare in Scotland, although it is found in many places in England. Mr. Stewart Murray observed the plant in ditches near Meikleom in Perthshire, and I have a specimen from the station, picked by Mr. Gorrie. Hopkirk mentions the plant as growing near Old Kilpatrick on the Clyde, but I have not been able to see it in that locality. I have gathered the plant abundantly near Oxford and in other parts of England, but I never before picked it in Scotland.

The shore on the south side of Loch Gruinart is partly gravelly and partly sandy. The sand occurs near the Nave, and on the west shore exposed to the Atlantic. The dunes of sand in this quarter attain a great elevation, and are as usual kept together by grasses and sedges. In lint fields near Gruinart, Camelina sativa was observed, and on the sandy shores Draba incana, Gentiana campestris and Amarella, and Arabis hirsuta. Scutellaria galericulata grew profusely among the pebbles on the shore, Papaver Argemone and dubium, in sandy fields, and Juncus maritimus in salt marshes; in moist places near the loch, Callitriche verna and pedunculata, Potamogeton pusillus and crispus, Helosciadium inundatum, Myriophyllum spicatum, and Scirpus glaucus.

Loch Gruinart has a sandy bottom, and it is nearly emptied when the tide is low. Sand-banks exist in many places, and on these we saw numerous seals sporting in the sun. The tide flows here with great rapidity. At the mouth of the loch a bar of sand extends across, and at its head there is an alluvial plain. The shores to the south-west of the point of the Nave are rocky and inhospitable, and exhibit reefs of various extent. The cliffs become more elevated as we proceed south, and caves occur in many places. The interior of the island in the neighbourhood of Loch Gruinart is composed of boggy and peaty soil, furnishing such plants as Droseras, Rhynchospora alba, and Utricularia minor. On Nave island Crambe maritima is said to grow.

In this part of the island there are the ruins of the old church of Kilnave. It is a building of considerable antiquity, and seems to have had only two windows, the arches of which are very peculiar. In the churchyard there is an old stone cross, which differs in the curvature of the cross portion from those which are seen at Campbelton and in Iona.

August 21st.—Early this morning I started for Ballytarson, and gathered Anthemis nobilis in abundance. This plant is by no means common in Scotland. In Islay it occurs in several places, and always associated with limestone rock. After breakfast we prepared for a visit to the south-eastern district of the island, but the stormy nature of the weather caused no small alarm to some of the party, and the number of zealous botanists willing to encounter a long and and wet walk was found to be very small. One of the party preferred botanizing near Ealabus, within sound of the dinner-bell. Undismayed by the desertion of friends, our little band proceeded in one of Mr. Chiene's conveyances as far as Kintra, at the southern extremity of Laggan sands, and thence walked towards the Oe. On the sands the chief plants were Convolvulus Soldanella, Poa pratensis var.

arenaria, and Koeleria cristata. On none of the sands in the island did we observe Sinapis monensis,—a plant which is common in many of the sandy shores on the west coast.

From Laggan sands we proceeded along the rocks to Slochd Mhaol Torrai,* where splendid precipices and caves are seen. The rocks in this district, and indeed all the way from Islay House to the Mull of the Oe, consist of alternations of a bluish quartz rock, clay-slate, and occasional trap dykes and veins. Some of the rocks are bent and contorted in a remarkable manner, and others are hollowed out into enormous caves, some of which extend a great way inland, and open at the distance of several hundred feet from the shore. Some of the rocks stand out prominently in the sea with rugged and peaked summits. One of these is called Saighdair Ruadh, or Red Soldier rock, from its colour. It is 150 or 200 feet high, and presents a very remarkable aspect. There are often very narrow chasms and rents in the rocks, into which the waves of the ocean are rolled with great force. Landslips have also occurred in some places. The rocks, although interesting in their appearance, are by no means productive. Beta maritima grows in considerable quantity on some of the cliffs, and Sedum Rhodiola and Pyrethrum maritimum abound. The other plants worthy of notice were Listera ovata, Luzula pilosa, Lastrea Oreopteris, Ligusticum scoticum, Lycopodium selaginoides, Hypericum humifusum and Androsæmum, Rubus saxatilis and Saxifraga aizoides. The last mentioned plant extends from nearly the sea level to a considerable elevation on the hills.

After examining the rocks in the Oe or Oa, a Parliamentary parish, we proceeded to the Moile or Mull of Islay, passing Lower Killian, where oddly twisted rocks are seen. The Moile is a fine cliff, or promontory, projecting into the sea, forming the south-eastern extremity of Islay, and surrounded by cliffs of a reddish colour, in which the alternations of quartz rock and clay-slate are well seen. On one of these rocks there are the remains of an old fort, called Dunad, or Dùn Athăd, which seems to have been a place of great strength in former times. The rock on which it is situated projects towards the sea, is bounded on three sides by perpendicular cliffs, and is connected with the land only by a narrow isthmus with precipices on each side. In some of the rocks near the fort, remarkable caves and arches are seen. After examining the fort, we proceeded through Upper Killian parish, towards Port Ellen. We passed Kinnabus and Assabus Loch, and at Cragabus we saw the remains of an old churchyard, marked by large stones placed so as to enclose graves, similar to some which occur near Lag, in the island of Arran. The party reached Port Ellen about half-past eight, P. M.,

* This means the Gulf of Mhaol Torrai, a person concerning whom there is some tradition. He is said to have been killed at the place in endeavouring to leap across one of the chasms on horseback.

after a long and fatiguing walk. At this port a lighthouse has been erected by Mr. Campbell.

August 22d.—Leaving Port Ellen at 7 A.M., we went along the shore to Ardinisteil, where we breakfasted with Mr. Stein. On our way we picked Galeopsis versicolor and Convolvulus sepium. After breakfast we directed our course towards Loch Knock and Knock Hill, where Mr. Campbell has a summer residence called Ardimersay Cottage. Here there is a considerable extent of thriving plantations, and we spent some hours in the examination of them. The chief plants which rewarded our exertions, were Circæa intermedia, Carex lævigata, Hymenophyllum Wilsoni, Polypodium Phegopteris, Cardamine sylvatica and Prunus Cerasus. On rocks in the neighbourhood were seen Milium effusum, Tanacetum vulgare, and Inula Helenium evidently an escape from an old garden. Near the cottage there is an old fort now in ruins, called Dun-naomh-aig, and pronounced Dunavaig, remarkable as being the last held by the MacDonalds. It was taken by the Campbells, who it is said resorted to the method of cutting the water pipes which were conveyed under the sea in the bay, and thus causing a surrender. The rock of the fort seems to be impregnable on all sides but that next the land. In the vicinity of the cottage a place is shown which is said to be the grave of the Princess Isla.

After partaking of refreshment, kindly supplied by the housekeeper at the cottage, we walked partly by the shore and partly inland, as far as Kildalton, where porphyritic rocks present themselves. Here a fine old church is seen in ruins. It had two windows on the east end, and two at each side, with two doors. Two stone crosses differing slightly in character are seen, one in the churchyard surrounding the chapel, and the other at a little distance from it. Some curious old gravestones occur. Nettles and Anthriscus sylvestris now grow in profusion within the precincts of the chapel, and the procumbent variety of the common juniper on its walls. The various species of nettle seem to follow the footsteps of man, and delight to grow places where nitrate of lime is produced:

> "At the wall's base the fiery nettle springs,
> With fruit globose, and fierce with poisoned stings."

In boggy places, in the vicinity of the old chapel, we found Helosciadium nodiflorum, Hypericum elodes, Carex remota and filiformis. This part of the island is separated from the district near Islay House by a lofty range of hills, some of them attaining an elevation of 1500 or 2000 feet, and composed chiefly of quartz rock. We ascended one of them called Ben Vigors or Ben Bhiggars, and found it by no means productive. The principal plants collected were Gnaphalium dioicum, Lycopodium Selago, Arctostaphylos Uva-ursi, Carex rigida, Armeria maritima var. alpina, and Juniperus communis var. nana. The occurrence of Arctostaphylos would probably indicate an elevation of at least 2000 feet, corresponding with the subalpine region of Mr. Watson. On reaching the summit of the hill we were involved in mist and rain, and the guide who had accompanied us lost his way, and after wandering for an hour or two landed us in the valley whence we had ascended. Fortunately he knew the direction which our place of destination bore to the valley, and accordingly we followed our compass and crossed the hills in a very thick mist, amidst the fears and doubts of our guide as to the correctness of our procedure. Our anxiety as to the result of our exploration made us forget all the discomfort of a thorough drenching, and one of the party who had been complaining sadly of fatigue now walked on most manfully. After reaching the summit of the range of hills, (probably the summit of Gloan Leor,) we descended, not without doubts as to the result. At this time a slight clearance took place in the mist, and we descried some green patches of verdure which seemed to indicate a limestone district. We knew that this was the geological nature of the district which we wished to reach, and our hopes of extrication from our difficulties brightened considerably. We now proceeded on our descent with increased vigour and alacrity, and reached Allaladh, when some oat cakes and milk from one of the cottagers were most thankfully received, and ere long we had the pleasure of finding ourselves at Cattadale, where a conveyance was waiting to convey us to Ealabus. This adventure shows, in a certain degree, the importance of knowing the geology of a district, and the kind of vegetation which is connected with particular rocks. The limestone district to which I have alluded is extensive. It crosses from Laggan to Ardmore point, and extends to the north-east of Islay House. In some places the water has hollowed out a passage for itself through the rocks, and in one instance we observed the rivulet disappear under ground for several hundred feet. Near Cattadale the ruins of a fort are seen, called Nose-bridge fort.

The party left at home had made some additions to the Flora of the island during our absence by gathering Ruppia maritima, Potamogeton rufescens, Polemonium cæruleum, Malva moschata, Carex acuta, Solanum Dulcamara, and Rubus affinis of Weihe and Nees, a species described in Mr. Babington's Manual, and the specimen named on his authority.

August 23d.—This day, like its predecessors, was gloomy and unpropitious, and acted in a most cooling manner on the enthusiasm of the party. One gave up botany for shooting, others remained at home, and a party of two only kept up the credit of the expedition. This party bent their steps towards Losset, passing Kilmeny and Ballygrant. At the latter place there is a beautifully wooded lake well stocked with trout, some of them presenting peculiar characters. On the way Ranunculus aquatilis var. fluitans, Potamogeton pusillus and rufescens were picked. Near Losset, in a glen not far from the Sound of Islay, Ribes rubrum grows in profusion apparently wild, along with Rubus idæus and saxatilis. We got fresh specimens from Mr. Stuart. Near Losset there is a lead mine which is worked, and there is abundance of iron in the vicinity. From Losset we proceeded to the lake of Finlaggan, or the Loch of Portaneilan, as it is sometimes called, and collected a few common aquatic plants. On an island in the loch stand the ruins of the Castle of Finlaggan, famous as the place where the MacDonalds, Lords of the Isles, were crowned. There is no means of reaching the island except by wading, inasmuch as there is no boat on the loch. The water is about four feet deep at the place where the island can be reached; we accordingly had to wade up to the middle in order to get a view of the ruins. The buildings seem to have been extensive. There are the remains of an old chapel, with some antiquated gravestones, having swords carved on them. The grandeur of this castle of the Lords of the Isles is now gone, and nettles and Stachys sylvatica, along with other ignoble weeds, occupy the halls of the MacDonalds. On the walls of the chapel Asplenium Ruta-muraria and Adiantum-nigrum grow in profusion, filling up every chink and crevice with their fronds. The contemplation of these crumbling walls, and the vegetation covering them, recalled to my mind the words of the American poet, who, when speaking of flowers as stars in earth's firmament, and describing the various lessons which they furnish, goes on to say,—

Not alone in her vast dome of glory,
  Not on graves of birds and beasts alone,
But in old cathedrals high and hoary,
  On the tombs of heroes carved in stone.

In the cottage of the modest peasant,
  In ancestral homes whose crumbling towers,
Speaking of the past unto the present,
  Tell us of the ancient games of flowers.

In all places then, and in all seasons,
  Flowers expand their light and soul-like wings,
Teaching us by most persuasive reasons,
  How akin they are to human things.

On an island near that already mentioned, and separated from it only by a narrow strait, are the ruins of some buildings where the Lords of the Isles held their councils. The islands were formerly united by a drawbridge. On one side of the island on which Finlaggan Castle stands there are the remains of a pier, and a similar pier exists in the mainland. In the loch grew Phragmites communis, Nymphæa alba and Potamogeton natans.

From Finlaggan we walked to Duisker, where Agrimonia Eupatoria, Eupatorium cannabinum and Festuca gigantea were found. This being a limestone district the vegetation was luxuriant, and the rocks were undermined in many places by the streams. On our way from this district to Ealabus we visited Loch Skiros, and gathered Potamogeton perfoliatus and pusillus, and Callitriche autumnalis.

In the evening the party were conveyed to Port Askaig, and went on board the steamboat which was to start early next morning for Tarbet.

Thus ended our Islay trip—one from which all of us derived the greatest gratification, and for which we were deeply indebted to the kindness and hospitality of Mr. Chiene. Without his kind offices we could not have examined the island in the manner we did. He spared no trouble in conveying us to different parts of the island, and in affording us every facility for the prosecution of our researches.

CATALOGUE

OF THE PHANEROGAMOUS PLANTS AND FERNS COLLECTED DURING THE TRIP IN THE MULL OF CANTYRE AND THE ISLAND OF ISLAY.

The letter C added to a species or variety indicates that it was found in Cantyre only, and the letter I that it was found in Islay only. The plants unmarked were found in both places. An asterisk (*) prefixed shows that the plant is doubtfully native.

DICOTYLEDONES.

I.—RANUNCULACEÆ.

Thalictrum minus.
Anemone nemorosa. C.
Ranunculus aquatilis. I.
——— hederaceus.
5 ——— Flammula.
——— acris.
——— repens.
——— sceleratus.
Caltha palustris.
10 Trollius europæus. C.
*Aquilegia vulgaris. I.

II.—BERBERACEÆ.

Berberis vulgaris. C.

III.—NYMPHÆACEÆ.

Nymphæa alba. I.
Nuphar lutea. I.

IV.—PAPAVERACEÆ.

15 Papaver Argemone. I.
——— dubium.
*——— somniferum. I.

V.—FUMARIACEÆ.

Corydalis claviculata. C.
Fumaria capreolata.

VI.—CRUCIFERÆ.

20 Cakile maritima.
Crambe maritima.
Capsella Bursa-pastoris.
Cochlearia officinalis.
Draba incana. I.
25 *Camelina sativa.
Cardamine pratensis.
——— hirsuta.
——— β. sylvatica.
Arabis hirsuta. I.
Nasturtium officinale.
30 Sisymbrium officinale.
*Hesperis matronalis. I.
*Brassica campestris. I.
*——— β. Rapa. C.
Sinapis arvensis.
——— alba.
35 ——— monensis. C.
Raphanus Raphanistrum.
——— β. maritimus. C.

VII.—RESEDACEÆ.

Reseda Luteola. C.

VIII.—VIOLACEÆ.

Viola palustris.
——— canina.
40 ——— tricolor.
——— β. arvensis.
——— lutea.

IX.—DROSERACEÆ.

Drosera rotundifolia.
——— longifolia. I.

Drosera anglica. I.

X.—POLYGALACEÆ.

45 Polygala vulgaris.

XI.—CARYOPHYLLACEÆ.

Silene inflata. I.
——— maritima.
Lychnis Flos-cuculi.
——— diurna.
50 ——— Githago. I.
Sagina procumbens.
——— maritima. C.
Spergula subulata.
——— nodosa.
55 ——— arvensis.
Arenaria peploides.
——— serpyllifolia.
——— marina.
Stellaria media.
60 ——— Holostea. C.
——— graminea. C.
——— uliginosa. I.
Cerastium glomeratum.
——— triviale.
65 ——— atro-virens.

XII.—MALVACEÆ.

Malva moschata. I.
——— sylvestris. I.

XIII.—TILIACEÆ.

*Tilia europæa.

XIV.—HYPERICACEÆ.

Hypericum Androsæmum.
70 ——— quadrangulum.
——— humifusum.
——— pulchrum.
——— elodes. I.

XV.—ACERACEÆ.

*Acer Pseudo-platanus.

XVI.—GERANIACEÆ.

75 Erodium cicutarium.
Geranium pratense.
——— molle.
——— dissectum.
——— robertianum.

XVII.—LINACEÆ.

80*Linum usitatissimum.
——— catharticum.
Radiola millegrana.

XVIII.—OXALIDACEÆ.

Oxalis Acetosella.

XIX.—LEGUMINOSÆ.

Ulex europæus.
85 Sarothamnus scoparius.
Ononis arvensis. I.
Anthyllis Vulneraria.
Medicago lupulina. I.
Trifolium repens.
90 ——— pratense.
——— medium.
——— arvense. I.
——— procumbens.
——— minus.
95 Lotus corniculatus.
——— major.
Vicia sylvatica. C.
——— Cracca.
——— sativa. C.
100 ——— sepium.
——— hirsuta.
Lathyrus pratensis.
Orobus tuberosus.

XX.—ROSACEÆ.

Prunus spinosa.
105 ——— Padus. I.
——— Cerasus. I.
Spiræa Ulmaria.
*——— salicifolia. I.
Dryas octopetala. C.
110 Geum urbanum. C.
——— rivale. I.
Agrimonia Eupatoria. I.
Potentilla anserina.
——— reptans. C.
115 ——— Tormentilla.
——— Comarum.
Fragaria vesca.
Rubus saxatilis.
——— fruticosus.
120 ——— macrophyllus.
——— rhamnifolius.
——— affinis. I.
——— plicatus. C.
——— Idæus.
125 Rosa spinosissima.
——— villosa.
——— tomentosa. C.
——— rubiginosa. C.
——— canina. C.
130 Alchemilla vulgaris.
——— arvensis.
Cratægus Oxyacantha.
Pyrus malus. C.
——— Aucuparia.

XXI.—ONAGRACEÆ.

135 Epilobium angustifolium.
——— parviflorum.
——— montanum.
——— palustre.
——— tetragonum.
140 ——— virgatum.
Circæa lutetiana. C.

Circæa alpina, β. intermedia.

XXII.—Haloragiaceæ.

Hippuris vulgaris.
Myriophyllum spicatum. I.
Callitriche verna. I.
145 ——— platycarpa.
——— pedunculata. I.
——— autumnalis. I.

XXIII.—Lythraceæ.

Lythrum Salicaria.
Peplis Portula.

XXIV.—Portulacaceæ.

150 Montia fontana.

XXV.—Paronychiaceæ.

Scleranthus annuus.

XXVI.—Crassulaceæ.

Sedum Rhodiola.
*——— Telephium.
——— anglicum.
155 ——— acre.
Cotyledon Umbilicus. C.

XXVII.—Grossulariaceæ.

Ribes rubrum. I.

XXVIII.—Saxifragaceæ.

Saxifraga aizoides.
——— oppositifolia. C.
160 ——— hypnoides. C.
Chrysosplenium oppositifolium.
Parnassia palustris.

XXIX.—Umbelliferæ.

Hydrocotyle vulgaris.
Eryngium maritimum.
165 Conium maculatum.
Apium graveolens. C.
Helosciadium nodiflorum.
——— inundatum.
Ægopodium Podagraria.
170 Carum verticillatum. C.
Bunium flexuosum. I.
Pimpinella Saxifraga.
Œnanthe crocata.
——— Lachenalii.
175 Ligusticum scoticum.
Angelica sylvestris.
Heracleum Sphondylium.
Daucus Carota.
Torilis Anthriscus.
180 Anthriscus sylvestris.
Myrrhis odorata. C.

XXX.—Araliaceæ.

Hedera Helix.

XXXI.—Cornaceæ.

*Cornus sanguinea. I.

XXXII.—Caprifoliaceæ.

Sambucus nigra.
185 *Viburnum Opulus. I.
Lonicera Periclymenum.

XXXIII.—Rubiaceæ.

Galium verum.
——— palustre.
——— saxatile.
190 ——— Aparine.
Sherardia arvensis.
Asperula odorata.

XXXIV.—Valerianaceæ.

Valeriana officinalis.
*——— pyrenaica. I.

XXXV.—Dipsaceæ.

195 Scabiosa succisa.

XXXVI.—Compositæ.

Oporinia autumnalis.
Hypochæris radicata.
Sonchus arvensis.
——— asper.
200 ——— oleraceus.
Crepis virens.
——— paludosa. C.
Hieracium Pilosella.
——— murorum. C.
205 ——— sylvaticum.
——— boreale.
——— umbellatum.
Taraxacum officinale.
Lapsana communis.
210 Arctium minus.
Carduus lanceolatus.
——— palustris.
——— arvensis.
Centaurea nigra.
215 Bidens cernua. C.
——— tripartita.
Eupatorium cannabinum. I.
Tanacetum vulgare.
Artemisia vulgaris.
220 Gnaphalium dioicum.
——— sylvaticum.
——— uliginosum.
——— minimum. C.
——— germanicum. C.
225 Petasites vulgaris.
Tussilago Farfara.
Aster Tripolium.
Solidago Virgaurea.
Senecio vulgaris.
230 ——— sylvaticus.
——— Jacobæa.
——— aquaticus.
Pulicaria dysenterica.
Bellis perennis.
235 Chrysanthemum segetum.

Chrysanthemum Leucanthemum.
Pyrethrum inodorum.
——— maritimum.
Anthemis nobilis. I.
240 Achillea Ptarmica.
——— Millefolium.

XXXVII.—CAMPANULACEÆ.

Campanula rotundifolia.
*——— latifolia. I.
Jasione montana.

XXXVIII.—ERICACEÆ.

245 Erica Tetralix.
——— cinerea.
Calluna vulgaris.
Arctostaphylos Uva-ursi. I.
Vaccinium Myrtillus.

XXXIX.—ILICACEÆ.

250 *Ilex Aquifolium.

XL.—JASMINACEÆ.

*Ligustrum vulgare.
*Fraxinus excelsior.

XLI.—GENTIANACEÆ.

Gentiana Amarella. I.
——— campestris.
255 Erythræa Centaurium.
——— linarifolia. I.
Menyanthes trifoliata.

XLII.—POLEMONIACEÆ.

*Polemonium cæruleum. I.

XLIII.—CONVOLVULACEÆ.

Convolvulus sepium.
260 ——— Soldanella.
*Cuscuta Epilinum.

XLIV.—BORAGINACEÆ.

Myosotis repens. C.
——— cæspitosa.
——— arvensis.
265 ——— versicolor.
Steenhammera maritima. C.
Symphytum tuberosum. I.
Lycopsis arvensis.

XLV.—SOLANACEÆ.

Hyosciamus niger. C.
270 Solanum Dulcamara. I.

XLVI.—SCROPHULARIACEÆ.

Veronica arvensis.
——— serpyllifolia.
——— scutellata. C.
——— Anagallis.
275 ——— Beccabunga.
——— officinalis.
——— Chamædrys.
——— hederifolia. C.
——— agrestis.
280 ——— polita. C.
Euphrasia officinalis.
——— Odontites.
Rhinanthus Crista-galli.
Melampyrum pratense.
285 Pedicularis palustris.
——— sylvatica.
Scrophularia nodosa.
Digitalis purpurea.

XLVII.—LABIATÆ.

Lycopus europæus.
290 Mentha aquatica.
——— sativa.
——— β. rubra. I.
——— arvensis.
Thymus Serpyllum.
Origanum vulgare. I.
295 Teucrium Scorodonia.
Ajuga reptans. I.
Lamium amplexicaule. C.
——— intermedium.
——— purpureum.
300 Galeopsis Tetrahit.
——— versicolor.
Stachys palustris.
——— β. ambigua. C.
——— sylvatica.
——— arvensis.
305 Glechoma hederacea.
Prunella vulgaris.
Scutellaria galericulata.

XLVIII.—LENTIBULARIACEÆ.

Pinguicula vulgaris.
——— lusitanica.
310 Utricularia minor. I.

XLIX.—PRIMULACEÆ.

Primula vulgaris.
Lysimachia nemorum.
Anagallis arvensis.
——— tenella.
315 Samolus Valerandi.
Glaux maritima.

L.—PLUMBAGINACEÆ.

Armeria maritima.
——— var. alpina. I.

LI.—PLANTAGINACEÆ.

Plantago major.
——— lanceolata.
——— β. altissima. C.
320 ——— maritima.
——— Coronopus.
Littorella lacustris. I.

LII.—CHENOPODIACEÆ.

Chenopodium album.
Atriplex laciniata.
325 ——— rosea.

Atriplex patula.
——— angustifolia.
——— erecta.
Beta maritima. I.
330 Salsola Kali.
Schoberia maritima. C.
Salicornia herbacea. I.
——— β procumbens.

LIII.—POLYGONACEÆ.

Polygonum Bistorta. I.
——— amphibium.
——— β. terrestre.
335 ——— Persicaria.
——— lapathifolium.
——— Hydropiper.
——— aviculare.
——— Raii. C.
340 ——— Convolvulus.
Rumex Hydrolapathum. I.
——— crispus.
——— obtusifolius.
——— sanguineus, β. viridis. C.
——— acetosa.
345 ——— Acetosella.

LIV.—ELÆAGNACEÆ.

*Hippophae rhamnoides.

LV.—EMPETRACEÆ.

Empetrum nigrum.

LVI.—EUPHORBIACEÆ.

Euphorbia helioscopia.
Mercurialis perennis.

LVII.—URTICACEÆ.

350 Urtica urens.
——— dioica.
*Ulmus montana.

LVIII.—AMENTIFERÆ.

Quercus Robur.
*Castanea vulgaris.
355 *Fagus sylvatica.
Corylus Avellana.
Alnus glutinosa.
Betula alba.
——— var. glutinosa. I.
*Populus alba. C.
360 ——— tremula. C.
*——— nigra. I.
Salix pentandra.
——— fragilis.
——— alba.
365 ——— purpurea.
——— Helix.
——— viminalis.
——— stipularis. I.
——— Smithiana.
370 ——— acuminata. I.
Salix cinerea.
——— aquatica. I.
——— aurita.
——— caprea. I.
375 ——— nigricans. I.
——— fusca, β. repens.
——— rosmarinifolia? I.
Myrica Gale.

LIX.—CONIFERÆ.

Pinus sylvestris.
Juniperus communis, β. nana.

MONOCOTYLEDONES.

LX.—ORCHIDACEÆ.

Listera ovata. I.
380 Orchis latifolia.
——— maculata.
Gymnadenia Conopsea.
Habenaria viridis.

LXI.—IRIDACEÆ.

Iris Pseudacorus.

LXII.—LILIACEÆ.

385 Allium ursinum. I.
Scilla verna. C.
Agraphis nutans.

LXIII.—ASPARAGACEÆ.

*Ruscus aculeatus. I.

LXIV.—JUNCACEÆ.

Juncus conglomeratus.
390 ——— effusus.
——— maritimus. I.
——— acutiflorus.
——— lamprocarpus.
——— supinus.
395 ——— compressus.
——— β. coenosus. C.
——— bufonius.
——— squarrosus.
Luzula sylvatica.
——— pilosa.
400 ——— campestris. C.
——— multiflora.
Narthecium ossifragum.

LXV.—ALISMACEÆ.

Alisma Plantago.
——— ranunculoides. I.
405 Triglochin maritimum.
——— palustre.

LXVI.—FLUVIALES.

Potamogeton pusillus.
——— crispus.
——— perfoliatus. I.
410 ——— heterophyllus. I.
——— rufescens. I.
——— natans.

Potamogeton oblongus.
Zostera marina.
Ruppia maritima, β. rostellata. I.
415 Lemna minor.

LXVII.—ARACEÆ.

Sparganium simplex. I.
——— ramosum.

LXVIII.—CYPERACEÆ.

Schœnus nigricans.
Rhyncospora alba. I.
420 Blysmus rufus.
Scirpus lacustris, β. glaucus. I.
——— setaceus.
——— Savii.
——— maritimus. C.
——— palustris.
425 ——— multicaulis. C.
——— pauciflorus.
——— cæspitosus.
Eriophorum vaginatum.
——— polystachion.
430 Carex dioica. C.
——— pulicaris.
——— stellulata.
——— ovalis.
——— remota. I.
435 ——— intermedia. I.
——— arenaria.
——— vulpina.
——— Goodenovii.
——— rigida.
440 ——— acuta. I.
——— flava.
——— extensa.
——— fulva.
——— distans. I.
445 ——— binervis.
——— lævigata. I.
——— panicea.
——— glauca.
——— filiformis. I.
450 ——— hirta. C.
——— ampullacea.
——— vesicaria. I.

LXIX.—GRAMINEÆ.

Phalaris arundinacea.
Anthoxanthum odoratum.
455 Phleum pratense.
——— var. nodosum. C.
Alopecurus pratensis. C.
——— geniculatus.
Milium effusum.
Agrostis canina.
460 ——— vulgaris.
——— — β. pumila. I.
Agrostis alba.
——— β. stolonifera.
——— γ. maritima. I.
Ammophila arenaria.
Phragmites communis.
Aira cæspitosa.
465 —— flexuosa.
—— caryophyllea.
—— præcox.
*Avena strigosa.
——— pubescens.
470 Arrhenatherum avenaceum.
Holcus lanatus.
——— mollis.
Triodia decumbens. I.
Kœleria cristata.
475 Molinia cærulea.
Catabrosa aquatica.
——— — β. littoralis.
Glyceria fluitans.
Sclerochloa maritima.
Poa annua.
480 —— pratensis.
——— var. arenaria. I.
—— trivialis.
Cynosurus cristatus.
Dactylis glomerata.
Festuca bromoides.
485 ——— ovina.
——— β. vivipara. C.
——— duriuscula.
——— elatior.
——— pratensis. C.
——— gigantea.
490 Bromus asper. C.
Serrafalcus secalinus.
——— commutatus. C.
——— mollis.
——— racemosus.
495 Brachypodium sylvaticum.
Triticum repens.
——— junceum.
Lolium perenne.
——— var. ramosum. I.
*——— multiflorum. I.
500 ——— temulentum.
Nardus stricta.

ACOTYLEDONES.

LXX.—EQUISETACEÆ.

Equisetum Telmateia.
——— arvense.
——— sylvaticum. I.
505 ——— palustre.

Equisetum limosum. I.
—— var. simplex. I.

LXXI.—Lycopodiaceae.

Lycopodium Selago.
—— selaginoides.

LXXII.—Filices.

Polypodium vulgare.
510 —— Phegopteris.
Polystichum aculeatum, γ. lobatum.
Lastrea Oreopteris.
—— Filix-mas.
Lastrea dilatata.
Athyrium Filix-fœmina.
515 Asplenium Trichomanes.
—— marinum.
—— Adiantum-nigrum.
—— Ruta-muraria.
Scolopendrium vulgare.
520 Blechnum boreale.
Pteris aquilina.
Hymenophyllum Wilsoni. I.
523 Osmunda regalis. I.

On reviewing the catalogue, it will be found that the total number of species collected in Cantyre and Islay, is as follows:—

Phanerogamous species, . .	501	Cryptogamous species (Ferns), .	22
" varieties, .	26	" varieties, . .	2
	527		24

Making a total of 523 species and 28 varieties, in all 551.

Of the Phanerogamous species 81 are peculiar to Islay, and of the varieties 9; while 50 Phanerogamous species and 10 varieties are peculiar to Cantyre.

There are 4 Cryptogamous species and 1 variety found in Islay, and not in Cantyre.

It will thus be found that in Islay there were gathered of

Phanerogamous species, . .	451	Cryptogamous species (Ferns), .	22
" varieties, .	16	" varieties, . .	2
	467		24

While in Cantyre there were observed of

Phanerogamous species, . .	420	Cryptogamous species (Ferns), .	18
" varieties, .	17	" variety, . .	1
	437		19

5th March, 1845.—*The* President *in the Chair.*

Mr. James Murray, Garnkirk, was admitted a member of the Society. The following paper was read:—

IX.—*Farther Observations on the State of the Blood after taking Food.* By Andrew Buchanan, M.D., *Professor of the Institutes of Medicine in the University of Glasgow.*

Last year I read to the Society a memoir "On the White or Opaque Serum of the Blood;" the object of which was to show, that after a meal consisting of various articles of food in common use the serum of the blood becomes white or otherwise discoloured, and continues in that state for a period, longer or shorter according to circumstances. It could not be determined, from the observations then narrated, whether this discolouration be produced by every sort of food, or follow only certain kinds of it. The present communication is principally intended to supply that deficiency, by giving an account of the effects of various simple alimentary principles, or definite combinations of such simple aliments upon the colour of the blood.

Another object which I have kept in view is to give an account of a white substance different from that which gives the opaque colour to the serum of the blood, but which closely resembles it in appearance, and exists in the serum still more generally and in greater abundance. It first became known to me in the course of these investigations. It exists both in the opaque serum and in that which is transparent, and is precipitated by supersaturating the liquid with common salt, or with sulphate of soda and certain other salts to be hereafter mentioned. It is characterised by being immediately redissolved on adding a little more water than sufficient to re-dissolve the excess of salt, while it is again precipitated by adding the salt to supersaturation.

I intended, farther, to have discussed the question of the existence in the blood of a fermentable principle, yielding carbonic acid gas on being treated with yeast; and had made a great variety of experiments with that object in view: but not having had sufficient time to repeat those experiments, so as to satisfy myself as to the true interpretation of them, I have omitted the subject altogether, except where it is incidentally introduced.

The investigations were conducted, as formerly, by examining the blood drawn from persons, who, after fasting from sixteen to twenty-four hours, had taken a full meal consisting of some simple aliment, or combination of such aliments. I shall narrate the observations nearly in the order in which they were made; and, as nearly as possible, in the words in which they were originally recorded; as there will be less chance of error in this way than if I attempted to arrange and abridge them. I conceive, also, that a detailed account of these observations may not be without use to those who shall hereafter, I hope with better success, engage in similar inquiries: an object which should be kept more especially in view by physiologists, as their observations cannot, like experiments in the physical sciences, be repeated at will, but require opportunities not always to be obtained, and of which, therefore, the most ought to be made. This must also be my excuse for introducing sundry observations on the state of the blood not immediately bearing on the subject of this memoir.

I begin by giving an account of the effects of Gelatin on the blood, with respect to which two series of observations were made.

Gelatin.—On the 2d of April, 1844, two stout men (to distinguish whom I shall employ the letters A. and B., as I shall employ other letters in the same way hereafter,) after fasting sixteen hours, had each for dinner two English pints of strong beef tea, (veal soup was intended, but could not be had,) and half-a-crown's worth of calf-foot jelly, being about the same measure of jelly. Each of them lost a few ounces of blood three hours after the meal, and the same quantity six hours after it.

The serum of the blood first drawn from A. was opaline, but translucent; and exhibited nothing remarkable under the microscope. That of the blood last drawn was very milky, being so opaque that the brightest light could not pass through it; and under the microscope it showed innumerable very minute amorphous particles, almost none of them being spherical. The coagulum of this blood was natural, while that of the former was mottled, but without any translucent crust, the mottling being as if from the intermixture of florid and black blood.

The serum of the other man's blood was much more abundant. That from the first bleeding was opaline, but less so than the corresponding serum of A. That from the second bleeding was more opaline, but still translucent in a good light. The coagulum of the latter was natural, while that of the former had a well-marked crust of transparent fibrin.

Common salt was found to separate a white cream not only from the milky serum, (A. at six hours;) but likewise from the three opaline specimens—of which the explanation will be found below.

These observations are alluded to in the last memoir, having been made immediately after it was submitted to the Society, but before it was printed. The conclusions to which they appeared to lead, when taken in connexion with the other observations there narrated, were, *first*, that the azotized articles of food, after being digested in the first passages, and absorbed into the blood-vessels, were found there, in the first instance, as the white substance which gives to the serum of the blood its milky colour; *second*, that oily substances appeared to contribute to the formation of the white matter; and, *third*, that most of the other non-azotized articles of food probably existed in the blood in the form of sugar. These conclusions were not, indeed, formally stated, because they were by no means established, and will indeed be shown below to be to a certain extent incorrect; but I mention them here, as they give the clue to the experiments now to be described, which were undertaken with the view either of confirming or overturning the hypotheses just stated.

The object of the first trial was to determine whether Starch—a non-azotized substance—made the serum white, and whether the serum was fermentable. Arrow-root was selected as one of the purest forms of starch; and as the conditions to be fulfilled forbade its being sweetened with sugar in the usual way, it was seasoned with aromatics to correct its insipidity.

Arrow-Root.—On the 12th of April, C., after fasting sixteen hours, had for dinner arrow-root, made with water, and seasoned with mace and nutmeg. He took from half-a-pound to a pound of it. He was bled at three and at six hours after the meal. The serum in both instances was quite transparent, without any white matter. The coagulum at three hours had a thick translucent fibrinous crust, marked with numerous red dots: that at six hours was natural. This man did not feel again hungry so soon as the men fed with gelatin, as if the latter substance were dissolved in the stomach more rapidly than arrow-root.

The serum treated with yeast evolved carbonic acid gas in abundance, as did also the crassamentum liquified by expression through a linen cloth.

It thus appears that pure Starch, taken as food, gives no white colour to the serum of the blood. This conclusion may be considered as established, as it will be seen below that the experiment was repeated three times, and always with the same result.

I now proceeded to test the hypothesis farther in reference to azotized food.

EGGS AND MILK.—On the 30th April, 1844, D., after fasting eighteen hours, had at noon a pudding, consisting of six eggs and a pint and a half of milk. He was bled twice, to the extent of eight ounces. The blood first drawn, three hours after the meal, gave but a small quantity of serum, which was opaline, resembling whey. The serum of the blood last drawn, at seven hours after the meal, was much more abundant. It had less whiteness, but still was not clear, being brownish like syrup, an appearance I have since found to depend frequently on the presence of a very minute quantity of the red part of the blood. The crassamentum of the blood first drawn had the translucent fibrinous crust well marked: that of the blood last drawn was natural.

Both specimens of serum showed, under the microscope, a few spherical granules. On adding salt to that marked *D. 3 hours*, a white matter immediately rose to the surface, and continued there some days without showing any tendency to fall to the bottom. The other specimen marked *D. 7 hours*, gave, on the addition of salt, much more of the white matter than its colour led me to expect, and, as in the former case, the white matter showed no tendency to precipitate. In this respect, as well as in general appearance, the white matter resembled closely a very abundant specimen which I accidentally procured more than four years ago, and which has continued at the top ever since, although the phial has been frequently uncorked. I do not know from what diet it proceeded, but the present and two other trials mentioned below seem to me to render probable that it may have been from eggs.

I was particularly struck with the difference in the quantity of serum procured by these two bleedings, practised upon the same person, with an interval of only three hours; that from the latter being about quadruple that from the former. I at first supposed that a large quantity of liquid must have been taken in the interval, but on inquiry I found the man had taken no drink of any kind. The small quantity of the serum in the first case, therefore, was probably entirely owing to the cup in which the blood was received being very full, and the surface covered with air-bells. These air-bells cause the coagulum to adhere to the rim and sides of the cup, and thus prevent the separation of the serum. I have since more than once observed a similar deficiency from the same purely mechanical cause.

FIBRIN.—On the same day, E., after fasting the same length of time as D., had a pound and a half of beaf steak, carefully freed from fat. He was bled at the same periods after the meal. The relative quantities of serum from the two bleedings were here reversed; that from the latter bleeding being considerably less in quantity, and apparently from the same cause. The serum at three hours was of the colour of whey; that at seven hours had the same hue, but less intense: in the former a few globules were seen with the microscope; in the latter numerous irregular particles. On adding as much salt as it could dissolve to the former, it immediately became quite opaque, and showed large flocculent white masses floating through it, which, however, had no tendency to ascend, and at length fell to the bottom. But for this last circumstance, the appearances would have been very much the same as are observed on adding water to an alcoholic solution of Camphor. The other specimen of serum was treated in the same way, with a similar result, only the flocculent precipitate was much less abundant.

The coagulum of the blood first drawn had a fibrinous crust: that of the last drawn none.

Two conclusions may be drawn from these last experiments: first, that the effect of the salt is not merely mechanical, but a true chemical precipitation; and, second, that the white matter proceeding from different kinds of food is probably not always the same, since in some cases it seeks the bottom, and in some the top. Subsequent trials tended to confirm both these conclusions.

As this is the first time I have had occasion to mention the action of salt in causing precipitation from serum, I shall here explain the mode in which the salt requires to be employed: as the process will thus be more readily comprehended, than if I left the knowledge of it to be gleaned in the way I myself learned it, from the experiments to be hereafter mentioned.

In the former memoir I described the action of salt in separating the white matter of milky serum to be purely mechanical, increasing the specific gravity of the liquid, and thus causing the solid particles diffused through it to rise to the surface. This I still believe to be the true mode of action of the salt, whenever it is added in less quantity than the serum is capable of dissolving; but no sooner is the salt added to saturation than it acts in a totally different way, and becomes a true chemical precipitant. This I was led to find out from my having adopted it as a consequence of the mechanical theory above stated, that the heavier the serum was made the more readily would the separation of the white matter take place; and expecting on this principle to obtain at once a maximum effect, I added the salt till a portion of it remained at the bottom undissolved. Operating thus, I was surprised to observe the great increase in the quantity of the white product, which, as stated above, was much greater than could have been anticipated from the whiteness of the serum, and I even found afterwards that it could be obtained in as great abundance from serum which was perfectly limpid. I was thus assured that the salt added to saturation did not act in a mechanical way, but acted as a true chemical precipitant.

To the white substance thus obtained I gave, provisionally, the name of *Pabulin;* on the supposition that it proceeds from the alimentary matter or pabulum, which has just undergone digestion in the first passages. This name will accordingly be employed below to designate the white substance obtained from the blood by the process just described, or by analogous processes to be hereafter mentioned. This however is only done for convenience, and without prejudging the questions as to the origin of the matter so designated, and its relations to the white matter which gives the milkiness to the blood.

EGGS.—On the 20th of May, F. had for dinner six eggs, which were eaten without any other accompaniment than a little salt. He was bled at two and at four hours after the meal. The serum was small in quantity in both cups, which were very full, and with the coagulum adhering, by means of froth, to the edges, so that the whole serum lay on the surface of the coagulum. It was deeply tinged red.

The serum from the blood first drawn was kept two days, that the red matter of the blood might subside from it. During that time it threw up a cream spontaneously. On filtering it, the white matter and a little oil were left on the filtering paper: the latter being shown, as formerly, by drying the paper. The filtered liquid was quite transparent, but on adding salt to supersaturation, a greyish sublimate separated, showing that the salt acted as a precipitant, if indeed that name may be applied to an agent separating a matter which swims on the surface.

The serum from the blood last drawn threw up no cream, although kept the same time as the other specimen. On adding salt in the usual way, a sublimate separated so abundant as to be equal to about one-fourth of the whole liquid in volume. It was loose and flocculent; greyish, like chewed meat; or more strikingly still—(although the physician only can appreciate the comparison)—like the characteristic discharge from the bowels in dysentery. It continued several days at the top, with no tendency to subside. It was then skimmed off, and a part of it left behind subsided probably from the agitation. The sediment thus produced was completely redissolved on adding water, the solution being then quite transparent, but on again saturating with salt becoming turbid.

The coagulum was, in both cups, natural.

CASEIN.—On the 29th of May, G. having taken no breakfast, had at 11 A.M. a Scotch pint of curds, (two English quarts nearly.) He was bled at two, and at four hours after the meal. The serum in both cups was very abundant, being after thirty hours about equal in volume to three-fourths of the whole blood drawn. That in the first cup was the most abundant, and the corresponding coagulum had a thick buffy coat. The other coagulum had only a trace of a paler fibrinous crust.

The serum in both instances was turbid; but that was owing to a minute quantity of red colouring matter, which, subsiding in six hours, left both liquids beautifully transparent, that from the blood first drawn having a greenish, while the other inclined to a yellow tint. Salt added to supersaturation gave an abundant precipitate, which partly rose to the surface, buoyed up by minute air-bells, but was chiefly diffused through the liquid in voluminous flocks, and at length the whole subsided to the bottom.

The transparent liquid placed under the microscope was observed to contain some minute entozoa (vibriones), although it was quite fresh. This was forty-six hours after the blood had been drawn, the weather being coldish at the time. I once before saw the same animalcules in blood taken from a man after a fast of sixteen hours. They were elongated, and of very rapid movement, and not accompanied by any of the globular and elliptical infusoria which commonly show themselves first in organic liquids undergoing decomposition.

Thinking that other salts naturally contained in the serum, and therefore not likely to interfere with its chemical equilibrium, might cause a precipitate like common salt, I tried phosphate of soda, but on adding it to supersaturation it did not at all affect the limpidity of the serum; and on afterwards adding common salt, the usual effect was produced. I tried also bicarbonate of soda, but with no better success; and my stock of serum being exhausted, I abandoned the inquiry, but, as will be seen below, without losing sight of it.

White-Fish.—On the 2d of June, H., after fasting the usual time, had four pounds of white-fish, of which he took a large proportion, with no other accompaniment than a little salt. He was bled at two, and at four hours after the meal. The serum on both occasions was scanty, obviously owing to air-bells on the coagulum, which had caused it to adhere to the edge of the cup almost all round. The coagulum was red on the surface, and very loose in texture from retained serum. The serum in both cups was quite transparent, and on being supersaturated with salt, gave a voluminous precipitate like that from milk already described.

These two last experiments fully satisfied me, that partaking freely of a highly azotized diet does not necessarily occasion any milkiness in the serum of the blood. It appeared to me, however, probable, that the white matter which in those instances was precipitated by the salt, was the very same that in other circumstances causes the serum to be milky, the only difference being, that in the former instances the white matter is completely dissolved, and in the latter only imperfectly. Now, in the experiment made on the 12th of April, a man fed on arrow-root was found to have the serum of his blood transparent, or without whiteness, and no farther examination of its qualities was made except ascertaining that it was fermentable on the addition of yeast. But it was desirable to know whether a diet of Starch, although it did not render the serum of the blood milky, might not, as in the cases just detailed, introduce with it a white matter precipitable by salt.

Arrow-Root.—Accordingly on the 15th of June, M., after fasting the usual time, had a meal of arrow-root, prepared with water, and seasoned with spice. He took it readily, but not so much of it as was taken on the last occasion. He was bled at two, and four hours after the meal.

The serum on both occasions was transparent, and with a greenish tinge. That from the blood last drawn gave a precipitate with salt, but not so abundnnt as in several former cases. The other specimen gave a much more abundant precipitate, in part rising to the surface. This last also, on being filtered, left oily stains upon the filtering paper, as I have since found the serum of the blood very frequently do. I found the white precipitate from salt to be completely resoluble on adding as much water as brings the solution somewhat under the point of saturation. On again saturating with salt, the precipitate falls, and on again adding water, it is redissolved, and so for several times in succession.

Does, then, Starch give a white precipitate with salt like the azotized principles? Before drawing this conclusion there are some causes of fallacy to be guarded against. The white matter may have proceeded from food taken before the fast, and the more abundant precipitate in the blood first drawn seemed to countenance this conjecture. The fast may not have been strictly observed. Both these sources of error will be precluded by drawing a little blood before the meal, and testing the serum with salt. Lastly, arrow-root contains a certain proportion of azotized matter, which, in some specimens examined by him, Dr. R. D. Thomson found to be about three per cent. This experiment appearing to me to be an important one, I repeated it twice, as will be seen below; and on one of these occasions a fast of upwards of twenty-four hours was rigidly observed before the meal, so as to remove entirely the second objection mentioned above, and diminish the first as much as I believe practicable.

ARROW-ROOT—STARCH AND SUET.—On the 5th of July, O. and P., after a fast of sixteen hours which I had no reason to suspect was not faithfully observed, had, the former a mess of spiced arrow-root prepared with water, and the latter a pudding composed of two parts common starch and one of suet. They were both bled immediately before the meal, and again at two, and at four hours after it.

The serum from the blood of O. was, the whole three times, quite transparent. On testing it with salt, the serum of the blood drawn before the meal gave a precipitate nearly as abundant as that from the blood drawn after the meal. The blood taken from P. before the meal gave a serum which was quite limpid, while the blood taken after the meal gave on both occasions a very white serum: that from the first bleeding after the meal threw up spontaneously a white cream, which on the third day was as abundant as I had ever seen it; that again from the second bleeding, although equally white, yielded no cream. On filtering the creamy serum, the filtering paper after being dried was found stained with oil, which it was natural to think was occasioned by the suet; but on filtering the corresponding limpid serum of O., who had taken only arrow-root, the oily stain was found not less deep. The serum of P. gave a precipitate with salt as well before as after the meal, and that from the serum after the meal was far more abundant than could possibly have proceeded merely from the matter in suspension. The serum of P. before the meal was kept many days in a phial only in part filled, and yet continued quite free of any unpleasant smell, both then and when afterwards poured into an open glass, and allowed to remain till the water had all evaporated. I have met with several other instances of serum resisting putrefaction, but can offer no probable conjecture as to the cause of so remarkable a property.

This experiment shows clearly the effect of an oily diet in giving milkiness to the serum, since the milkiness was as great from the diet of starch and suet just mentioned, as from the more highly azotized diet of flour and suet mentioned in the last memoir. To illustrate the mode in which the milkiness is occasioned, I added a few drops of oil to the limpid serum of the man who had dined on the arrow-root alone, and on shaking them together I found the liquid become turbid and throw up a kind of cream. This effect, which I had often before observed, I have been in the habit of ascribing to the action of the free alkali of the serum upon the oil forming with it a kind of emulsion. There are indeed good reasons for thinking that the white matter of milky serum is not a mere emulsion of this kind, but an azotized substance, yet it seems probable that the introduction of an oil into the blood is one, and probably the most frequent cause of the white colour of the serum. It is also worthy of remark, that the effect seems to be only occasioned by oil recently introduced with the food, since, as in the case just mentioned, we often find serum abounding with oil, and yet quite limpid, which must be owing to the oil, whether absorbed from within or from without, having been so adjusted by the processes of the vital economy to the other ingredients of the blood, as no longer to disturb their chemical equilibrium.

Reflections not less important are suggested by the fact brought out by both the two last experiments, that the serum of the blood after a fast of sixteen hours gave a precipitate with salt added to supersaturation. Was the fast not strictly observed by men who might naturally be supposed to care little for the result of the experiment, and more for their breakfast of which they were deprived? Was the white matter from the supper of the previous night? or, lastly, does all serum give a white precipitate with salt? To this last query, which I had both put to myself, and which had been put to me by others, I had hitherto answered in the negative, relying upon a specimen of beautifully limpid serum which has been in my possession since 1840, and was shown to the Society last spring, and which I believed to have been saturated with salt, when most probably no more had been dissolved in it than was necessary to keep it from decomposing. Now, however, that the inquiry was again forced upon me, I examined a great many specimens of the serum of blood; and I found all of them, without exception, to give a precipitate with salt, although in very different degrees of abundance. I next examined the liquid of the serous cavities, thinking that possibly it might not be effused till the secondary digestion was completed. In this, however, I was mistaken, as all the specimens of hydrocelic fluid which I examined gave a white precipitate with salt.

I was thus fully satisfied that in all ordinary circumstances serum contains a white matter precipitable by salt. This, however, is by no means inconsistent with the opinion, that the white matter in question is the nutritious part of the food absorbed from the digestive passages, but, on the contrary, renders that opinion the more probable. Iodine taken so as to saturate the system, is found in the blood, in the liquid of the serous cavities, and in the synovia of the joints; and it may be detected in the excretions not only as long as the medicine continues to be taken, but for four days thereafter.* If then a substance taken once or twice daily, to the extent of a few grains, continues so long within the body, it is surely not surprising that we should find there as uniformly traces of our food, which we take three or four times a-day or oftener, to the extent of several pounds.

It was, however, desirable to determine with greater accurary, whether the white matter precipitated by salt from the serum of the blood was really derived from the recently taken food. To accomplish this object, three methods of proceeding suggested themselves, viz.:—to compare the quantity of precipitable matter found after taking food—1st, with that found in the serum of a person who had fasted, *bona fide*, for twenty-four hours—2d, with that obtained from a person

* London Med. Gaz., 1836.

labouring under some disease for which he had been put upon an antiphlogistic regimen—and lastly, with that obtained from an animal kept long without food.

The first method being that most readily put in practice, was tried first. As a twenty-hour hour's fast is attended at least with eight hours of uneasy sensation, it could not be expected, unless enforced, to be rigidly performed but by a person interested in the success of the experiment. It was also desirable that the person experimented upon should not be under confinement, but take as much exercise as possible to promote the assimilative actions of the system. I therefore tried this experiment upon myself.

ARROW-ROOT.—I dined lightly between four and five o'clock in the afternoon of the 25th of July; in the evening I took exercise on horseback, and next day went about my usual avocations with a good deal of walking, till between five and six in the afternoon, having taken nothing in the interval but a draught of water before going to bed. I now had blood drawn from the arm by a medical friend, and thinking the opportunity a favourable one for trying the effect of starch, I dined upon arrow-root, prepared with water and sweetened with sugar, of which I took a large bowlful—in appearance a mess for a ploughman, but which in reality contained no more than three ounces of dry arrow-root powder. I also drank freely of water sweetened with sugar, and was bled again three hours after the meal.

The serum from both bleedings was quite limpid, and of a deep amber yellow. That from the first bleeding had the deepest tinge; on supersaturating it with salt it became slightly troubled, but without losing its transparency, and at length showed pale flocks, which became whiter in colour as they subsided to the bottom. The serum from the second bleeding gave a precipitate, which was likewise flocculent, of a more decidedly white colour, and more abundant, although very insignificant in point of quantity when compared with the precipitates obtained after a full azotized meal.

This experiment shows, that abstinence from food for twenty-four hours, by a person in good health, taking active exercise in the open air, reduces to a minimum, but does not altogether remove the precipitable matter of the blood. The two other experiments suggested above, lead to the same conclusion; and the last further shows, that a very prolonged fast introduces a new complication into the question by occasioning an incipient decomposition of the blood.

In the beginning of August I got from a medical friend some serum from the blood of a man bled for a pleurisy, of which he died soon afterwards. It gave a scanty precipitate on being saturated with salt.

On the 16th of August, a dog, which had been kept fifty-one hours without food, and had drunk little although allowed a free supply of water, was bled from the saphena, to the extent of about two ounces. The blood trickled slowly down the leg, and was coagulated in part before the whole had been received in the cup. Whether owing to this circumstance, or to the long fast, the serum was tinged deeply red, apparently from the colouring matter being dissolved, for it was quite transparent, and did not lose the colour by standing at rest. Salt gave a precipitate, although little abundant.

We may infer then from these experiments, that it is not possible, without carrying fasting to a greater length than prudence or humanity permit, to deprive the blood altogether of its white precipitate. This conclusion is quite conformable to what our experience of the persistance of Iodine in the body would lead us to expect. It has, however, been ascertained that the white precipitate obtained from the serum of the blood by supersaturation with salt, is most abundant after a meal; that it is less abundant as the period of taking food has been more remote; and that, after a fast of twenty-four hours, it is very insignificant in quantity. Still farther, after certain kinds of food, such as eggs, casein, and white-fish, a much larger quantity of white matter is found in the serum than after certain other kinds of food, such as starch. Last of all, the characters of the precipitate vary, so that it may either be made to swim on the surface, or sink to the bottom, according to the kind of food. It appears, therefore, not unreasonable to conclude, that this white precipitate proceeds from the food, being the newly digested nutritious matter introduced by certain aliments into the blood.

The only other view that can be taken of the nature of this precipitate, is, that it is occasioned by the salt re-acting upon the albumen dissolved in the serous liquid. This view does not seem to me reconcileable with the great variations in the quantity of the precipitate, without any corresponding difference in the quantity of the albumen. Thus in a specimen of hydrocelic serum, of which the specific gravity was 1·038,* the precipitate was so scanty as merely to render the liquid a little turbid; and in another specimen of the same kind of serum, of which the specific gravity was only 1·025, the precipitate was in great abundance. The following considerations and experiments may serve to elucidate this question.

After finding that hydrocelic serum gave a precipitate with salt, I took the opportunity afforded by my getting a plentiful supply of that liquid, to resume the inquiry mentioned above, as to whether any other saline substances acted in the same way upon serum as common salt. I first tried the sulphate of soda, which I found to produce the same effect as the common salt, only I thought the precipitate for the most part more abundant. I found also that this precipitate was immediately redissolved on the addition of water, and was again thrown down on supersaturating with the sulphate. On afterwards trying this salt with the serum of the blood, I found that the precipitate obtained sometimes floated, and sometimes fell to the bottom, and that in this respect there was not always a correspondence in the action of the two salts on the same liquid.

I found sulphate of magnesia to act in the very same way, so that I have since been in the habit of employing commonly these three salts as precipitants.

I found that neither the sulphate of soda nor the common salt threw down the whole precipitable matter contained in the serum. To show this, I saturated some serum with each of these salts separately. I then removed the precipitates by the

* This specific gravity is, I believe, the highest upon record of any serous liquid. The serum was taken from one of the strongest men in this city, who has laboured under hydrocele for about ten years, and from whom I have regularly removed it at intervals of from six to ten months. The specific gravity mentioned above was determined by the hydrometer, but to remove all doubt, I had it again determined with great accuracy by the balance, when it was found to be 1·0377.

filter, so as to get the liquids again quite clear. I now saturated each solution with the salt not before dissolved in it, when I obtained a fresh precipitate in each about as abundant as at first. Still farther, on filtering the liquids again, and saturating with sulphate of magnesia, I obtained an additional precipitate, but much less abundant than I obtained with that salt used in the first instance.

I now tried various other salts, the mode of action of which will be best seen from the following Table, from which are excluded all saline substances, such as the acetate of lead, chloride of mercury, and sulphate of alumina and potass, which, in whatever quantity added, produce a precipitate in serous liquids. It comprehends only those substances, which may be added in any quantity under the point of saturation, without troubling the serum. These may be divided into three classes. Some of them like common salt, produce a precipitate resoluble on the addition of water; some, like the carbonate of potass, and muriate of lime, cause a precipitate not resoluble by water, and some, like the phosphate of soda, cause no precipitate.

I.

Chloride of Sodium,	Abundant Precipitate,	Resoluble.
Sulphate of Soda,	Do.	Do.
Carbonate of Soda,	Considerable,	Do.
Sulphate of Magnesia,	Abundant,	Do.
Tartrate of Potass,	Do.	Do.
Tartrate of Soda and Potass,	Considerable,	Do.

II.

Carbonate of Potass,	Abundant,	Not Resoluble.
Bicarbonate of Potass,	Slight,	Do.
Muriate of Lime,	Abundant,	Do.

III.

Phosphate of Soda,	No Precipitate.
Borate of Soda,	Do.
Bicarbonate of Soda,	Liquid slightly turbid.
Sulphate of Potass,	Do.
Nitrate of Potass,	No Precipitate.
Chlorate of Potass,	Do.
Hydriodate of Potass,	Do.
Triple Prussiate,	Do.
Sulphate of Iron,	Do.
Carbonate of Ammonia,	Do.
Muriate of Ammonia,	Do.

A solution of the albumen ovi gives a precipitate on being saturated with salt, but it is not resoluble on the addition of water.

I may now relate a few additional experiments and observations, some of which were made before those last mentioned, but the account of them was deferred, not to interfere with the preceding argument.

Chyle and Serum.—Having obtained a little chyle from the thoracic duct of a dog fed a few hours previously with oatmeal porridge and milk, I mixed it with some serum which I had brought with me for the purpose. It rendered the serum turbid, and very like in appearance to that which separates from blood after taking food. A very delicate voluminous coagulum soon formed in the liquid.

Serum of Diabetic Blood.—Towards the end of July, I obtained from a medical friend some very opaque serum from the blood of a woman labouring under diabetes, for which she had been bled three times, the blood each time exhibiting the same characters. The discolouration was occasioned by a flocculent brownish white matter, which, in the course of two days, collected in the upper half of the vessel, leaving the liquid below quite clear. This matter exactly resembled in appearance that separated by salt, and this strengthened the opinion which I had begun to entertain, that the substance separating spontaneously and that separable by salt, were mere modifications of the same substance. On drawing off the clear liquid, and saturating it with salt, it gave a precipitate not less abundant than that which had previously separated spontaneously. As I had never before seen serum so loaded with alimentary matter, I inquired as to the diet of this woman, and found it to consist daily of beef 24 oz., bread 12 oz., milk 12 oz., cabbage 6 oz., and 11 lbs. of drink including the milk. She took besides 3 gr. of opium daily The urine amounted to 26½ lbs. on an average in the twenty-four hours, and was highly saccharine.

It is also worthy of remark with respect to this serum, that after it had been a day in my possession I found it to have a most distinct acid reaction. This fact can scarcely be explained, but on the supposition that the serum contained sugar, which had been converted into lactic acid.

HERRINGS.—On the 2d of August, after a fast of eighteen hours, R. took a full meal of fresh herrings, with no other accompaniment than salt. He was bled immediately before the meal, and at two, and four hours after it.

The serum from the first bleeding was quite limpid, that from the second was highly opaline, and that from the third was quite opaque. All of them gave a precipitate with common salt, but in none of them was it very abundant, and in the first it was little less in quantity than in the two last. On the other hand the two last gave a very abundant precipitate with sulphate of soda, while the first gave only a scanty one.

In all probability a much larger precipitate would have been obtained from the blood of this man, had the bleeding been deferred to six or eight hours after the meal, for it may well be supposed that the digestion of such a heavy meal would be laborious, and, therefore, probably the alimentary matter would be late of entering the blood-vessels.

POTATOES—WHISKY.—On the 9th of August T., a stout healthy man, after fasting eighteen hours, dined abundantly upon potatoes and salt. He was bled at four hours after the meal. He had then three glasses of Glenlivet whisky with hot water and sugar, and half-an-hour thereafter he was again bled.

The serum from the first bleeding was rather scanty: that from the last very abundant. Both were quite limpid, and of a yellowish-green tinge, less deep in the latter. Both gave a scanty precipitate with common salt and sulphate of soda: but it was remarkable that while the latter gave the most abundant precipitate with common salt, the former gave the most abundant with sulphate of soda; and that while the precipates with the salt were truly such falling to the bottom, the matter separated by the sulphate of soda was in both cases more properly a *sublimate* rising to the surface.

There was a most striking difference between the clots obtained from these bleedings. That from the first was quite natural, being red on the surface, and without contraction; while that from the second was cupped and buffy. The buff, when seen under the serum, was like that of inflammation; but when viewed attentively, after pouring off the serum, it was found to consist of transparent fibrin, with very opaque filamentous and granular particles imbedded in it.

The only conclusion that can be drawn from the last part of this experiment is, that alcohol has no effect in rendering the serum of the blood white; but it would require to be repeated several times to enable us to judge, whether the appearances of the clot were really due to the action of the alcohol, or were owing to some accidental circumstance.

EGGS.—On the 16th of October, U., after fasting sixteen hours, had six eggs for dinner, which were eaten, as before, with a little salt and nothing else but water for drink. He was bled immediately before the meal, and again four hours after it. The serum from the first bleeding was limpid, and, on supersaturating it with salt, gave a true precipitate falling altogether to the bottom. The serum from the second bleeding was whitish, and, on being treated in the same way, it gave only a scanty precipitate, but a very abundant sublimate, which remained swimming at the surface for many days thereafter. The coagulum of the blood first drawn had a plentiful fibrinous crust, very transparent; the other coagulum was natural.

This result corresponds with those obtained on two former occasions mentioned above, when eggs had been eaten. The experiment was repeated, for the purpose of confirming an argument which has been employed above as to the source of the white matter of the serum. It is obvious, that the meal of eggs either introduced into the blood a sublimable substance not before present, or that it altered the quality of some substance previously existent; which last is a less probable supposition. The small quantity of the serum first obtained, prevented any comparison of the relative quantities of the precipitates.

The following conclusions may be deduced from the observations and reasonings contained in this and the former memoir.

1. The serum of the blood of a healthy man fasting, is perfectly transparent, and of a yellowish or slightly greenish tint.

2. A heterogeneous meal, such as that usually set on the tables of the rich, renders the serum white.

3. The whiteness may commence as early as half-an-hour after eating, and may continue ten or twelve, and sometimes as long as eighteen hours, according to the kind and quality of the food, and the state of the functions of primary and secondary digestion.

4. *Starch*, and *Sugar*, and probably all vegetable substances destitute of oil, give no whiteness to the serum of the blood.

5. *Fibrin*, *Albumen*, and *Casein*, and probably *Protein-compounds* in all their forms if destitute of oil, give no whiteness.

6. Oils combined, whether naturally or artificially, with protein-compounds or with starch, render the serum of the blood white; probably, therefore, oils produce that effect in whatever way taken.

7. Gelatin seems to render the serum of the blood white; this, however, cannot be considered as certainly established, as there may have been some fat in the beef-tea which was taken along with the calf-foot jelly in both experiments on which the above conclusion rests.

8. The coagulum of the blood very frequently exhibits, after taking food, a crust of pellucid fibrin, or of pellucid fibrin dotted with more

opaque particles, and with little of the contraction technically named "cupping."

9. The appearances of the coagulum just mentioned are much more common after azotized than after non-azotized food.

These conclusions relating to the visible characters of the blood may be considered, with the single exception above mentioned, as well established. The conclusions which follow relate chiefly to the chemical properties of the blood, and are not worthy of the same reliance; but the evidence on which they rest has been laid before the reader, and he must judge of them for himself.

1. The substance defined above under the name of Pabulin, is most abundant in the blood a few hours after taking food, sooner or later according to the rapidity of digestion.

2. It is less abundant as the time when food has been taken is more remote, and is small in quantity after a fast of twenty-four hours.

3. It is much more abundant after azotized, than after non-azotized food.

4. It varies in quality, floating or subsiding, according to the kind of food taken.

5. It is probably analogous in nature to the white substance which gives colour to the serum of the blood.

6. The difference between these two forms of this substance probably is, that it is sometimes combined with an alkaline, or earthy salt (choride of sodium, sulphate of soda, &c.), and sometimes with an oily body (stearate of glycerine, &c). In the former case, it seems to dissolve completely in the blood, while in the latter it is only partially dissolved, and renders the serum opaque.

7. The azotized principles of the food are probably made to combine, in the digestive tube, with the alkaline, earthy, and oily salts mentioned above; and thus become capable of being absorbed into the blood.

8. The alkaline and earthy compounds are probably absorbed directly by the blood-vessels, while it seems to be well ascertained that the oily compounds are absorbed through the lacteals.

The subjoined table exhibits, at one view, the results of the observations contained both in this and the preceding memoir, so far as they relate to the visible characters of the blood.

	Diet.	Time of Bleeding after Meal, or before it.	Serum.	Coagulum.
1.	Beef Steak, Bread, Soup, Porter	½ hour	Whitish	Natural.
		1 hour 40 minutes	White	Do.
		18 hours	Limpid	Pellucid Fibrinous Crust.
2.	Beef Steak, Bread, Soup	Before	Do.	Natural.
		3 hours 15 minutes	White	Pellucid Crust.
		3 hours 15 minutes	Do.	Do.
		18 hours	Limpid	Do.

	Diet.	Time of Bleeding after Meal, or before it.	Serum.	Coagulum.
3.	Beef Steak, Bread, Potatoes, Soup, Porter	Before	Do.	Natural.
		2 hours 10 minutes	Whitish	Do.
		8 hours	Gruel-like	Pellucid Crust.
		18 hours	Whitish	Do.
4.	Wheaten Flour, Suet	Before	Limpid	Natural.
		3 hours	Whitish	Do.
		6 hours	Milk-white	Do.
5.	Calf Foot Jelly, Beef Tea	3 hours	Opaline	Mottled.
		6 hours	Quite Opaque	Natural.
6.	Calf Foot Jelly, Beef Tea	3 hours	Opaline	Pellucid Crust.
		6 hours	Very Opaline	Natural.
7.	Arrow-Root, Spiced	3 hours	Limpid	Pellucid Crust.
		6 hours	Do.	Natural.
8.	Eggs, Milk	3 hours	White	Pellucid Crust.
		7 hours	Whitish	Natural.
9.	Beef Steak, Without Fat	3 hours	White	Pellucid Crust.
		7 hours	Whitish	Natural.
10.	Eggs	2 hours	Do.	Do.
		4 hours	Do.	Do.
11.	Curds & Whey	2 hours	Limpid	Buffy Crust.
		4 hours	Do.	Slight Pellucid Crust.
12.	White-Fish	2 hours	Do.	Natural.
		4 hours	Do.	Do.
13.	Arrow-Root, Spiced	2 hours	Do.	Do.
		4 hours	Do.	Do.
14.	Arrow-Root, Spiced	2 hours	Do.	Do.
		4 hours	Do.	Do.
15.	Starch, Suet	2 hours	White	Do.
		4 hours	Do.	Do.
16.	Arrow-Root, Sugar	Before	Limpid	Do.
		3 hours	Do.	Do.
17.	Beef Steak, Bread, Cabbage, Milk		Thick from diffuse grey flocks.	
18.	Herrings	Before	Limpid	Do.
		2 hours	Opaline	Glistening.
		4 hours	Quite Opaque	Do.
19.	Potatoes	4 hours	Limpid	Natural.
20.	Alcohol	½ hour	Do.	Buffy.
21.	Eggs	Before	Do.	Fibrinous Crust.
		4 hours	White	Natural.

12th March, 1845.

A Conversational Meeting of the Society was held this evening, in the Merchants' Hall, at which upwards of 400 persons were present.

The chief curiosities shown on this occasion were the specimens of French art and manufacture, purchased by Government at the late Exposition at the Champs Elysées in Paris for the School of Design in London, and which have been sent down for inspection to the institution in Glasgow, the directors very handsomely placing them at the disposal of the Council of the Philosophical Society for this evening. These articles are of a choice and valuable description, and, presenting a high standard of excellence in various branches of art and manufacture, the study of them in the recently established institutions for the use of which they are intended cannot fail to stimulate the ingenuity of our own artisans and manufacturers. One of the most curious was a drawing or pattern for a rug, being a specimen of the manner in which French designs are executed for the manufacture of these articles. It might be about twelve inches long, by about six or eight in breadth, and consisted of a series of figures of flowers, drawn and coloured with exquisite skill, finished with the minuteness and nicety of miniature painting, and showing an amount of labour which, it was stated, would be poorly compensated to the artist by fourteen guineas, the price at which the pattern was purchased. There were a number of specimens of pottery, and glass manufacture, and jars and vases cast in metal, remarkable for their classic elegance of form and beauty of design. Amongst these were—a valuable bronze vase, with an allegorical design, representing two groups of figures, the most prominent of which were Justice and Peace on one side, and Patience and Hope on the other, all the figures being produced with admirable sculpturesque effect. A jar in common Beauvais ware—the coarsest potter's clay, in fact—showed in a remarkable manner the value of art in moulding forms of perfect grace and symmetry out of the most ordinary and inexpensive materials. One of these elegant jars might cost sixpence, and in France they are much sought after for household purposes. A vase cast in argent-platina, of singularly fine proportions; the chasing elaborated with the minuteness of insect-work; produced in the *atelier* of M. Rudorf; the price of this article was forty guineas, being considered a perfect specimen of the art, and without its equal as yet in British manufacture. Glass-china vase, from the work called Choisi le Roi, situated on the Seine, about seven miles from Paris; value £16. In this specimen the classical proportions of the other vases were produced in a material of exquisite delicacy, combining the purity of crystal with the pearly whiteness and transparency of the finest porcelain, and affording a ground susceptible to the minutest shades of the pencil. Vases of this description are painted by the hands of ladies; and the present specimen bore testimony to the industry and taste with which the paintings are executed. Two Terra Cottas moulded in common tile-clay, and intended for holding flowers;—both very pretty examples of the same union of taste and economy already noticed. Four specimens of enamelled ware, another cheap and beautiful invention, applicable to a variety of purposes, such as plates, dishes, and other articles made of earthenware. The figures are moulded in *intaglio* instead of in *bas relief*, and the mould may be wrought by any man who can make bricks and tiles, and with equal ease and expedition. When the cast is hardened, it is covered with a coat of enamel or varnish in the usual way; and the lowest lines or hollows of the *intaglio* being designed to throw up the shaded parts of the picture, they receive the thickest coating of varnish, while the more elevated lines take on the least, and the mixture of light and shade thus produced is so well managed as to give the picture all the prominence to the eye of *bas relief*. Amongst the more finished and valuable specimens of porcelain manufacture was the Adelaide Vase, painted in enamel, in imitation of middle-age art, the painting, as in a former instance, being done with the pencil. There was also a slab of lava, enamelled and painted in a beautiful manner. It is stated that slabs of this seemingly impracticable material are now used in Paris for the purpose of painting on their enamelled surface the names of the streets. They are thus rendered impervious to atmospheric influence, and are considered indestructible. Among the other casts in metal were part of a bronze architrave of the door of the church of the Madeleine at Paris, and which cost £14; and casts of ornamented outer plates of locks, in iron and brass, cleverly designed and moulded; besides a variety of bronze figures, &c. Some ingenious specimens were also shown of carving in leather, in imitation of casting; and specimens of the ornamental flooring used in the houses in France, where they have no carpets. But the French are rapidly acquiring a taste for this domestic luxury, and have fairly commenced the manufacture of carpeting, which promises soon to become an item of great importance in the trade of the country. Considerable attention was paid to a specimen of their carpeting exhibited in the room, and which exceeded ours as much in the beauty of the pattern, as it fell short of the British manufacture in the fineness of the fabric. In like manner, the white damask table-cloth was unknown in France eight years ago, but is now both manufactured and used in the country, and a specimen exhibited on the present occasion evinced still greater progress than in the case of the carpet manufacture. But, however deficient the French may be in the production of these articles, as compared with our own manufactures, the profuse display of gorgeous damask silk, from the factories of Tours and Lyons, must have challenged universal admiration by the superiority of their fabric and designs. Some of the richest effects were brought out in these manufactures by using glass thread, which is prepared so fine as to be capable of being tied in knots without breaking, and woven in every respect like ordinary thread. But the fabric which excited the strongest interest, both on account of its beauty and its novelty and ingenuity, was a large square of Wool Mosaic, or India-rubber cloth, a manufacture peculiar to France and some parts of Germany. The pattern was perhaps the most perfect, in respect of design, of any work of art in the exhibition. The flowers and leaves were copies from nature, and were much admired for their botanical accuracy. Even the least prominent of the plants represented in the composition, such as the fronds or leaves of ferns, were delineated with so much fidelity, as to enable botanists to distinguish the different species, and give them their specific names. The triumph of art in this instance is the more remarkable, that, after the design passed from the hands of the pattern-drawer, it was wrought into the fabric by one of the most complicated processes that can well be imagined. The pattern is, in fact, produced in the fabric by the *ends* of threads standing out transversely from a foundation of India-rubber cloth, and not, as is usually the case, by the threads being interwoven longitudinally. In order to understand how this is accomplished, let us suppose a piece of cloth equal in size to the square of a good-sized handkerchief, to represent, not the upper surface of the threads of which it is woven, but the ends of the threads; and suppose farther that the threads, thus piled in successive layers, extend inwards for perhaps a yard, like the straws in a hay-stack. Then these threads are coloured throughout their whole length, according to the place which each holds in the pattern; and the way in which the surface is prepared is by making a transverse section of the whole mass of threads, which is then embedded in a foundation of India-rubber cloth. It will be seen, therefore, that the operation bears some resemblance to the lapidary's process of cutting a transverse section of recent or fossil wood. The manufacturer of wool-mosaic, having his pattern arranged to a given depth, cuts section after section off one end of it, till the whole has been sliced down. The advantage of conducting this part of the process apart from the other, is, that when the fabric is indented in the India-rubber, it preserves its velvety softness and clearness, which would be lost were it woven along with the India-rubber cloth. The cloth is sold at £5 a yard.

An exceedingly interesting and instructive part of the exhibition consisted of the electric telegraph, and electric clock, constructed by Mr. Bain of Edinburgh, which are now well known and appreciated.

19*th March*, 1845. *The* President *in the Chair.*

A report from the committee appointed to arrange the Conversational Meeting was read and approved of. The following paper was read:—

X.—*On the Action of Bleaching Powder on the Salts of Copper and Lead.* By Walter Crum, F.R.S., *Vice-President of the Society.*

In February, 1843, I read to the Philosophical Society of Glasgow an account of a rose-coloured oxide of copper which I had obtained by the action of bleaching powder and lime upon nitrate of copper. Although I had then made numerous analyses of this substance, prepared under a variety of circumstances, I had been unable to obtain from it the full amount of oxygen which a definite compound must contain, and delayed therefore to make it farther known until I should have the opportunity of producing it in a purer form. In the meantime the rose-coloured substance has been noticed, and correctly described by Krüger of Berlin, as a combination of the oxide, or, as he calls it, of cupric acid, with lime. Having completed my experiments on this subject, as far as my leisure will permit, I shall now state the results I have obtained.

When the hydrated oxide of copper is added to a solution of bleaching powder it soon changes colour, particularly when assisted by heat, and becomes brown. Oxygen gas is then plentifully disengaged, and the effervescence continues till the whole of the hypochlorite of lime is decomposed. The brown precipitate suffers no change during this decomposition; when separated from the soluble matters, it is found to contain no chlorine, and no excess of oxygen; it is anhydrous oxide of copper. Hypochlorite of soda produces the same effects.

If we add nitrate of copper to a solution of bleaching powder in which is mixed a considerable quantity of lime, and previously cooled to the freezing point of water, a bluish green precipitate is formed. When the precipitate subsides, we find the solution of a fine blue colour, and containing copper; but in what state I have not examined. As the heat advances to the ordinary temperature, the copper in solution, as well as the precipitate, changes colour, and both at last become an insoluble purplish black powder. Oxygen gas is disengaged during the latter part of this process, and continues for some time to prevent the precipitate from subsiding; but after twenty or twenty-four hours the evolution of gas nearly ceases, the particles having united into larger grains sink to the bottom of the vessel into moderate bulk, and may then readily be separated from the soluble matters, by repeated mixing with cold lime-water, and drawing off the clear liquid with a syphon. The precipitate thus obtained is, as I have said, nearly black; but by triturating upon a piece of glass, it is seen that its real colour is rose.

Exposed to the action of boiling water, oxygen gas is disengaged from this substance, and brown anhydrous oxide of copper is left behind. Acids dissolve it, with the liberation of oxygen gas, mixed with the carbonic acid taken down by the lime. The solution in nitric acid gives no precipitate with nitrate of silver. Exposed to the air the substance is speedily changed into green carbonate. In attempting to press, and then to dry it in vacuo over sulphuric acid, a large proportion was changed into the brown oxide, mixed with carbonate. It can only, therefore, be examined in the moist state, and newly prepared. I shall describe the process by which I have obtained the best results.

20 grains of black oxide of copper, prepared by calcining the nitrate, are dissolved with the assistance of heat in 70 grains of nitric acid, spec. grav. 1·35. 50 grains of fresh hydrate of lime, sifted through a fine calico, are mixed with 1 lb. solution of bleaching powder of spec. grav. 1·06, and added to the solution of copper. When the precipitate becomes granular, as already described, it is quickly washed by alternate mixing with lime-water, and decanting after subsidence, until the lime-water comes off nearly pure. The precipitate is then put into a wide tube over mercury; an excess of sulphuric acid is added to it; and, after pouring out as much as possible of the solution which is thus formed, caustic soda is added to absorb the carbonic acid. In six experiments made in this way, 20 grains oxide of copper produced a compound which yielded of oxygen gas, after the necessary corrections—

1·875
1·886
1·748
1·915
1·795
1·747

Mean 1·828 grains.

By calculation, 20 grains CuO, changed into Cu_2O_3, ought to yield, by Berzelius' numbers, 1·98 grains of oxygen, or 1·888 by Dr. Thomson's weights. A nearer approximation than in the foregoing results is scarcely to be expected; for although there was no perceptible disengagement of gas during the washing of the precipitate in these experiments, it is certain that oxygen always escapes during the time so employed.

The quantity of lime necessary to the production and stability of this oxide, is not more than one equivalent after saturation of the nitric acid. One atom of lime to three of copper gave only 0·558 grains of oxygen gas, instead of the mean quantity of 1·828. Two atoms to three of copper yielded 1·295. I conceive the rose-coloured powder, then, to be a compound of an oxide of copper with lime, in which the copper exists in the state of sesquioxide, Cu_2O_3.

I have not succeeded in producing this oxide by means of the hypochlorites of potash or soda, even with the alkali in great excess; but by adding caustic soda to a solution of hypochlorite of lime, and afterwards nitrate of copper, we obtain the calcareous compound (lime being precipitated along with the copper) in a state of division so fine as to show the rose colour as soon as it is formed. This method, however, does not serve for the purposes of analysis, for the powder never becomes granular, and remains therefore too bulky to be washed.

It will now be observed that the dehydrating action of the hypochlorites upon oxide of copper depends upon the momentary formation of a sesquioxide, in which the oxygen has replaced the previously combined water.

The solution of bleaching powder in which the sesquioxide has been formed is of a fine, but very pale pink colour; and contains so small a proportion of its colouring ingredient, that the nature of that body can scarcely be discovered by analytical means. The second washing of the oxide is colourless; but if a very minute portion of sulphate of manganese be added, the pink colour is restored. When manganate of potash is dropped into nitric acid, the well-known red colour of hypermanganic acid is produced. Dropped into lime-water its colour is bluish green; but in bleaching liquor, even with excess of lime, the manganate yields the peculiar amethystine colour of the solution in which the sesquioxide of copper has been produced. Bleaching powder has long been said to contain manganese, which is believed to pass over, during its formation, along with the chlorine, in the state of the gaseous hyperchloride of Dumas; and to this I at first attributed the pink colour of the original solution, but I afterwards found that it could be reproduced from the Irish limestone which I employed.

The vessel in which the sesquioxide has been produced, is lined with a beautiful rose-coloured deposit, which remains attached to the glass when the other matters are washed out; but it fades away in a few hours, particularly when exposed to light, and cannot even be long preserved in the solution which forms it. Dissolved in dilute nitric acid, copper is found in the solution, and no manganese. There can be no doubt, that, like the precipitate, it is the sesquioxide of copper in combination with lime.

The red oxide of iron has also the power of decomposing the hypochlorites. This fact, as well as the formation of a superoxide of copper, was observed many years ago by Mr. Mercer of Oakenshaw, and stated by him to the British Association in 1842, in a paper containing some interesting speculations on these and other weak affinities, which give rise to many of the phenomena of catalysis.

When a clear solution of bleaching powder is mixed with nitrate of copper, a light bluish green powder precipitates, the bulkiness of which renders it somewhat difficult to wash. This powder is very slightly soluble in water, and scarcely changes colour in boiling. Heated in a glass tube over a spirit-lamp, chloride of copper sublimes into a cooler part of the tube, and water escapes. The residue consists of black oxide of copper, mixed with a quantity of chloride, which may be separated from the oxide by washing. Professor Graham, who suggested to me this experiment, remarked on the analogous effect of boiling water in separating water from a hydrate. It proved to be a hydrated oxichloride of copper—the substance known by the name of Brunswick green, and found in a variety of other circumstances. Analysis gave me a result approaching more nearly to 3 CuO, Cu Cl than to 4 CuO, Cu Cl; but the presence of carbonate in the specimen left me in doubt upon this point, and I could not resume the inquiry. In this reaction the whole of the hypochlorous acid is set free.

$$4\,(\mathrm{CuO\ No_5}) + 3(\mathrm{CaO\ ClO,\ Ca\ Cl}) =$$
$$4\,(\mathrm{CaO\ NO_5}) + 3\ \mathrm{CuO,\ Cu\ Cl,} + 2\ \mathrm{Ca\ Cl} + 3\ \mathrm{ClO}.$$

Peroxide of lead is often produced by passing a stream of chlorine through a solution of sugar of lead. The chloride which accompanies it in this way may be also converted into peroxide, by employing a solution of bleaching powder instead of chlorine. By adding free lime to the bleaching powder, and applying heat, we obtain a compound, nearly colourless, of the peroxide of lead with lime:—Dissolve in water 1 lb. of nitrate of lead, and add it, along with three equivalents of lime, to 16 lbs. of a solution of bleaching powder, sp. gr. 1·08. Heat the mixture gradually to 160° Fahr., and stir it frequently during five hours. Pour off the clear liquid, add 16 lbs. more of the same solution, and continue the heat three hours longer. The combination is obtained with only a slight brown tinge. It is quite insoluble in water, and, when dried, does not alter in the air. Nitric acid, by dissolving the lime, leaves the peroxide of a jet black colour; and, therefore, much deeper than that obtained by any of the processes usually employed. I have had no means of determining the proportion of lime contained in this plumbate. With less than two equivalents to one of oxide the compound is not white. An excess of lime cannot afterwards be dissolved away by an acid without discolouring the salt.

I found it convenient in these experiments to prepare a quantity of cream of lime, by dropping newly burnt lime into boiling water, stirring up, allowing the sand and the grosser parts to subside, and pouring off the superstratum. When this again had subsided for some time, the water was poured away, and the cream of lime which remained corked up in small bottles for use. By this means I had always at hand a quicklime, whose equivalent I knew, free from sand and free from carbonate. Marble, of course, answers best for this purpose.

Manganese again appears in the nitric acid which has been employed to decompose the plumbate, in the state of the pink-coloured hypermanganic acid. When this solution is poured off, and more water and nitric acid added to the peroxide that is left, a small quantity of sulphate of manganese restores the colour. Peroxide of lead, prepared by the same, or by other means, when dried, does not yield the pink colour without the application of heat. Ten grains of Irish lime dissolved in nitric acid, and heated with water containing nitric acid and peroxide of lead, yielded a pink solution as deep as that produced in similar circumstances from one-hundredth of a grain of sulphate of manganese. That species of lime may therefore be presumed to contain $\frac{1}{3000}$ of its weight of manganese. White marble, even, is found by this test to be not altogether free from manganese.

2d April, 1845. *The* PRESIDENT *in the Chair.*

Messrs. Robert Salmond, John Smith, LL.D., James Mitchell, and William G. Miller, were admitted members of the Society.

Dr. Nichol gave a short description of the methods of observation in use at the Glasgow Observatory. Mr. Lawrence Hill, jun. exhibited and described a model of a Self-acting Railway Break. The President having vacated the chair, it was taken by the Vice-President, who stated that the council had resolved to recommend to the Society that the President be respectfully requested to sit for his portrait, to be preserved in the Society's hall, from which an engraving might afterwards be taken. The proposal was cordially and unanimously entertained by the meeting, and a subscription immediately commenced.

16*th April*, 1845. *The* PRESIDENT *in the Chair.*

Mr. John Thomson, Annfield, and Mr. David Chambers, were elected members.

Mr. Michael Scott read a paper on a new hydraulic machine, stated to be applicable as a substitute for the air pump in marine steam engines, also to the pumping of ships, and to the raising of water on shore.

30th April, 1845. *The* President *in the Chair.*

The following paper was read:—

XI.—*On the Unemployed Lands of Great Britain.*

By G. Sutherland, Jun., Esq.

The writer stated that this subject was brought before the Society for the purpose of drawing attention to the fact, that there exist no *official periodical* sources of information on the relative quantities of cultivated and of waste lands. *Authorised periodical* statements afford the most certain data for speculations on the population, wealth, and power of this country when compared with other nations, the extent of cultivation and quantity of food produced affecting the social and political status of the country, both absolutely and relatively, especially when viewed with reference to the contingencies of war, and the rapid progress of manufactures and commerce among rival powers.

The following Table is compiled from M'Culloch, M'Queen, and Browning, these authors founding on Parliamentary Reports from 1829 to 1835; but as there are discrepancies in the Tables, the following may be assumed as the present areas, expressed in millions of acres and fractional parts of a million:—

	Millions of Acres			
	Cultivated.	Improvable.	Barren.	Total Area.
England,	$25\frac{2}{3}$	$3\frac{1}{2}$	$3\frac{1}{4}$	$32\frac{1}{3}$
Wales,	$3\frac{1}{8}$	$\frac{1}{2}$	1	$4\frac{3}{4}$
Scotland,	$5\frac{1}{4}$	6	$8\frac{1}{2}$	$19\frac{3}{4}$
Ireland,	$14\frac{1}{2}$	$4\frac{1}{4}$	$1\frac{1}{4}$	20
British Isles,	$\frac{1}{3}$	$\frac{1}{6}$	$\frac{1}{2}$	$1\frac{1}{8}$

The area of the United Kingdom is about 78,000,000 acres, of which are cultivated 47,000,000,—*viz.* 19,000,000 in arable and gardens, and 28,000,000 in pasture, meadows, &c.

The uncultivated improvable, in England and Wales,	4,000,000
Do. do. do. Scotland,	6,000,000
Do. do. do. Ireland,	4,000,000
Total,	14,000,000

From these data it appears that an improvable area, equal to two-sevenths of the surface now in cultivation, still remains to be taken in for agricultural and pastoral purposes, an important fact when we reflect that the population is increasing at the rate of 300,000 per annum, and that this increase is pressing upon the means of subsistence, as is evinced by the annual importations of grain, and by crises and depressions occurring almost periodically, consequent on bad harvests.

To show how much this branch of statistics has been neglected, the evidence of certain Tithe Commissioners, printed last session, represents about 8,000,000 acres of land in England and Wales as lying in wastes and *commons*,—upwards of one-fifth of the country. This is scarcely credible, and can only be reconciled with the generally received Tables by supposing that the partially improved, or pasture land of the commons, has been included in details of cultivated area; for example, the small town of Ledbury has about 7,000 acres enclosed, and about 14,000 in commons.

"The better land is cultivated, the more people it maintains, and the more people it maintains, the greater number will it employ, therefore when people are idle, and lacking food, the severance and enclosure of land is a public benefit."—*Adam Smith, B.* 1, *ch.* 2.

The process of enclosing and improving has been going on actively since 1760.

During the seventy-two years prior to 1832, not less than 5,500,000 acres were enclosed in Great Britain, an extent equal to the whole cultivated area of Scotland, while the produce of the land in the same period has increased four or five-fold.

The occupants of commons in England are not, as is generally supposed, the community at large, but ascertained classes of persons, as freemen, &c., who have sub-divided, and in general retained the commons as heaths, without cultivation, to the detriment of the community.

"The natural limit of population" has given rise to much useless discussion.

During the wars of William III. and Queen Anne, it was believed that tillage had reached its terminus; yet since that period our numbers have trebled, and in 1833-4 the home growth was adequate to the maintenance of the population.

The average density of population in Europe is about 79 persons to each *cultivated* square mile. In populous countries the density is much greater. Thus—

France	has 159	persons to the	square mile.
Saxony	has 183	do.	do.
Holland	has 217	do.	do.
Belgium	has 322	do.	do.
Great Britain . . .	has 189	do.	do.
Ireland	has 269	do.	do.

ACRES TO EACH PERSON.

France, . . .	2¼	Great Britain, .	2	Ireland, . . .	1⅝

Even supposing this country to be restricted to the produce of her own soil, at the present ratio of increase and of consumption, "the natural limit of population" may be attained in forty-seven years.

Ireland is capable of sustaining double the number of its present inhabitants.

The quantity of grain of all kinds requisite to the sustenance of the population is estimated at about two quarters to each individual. A table, carefully compiled from the London Gazette, by Mr. J. Young, in November, 1841, gives the following results, as the consumption for the year 1835:—

	Quarters Consumed by					
	Man.	Animals.	Seed.	Distilling, &c.	Manufactures.	Total.
Wheat,	18,696,694	—	3,277,143	—	966,163	22,940,000
Oats,	12,845,000	16,000,000	4,807,500	—	—	33,652,500
Barley,	2,828.571	348,858	1,810,000	7,688,571	—	12,670,000
Rye,	790,000	20,000	190,000	—	300,000	1,300,000
Beans and Pease,	1,000,000	2,187,480	531,270	—	—	3,718,750
	36,160,265	18,550,338	10,615,913	7,688,571	1,266,163	74,281,250

These are the ascertained quantities used by 26½ millions of inhabitants.
Do. do. 1½ — animals.

The wheat imported for the ten years prior to 1841 for home consumpt averaged 790,918 qrs. each year.

The nett imports of 1838, 39, 40, averaged 1,911,494 qrs. per annum, that of 1839 being the highest, viz.: 2,626,786 qrs., which, at sixty shillings a quarter, would cost £7,880,358; the duty paid amounted to £631,608.

The paper concluded by urging the necessity of government obtaining annual returns of the produce and classification of lands, similar to the celebrated Doomsday-book, to be included in the schedules issued to the agriculturists.

XII.—*Nepaul Barley.*

A note from Mr. Fleming of Barochan, to Dr. R. D. Thomson, was read, stating the result of an experiment with Nepaul Barley, which Dr. T. had procured from Dr. Balfour.

"The land upon which the Barley was sown had been in potatoes the year before, and manured with 24 tons of good dung, and 14 bushels of bone dust, per imperial acre. It was sown thin, but it did not *tiller* out much, and remained, of course, thin on the ground, although it came into ear ten days before the common barley in the same field. It did not ripen earlier, and was greatly deficient in straw. It however yielded a fair return of grain, considering it was so thin on the ground. The following are the comparative results from common and Nepaul barley on the same field:—

	Common Barley.	Nepaul Barley.
Measure of Grain per imperial acre,	7 quarters,	$5\frac{1}{4}$ quarters.
Weight of Straw, do.	48 cwt.,	24 cwt.
Weight of Grain, per bushel,	54 lbs.,	58 lbs.

"The common barley was very fine. The weight of the bushel of Nepaul barley was above the standard very considerably. The field in which both kinds of barley were sown had been trenched for the potato crop 16 inches deep, that is, in the winter of 1842-43, and was in good condition; indeed, the common barley was too strong and rank. It is probable that the Nepaul barley may do better in another year; and the extraordinary weight of the grain, per bushel, fully warrants another trial on a more extensive scale. The quantity of land sown this year did not exceed three square poles, from which the quantity per acre was calculated."

Some of the seed raised by Mr. Fleming, and exhibited to the Society, was this year sown in the neighbourhood of Glasgow, and came into ear about ten days before the common barley.

The following report was received from the Botanical Section:—

25th March, 1845.—The Chairman, Dr. Balfour, exhibited several ferns and lycopodiums from New Zealand, and a section of the wood of Cedar of Lebanon, and some other botanical specimens from Palestine. He also read an account of an excursion to Ben Lawers in 1844.

April 29th, 1845.—A paper on the uses of the fibre of plantain, was read by the chairman, also an account of an excursion to Ailsa Craig last autumn. The section elected its office-bearers for the next twelve months.

Dr. Balfour, Chairman.
Mr. Wm. Gourlie, Jun., Vice-Chairman.
Dr. Henry Böttinger, Curator of Herbarium.
Mr. Wm. Keddie, Secretary.

The following notices have been communicated to the Section during the present summer:—

May 27th, 1845.—Dr. Balfour exhibited a spatha of the Areca oleracea upwards of four feet in length; also specimens of the stem of the Guāiac tree, Rose-wood tree, and Moreton Bay Pine. Dr. Balfour also exhibited some specimens of American ferns, belonging to the section Osmundaceæ, and traced the changes which take place in cases where the leaves are transformed into fructification, thus illustrating morphological doctrines.

Dr. Balfour exhibited a large specimen of the fruit of Cocos lapidea, with the concrete oil obtained from it; and a specimen of Cycas revoluta, with the seeds developed on the peculiarly altered leaves. He also exhibited hazel-nuts, presented to him by Mr. Kidley, which had been found in a peat moss, under sand, and in which the pericarp was soft and natural, while the kernel was hardened by a siliceous deposit.

Dr. Balfour then gave an account of a botanical trip to Bowling and Kilpatrick, on the 17th May, current; and of a trip to Castlecarey, Denny, the banks of the Carron, and Falkirk, on the 26th May. Fresh specimens were shown of most of the plants gathered in the latter excursion, amongst which were:—Adoxa moschatellina, Viola lutea, both yellow and blue, Paris quadrifolia, Stellaria nemorum, Melica nutans, Carduus heterophyllus, with entire and pinnatifid leaves on the same stem, Prunus Padus, Polypodium Dryopteris, Trollius Europæus, Potentilla Fragariastrum, Ranunculus auricomus, Myrrhis odorata, which occurred in great profusion in Castlecarey Glen, as well as on the banks of the Carron, Geranium sylvaticum, Orchis mascula, and various other species.

Dr. Balfour afterwards gave an account of a trip to Arran on the 4th and 5th of July, 1845. An account was given of the geological appearances of the places visited, and dried specimens were exhibited of the plants gathered. He also noticed a trip to Toward Point, and the shore between that and Dunoon, and alluded to the discovery of Carex vesicaria and Thalictrum flavum in that quarter.

Dr. Balfour laid on the table Mr. Keddie's prize Herbarium, which, he stated, Mr. Keddie had kindly proposed to incorporate with the Society's collection, on condition that it is to be accessible, under proper regulations, to the students of the Botanical class in the University.

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PROCEEDINGS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

FORTY-FOURTH SESSION.

5th November, 1845.—*The* PRESIDENT *in the Chair.*

Mr. Griffin gave in a Report with reference to a settlement of the affairs of the Library between the Andersonian Institution and the Philosophical Society.

The Minute of Council of date 2d April, 1845, recommending that the Society should take steps for obtaining a Portrait of Dr. Thomas Thomson, the President, was read; and also the Minute agreeing to the proposal, and appointing a Committee to carry it into effect. Mr. William Murray, Convener of the Committee, in presenting the Portrait to the Society, in name of the Subscribers, stated, that the Committee had employed Mr. John Graham Gilbert to execute the Portrait now in the room, which would be recognised as an excellent and characteristic likeness of their President. The chair having been taken by the Vice-President, the President read the following paper:—

XIII.—*Biographical Account of the late* JOHN DALTON, D.C.L., F.R.S., &c. By THOMAS THOMSON, M.D., F.R.S.

JOHN DALTON was born on the 5th day of September, in the year 1767, in the village of Englesfield, about two miles west of Cockermouth, Cumberland. He attended the village school there, and in the neighbourhood, till he was eleven years of age, at which period he had gone through a course of mensuration, surveying, navigation, &c. When twelve years of age he began to teach the village school, and continued to do so for two years. After this, for a year or more, he was occasionally employed in husbandry.

At fifteen years of age he removed to Kendal, as assistant in a Boarding School. In that capacity he remained for three or four years. He then undertook the same school as a principal, and continued it for eight years. During some part of this long period, I have been told that he was somehow connected with the celebrated John Gough of Kendal, who, in spite of his blindness, was no mean mathematician, and was even acquainted with some branches of science that it would seem at first impossible to cultivate without the advantage of sight. Thus he was a chemist and a botanist; and he assured me (for I had the pleasure of being acquainted with him) that he could discover the colour of flowers by the sense of touch.

While at Kendal, Mr. Dalton employed his leisure hours in studying Latin, Greek, French, and the Mathematics, together with the most interesting branches of Natural Philosophy.

He removed to Manchester in 1793, where he was employed as a tutor in mathematics and natural philosophy in the New College—a scientific establishment lately constituted in that great manufacturing capital. After continuing six years in that employment, he gave it up, and commenced a private teacher in mathematics; an employment in which he took great delight, and which he continued till his health began to break, about seven years before his death.

It was in Manchester that he first turned his attention to chemistry, and about the year 1802 or 1803 he delivered a short course of lectures on that science in Edinburgh, in which he explained his peculiar views. These lectures were also delivered in Glasgow. A year or two after, he delivered a short course of lectures in the Royal Institution, London. These lectures were afterwards repeated in Birmingham and in Leeds.

Mr. Dalton was a member of the Society of Friends, and was in habits of intimacy with the most respectable members of that body in Manchester. He never kept house, but lived in lodgings, chiefly in the house of a respectable Unitarian clergyman. His income as a teacher must have been small; but his mode of living was economical. He enjoyed a pension of £300 a year from government during the last twelve or fifteen years of his life. He is said also to have had a small estate in Cumberland, doubtless an inheritance. He is said to have left behind him about £10,000.

About eight years ago he had a paralytic shock, from which he partially recovered; but his speech was so much impeded, that he could with difficulty be understood. His faculties continued unimpaired, and he still prosecuted his meteorological observations, of which he was very fond, and occasionally made chemical experiments. But about the beginning of 1843 he had another shock, which completely put a stop to all study of every kind. He died on the 27th of July, 1844, in the 78th year of his age.

He was much beloved and respected by the society of Manchester, who honoured his remains with a public funeral. Such is a short sketch of the few events which distinguished the career of this eminent philosopher. I must now endeavour to make the Society acquainted with the additions to our knowledge for which we are indebted to Dr. Dalton.

His first important paper was published in 1802, in the fifth volume of the first series of the Manchester Memoirs, and was entitled, *On the Expansion of the Elastic Fluids by Heat.* At that time by far the greater number of the gaseous bodies at present known had been discovered; many experiments had been made on the expansion of these bodies by heat by Deluc, General Roy, Saussure, and some other philosophers; and in the first volume of the Annales de Chimie, published in 1788, there appeared an elaborate paper by M. M. de Morveau and du Vernois, showing that every gas had a peculiar expansibility of its own, and that the same addition of heat caused some gases to expand twelve times as much as others. Mr. Dalton made a set of experiments to ascertain the accuracy of these determinations. The result was, that all gases expand the same, or experience the same increase of volume, when the same quantity of heat is added to them; according to Dalton, 1000 volumes of air, or of any gas when dry, becomes 1325 volumes when heated from 32° to 212°.

The experiments of Dalton were read to the Philosophical Society of Manchester in October, 1801. About six months after, a similar set of experiments by Gay-Lussac was published in the Annales de Chimie volume 43d. He obtained the same results as Mr. Dalton had done,—but he found the expansion from 32° to 212° to be from 1000 to 1375 volumes. Mr. Dalton afterwards in his system of chemistry adopted this number as more accurate than his own.

Many years after, Dr. Prout found the weight of 100 cubic inches of air at 32° to be 32·79 grains, while at 60° they weighed only 31·0117 grains. Hence, 1000 volumes at 32° become, at 60°, 1057·34 volumes. Hence, as the expansion is equable, 1000 volumes, if heated from 32° to 212°, would become 1368·61 volumes. Still more lately, Rudberg, a Swedish chemist, made a great number of experiments, being at great pains to dry his gases. He found that 1000 volumes of air at 22° when heated to 212° became 1364·57 volumes. In 1842, a most elaborate set of experiments was made by Regnault, on the expansibility of air and ten other gases. He, like his predecessors, found the expansibility of all of them the same, and that 1000 volumes, when heated to 212°, became 1366·5 volumes. Thus we have four determinations.

By Dalton and Gay-Lussac	1000 at 32° become	1375 at 212°.
Prout,	1000	1368·61
Rudberg,	1000	1364·57
Regnault,	1000	1366·5
Mean,	1000	1368·67
Or leaving out Dalton and Gay-Lussac	1000	1366·56

According to Dalton and Gay-Lussac the expansion of air, or of any of the gases, for 1° of Fahrenheit is $\frac{1}{480}$. But the mean of the expansion, for 1°, according to the experiments of Prout, Rudberg, and Regnault, is $\frac{1}{491}$. Thus Dalton's determinations, notwithstanding the simplicity of his method, and the rudeness of the apparatus which he employed, approached very near the truth.

In the year 1801, Mr. Dalton read a paper on the constitution of mixed gases, which was published in the fifth volume of the first series of the Memoirs of the Literary and Philosophical Society of Manchester. According to his view of the subject, the particles of simple gases repel each other with a force inversely as the distance of their centres. But the particles of heterogeneous gases neither attract nor repel. The consequences of this will be, that when heterogeneous gases are mixed, they mix equally, and occupy just as much space as they did before mixture.

He explained, at the same time, that when water mixed with the atmosphere, it assumed the form of vapour, which possessed all the properties of a gas, except that by compressions and cold it was easily reduced again to the state of vapour. He pointed out a very simple method of determining the bulk of vapour in air at all temperatures, and constructed a table by means of which the volume of vapour in the atmosphere may be determined at all temperatures. If we suppose that the specific gravity of steam increases as the temperature, it is easy from this table to deduce the weight of vapour in the atmosphere at all temperatures.

This theory of mixed gases, which is explained by him in the third volume of Nicolson's Journal, is of immense importance in meteorological investigations, and constitutes, undoubtedly, one of the most important of the additions which Mr. Dalton made to natural science.

In the Annales de Chimie, for October, 1845, there is an elaborate paper by Regnault on this subject. He gives, from his own experiments, a table showing the elasticity of vapour, from 32° to 107·5°. But he takes no notice whatever of similar tables that had been long before constructed by Dalton, Ure, and Southern. One would suppose that he was ignorant of what had been done forty years before, were it not that in a previous paper on the expansion of vapour, he quotes the very paper of Dalton in which the table occurs.

	Dalton.	Ure.	Southern.	Regnault.
32°	0·2 inch	0·2	0·16	0·18
39·2	0·255	0·245	0·221	0·24
93·2	1·483	1·538	1·460	1·557

In the same volume of the Manchester Memoirs, there is inserted a paper by Mr. Dalton, entitled, *Experiments and Observations to determine whether the quantity of rain and dew is equal to the quantity of water carried off by the rivers, and raised by evaporation ; with an inquiry into the origin of springs.*

He gives a table of the mean quantity of rain in thirty-one different places in England. The common mean of the whole is 35·2 inches. But as twenty-four of the places given are situated near the sea, he thinks this mean above the true average quantity for England. He reckons the true mean to be 31 inches, and to this adding the dew (reckoned at 5 inches), we have for the mean quantity of rain in England, 36 inches annually. The most rainy place is Keswick, in Cumberland, where the quantity of rain that falls annually is 67½ inches.

Thus the annual fall in England amounts to 28 cubic miles, or 115,000 millions of tons. This immense mass, since it does not accumulate, must be annually carried off by evaporation, and by rivers.

From a somewhat loose estimate, he reckons the water carried to the sea by all the rivers in England, to amount annually to 13 inches, or 10 cubic miles, or 41,000 millions of tons.

From the experiments of Dr. Dobson of Liverpool, and from a set made by himself and Mr. Thomas Hoyle, he concludes that the evaporation amounts annually to 30 inches. Thus the rivers and evaporation together, amount to 43 inches. This exceeds the rain by 7 inches. This difference he considers as only apparent, and owing to inaccuracy in the experiments.

I believe the true cause of the discordance is, that he estimates the quantity of water thrown into the sea, by rivers, too high. Instead of 13 cubic inches, it does not amount, I conceive, to more than 6 inches.

Mr. Dalton began very early to pay particular attention to meteorology. He began a meteorological register when at Kendal, and continued it to the very last year of his life. In 1793, soon after going to Manchester, he published a small book, to which he gave the name of *Meteorological Observations and Essays.* A second edition of this book was published by him in the year 1834. This second edition was a re-print of the first, but there was an appendix added, containing 60 octavo pages.

The only part of this book which seems to require attention in this brief abstract, is his theory of the Aurora Borealis.

He demonstrated, by the application of mathematical principles to the phenomena of the Aurora Borealis, that the luminous beams of the Aurora are cylindrical, and parallel to each other, and to the magnetic meridian of the earth; that the height of the rainbow-like arches of the Aurora, is about 150 miles; that the beams are similar, and equal in their real dimensions, and that the distance of the beams from the earth's surface is nearly equal to their length. The light he considered as electrical, and the beams themselves of a ferruginous nature. He conceives that there exists in the higher regions of the atmosphere, an elastic fluid partaking of the properties of iron, to which the phenomena of the Aurora Borealis are owing. It is unnecessary to discuss this opinion, as the discoveries in electricity and magnetism made since 1793, render the opinion unnecessary.

The discovery for which Dalton is indebted for the high reputation which he obtained in this country, is what is called *The Atomic Theory.* As the history of this great discovery is very imperfectly known in this country, it will be necessary to enter somewhat into detail.

In the year 1792, Richter published a treatise, to which he gave the name of *Stechiometrie.* This work was founded on the following proposition, which Richter had established by numerous experiments.

If two neutral solutions of salts are mixed together, supposing them such that mutual decomposition ensues, the new salts formed will be equally neutral with the original salts. Thus, suppose we mix together solutions of nitrate of barytes and sulphate of potash, two new salts will be formed, namely, sulphate of barytes and nitrate of potash. These two salts will be as neutral as the original salts from which they are derived. And if we employ the original salts in the requisite proportions, the decomposition will be complete. We have only to employ 16¼ nitrate of barytes and 11 sulphate of potash to accomplish this object. This fact had been observed by chemists before the time of Richter, but he was the first who drew from it the conclusion to which I wish to call your particular attention. Richter reasoned on it in the following manner:—

The quantity of two alkaline bases which are necessary to neutralize equal quantities of an acid, are, in the proportion of the quantities of the same bases, necessary to neutralize any other acid. Thus if 4 soda and 6 potash neutralize nitric acid, we must employ the same proportions of these bases to neutralize any other acid. The soda in phosphate of soda will be to the potash in phosphate of potash as 4 to 6. And the same will apply to every compound of potash and soda, with any acid whatever.

Suppose we have sulphuric acid, nitric acid, and potash, and soda. If we know the composition of sulphate of potash, and sulphate of soda, and also of nitrate of potash, then we can determine the composition of nitrate of soda by calculations.

Hence it follows that figures may be attached to every acid, and every alkali, indicating the quantity of each necessary to saturate the quantities of every other acid or base indicated by the numbers attached to it. The whole of Richter's time from 1792, till his death, about the beginning of the present century, was occupied in endeavouring to determine these numbers by experiment. He published a variety of tables showing their numbers. But his views were so obscured, by opinions which he took up concerning certain arithmetical ratios in which they stood to each other, that it is very difficult to peruse his papers; and as his experiments were not very accurate, his views were very generally neglected, except by Berzelius, who devoted about eight years to the repetition and correction of these analyses of Richter.

Fischer showed that all the tables of Richter might be reduced to one, indicating the saturating power of the acids and bases examined by him. Sulphuric acid was reckoned 1000, and all the acids and bases were referred to that number. It will, perhaps, be better if we reduce them to our present scale, in which oxygen is represented by 1. Beside Richter's table I shall place the atomic weights of these bodies as they have been determined by the latest and most accurate experiments.

1. BASES.

	Richter.	Atomic Weight.		Richter.	Atomic Weight.
Barytes, . .	9·5	9·5	Lime, . .	3·3	3·5
Potash. . .	6·8	6	Ammonia, .	2·8	2·125
Strontian, .	5·6	6·5	Magnesia, .	2·6	2·5
Soda, . . .	3·6	4	Alumina, .	2·2	2·25

2. ACIDS.

	Richter.	Atomic Weight.		Richter.	Atomic Weight.
Sulphuric, .	5	5	Succinic, .	6	6·25
Phosphoric, .	4·9	9	Nitric, . .	7	6·75
Oxalic, . .	3·75	4·5	Acetic, . .	7·4	6·375
Muriatic, . .	3·56	4·625	Citric, . .	8·4	20·625
Carbonic, . .	2·88	2.75	Tartaric, . .	8·5	16·5
Fluoric, . .	2·13	2·25			

Thus Richter had the merit of showing that the saturating power of acids and bases might be represented by numbers attached to them; and he showed how useful such numbers would be in determining the compositions and decompositions of compounds. It is true that the numbers which he supplied were far from accurate; but that was owing to the imperfect state of experimenting. The only chemist who approached accuracy in his analyses of the salts was Wenzel, and his results were almost quite neglected and unknown.

It was easy to extend the law of Richter to all combinations, such as oxygen with metals, sulphur with metals, and oxygen with hydrogen, sulphur, carbon, &c.; this was accordingly done by various chemists, particularly by Berzelius, who by assiduous experimenting, and repeating his analyses with data rendered more and more accurate, succeeded in showing that numbers might be affixed to every chemical substance indicating the proportion of it which was capable of neutralizing the quantity of other bodies indicated by the numbers attached to them. These were published by him under the name of *Synoptical Tables*; and after he became aware of the view taken by Dalton, he called them *Tables of Atomic Weights*.

Mr. Dalton, about the year 1802 or 1803 was occupied with the analyses of olefiant gas and carburetted hydrogen. He found that, for complete combustion, a volume of olefiant gas required three volumes of oxygen, and that after the combustion there remained two volumes of carbonic acid. Now, one of the volumes of oxygen combined with two volumes of hydrogen, and formed water; while the other two volumes of oxygen combined with two volumes of carbon, and formed two volumes of carbonic acid. Hence a volume of olefiant gas is composed of $H^2 + C^2$ condensed into one volume.

Carburetted hydrogen gas, on the other hand, required only two volumes of oxygen to consume it, and left only one volume of carbonic acid. One of the volumes of oxygen combined with two volumes of hydrogen, and the other volume with one volume of carbon, and formed a volume of carbonic acid. Hence carburetted hydrogen is composed of $H^2 + C$ condensed into one volume.

It was this that suggested to him the notions which he entertained respecting the atomic theory. I do not know when he adopted these notions, but when I visited him in 1804 at Manchester, he had adopted them; and at that time both Mr. Dalton and myself were ignorant of what had been done by Richter on the same subject.

The ultimate particles of all bodies, in his opinion, consist of atoms incapable of farther division. It is these atoms which combine. These atoms are spherical, and he seems to have thought that they all have the same bulk; though they differ in weight. We can determine the atomic weight of a body by determining how much of it will combine with another body. He represented the atomic weight of hydrogen by unity, and that of oxygen by 7.

Water, according to him, is	O H
Olefiant gas is	H C H C
Carburetted hydrogen	H C H

So that if we take an atom of carbon from olefiant gas we convert it into carburetted hydrogen, and if we add an atom of carbon to carburetted hydrogen, we convert it into olefiant gas.

These two gases constituted the only example of the combination of 1 and 2 atoms of one substance, with an atom of another. I furnished him with another example in the oxalate and binoxalate of strontian. The first salt is a compound of 1 atom oxalic acid with 1 atom of strontian, and the second, of 2 atoms of oxalic acid with 1 atom of strontian. Dr. Wollaston furnished him with another in oxalate, binoxalate, and quadroxalate of potash.

1. 1 atom Oxalic acid with 1 atom Potash.
2. 2 atoms.....................1 atom Potash.
3. 4 atoms.....................1 atom Potash.

These were the data from which he deduced what is now called the *Theory of Atomic Weights.*

At the end of the first volume of his *New System of Chemical Philosophy*, published in 1808, there is an engraving, on which are represented the symbols by which the different simple bodies are distinguished. He gives 20 symbols, each consisting of a circle, with some internal mark of distinction. Oxygen is represented by a circle, hydrogen by a circle with a dot in the centre, azote by a circle with a perpendicular line, carbon by a circle blackened within, ●, the metals by circles within which the first letter of the name of the metal is given; thus, (i), (z), represent an atom of iron and zinc respectively. He gives 20 symbols, and shows how 2, 3, 4, 5, 6, and 7, of these atoms may be united together so as to form new compound bodies. To each of these 20 simple bodies, he has attached a number denoting the atomic weight, or the weight of an atom of each body respectively. Hydrogen, as the lightest, has its atomic weight represented by unity, and oxygen by 7. Every one of his atomic weights is erroneous; this was the consequence of the want of accurate analyses of compound bodies.

Dr. Prout first demonstrated that water is a compound of 1 hydrogen and 8 oxygen by weight. Therefore, if we represent water as composed of 1 atom hydrogen and 1 atom oxygen, their respective weights will be to each other as 1 to 8. In the same volume Dalton gives the atomic weight and constitution of 37 bodies, but all of them so inaccurate that it would be needless to state them. In the appendix to the second volume of his *System*, published in 1810, he has given a few additional compounds, but not more accurate than those given in the preceding volume. Indeed, at that time it was impossible to give the atomic weights accurately, because few or no accurate analyses of compound bodies existed.

Mr. Dalton represented the atomic weight of hydrogen by unity; but Dr. Wollaston pointed out the numerous advantages which would result from considering the atomic weight of oxygen to be unity. And this suggestion was adopted by Berzelius in his tables, and has now become almost universal.

I made a very careful and extensive set of experiments above twenty years ago, from which I deduced that the atomic weights of all bodies are multiples of that of hydrogen. If we denote oxygen by 10, then hydrogen will be 1·25, carbon 7·5, azote 17·5, sulphur 20, phosphorus 20, soda 40, potash 60, &c. These numbers have till lately been almost completely overlooked; but within these two or three years the subject has been again taken up, and so far as the investigation has gone, my numbers have been verified. Thus Dumas found the atomic weights of hydrogen, carbon, azote, and oxygen, as follows:—

Hydrogen, . .	0·125	Azote, ...	1·75
Carbon, . . .	0·75	Oxygen, ...	1·00

Zinc, lead, mercury, silver, have been found.

Zinc, . . .	4·125	Mercury, . . .	12·5
Lead, ...	13	Silver, ...	13·5

Potash and soda have been represented on the continent by

Potash, . .	5·89916	Soda, ...	3·90897

But whoever will take the trouble to examine the experiments of Thenard and Gay-Lussac on the oxydizement of potassium and sodium, and my analyses of the salts of potash and soda, must, I conceive, admit that the true atomic weights of these bodies are

Potash, ...	6	Soda, ...	4

Though Mr. Dalton lived more than thirty years after the publication of the first volume of his Chemistry, he never again adverted to the subject, nor did he adopt any of the numerous alterations in the weight of the atoms subsequently made. His merit consisted in suggesting the idea of atomic weights: and this idea he must share with Richter,—and nobody knows better than myself that Dalton was ignorant of what Richter had done about ten years before him. But it is our business to do even justice to all parties.

Mr. Dalton in his chemistry suggested various new views, and stated experiments on the expansion of liquids, and the heat evolved by the combustion of various bodies, that deserve attention. But it would not do to state these isolated facts in so general a view as we are taking.

In the Memoirs of the Literary and Philosophical Society of Manchester, of which Mr. Dalton was for many years president, there occur a good many papers by him on various subjects: chemical, meteorological, geological, and physiological; all of them ingenious, and many of them giving the results of important experiments; but not sufficiently so to claim a place in this sketch. The same remark applies to his papers in the Transactions of the Royal Society, and in the Annals of Philosophy. His great discoveries, to which he is indebted for his high reputation, are the *Constitution of Mixed Gases*, and the *Atomic Theory*. I do not at present inquire how far his notions on this theory were accurate.

Dr. R. D. Thomson presented to the Society, for the use of the Botanical Section, upwards of six hundred specimens of Plants from Upper India, collected by Dr. Thomas Thomson, jun., to whom the thanks of the Society were voted.

Mr. Gourlie called the attention of the Society to various specimens of diseased potatoes.

19*th November*, 1845.—*The* President *in the Chair.*

Dr. Alfred Hall was admitted a member of the Society.

Mr. Griffin read a minute in reference to the arrangement of the Library. The Society decided that a suitable book-case should be provided.

The Treasurer, Mr. Liddell, laid the following abstract of his account on the table.

1844.		
Nov. 15.—To amount in Bank,........................	£140 0 0	
— Less due to Treasurer,................	1 4 10½	
		138 15 1½

		Brought up,	£138 15 1½
1845.			
Nov. 18.—To Annual Payment from 15 original Members, @ 5s.	3 15 0		
— Annual Payment from 159 ordinary Members, @ 15s.	119 5 0		
— Entry-money from 33 do. @ 21s.	34 13 0		
			157 13 0
			£296 8 1½

1845.	
Nov. 18.—By Printing,	£16 9 6
— Periodicals, &c.	26 2 11½
— Rent and Gas,	13 4 0
— Conversational Meetings,	5 19 10
— Collecting payments,	6 0 0
— Postages and delivering Circulars,	4 4 4
— Miscellaneous payments,	4 7 6
— Union Bank, in Account,	220 0 0
	£296 8 1½

The society is under liabilities to nearly the amount of the preceding sum of £220 as follows:—

Fitting up and Painting the New Hall,	£60 0 0
New Bookcase,	20 0 0
600 Vols. of Scientific Books, newly purchased,	45 0 0
Binding,	35 0 0
Printing New Catalogue and Society's Proceedings, estimated at	40 0 0
Current Account for Periodicals,	25 0 0
	£220 0 0

The Society then proceeded to the forty-sixth annual election of office-bearers, when the following were chosen:—

President,

DR. THOMAS THOMSON.

VICE-PRESIDENT,...WALTER CRUM.
TREASURER,.........ANDREW LIDDELL.
SECRETARY,....ALEXANDER HASTIE.
LIBRARIAN,.....JOHN J. GRIFFIN.

Council.

A. ANDERSON, M.D.
A. BUCHANAN, M.D.
J. FINDLAY, M.D.
PROFESSOR GORDON.
WILLIAM GOURLIE, JUN.
ALEX. HARVEY.
WILLIAM KEDDIE.
WILLIAM MURRAY.
JOHN STENHOUSE.
R. D. THOMSON, M.D.
GEORGE WATSON.
ALEX. WATT, LL.D.

Mr. Crum then drew the attention of the Society to the disease of the potato crop.

XIV. *Artificial Production of the Potato Disease.* *By* Walter Crum, Esq., F.R.S.

On grating down a healthy potato, the surface of the pulp, or the part of it immediately in contact with the air, soon acquires a flesh-red colour, which goes on increasing in depth to a mahogany brown. In a few hours this is changed into a sooty black colour, such as occurs in certain stages of the potato disease; and at last, after five or six days we have again a brown colour, similar to what appears in that stage of the disease when the part has lost its firmness. This is a well-known process of putrefaction. It occurs in the apple, where a part that has been bruised very soon becomes brown. And the cause is also well understood to be the rupture of the vessels or bags in which, while the fruit remains entire, the saccharine matter is contained and kept apart from the nitrogenous or fermenting principle. The grape also, in which the solution of sugar is contained in cells distinct from the gluten, may be preserved for a long time unchanged; but as soon as it is bruised, and the contents of the various cells are thereby allowed to mix together, the gluten, by attracting oxygen from the atmosphere, becomes converted into yeast, and fermentation goes on. By the continued exposure of such mixtures to the air, putrefaction ensues, and the conditions are fulfilled for the development of fungi. Such is the case when the potato is broken up and exposed. Its sap, which contains albumen (similar in composition and properties to the white of egg), and occasionally also casein, is thus brought in contact with the other ingredients of the root and with the air. The consequence is a commencement of putrefaction, and the production of a disease, to all appearance similar to that which has occurred in nature during the present year. Examination by the microscope confirms their identity. In two or three days a mouldiness appears upon the surface of the blackened pulp, consisting of fungi with long stalks and globular heads, which emit when compressed a profusion of small round bodies, called sporules, the seeds of new fungi. These seeds are in no danger of being confounded with the granules of starch, most of which in comparison with them, are several hundred times as large. Lastly, after an exposure of eight days (and my observations extend over no longer time), when the pulp has in a great measure lost its blackness, and taken the (I believe more permanent) brown colour, small, extremely white, and fine tufts appear on its surface, of a totally different variety of fungus, having apparently no head like the earlier crop, and consisting of long slender stems, which, when pressed down between pieces of glass, appear lined on both sides with multitudes of very small sporules. This fungus corresponds with the tufts which grow on the outside of the diseased part of the potato. Their appearance is the same, but any specimens of the tuft from the diseased potato I have at present at command, are much older than the crop of which I speak, and perhaps for that reason show fewer sporules. That a rupture of the cellular tissue of the diseased potato has actually taken place during the present year, has been already made known by Professor Kützing, a German physiologist, who describes the so-called dry rot of former seasons, as a disease in which the starch granules are so altered as to exhibit minute brown fungi, previous to the destruction of the cellular tissue; whereas at present the cells become destroyed, while the starch granules remain entire. On account of this peculiarity he has given to the existing disease the name of cell rot. In the short time during which I have been occupied with this subject, I have not been able to verify under the microscope, these observations on the structure of the cellular tissue, from the difficulty, perhaps, of obtaining thin enough perfect sections of the substance. Professor Kützing attributes the effects he describes to the weakness of the parts, occasioned by the too rapid growth of the tubers, and the absorption of too much water, which render the formation of a strong and durable cellular membrane impossible. But on making the experiment, I have not been able to find that the quantity of water contained in a perfectly healthy potato is less than in one liable to the disease. I rasped down very fine white potatoes, from a moderate crop, grown on poor land with but little manure; and having put a pound of the pulp into a bag, and squeezed it firmly with the hand, I obtained from it 59 per cent. of juice. A red potato from the same field, and equally unaffected with the disease, yielded 58 per cent. Another red potato, itself sound, but from a field which had been well manured, and which was much affected with the disease, gave 58½. In another experiment, where the juice was pressed out and the solid part dried, the fine white potato left 21·1 per cent. of solid matter, and a portion of a diseased potato left 20·79 per cent. There is, therefore, no difference in the quantity of water.

I shall not trouble the Society with any speculations of my own as to the manner in which this rupture of the potato may have been effected. The subject is surrounded with difficulties, and much close investigation is wanted to learn the circumstances which attend it. If the statements now made are correct, we shall find that fungi are not the cause, but a consequence of the disease in question, and our attention will be directed to prevent the formation in the potato, of a soil in which the fungus always fructifies, rather than to the parasite itself, of whose existence we should be ignorant without it.

Mr. Alexander Anderson exhibited turnips affected with the same disease, from a farm on the Ardincaple estate.

3d December, 1845.—*The* President *in the Chair.*

The following gentlemen were admitted members of the Society:—Messrs. George Harvey, Andrew Risk, Moses Hunter, J. A. Hutchisn, James Shanks, C. E., David Cunningham.

17*th December*, 1845.—*The* President *in the Chair.*

Mr William Ambrose was admitted a member of the Society. The tables of mortality in the metropolis for 1845, were presented by Dr. R. D. Thomson. On the motion of Mr. Liddell, a sum not exceeding £35, was unanimously voted for the purpose of procuring a President's chair, and a table, for the Hall.

Mr. Gordon gave an account of Auld's Patent Self-Regulating Damper for Steam-engine Boilers.

Dr. Findlay stated that in some specimens of diseased potatoes examined by him, the skin of the tuber (both the cutis or external skin, and the cutis vera, or under skin), was quite sound, and the cells quite uninjured for some distance below the skin.

The disease appeared to be entirely isolated; the diseased cells being contracted and filled with a brownish fluid. He conjectured that the cells had been previously ruptured, since if they had been entire, the mere change of the fluid, or colour of the fluid contained in them, could not possibly have caused them to contract.

In another specimen, apparently more diseased, in one part there were brownish empty bags, arranged longitudinally, which might be the diseased cells deprived of their contents; on each side there was a canal quite destitute of all solid matter. And, in another portion, considerably more decayed, there were brownish, fibrinous looking, long streaks of solid matter, with perfectly defined edges, which might have been the cells, or the tissue of the cells in a further stage of the disease. The neighbourhood of these last mentioned elongated bodies was quite free from all solid matter, showing, that from whatever source they derived their solidity, it was at the expense of the whole organised structures in their vicinity; or, at least, that they became solid, and the contiguous structures were destroyed simultaneously.

7*th January*, 1846.—*The* President *in the Chair.*

Mr. James Thomson was admitted a member.

XV.—*Additional Observations on the Potato Disease—Quantity of Water in Sound and Diseased Potatoes.* By Walter Crum, Esq., F.R.S.

In the month of November, I read to the Philosophical Society an account of some experiments on the potato, from which it appeared that simply by bruising a sound potato, and exposing it to the air, all the appearances are assumed which accompanied the diseased potato of the past year. I mentioned the production in a few days of fungi of various kinds on the surface of the artificially diseased mass, and showed that there, as in most other cases of decay, these plants have no share in producing disease in vegetables, but are a necessary consequence of the production of putrid matter—a soil in which alone they can vegetate. I made known these experiments as extensively as possible, for at that time some countenance had been given tô the opposite opinion, that the seeds of fungi do fix themselves upon, and produce disease in otherwise healthy plants; and some apprehensions were consequently entertained, particularly in Ireland, that danger might result even to grain crops sown upon land which had grown diseased potatoes, from the prevalence in it of the seeds of these fungi.

I related at the same time an experiment which led me to doubt the statement of Professor Kützing, (although the wetness of the season appeared to confirm it), that the rupture of the cells was occasioned by their containing a more than ordinary quantity of water. All facts on such a subject are important, and as these views are still held by some who have adopted the general statements contained in my first paper, I shall relate some recent experiments which satisfy me that diseased potatoes contain no more water than healthy ones.

I had no means of comparing satisfactorily the potatoes of this with those of other years; but I experimented upon various kinds, some of them as sound as the potatoes of any previous year. The potatoes, after being wiped dry were carefully sliced into pieces of about two lines in thickness, and two middle slices from different specimens were employed in each experiment. The drying was performed at a steam heat, and was continued nearly three days, when they had ceased for some hours to lose weight.

Specimens 1, 2, 3, and 4, in the table which follows, were potatoes from the same field. 1 and 2 had been pitted a month. 3 and 4 had been left in the ground, and were kept moist till operated upon. 1 and 3 were perfectly sound and excellent potatoes. 2 and 4 were diseased.

5 and 6 were sound potatoes grown on wet bog land, and pitted a month in a damp situation. 7 was the same, diseased.

8 and 9 were potatoes of different sorts; both perfectly sound, as was the whole of the crop in the two fields from which they were taken. 8 was a mealy good potato; 9 was a waxy potato, not well tasted.

10 was a rough red potato and quite sound—dug end of August before the disease had appeared in this country. 11 the same, left accidentally in the ground till December, and also quite sound. 12, forty-fold potato, left in the same manner in the ground, and quite sound.

If a potato be cut into slices, and one of the middle pieces be held up to the light, it will be seen that the outside, all round, is denser than the centre. A distinct boundary (a narrow space containing the spiral vessels) divides the two portions, which, in a middle slice, are nearly of equal weight. It is in the external denser portion that the disease appears—commencing at the surface and proceeding inwards. The boundary I have mentioned often arrests its progress. The following table shows the proportion of water in each of the foregoing specimens—inside, outside, and in the whole slice :—

	Inside.	Outside.	Whole Slice.	
1	74·5	69·9	72·2	sound.
2	76·2	73·3	74·8	diseased.
3	79·3	75·0	77·7	sound.
4	76·2	74·8	75·6	diseased.
5	78·2	75·1	76·9	sound.
6	77·9	73·2	75·9	do.
7	81·8	76·1	78·6	diseased.
8	76·5	71·6	74·6	sound.
9	82·6	77·6	80·5	do.
10	77·2	72·0	74·9	do.
11	79·1	74·7	77·3	do.
12	81·0	76·2	78·8	do.
Average,	78·6	74·2	76·6	

If a potato be grated down, and the juice squeezed and washed out of the pulp, the latter has no tendency to change colour by exposure to the air. The juice also, if bottled up, as soon as it is expressed, retains its yellow colour unchanged, letting fall after some time, a deposit of the same colour. But if the juice be freely exposed to the air it soon becomes brown, and deposits a blackish powder, which by washing and filtering, may easily be obtained in a separate state. It consists partly of the woody matter of the cells, and partly of a black extractive matter, which is known as a frequent result of the decay of plants. It is this substance, entangled among the cells and farinaceous matter which occasions the brown colour peculiar to the naturally diseased potato.

XVI. *Mode of Testing Minute Quantities of Alcohol.* *By* ROBERT D. THOMSON, M.D.

THE determination of the presence of minute quanties of alcohol, is a chemical point of some importance, especially in judicial cases. The usual method hitherto adopted for detecting alcohol in mixed fluids, is to subject the fluid suspected to contain it to distillation, at a temperature not greater than that which is required to cause the alcohol to pass over into a receiver, and then to judge of the presence of spirit by the vinous odour of the distilled fluid. When alcohol in the form of gin, whisky, or brandy, &c., has been swallowed, if death takes place within a short period of the introduction of the fluid, the odour of the spiritous liquors will be distinctly perceptible to one inspecting the interior of the stomach; but if a considerable time should elapse, as, for example, a few hours between the introduction of the spirit and death, it is rarely found that the smell can be detected. Again, if the person should die under the influence of spirituous liquors, and the stomach were not examined within a limited period, the odour of alcohol might not be perceptible, since, as absorption goes on for several hours after death, and as volatile fluids appear to be peculiarly susceptible of rapid absorption, the whole of the alcoholic fluid might be removed from the intestinal canal into the circulation. It has been affirmed that alcohol has been detected in the brain of gin drinkers; but as the mode of testing adopted was merely the impression made upon the nerves of smell, we may perhaps be allowed to doubt the accuracy of the experiment. It has even been affirmed, that the gin obtained from the brain has been inflamed, and if this were correct, we should then be entitled to quote nasal and ocular proofs of the presence of alcohol in the brain, but as the gin of the shops is so weak, that in its natural state it will scarcely burn—we may also be permitted to be sceptical in reference to this second proof. These views do not tend to disprove the possibility of the presence of alcohol in the vessels of the brain and other portions of the body; because we know that hydrocyanic acid passes to the very extremities of the body, and can be distinctly detected by its odour, until it has either been removed from the system by the combustion of respiration, or simply by exhalation from the lungs. Now, alcohol and hydrocyanic acid are somewhat analogous, in a chemico-physiological point of view, as they possess a powerfully sedative effect upon the system, are exceedingly volatile, readily absorbable, and require much oxygen to resolve them into simpler forms. For these reasons, it appears highly probable that alcohol may be capable of detection in the vessels of the system, when it has been swallowed in large quantities. The experiment, however, could only be made on the inferior animals, and we should require some more definite test than the mere smell of the alcohol. There are other circumstances, in a judicial point of view, in which it may be of importance to detect minute quantities of alcohol. For example, to distinguish small portions of the liquid preparations of opium. In medicine there are used the solution of opium in alcohol; the solution of opium in wine; the solution of opium in alcohol, with benzoic acid and ammonia; the solution of opium in vinegar; and lastly, the solution in water. When these preparations are entire, there is not so much difficulty in their discrimination, but if they have been exposed to the air, much of the alcohol escapes, and they may all become analogous to a solution of opium in water. To distinguish those which contain alcohol from those which do not, enables us to divide them into two classes, and thus to simplify the inquiry. For these, and many other cases where minute detection is necessary, I have been in the habit for some years of employing a method which depends upon a well-known fact, viz. the dehydrogenation of the alcohol by means of oxygen. For this purpose, the fluid to be tested, if coloured, or a mixed one is to be distilled in the water bath, until one-third of it passes over. Should the liquor contain any acetic acid, this may be saturated previous to distillation with carbonate of soda, if the amount should be considerable, in order to remove the vinegar smell which might interfere with the odour of the subsequent test. Into the distilled liquor, supposed to contain alcohol, should be dropped a crystal or two of chromic acid, and the liquor stirred. If the smallest quantity of alcohol is present, the green oxide of chrome will begin to be disengaged, and at the same time the smell of aldehyde is distinctly perceptible.

The production of the aldehyde from the alcohol depends on the separation of ogygen from the chromic acid, its union with the hydrogen of the alcohol, and their consequent removal in the form of water; the formulæ for the two bodies being,

$$C^4\,H^5\,O + HO \text{ Alcohol}$$
$$C^4\,H^3\,O + HO \text{ Aldehyde}$$
$$\overline{\qquad\qquad}$$
$$H^2$$

By means of this simple test, it is possible to distinguish a drop of alcohol in half-an-ounce and even in an ounce of water. When chromic acid is not at hand, the experiment may be made with bichromate of potash, and sulphuric acid. This perhaps affords the most distinct method of performing the experiment, and may be conducted as follows:—Drop in a few grains of powdered bichromate, into a small test glass (which tapers towards the bottom,) containing the solution to be examined, and add a few drops of oil of vitriol. If alcohol is present, the green oxide will be observed to form on the surface of the undissolved salt, and the characteristic odour of aldehyde will speedily be perceptible. As an instance of the utility of this test, it is only necessary to give one illustration. Some months ago I had sent to me by Dr. Joseph D. Hooker, a bottle containing 7 cubic inches of a fluid which was obtained from a species of Eucalyptus, or gum-tree, in Van Dieman's Land, a fluid which is drunk by the natives as an intoxicating liquor. It possessed a powerful odour of vinegar, to such an extent, that it overcame every other smell which might be present. On neutralizing it with carbonate of soda, it was found to require 28·6 grains of this salt to saturate the acid, equivalent to 10·12 grains of dry acetic acid in the whole fluid. On distilling one-third of the liquor, a fluid came over having a faint odour of foreshot. When chromic acid was added to it, or bichromate of potash and sulphuric acid, the liquor became green, and the odour of aldehyde was powerfully evolved. This proved the presence of alcohol. On evaporating the liquor in the retort, a small quantity of sugar, and needle-shaped crystals remained. The latter when treated with sulphuric acid, gave out a strong smell of acetic acid. These were satisfactory proofs that the eucalyptus sugar is capable of fermentation, and that the alcohol produced from it is convertible into acetic acid—facts which show us that the Australian sugar is not manna or peculiar but, common sugar.

XVII.—*Analyses of some Minerals, made in Glasgow College Laboratory, by* Robert D. Thomson, M.D.

ZEOLITES.

Wollastonite.—The name of Wollaston, to whom mineralogy was so much indebted, was given to table spar by Hauy; but as that beautiful mineral is so universally known by the latter title, the term Wollastonite has become a mere synonym. In the year 1829, a mineral was found at Kilsyth, occurring in veins in a greenstone rock, on the banks of the Forth and Clyde Canal. This species I analysed, when but a very youthful chemist, in the beginning of 1830; and as it approximated in composition to table spar, although quite a distinct species, Dr. Thomson gave it the name of Wollastonite, and published an account of it in the Transactions of the Royal Society of Edinburgh. A notice of it was also printed in the Records of General Science, Vol. I. p. 220, in 1835.

The same mineral has recently been obtained in the formation of the Bishopton Tunnel, on the Glasgow and Greenock Railway. About the beginning of this century, an analysis was published by Dr. Kennedy, a very able analytic chemist, of Edinburgh, "of an uncommon species of zeolite," found in the Castle Hill of Edinburgh. (Edin. Trans., Vol. V., and Phil. Mag. XIV., 310.) The analysis agrees so closely with that of Wollastonite, that I have ventured to republish it, and with less hesitation, since Lord Cathcart (then Lord Greenock) procured the same mineral, some years ago, from the locality in which it was obtained by Dr. Kennedy. Professor Kobell has described, under the name of Pectolite, a mineral from Tyrol, (*Kastner's Archiv.* XIII. 385,) which corresponds nearly with Wollastonite; but the analysis which he has published is so imperfect, that an accurate conclusion cannot be drawn as to its true composition.

The description given in Dr. Thomson's mineralogy, Vol. I., 131, I believe to be descriptive also of the Bishopton specimens, with the exception that the hardness is too low. The number given in that volume is obviously a typographical error. The true hardness I find to be, of all the specimens in our private collection, 5·25.

In the following table, the first column represents the analysis of Dr. Kennedy; the second, my analysis, made in 1830; the third, an analysis of Wollastonite, from Bishopton, made by my pupil, Mr. James C. Stevenson, during the present year; and the last column represents the composition of the Pectolite of Von Kobell. The specific gravities, as obtained by the different experimenters, are as follows:—

Kennedy,	2·643 to	2·740
R. D. Thomson,	2·550	2·876
Von Kobell,	2.69	—

	I.	II.	III.	IV.
Silica,	51·50	52·744	52·059	51·30
Lime,	32·00	31·684	32·817	33·79

Soda,	8·50	9·600	—	8·26
Potash,	—	—	—	1·57
Magnesia,	—	1·520	1·624	—
Protoxide of Iron,	0·50	1·200 }	2·682	0·90
Alumina,	0·50	0·672 }		
Water,	5·00	2·000	—	8·89
	98	99·420		104·69

The formula for this composition is 4 Cal. Si^2 + NaSi + Aq.

Since the preceding account was written, I find that Kobell has published a new analysis of this mineral in his *Grundzüge der Mineralogie*, p. 226, in 1838, or eight years after my analysis was made. His last results agree nearly with mine, and he finds only traces of potash. His numbers are—Silica, 52·34; Lime, 35·20; Soda, 9·66; Water, 2·80.

These facts are sufficient to point out to mineralogists the name which is entitled to precedence.

Harringtonite.—The following analyses of Harringtonite, a mineral which gelatinizes with hydrochloric acid, were made by Messrs. Hugh B. Tennent, P. Kater, and John Stevenson:—

	I.	II.	III.	IV.	V.
Silica,	42·11	45·03	38·40	40·70	38·00
Alumina,	25·14	26·62	32·52	30·77	32·01
Lime,	11·52	9·25	11·14	10·41	13·00
Protoxide of Iron,	0·77	0·60			
Soda,	4·44	3·09	2·44	1·86	2·28
Potash,	trace.	trace.	trace.	trace.	
Water,	16·02	14·02	15·50	15·26	14·71

In the first two analyses, the specimen was from a different locality from that represented by the last three, and obviously contained an excess of silica.

Antrimolite.—This mineral was carefully examined by William Parry, Esq., late of H. M. 4th Regiment of Foot.

	I.	II.
Silica,	43·37	43·47
Alumina,	26·29	27·32
Lime,	9·58	11·09
Soda,	4·83	—
Potash,	trace.	—
Water,	15·12	—
	99·19	

The excess of lime arises from the calcareous spar which forms the nucleus of the mineral.

Phacolite, from Glenarm.—This mineral has usually been confounded in this country with Levyine. Mr. Parry found it to yield, by two analysis, very carefully made—

	I.	II.
Silica,...........................	47·03	47·85
Alumina,...........................	19·47	18·84
Lime,...........................	10·74	9·50
Potash,...........................	1·18	1·66
Soda,...........................	—	trace.
Water,...........................	—	21·86

This mineral loses from 3 to 4 per cent. of water in a vacuum. It may be readily distinguished from Levyine, by the character which the latter possesses of intumescing before the blowpipe.

Gismondine, from Mount Vesuvius, in small mamillary crystals, resembling a dew-drop on the surface of volcanic rocks—analysed by Mr. Parry.

Silica,...........................	42·33
Alumina,...........................	23·44
Lime,...........................	7·63
Potash,...........................	8·21
Soda,...........................	1·25
Water,...........................	17·26

The following minerals are not Zeolites.

Brown Tourmaline from Perth, Upper Canada, was examined by Mr. Parry:—

	I.	II.	III.
Silica,........................	39·36	37·68	38·14
Alumina,........................	28·62	28·68	29·54
Protoxide of Iron,..........	16·21	18·04	17·50
Magnesia,........................	2·72	3·84	3·36
Lime,........................	1·29	2·99	1·61
Potash,........................	—	—	0·91
Boracic acid,...............	—	—	3·62
Volatile matter,...........	—	—	0·28

Raphilite, or *Grey Tremolite,* from Canada, Sp. Gr. 2·87.

	I.	II.
Silica,...........................	57·38	56·81
Lime,...........................	14·40	14·81
Alumina,...........................	2·13	2·08
Protoxide of Iron,..................	4·46	7·05
Magnesia,...........................	16·00	16·80
Water,...........................	—	2·42

The first analysis was made by Mr. Clutterbuck, the 2d by Mr. Hugh B. Tennent.

Humboldilite, from Italy.—The two first analyses were executed by Mr. Clutterbuck, the third by Mr. George Alexander.

	I.	II.	III.
Silica,	42·57	45·36	43·16
Alumina,	2·77	4·76	17·60
Peroxide of Iron,	14·00	12·40	
Magnesia,	3·40	5·88	2·40
Lime,	30·56	30·60	—
Soda,	—	1·20	—

Primitive Clay Slate, Mica Slate, and Graywacke.—The first was analysed by Dr. Lewis, R.N., the second by Mr. John Adam, the third by Mr. James Macbryde.

	Clay Slate.	Ben Lawers Mica Slate.	Wigton Graywacke.
Spec. Grav.,	2·70	2.74	2·77
Protoxide of Iron,	5·86	11·96	9·47
Perphosphate of Iron,	1·36	1·38	0.94
Lime,	0·62	1·16	0·96
Magnesia,	1·20	0·95	2·30
Potash,	1·84	0·29	0·95
Soda,	—	—	
Alumina,	25·13	17·12	11·68
Silica,	58·47	66·63	72·18
Water,	3·12	1·00	2·40
Sulphur,	0·66	—	—
	98·26	100·49	100·88

Reports from Botanical Section.

24*th June*, 1845.—The President *in the Chair*.

Specimens of Cypripedium pubescens and spectabile were exhibited from the Botanic Garden. The specimens had been transmitted by Dr. Gavin Watson of Philadelphia. The President also exhibited dried specimens of Cheirostemon platanoides, the Hand-tree, or Manitas, of South America,—explaining the peculiar structure of the stamens;—and a specimen of Androsace alpina, which had been gathered by Dr. Barry on Mont Blanc, at the height of 10,000 feet.—Dr. Balfour then gave a short account of a botanical trip, with his pupils, to Roseneath, the Row, Largs, and Wemyss Bay, Dumbarton, and Bowling, and noticed a few of the more interesting plants collected,—such as Hymenophyllum Wilsoni, in Ardenconnel Glen; Valeriana pyrenaica, Cardamine amara, Sedum Telephium, Carum verticillatum, Œnanthe crocata (exhibiting no orange juice when cut), Rumex sanguineus β viridis, Milium effusum, Sagina maritima, Raphanus raphanistrum β maritimus, Sinapis Monensis, Steenhammera maritima, Trollius europæus, Mimulus luteus (naturalised near Largs), Pinguicula Lusitanica, Osmunda regalis, Peucedanum ostruthium, Lysimachia nummularia, Asplenium marinum, Smyrnium olusatrum, Carex muricata, Inula Helenium, Conium maculatum, Malva moschata and sylvestris, Poa maritima, Geranium columbinum.—Dr. B. also gave an account of an excursion to Lochwinnoch and Castlesemple woods, and exhibited, in a fresh state, most of the plants collected. Amongst these were Nuphar lutea, Ranunculus lingua, Hippuris vulgaris, Carex acuta and vesicaria, Scirpus sylvaticus and lacustris, Cornus sanguinea, Aconitum napellus, Hesperis matronalis, Serrafalcus commutatus, Trollius europæus, Sedum villosum and Telephium, Littorella lacustris, Staphylea pinnata, Berberis vulgaris, Lythrum salicaria, Spiræa salicifolia, Verbascum thapsus, Acer campestre, Epipactis latifolia. He also described the gardens at Castlesemple, which are very extensive. The quantity of glass in the vineries, peach, and pine houses, greenhouses, and stoves, is probably unrivalled in any private garden in Scotland. The party were received most hospitably by the proprietor, Colonel Harvey, who accompanied them through the woods in the neighbourhood of the castle. In the plantations, some fine cedars, larches, and oaks, were observed.

A specimen of Cirsium setosum was received from Dr. Dewar of Dunfermline, for the Herbarium.

Dr. Böttinger exhibited specimens of the following vegetable Alkaloids, viz.:—Morphin, Meconin, Codein, Narcotin, Solanin, Atropin, Delphinin, Lactucin, Emetin, Berberin, Aconitin, Veratrin, Picrotoxin, Brucin, Peucedanin, Cinchonin, Jalapin, Æsculin, Santonin.

July 29, 1845.—*The* President *in the Chair.*

Dr. Böttinger reported progress in the arrangement of the Herbarium, and invited contributions of plants from the members.

The President exhibited a growing specimen of Phallus impudicus, which had been gathered in the undeveloped state near Linlithgow, and had been put into a pot among mould and leaves. It had burst the volva, and pushed up its stipe and pileus to the height of several inches in the course of a night.

A specimen of Babel Bark, imported from Calcutta, for the purpose of tanning, was exhibited. Also, a specimen of coffee, covered with what is technically called "parchment," or the thin brittle covering which is spread over the seed, within the pulpy part of the fruit. Coffee was occasionally imported in this state, with the view of its being cleaned and winnowed in this country; but it was not found profitable. There was likewise exhibited, a specimen of a species of Mespilus, destroyed by the attack of a moth of a gregarious nature.

The President read extracts from a letter from Dr. R. C. Alexander, dated Naples, 21st June, 1845, describing the botany of the south of Italy and Sicily.

The next communication was an account of a trip by Dr. Balfour and his pupils to Ardentinny and Loch Eck, on the 28th June. The party examined the woods and rocks in Glen Finnart, and proceeded towards the shores of Loch Eck, skirting them as far as Benmore, and thence walking to Kilmun. The chief plants noticed were Hymenophyllum Wilsoni, Osmunda regalis, Jungermannia minutissima, Sphærophoron compressum (in fine fruit), Rubus saxatilis, Saxifraga aizoides and stellaris, Gymnadenia albida, Carex stricta, fulva, and remota, Polygonum Bistorta, Sedum anglicum, Silene maritima (on the sandy shores of Loch Eck), Bromus commutatus, Carum verticillatum. In the woods of Glen Finnart fourteen species of Ferns were gathered.

Bute was visited on the 4th of July. Between Rothesay and Mount Stuart, the party picked Pinguicula Lusitanica, Saxifraga aizoides, Habenaria chlorantha and bifolia, Anagallis tenella, Osmunda regalis, &c. The party visited the garden at Mount Stuart, where many delicate plants thrive in the open air. Betwixt Kingarth and Scalpsie Bay, they gathered Hypericum elodes, Utricularia minor, Carex vesicaria, Cotyledon umbilicus, Sinapis monensis, and many other good plants.

On Thursday, July 10, Dr. Balfour and his party visited Arran, and examined the hilly districts of the island, especially Goatfell and Cior More, whence they proceeded to Loch Ranza. From this they returned by the Cock of Arran and Corrie to Brodick. One of the most interesting plants noticed was Pyrus pinnatifida, which was obtained in considerable quantity on the banks of a mountain stream, which terminates at Loch Ranza.

This closed the meetings of the Section till session 1845-46.

December 23, 1845.

Dr. Balfour, Professor of Botany in the University of Edinburgh, having come to town to attend the opening meeting of the session, was unanimously called to the chair.

The Curator (Dr. Böttinger) directed attention to the necessity of procuring an additional press for the Herbarium; also, a copy of Endlicher's Genera Plantarum, and Steudel's Nomenclature, to assist in arranging foreign plants.

Mr. Lyon presented to the section Loudon's Encyclopædia of Plants. —Thanks voted.

Dr. Balfour, as President of the Botanical Society of Edinburgh, presented to the section a copy of the Transactions of that Society.—Thanks voted.

The Secretary (Mr. Keddie) read an account of a botanical excursion to Linlithgow, South Queensferry, North Queensferry, and thence by the Fife coast to Burntisland, in company with Dr. Balfour and party, on the 18th and 19th of July last. Among the plants gathered were, Typha latifolia, Rosa rubiginosa, Thalictrum flavum, Astragalus glycyphyllos, Reseda lutea, Geranium pusillum, Allium Scorodoprasum, Medicago maculata, Spiræa filipendula, Salvia verbenaca, &c.

Total Phanerogamous species and varieties seen during the trip, ...419
Ferns,.. 15
——434

Grasses, 43 species.

List of plants gathered, which are common on the east coast of Scotland, near Edinburgh, and which occur rarely, or not at all, near Glasgow :—

Thalictrum majus.
——— minus.
Papaver Argemone.
Sisymbrium Sophia.
Reseda lutea.
Helianthemum vulgare.
Malva rotundifolia.
Acer campestre.
Geranium pusillum.
——— sanguineum.
Medicago maculata.
Trifolium arvense.
——— scabrum.
Astragalus glycyphyllos.
——— hypoglottis.
Oxytropis uralensis.
Spiræa Filipendula.
Rosa rubiginosa.
Vicia lutea.
Fedia dentata.
Dipsacus sylvestris.
Salvia verbenaca.
Lamium album.
——— incisum.
Hippophaë rhamnoides.
Allium scorodoprasum.
Hordeum murinum.
Briza media.
Knautia arvensis.
Carduus tenuiflorus.
Ballota nigra.
Primula veris.
Chenopodium rubrum.
Euphorbia peplus.
Avena flavescens.
——— pubescens.

Dr. Balfour read an account of a botanical trip to Ben Nevis last autumn, exhibiting specimens of some of the plants collected; also, Typha angustifolia, from Lochmaben.

January 27, 1846.—Dr. Balfour in the Chair. Mr. Adamson read a paper on the Genus Rubus, illustrated by specimens. Dr. Balfour exhibited specimens of plants in various stages of growth, showing the effects of the extraordinary mildness of the season. The Professor presented a valuable collection of plants to the Herbarium, for which thanks were voted.

February 24, 1846.—Dr. Blackie in the Chair. Several seeds from the Sandwich Islands were exhibited. Dr. Blackie presented to the Herbarium, a Fasciculus of Salices.—Thanks voted.

24th January, 1846.—*The* President *in the Chair.*

It was announced that a few members of the Chemical Section intended giving a Conversational Meeting next Wednesday evening, and for that purpose Mr. Griffin had kindly granted the use of his suite of rooms. Professor Gordon read a paper on the theoretical mechanical effect of steam.

4th February, 1846.—*The* President *in the Chair.*

On the motion of Dr. Buchanan, the thanks of the Society were unanimously voted to Messrs. Griffin, for the use of their rooms at the late Conversational Meeting, arranged by some members of the Chemical section. The following paper was read:—

XVIII.—*On the Wound of the Ferret, with Observations on the Instincts of Animals. By* Andrew Buchanan, M.D., *Professor of the Institutes of Medicine, University of Glasgow.*

Having often heard of the remarkable way in which the Ferret destroys its victims, I willingly availed myself of an opportunity presented to me on the 26th of August last (1845), of seeing two rats killed by this animal. I found the common account quite correct, that the Ferret kills by means of a small wound in the neck; but the explanation usually annexed I found quite erroneous, that the Ferret aims at the jugular vein, and destroys life by sucking the blood of its victim. The rapidity of the death was quite inconsistent with so tedious a process as blood-sucking, and the dissection showed the true cause to be totally different, and so very curious, that I have thought it not unworthy of the notice of the physiological section of the Society.

The two rats being put into a large barrel, concealed themselves under some hay in the bottom of it. On the Ferret being introduced, it seemed dazzled with the sunshine, for it took no notice of one of the rats placed right before it; but soon finding the scent, it burrowed under the hay, taking the very track which the rat had just taken, and thus came round directly upon him. The rat, which was of large size, resisted stoutly, but the Ferret instead of returning the bites it received, seemed entirely occupied with putting itself into a proper position, applying itself to the body of its antagonist, breast to breast, and using the fore paws and head, as if going to embrace it. No sooner had it assumed this position, than it inflicted a wound, which was so instantaneously fatal, that a physiologist might have guessed from that circumstance alone, what the nature of the wound must have been. The rat died without a struggle: and the Ferret immediately dissengaged itself from the body, instead of remaining to suck the blood, and soon falling on the track of the other rat, destroyed it exactly in the same manner.

I now proceeded to examine the dead animals. Neither of them exhibited any marks of injury inflicted by the Ferret, except a bloody patch on the side of the neck, under the ear. In the first one which I looked at, there was at the upper part of this bloody patch, or a little below and behind the ear, a very small punctured wound, and on dissecting it carefully to the bottom, I was surprised to find, that the sharp dens caninus, by one of which the wound was obviously inflicted, had gone right down to the spinal cord, piercing it between the occiput and the uppermost cervical vertebra. The Ferret therefore destroys its victims by pithing, a process well known to be the most immediately fatal, to the upper orders of vertebrated animals, of all modes of destroying life: and it employs for the purpose one of its long slender dagger-like tusks, a weapon singularly well adapted to inflict a wound which proves fatal, neither by laceration nor contusion, but by penetrating into the very centre of the nervous system, on which the most important functions of life immediately depend.

The death of the other rat was obviously produced in the same way; but there was no external wound visible, on any part of the bloody patch on the neck, the tusk having been inserted into the external ear, and then penetrating the cartilaginous side of the auditory passage had been carried towards the vertebral canal, which it entered under the occiput, more laterally than in the former case.

It is certainly very remarkable, that instinct, or the promptings of bodily organization, should lead an irrational creature to use its weapons in the very way in which a profound knowledge of the functions of the nervous system teaches that they may be used with the most deadly and instantaneous effect. The cerebro-spinal axis, or great central nervous column, lodged in the elongated cavity of the head and spine, cannot be wounded at any point, without interfering more or less with sensation and motion; but the part of this nervous column, on the integrity of which the continuance of life immediately depends, is the medulla oblongata, or part of the column lying intermediate between the head and spine. Wound an animal below this point, and you paralize his limbs more or less, but life may be protracted for years after such injuries. Wound the animal above this point, and you not only produce palsy, but impair or destroy consciousness and the faculties of the mind. Still, however, just as we see in a man struck down by a fit of apoplexy, the action of the heart and the respiration may go on little or not at all affected. It is on the upper part of the cord that these important functions immediately depend, and hence it is that to the higher vertebrata, a wound inflicted there is the most instantaneously mortal of all wounds, at once destroying consciousness, sense, and motion, and arresting the action of the heart and respiratory muscles. It is not a little remarkable, that the Ferret should select this very part of the cord into which to thrust his tusk; and serves to show how the promptings of instinct may anticipate the deductions of science.

To those who love to speculate on the mental endowments of brutes, it many not be uninteresting to know, how two young Ferrets that had never before seen a rat killed, deported themselves on the occasion. Before putting the old Ferret into the barrel where the rats were, a trial was made with two young ones, her offspring. The untutored creatures, instead of having for their single object, to put themselves into the proper position to inflict the death-wound, engaged in conflict with the rats, returning bite for bite; and, although one of the rats had its leg bitten through, they at length beat off their assailants. Still farther, after the old Ferret had despatched the first rat, one of the young ones immediately threw itself upon the dead body, assuming the very position and motions which the old one had assumed, and so far as could be judged from there being but one wound, thrusting its tusk into the very same aperture. Did then the young Ferret receive a lesson from the old one? The facts do not at all accord with this hypothesis, for the young one, instead of attending to the lesson given it, was all the while engaged in skirmishing with the other rat. Besides; the headlong fury with which the young animal threw itself upon the dead body had nothing in it of the caution of an experimental and intellectual act, but partook altogether of the character of a blind impulse—an intense feeling of bodily gratification, impelling the creature to the act which it performed.

The acts which we name instinctive, appear to me to be best explained upon the hypothesis, that they proceed from the promptings of bodily organization. The bodily organs of animals are formed in a certain way to adapt them to the performance of certain acts, which acts the animals perform readily, and with pleasure to themselves: other acts to which their organs are not adapted, they cannot perform at all, or not without a painful constraint, and therefore they do not perform such acts. One animal goes to sleep stretched upon the ground, finding that to be the position in which there is the most complete repose of the muscular system; another supports itself on one leg, upon a spar, a position which the former animal could not maintain, without the most painful efforts, for more than a few seconds. That position, however, is admirably adapted to the organization of birds, their bodies maintaining their equilibrium in perfect security, and without muscular exertion, by a mechanism which Borelli has explained. According to the same law of the adaptation of organs birds fly, fish swim, quadrupeds walk and run, and every animal uses its weapons, offensive and defensive, in the way in which the Author of nature meant them to be used. This physiological theory of Instinct seems to me more probable than that which refers it to innate ideas, or any other peculiarity of mental constitution; or than the extraordinary hypothesis of Lord Brougham,* who refers all instinctive acts to the immediate inspiration of the Deity—the divine mind supplying the place of reason, and directing the bodily organs. This is

* Dissertations on Subjects connected with Natural Theology.

exactly the doctrine of Pope, and with deference to so great a man, seems to me to savour more of poetry than of philosophy.

> "Reason exalt o'er Instinct as you can,
> In this 'tis God directs, in that 'tis man."

It is commonly said, that Instinct is independent of all reasoning, education, and experience; and it has been assumed as a character of the instinctive acts, that they are performed as perfectly at the first as at any subsequent time. This holds good only among the lowest animals, whose whole actions are automatic, or without any intervention of the reasoning power; but it is so far from being universally true, that it may be affirmed, that in all animals capable of reasoning, the instinctive acts are under the control of the reasoning power, and are frequently not performed aright at the first, as in the case of the young Ferrets above mentioned. The ultimate result, however, of the reasoning process in such cases cannot be doubtful, since the bodily organization operating upon the mind will admit of only one conclusion; and hence, even in the highest species of animals, these instinctive acts are always ultimately performed exactly in the same way.

The instinctive acts which excite our wonder most are such as those we observe among the insect tribes, in which the intervention of reason cannot be suspected, and which are, on that account, the better fitted to elucidate the true nature of Instinct. But the wonder with which we regard the workmanship of insects proceeds mainly from an erroneous view of the directing power by which it is carried on. The honey-comb and the spider's web are, without doubt, wonderful in their structure; but they are in no respect more wonderful than the elaborate structures which the microscope displays to us in every tissue of animals and vegetables; even in the mathematical exactness of form, so much celebrated, they are not superior to the regular hexagons which form the epidermis of many plants, and which we find equally regular in the same tissue of certain reptiles. Now, the former structures are not held to be more wonderful than the latter, because they are fabricated by the instrumentality of muscular fibres; for in that point of view we should marvel more at the latter, which are fabricated by less perfect instruments—vessels and cells. The true cause why the former structures have been regarded with most wonder is, that it has been supposed that the action of the muscles which form them must be voluntary—a supposition which implies necessarily the existence of a directing mind. Now, the physiology of the present day gives no countenance to such a supposition. It shows us, on the contrary, innumerable muscular acts in all animals, with which volition has no more to do than with digestion or nutrition. Such acts may originate in external impulses which excite the nervous system, and the acts follow immediately, as if from a physical necessity. They may originate, also, as in the case before us, in internal impulses, derived from the organic condition of the tissues of the body, and the changes they are continually undergoing. The two series of structures which we have brought into comparison are, therefore, to be regarded as the products of the same organizative or plastic force: which, acting in one way, employs vessels and cells for its instruments, and produces, within the body, the innumerable structures of which animals and vegetables are made up; and, acting in another way, employs for its instruments muscular fibres under the direction of the nervous system, and produces, without the body, structures which bear the same impress of regularity and beauty as those within it, and co-operate with them to the same ends—the preservation of the individual and the species. Corals, and other polypidoms, may be considered as standing in the very same relation to the swarms of zoophytes which people them, in which the honey-comb does to a swarm of bees. Both are structures external to the bodies of the animals which produce them, and both are the products of the same organizative power: the only difference being, that in the one case this formative power employs its ordinary instruments—cells, and, possibly, vessels—while, in the other, it employs the more unwonted apparatus of muscular fibres.

I have more recently had an opportunity of examining several animals killed by the Ferret. I found that instead of there being only one wound, there are always several, as might, indeed, have been inferred from the mechanism of the jaws, and their being armed with four tusks. The wounds are so minute as to be imperceptible externally, unless one of the tusks has pierced the jugular or some other superficial vein, so as to stain the surrounding skin with blood; but as this, although generally, does not always happen, there may be no external mark visible. But, on dissecting off the skin, the wounds become at once apparent in the cellular and muscular substance beneath. The injury done to the upper part of the spine is, therefore, more extensive than I had at first supposed. It is also less uniform in its seat: as I more than once found that the tusk had pierced the cranium, and gone deep into the back part of the brain. The mode of attack is also very various, according to the relative strength of the combatants; but the struggle is always brief; and the Ferret never remains after it to suck the blood.

From these observations, confirmed as they were in all essential respects by many others made under the eye of an intelligent friend, I was disposed to conclude that the vulgar belief of the Ferret destroying its victims by blood-sucking was erroneous; and that it had, most probably, arisen from the appearance of the dead animals, which exhibit commonly no mark of injury but a small wound, surrounded by a bloody patch on the neck. Now, the very same appearance would be produced by a leech fastening on the neck: and hence, most probably, it was inferred that the leech and the Ferret practised the same mode of attack. This opinion has, however, received the sanction of the highest authorities in natural history. Buffon says,*—" The Ferret is naturally the mortal enemy of the rabbit. On presenting a rabbit, even dead, to a young Ferret, that has never seen one before, it throws itself upon the body, and

* Histoire Naturelle, Vol. vii. p. 211.

bites it with fury; and, if the rabbit be alive, the Ferret takes it by the neck, or by the nose, and sucks its blood."—In the Dictionnaire des Sciences Naturelles,* Ferrets are described as being of a most sanguinary nature—"It is even more the blood than the flesh which they seek for their nourishment."—MM. Geoffroi St. Hilaire, and Fred. Cuvier, the authors of the splendid work, "Histoire Naturelle des Mammifères," repeat the same opinion:—"The Ferret, in attacking a rabbit, seizes it by a part of the head, masters it, and sucks its blood, and, as soon as satisfied, falls asleep."

As the above quotations refer chiefly to the rabbit, and as it was possible the Ferret might not practise the same mode of attack upon that animal as upon the rat, I resolved to put the matter to the test of experiment. My first trial was made with a full-grown male rabbit, and a Ferret nine months old, which had never seen a rabbit before. The Ferret immediately commenced the attack, but it was always repulsed, and ultimately obliged to retire altogether; the rabbit adopting a very remarkable mode of defence,—for whenever the Ferret came near, he sprung right upwards, and came down with the whole force of his hind legs upon the head of his assailant. I now sent off the rabbit, to be tried with the old Ferret which had killed the two rats, as mentioned above. The distance was too great to admit of my being present; but I received a full report of what passed from the friend already mentioned, whose zeal in natural science led him to take an interest in the experiment. The rabbit pursued the same tactics in defending himself as before; and so long as he had free space for his evolutions, he came off victorious, as the Ferret could never get an opportunity of laying hold of him. They were therefore put together into a box. There the Ferret soon succeeded in seizing the rabbit across the root of the nose, shaking him, as a dog does, from time to time, and never letting go the hold till the rabbit ceased to live. Instead, however, of despatching him in the course of a few seconds, there was a full half hour from the commencement till the end of the struggle. It was agreed by all present, that while the Ferret held on by means of her teeth, she sucked the blood flowing from the wound. The dead rabbit being sent to me for examination, I found the vessels as full of blood as usual; the brain had not been injured; the bones of the nose and orbit had been pierced; but the main injury done had been to the eyes, which were completely disorganised and full of blood.

It thus appeared that the idea of the Ferret sucking blood was not without some practical foundation. I was, however, at the same time convinced that the observations from which it had been inferred, that the animal always causes death by the abstraction of blood, must have been very superficially made. I have been assured by persons well versed in such matters, that even the rabbit is frequently destroyed by a wound in

* Article Martes, division Putois.

the neck; and I recollect well, when a schoolboy, of having had a young rabbit destroyed by a weasel, and of the astonishment I felt at seeing upon it, when dead, no mark of injury of any kind, but the mysterious bloody patch and small wound on the side of the neck, described above. The truth seems to be, that whenever the Ferret attacks an animal which it is capable of mastering by main force, it despatches him, not by blood-sucking, but by the most speedy and merciful of all modes of inflicting death—piercing the upper part of the spinal marrow; but that when it is opposed to animals of large size and strength superior to its own, it alters its mode of warfare, seizing them where opportunity offers, and clinging to them till they expire from loss of blood, pain, and exhaustion of strength.

An interesting discussion ensued upon the instincts of various animals, and more especially upon the mode in which they destroy their prey. The Ferret, the Weasel, and the Pole-cat seem all to practise the same mode of attack; which is therefore, probably, common to the whole of the Weasel Family.* The well-known "otter-bite," by which so many salmon are destroyed, exhibiting no mark of injury but a single deep wound in the nape of the neck, and the ravages of the same animal when driven by the freezing of the rivers into the poultry-yard, were particularly insisted on, as showing that the Otter, although differing from the rest of the family in its aquatic habits, resembles them, nevertheless, in instinctive propensities, as it does in general organization.

18*th Feb.*, 1846.—*The* PRESIDENT *in the Chair.*

George Brown, Esq., and John Crawford, M.D., were admitted members of the Society. Professor Gordon read a paper on the Consumption of Smoke.

4*th March*, 1846.—*The* PRESIDENT *in the Chair.*

George Arnott Walker Arnott, LL.D., Reg. Prof. of Botany in the University of Glasgow, was admitted a member. On the motion of Mr. Gourlie, it was agreed that £3 should be voted to the Botanical Section, to assist in defraying the expenses of the Herbarium. Mr. Crum read a note on Professor Liebig's Researches on Protein and Casein, which have been since published by the Professor himself.

* "Mustelidæ" of Bell's British Quadrupeds, corresponding to the division "Martes" of Cuvier.

23*d March*, 1846.—*The* PRESIDENT *in the Chair.*

Messrs. George Mitchell and William Somerville were admitted members. Mr. Liddell moved, in accordance with a recommendation from the Council, that a Committee be appointed from this Society, to co-operate with any Committee that may be named by the Town Council, for the purpose of making arrangements for a public exhibition of models of machinery, geological specimens, &c., and that a sum not exceeding £50 be placed at their disposal as a guarantee against loss. The following Committee was appointed:—Messrs. Crum, Murray, Hastie, Gourlie, Keddie, Dr. R. D. Thomson, Messrs. Liddell and Bankier, with power to add to their number. Mr. Liddell, Convener.

A copy of Dr. Watt's work on the Vital Statistics of Glasgow, for 1843-44, was presented to the Society by the Town Council.

Dr. R. D. Thomson made some observations on the nutritive power of maize or Indian corn, as compared with other kinds of grain.

Specimens of different kinds of bread, &c., were exhibited,—1. *Bread*, consisting of maize and wheat flour, it being impossible to raise bread baked of maize alone; second, of maize, flour, and rice—forming a white loaf; third, of coarse maize and flour; and, fourth, unfermented bread, raised by means of hydrochloric acid and sesquicarbonate of soda. 2. *Biscuits*, consisting first of maize and flour; second, of maize, flour, and rice; and, third, of the same with butter. 3. *Puddings*, made of maize alone, and of maize with Irish moss, &c. The peculiarity of these specimens was, that they were as wholesome and palatable as common wheat bread, and much cheaper.

1*st April*, 1846.—*The* PRESIDENT *in the Chair.*

Mr. Liddell read a minute from the Joint Committee of the Society and Town Council, relative to the arrangements for the proposed exhibition of models at the new year. The following paper was read:—

XIX.—*On the Reaction of Water, and the Theory of the Reaction Water-Wheel.* By W. M. BUCHANAN, Esq.

REACTION Water-Wheels constitute a distinct and extensive order of prime movers, to which, till of late, comparatively little attention has been directed by the engineering profession in this country. It is now upwards of a century (1732) since the fundamental principle of their action was announced in the Hydraulica of J. Bernouilli; and at a still earlier period (1704), the fact that a motive power could be obtained from a jet of effluent water, was practically demonstrated by Dr. Barker in England, and by M. Parent in France. The general problem of the reaction of fluids had indeed obtained a partial solution in the steam-engine of Hero, full eighteen centuries prior (120 B.C.); and when the history of this branch of mechanics shall be fully investigated, it will be necessary to award to the sage of Alexandria the merit of the first discovery, and to point to his engine as the archtype of all those mechanisms by which the motive force developed in the reflex action of fluids is rendered available. Between the rotatory steam-engine of Hero, and the Water-Mill of Dr. Barker, there is, in the present comparatively advanced state of hydrodynamical science, no other essential difference than belongs to the two conditions of fluidity of the agencies employed: their dynamical efficiency may be measured and expressed by formulæ, of which the terms are strictly homologous; and the conditions of their action are reducible to laws common to elastic and non-elastic fluids. But, at the time when Dr. Barker added his machine to the scanty list of hydraulic motors then in use, the laws of hydrodynamics were too partially developed to justify us in assuming that he was guided by analogy, much less, by a rigorous induction of elementary principles. Hydraulics had no foundation in experiment, and those abstract methods of investigation which had led to results of surprising accuracy in the mechanics of solid bodies, in their applications to the motions of fluids, conducted to conclusions which were much too general to constitute a practical theory.

But, although we are thus conducted to the inference that the discovery of the Reaction Water-Mill was empirical, and independent of all scientific deduction, and although in its original form, it is admitted to be nearly worthless—far inferior to the common bucket wheel, as a means of economising hydraulic power—still the merit of the discovery remains unimpaired. A new principle in hydraulics was thereby established, and bequeathed to science; and although its value in the arts has been slowly recognised, the explanation is readily found in the absence of that experimental knowledge which is necessary to appreciate correctly those collateral influences which enter as elements of the technical problem. This is fully manifested by the fact, that the machine, when constructed with due attention to those conditions for which an extended knowledge of the principles concerned in the motions of fluids, and an advanced state of the mechanical arts, have enabled us to provide, is found capable of transmitting fully 80 per cent. of the power of the water expended: whereas, in the older examples, and in some also of modern date (*e.g.* the American tub-wheels), constructed less in accordance with those hydraulic precepts with which experiment has made us acquainted, the result has seldom been found to exceed half the mechanical value of the water expended; and even half that moiety would, in general, be a full measure of the efficiency of the machine if applied in its primitive form. This form it has, nevertheless, steadily retained in scientific treatises which touch on the practical applications of hydrodynamics, and even in the model rooms of our scientific institutions, and periodically on the lecture-table, where it is adduced in illustration of the principle of fluid reaction, it may be recognised under the same uncouth form.

The value of the machine as a hydraulic mover, depending thus entirely upon its construction, it would perhaps have been more in conformity with the order in which the conditions of the problem present themselves, to have devoted the present opportunity to an investigation of those principles which determine the condition of maximum efficiency. That part of the inquiry possesses, besides, a popular interest which does not belong to an examination, necessarily compressed and incomplete, of the dynamical relations involved in the working of the machine. But the order adopted has, in some degree, been forced upon me by the continually iterated and erroneous interpretations of the terms of the problem to be found even in late works of much pretension; and as the problem of construction has not hitherto undergone any professedly scientific investigation, and is consequently not encumbered with any false hypotheses,* its discussion is less urgent, and may be deferred until another opportunity shall offer to bring the subject under the notice of the Society.

But although it does not come within my present purpose to examine the technical conditions prescribed by the *modus operandi* of the machine, it will still be necessary to indicate the general features of the mechanism. Without this it would be difficult to induce a clear conception of its mode of action, and especially of those conditions of dynamical equilibrium to which a mathematical investigation of its principles must have essential reference. I might indeed refer to the primitive form of the machine which is familiarly known to all in any degree conversant with the elements of hydrodynamics: but an apparatus so manifestly ill adapted to fulfil the condition most eagerly desired in the construction of all prime movers—the greatest possible effect from a given expenditure of power—can convey only a very imperfect idea of the adaptations of the machine in its recent and more complete forms. The same is true, although in a less degree, of all those various modifications of the parent machine which have from time to time been attempted on the Continent, where horizontal water-wheels—on account of their economy as regards first cost and readiness of application—have been far more extensively studied and employed than in this country. Several of these have, indeed, yielded results, at least, sufficiently high to throw doubt upon the crude hypothesis, that "the mechanical effect, derivable from a given head of water, is essentially greater in amount when it acts by pressure, than by impulse or reaction." But the success has in no instance been complete; and it is not difficult to per-

* If we except the rules given by Waring, (Trans. American Phil. Soc., Vol. III., p. 193,) which are repeated by Dr. Gregory in his Treatise on Mechanics, (Vol. II., p. 111,) and by Sir David Brewster in his Edition of Ferguson's Lectures on Select Subjects, (Vol. II., p. 208,) but which are too evidently erroneous to have any injurious influence.

ceive by the light of a more exact knowledge of the conditions and data of the problem, that the degree of approximation corresponds in all recorded examples with the degree of obedience to the laws of fluid movement, manifested in the construction of the machine, and in those subordinate arrangements, by which its practical efficiency is hardly less influenced.

The form in which the machine has principally occupied my attention, is that made by Messrs. Randolph, Elliot, & Co., of this city, under the patent of Messrs. Whitelaw & Stirrat. In this the precepts of legitimate theory are united with the highest quality of workmanship, and with a fertility of technical appliance and adaptation unknown in the Reaction Water-Wheels of the Continent. It is not, however, to be supposed that it started into the high state of efficiency which it has ultimately attained, with the first effort. The first trials were sufficiently successful to encourage a reasonable expectation of the final result; but much active experience was required to arrive at the root of the quantative of all those influences which necessarily enter as elements of the practical question. A correct theory required to be constructed, and, in order to arrive at the requisite data, it was found necessary to institute an experimental examination of those laws of hydraulic action concerned in the problem, perhaps more searching and comprehensive, more intense and persevering, than had previously been directed to any question involving the economy of water-power. Mathematical deductions required a more precise interpretation than they commonly received in practice, loose analogies were to be rectified, defective formulæ to be rendered complete by new inductions, modified in their coefficients by the facts of experiment, and reduced from the condition of abstract generalizations to maxims of practice of ready and certain application.

This protracted and laborious inquiry was necessary to the development of the actual theory of the machine, and collaterally to establish its position in relation to prime movers of the same class. Comparative efficiency among hydraulic motors is the criterion of absolute value, and although the standard is unstable—altogether deficient in numerical exactness, and especially at the higher points of oscillation, ill defined—still there is an acknowledged measure which must be reached, and reached through the strict ordeal of experiment, before a claim to the first rank of excellence can, with propriety, be instituted. This is the more requisite, that in general the impelling agency is sparingly dealt out, and neither admits of augmentation nor of unlimited accumulation. If this constant dependence on the immediate supply which Nature affords in her fertilising operations, has the effect of rendering water-power commercially less valuable, especially in those localities where the bowels of the earth are replete with the means of cheaply feeding the energies of the all-mighty steam-engine; it has also the effect of inducing economy in the means of application. Where the power is abundant and admits of ready increase, we can afford to look less narrowly into the expenditure;

but where a deficiency is felt, and especially in districts destitute of mineral resources, there is an inducement amounting often to necessity, to apply that agency which Nature affords with strict reference to the condition of maximum economy. It is this economy of means which constitutes the true problem in the transfer of water-power, and which has found a new and complete solution in the Reaction Water-Wheel.

Description of the Machine:—The Reaction Wheel in its improved and best form, consists of two metal discs, between which the diaphragms, forming the lateral limits of the two water-channels, or arms, are fixed. The transverse sections of these channels are rectangular at all points of their length, but continually diminish in area according to a certain law, from the base to the orifice. The water is admitted to the interior of the machine by a circular opening in the undermost disc, and thence flows radially outwards in the channels, and finally escapes by the orifices at the circumference in lines tangential to the circle of revolution. This direction of the jets is obtained by a curvature of the arms conforming to a definite law which, for our present purpose, it will be sufficient to describe as a simple deflexion of the axes of the channels through an arc of ninety degrees. The circular margin of the central opening, through which the water is admitted into the machine, is formed with a projecting ledging, truly adjusted by turning in a lathe, to the equal and concentric edge of a compound and adjustible ring called the *mouth-piece*, and which is fitted upon the recurved end of the supply-pipe. These annular labra (of the central opening and mouth-piece) being brought lightly (not pressed) into contact, a water-joint is produced possessing all the advantages of a packed-joint without its inconvenience and friction.

The arrangement will be rendered more fully intelligible, by reference to the accompanying figures, (Plate III.) in which *a* denotes the machine, *b* its vertical shaft, by which the power is carried to any required height, *c* the water-joint, formed by the coincidence of the projecting margin of the central opening and the edge of the *rising-ring d*, of the mouth-piece; *e* is the *collar-ring*, into which the rising-ring *d* is fitted water-tight by turning, and which is secured by bolts to the horizontal flange of the recurved end of the supply-pipe *f*. This flange is commonly of large size, and rectangular form, to allow of its being batted to a foundation of stone.

The part *d* of the mouth-piece, it will be observed, admits of vertical adjustment, in case of wear, at the joint. When the diameter does not exceed a certain limit (2 ft.), it is fitted into the collar-ring by chasing, and can therefore be adjusted at any time by a simple horizontal movement. When the parts become too large to be conveniently chased, they are fitted together by plane turning, and rendered water-tight by a small packing let into a groove cut in the periphery of the rising-ring *d*. In this case the vertical adjustment is accomplished by a number of set screws made to act on the two contiguous flanges.

By these means, a connexion of the most simple and complete kind is obtained between the machine and the supply-pipe—thereby effectually removing one of the chief practical difficulties experienced by the continental engineers; and which, perhaps more than any other, led to the abandonment of the machine of Prof. Segner in Germany, and of M. D'Ectot in France.

An obvious and essential advantage resulting from the admission of the water into the machine on the under side, and which gave occasion for the contrivance described, is the facility thereby afforded of counterpoising the superincumbent weight of the machine by means of the hydrostatic pressure due to the particular head of water employed. The pressure being directed upwards with a known intensity upon a given horizontal area; and the area of the central opening being fixed in every case by the volume of water and the height of fall to be employed—conditions which determine the size of the machine—the weight can generally be adjusted to equipoise it. It rarely happens that any difficulty is experienced in making the machine sufficiently light for the fall under which it is intended to act; but it not unfrequently occurs that the fall, and therefore the pressure, is so great, that the machine would become unwieldy were it made of equivalent weight. In cases of this kind an artifice is resorted to, by which a part of the upward pressure is received upon a fixed saucer-shaped disc *g*, projecting from the mouth-piece by a hollow stem, and forming at its circular edge—which meets the internal surface of the upper plate of the machine—a water-joint, in every respect similar to that formed by the coincidence of the mouth-piece with the marginal edge of the central opening. This disc is made of sufficient area to countervail the excess of the upward pressure of the fluid over the proper weight of the machine, and consequently increases relatively with the height of the fall. The small quantity of water which passes the joint is allowed to escape by the hollow stem descending from the disc into a transverse pipe *h*, cast in the rising-ring of the mouth-piece, and opening into the atmosphere.

This contrivance enables the highest falls to be equipoised without inconveniently increasing the weight of the machine, and with the same facility as those of moderate height.

To this brief indication of the technical appliances by which the machine has been brought to the condition of a hydraulic mover of the first class, in respect of efficiency, it may be well to add that, in most cases, the operations of the factory to be impelled require that the mover be provided with governing apparatus, by which its motion may be rendered uniform under variations of burthen. This condition is fulfilled by rendering the centrifugal force generated by the angular velocity of the machine, subservient in adjusting the size of the orifices to the increase or diminution of power which, for the time, may be required. The extreme portions of the inner curves of the water-channels are made detached, and constitute *valves* which move parallel to the plane of diameter in which the channels terminate. In the smaller class of machines, these valves are usually acted upon by springs carefully adjusted in tension to the centrifugal force due to their weight and angular velocity. By this arrangement it is easy to perceive, that if the velocity of the machine be reduced by an addition of burthen, the centrifugal force will at the same time decrease in a duplicate ratio; and the springs acting as centripetal forces, will cause the valves to move towards the centre of the machine, and thereby enlarge the orifices. And conversely, should the velocity be unduly increased by a diminution of burthen, the centrifugal force will in like manner increase in the duplicate ratio of the increment of speed, and will consequently cause the valves to move outwards against the action of the springs, and thereby contract the orifices, and allow a less quantity of water to flow through them.

In the larger class of machines, the springs give place to a more complex apparatus, by which the valves are worked directly by eccentrics acted upon by a system of external geering. A rod *i*, having one end heavier than the other, traverses the whole diameter of the machine, passing through the projection of the eye and the boss of the shaft, and carrying a vane-wheel *k*, at each of its extremities. The rod is free to slide endlong in bearings which project above the upper surface of the machine, but is retained in a given position by a spiral spring *r*, so long as the proper velocity of the machine is maintained. But the instant that velocity is disturbed, the rod moves endlong, and bringing *one* of the vane-wheels within the action of the jet from the contiguous orifice, it is made to revolve round its axis in the direction of the impulse communicated to the vane-wheel. This motion is transferred to the geering of the two valves simultaneously, by two endless screws *l*, which slide by sunk-keys upon the rod, and thence to the eccentrics *n*, within the valves, which are thus made to turn in directions to contract or enlarge the orifices according as the vane-wheel upon the weighted or unweighted end of the rod is in action. When the velocity of the machine is unduly accelerated, the spring yields to the increased centrifugal force of the weighted end of the rod, and the corresponding vane-wheel is thrown into action; and its operation is to contract the orifices, and allow a smaller quantity of water to pass. On the contrary, when the velocity falls below the proper rate, the tension of the spring predominates, and the vane-wheel on the unweighted end of the rod is brought into action; and the effect is an enlargement of the orifices and an increase of the power directly proportional to the increase which takes place in the quantity of water discharged.

These and a few other constructive details which would occupy too much time to enumerate, are essential to the practical application of the machine as a prime mover; but the grand technical problem—that upon which the positive value of the machine mainly depends, and to which all appliances are subordinate—is the proper form of the water-channels. If these be incorrectly determined, no elegance or accuracy of workmanship will render the machine effective. They cannot, it is true, by any chance be so ill constructed as completely to nullify the reacting force of the water; but it is quite possible, without any attempt to produce a malformation, to find the machine yielding only forty, instead of eighty per cent., which it ought generally to realize. But although inviting, the discussion of this part of the general problem must be deferred. At present it will be sufficient that we establish the theory of the machine—the measure of its efficiency—assuming the technical conditions to be strictly fulfilled. The details submitted are preliminary to this end, and were entered upon only because they appeared necessary to insure a clear conception of the *modus operandi* of the machine in its practical and most effective form.

Fundamental Principles.—The characteristic property of fluids—that which essentially distinguishes them from solids—is the remarkable property they possess of transmitting equally in all directions the pressure applied to their surfaces. From this property it follows, that when a vessel is filled with water to a given depth, the pressure produced by the gravity of the fluid alone upon any unit of the interior surface of the vessel, horizontal or lateral, is always equal to the weight of a vertical column of the fluid, having that unit of surface for its base, and the depth from the water level as its length. But the pressure being propagated equally in every direction, motion does not ensue; the horizontal filaments of the fluid pressing from within outwards, in virtue of the universal principle of action and reaction equally and contrary, mutually counteract each other's effect, pair and pair, over the entire interior of the vessel, and the system of pressures remain in equilibrio. If the vessel be suspended by a cord, it will remain at rest, and the line of suspension will be vertical; the horizontal components of pressure cannot put it in motion, and the sum of the vertical pressures are neutralized by the tension of the cord. But if a lateral orifice be made in the vessel below the level of the water, the equilibrium will be destroyed; for, by taking away a portion of the retaining surface, the pressure on that side of the vessel must necessarily be diminished, and will no longer balance the pressure on the surface opposite. In consequence of this difference of pressure on the two surfaces, the vessel will no longer hang vertically, but will be deflected in a direction opposite to that in which the jet of fluid is projected, in obedience to the unbalanced force exerted within it.

This is immediately evident on the mere statement of the condition of equilibrium; but it does not follow, because there is no pressure on the part of the surface which is removed, that we have found a measure of the unbalanced pressure or *reaction* exerted on the equal portion of the retaining surface immediately opposite. When the orifice is opened, it is no longer a question of hydrostatic, but of hydraulic pressure, which we are called upon to consider. In the former case we are required to regard only the weight of the fluid; but in the latter we have weight and motion combined.

To determine the amount of this reaction, it will be necessary and sufficient to determine the quantity of action expended by the jet. Those forces we know to be equal and contrary; and therefore, by ascertaining the power expended in giving motion to the water ejected, we arrive at the true measure of the reflex action produced upon the vessel. Now, the force expended must obviously depend upon the velocity and volume of the jet, and will therefore be known when those elements are found. If μ be the mass of a particle of the fluid, (meaning by the mass the weight divided by gravity,) and V the velocity with which it is ejected at the orifice, its *vis viva* is expressed by μV^2, and therefore $\Sigma\mu V^2$ will be the sum of the *vires vivæ* of all the particles ejected with that velocity referred to a unit of time. But the number of particles which flow through the orifice will obviously be as their velocity, and that velocity as the square root of the height of the fluid-level above the orifice, representing the pressure by which the particles are urged. Assuming, for simplicity, that the orifice is formed in the bottom of the vessel, and that some means are contrived for maintaining the water-level constant; if we suppose that under these circumstances, a lamina of water immediately over the orifice is put in motion, at every indefinitely small instant of time, by the pressure of the whole column of fluid standing above it, the entire gravitation of the column, being employed in generating the velocity of the lamina, will urge it forward by a force as much greater than its own weight as the column exceeds it in height, and through a space as much less, in the same proportion. But when the forces are inversely as the spaces described, the final velocities are equal, and, therefore, the velocity with which the laminæ of the water issue by the orifice must be equal to that which they would acquire by falling *in vacuo* from the height of the surface of the water to the orifice. Denoting this height by H, we shall then have the relation $V^2 = 2gH$, and consequently

$$\Sigma\mu V^2 = \Sigma\mu g \times 2H,$$

which is the sum of the weights of all the particles of a column of the fluid of a height $= 2H$, and expresses the measure of the pressure which is constantly being expended during the efflux of the water. But agreeably to the principle of reaction equal and contrary to action, the orifice being vertical, an equal amount of weight will be deducted from the entire pressure of the fluid upon the bottom of the vessel. Now, what is true with respect to the effect of a vertical jet must be equally true when the efflux is lateral, since the vertical and horizontal components of pressure at equal depths, and referred to the same unit of surface, are equal; and, therefore, the jet being projected horizontally, $\Sigma\mu g \times 2H$ will represent the weight which must be applied to the suspended vessel in the line and direction of the efflux, to prevent it from being deflected from its vertical position.

This conclusion may be arrived at simply by reflecting, that when part of the weight of a body is expended in producing motion in any direction, an equal weight must necessarily be deducted from its pressure in the opposite direction, since the gravitation employed in generating velocity cannot at the same time be causing pressure. The orifice of issue being formed in the bottom of a vessel containing water, a column of the fluid will descend through it, and expend, during its descent, a quantity of pressure equal to that of its own volume. Now admitting the velocity of the effluent particles at the orifice to be the same that they would acquire by falling freely from the height of the water-level, which, for simplicity, we shall suppose to be 16 feet above the orifice, the velocity of issue will be at the rate of 32 feet in a second; and, therefore, a column of 32 feet in length will pass through the orifice every second with the whole velocity derivable from its weight. It is therefore clear that an amount of gravitation sufficient to generate that velocity in the volume of fluid discharged must have been expended, and consequently falls to be deducted from the pressure exerted by the fluid upon the bottom of the vessel. In like manner, if the jet issue from a lateral orifice at the same depth below the water-level, the pressure upon that side will be diminished by a quantity equal to the gravitation employed in producing the motion of the fluid. But the amount of gravitation thus expended is equivalent to a column of the fluid of twice the head, and therefore the effect upon the vessel will be the same as if it were subjected to an equal pressure of any other kind in an opposite direction. And moreover, the pressure being lateral, and therefore perpendicular to the only direction in which a vertical force like that of gravity can itself act, it must be derived by reaction of the moving particles on the opposite surface of the vessel, and may be assimilated to the constant pressure of a spring, interposed between the particles of fluid and the unit of surface immediately opposite to the orifice. In this position the spring must needs act in a direction exactly contrary to that of the movement impressed upon the issuing fluid, and with an intensity exactly equal to the hydraulic pressure of the jet.

This principle of reaction equal and contrary to action, as applied in hydraulics, has been acknowledged upwards of a century. Daniel Bernouilli, in his Hydrodynamica, (Strasbourg, 1738,) among other propositions, then new to science, announced that "the reaction of a jet of water is equal to the weight of a column of the fluid of double the height due to the velocity of efflux, and having for its base the area of the orifice." This proposition was afterwards submitted to the test of experiment, and partially confirmed; but I cannot find that it at any time received that rigorous investigation which was necessary to secure confidence in the result, and justify an unqualified acceptance of the literal terms of the proposition as the basis of a practical theory of the Reaction Water-Mill. Under this feeling of doubt, and impressed with the necessity that existed of obtaining accurate data for the calculation and construction of those machines, a very extensive series of experiments was undertaken and conducted by Mr. C. Randolph and myself, with every opportunity and intention of obtaining a quantative result upon which we could rely. The apparatus employed was that depicted in the accompanying drawing. (Plate IV.) It consisted of a small reaction machine, capable of passing about 12 cubic feet of water per minute, under a head of 10 feet. The area of the orifices was determined with the utmost precision; and provision being made for measuring the water discharged within the five thousandth part of a cubic foot in 2 minutes, the velocity of emission could be calculated with great exactness from the relation,

$$\frac{\text{Volume of water,}}{\text{Area of orifices,}} = \text{velocity of efflux.}$$

To determine the corresponding reaction, one arm of a friction-brake applied upon the vertical spindle of the machine, was loaded with a weight known to be considerably less than the pressure to be measured, and the other was attached to a delicate dynamometer, which indicated the additional weight necessary to balance the reaction, and keep the machine at rest. It would be tedious to describe the precautions adopted to secure accuracy; but it may be remarked, that the effect of the friction of the journals, which is the most obvious source of error, was eliminated, by causing the arms of the brake, and consequently the machine, to oscillate slowly through a small arc, and taking the mean of the tension on the dynamometer when the motion was with, and opposed to the direction of the jets. The experiments were, besides, only accepted when satisfactory: in every instance when a doubt arose, the experiment was cancelled. The mean of the recorded results was subsequently calculated by Legendre's method of Least Squares, and stood thus: The velocity of efflux determined from the volume of water discharged was found to be that due to 0·85682 of the mean actual head of 10 feet, taken as unity; and the hydraulic reaction referred to a column of water having the sum of the areas of the orifices as a base, was 1·80832 of the same actual mean head. We have therefore the general ratio of comparison,

$$\frac{\cdot 85682\ \text{H}}{1\cdot 80832\ \text{H}} = \frac{1}{2\cdot 1105}$$

that is, the head due to the velocity of efflux at the orifices being $= 1$, the measure of the reaction referred to the same unit $= 2\cdot 1105$, which is greater by $\frac{11}{100}$ H than the measure assigned by theory.

This result, which at first view appears anomalous, is corroborated by the experiments which have been made to determine the hydraulic pressure of isolated jets projected perpendicularly against a plane surface. Newton (*Principia*, Bk. II.) demonstrated from elementary principles that the measure of the impulse of the jet is identical with that stated by Bernouilli as the measure of the reaction; and M. Poisson (*Mechanics*, Bk. V.) arrives at the same conclusion by a different process of reasoning. But on submitting the proposition to the test of experiment, it has been found that the actual result is uniformly in excess of that assigned by calculation; and moreover, that the ratio varies with the head-pressure, and also with the size of orifice. Thus in the experiments of M. Morosi, the ratio from difference of head alone varied from $\frac{1}{2\cdot 1}$ to $\frac{1}{2\cdot 22}$; and in those of M. Bidone, the ratio from difference of size of orifice (circular of 0·02 to 0·036 metre's diameter,) varied from $\frac{1}{2 \cdot 04}$ to $\frac{1}{2 \cdot 23}$.

These seeming anomalies are explicable by reference to a principle which will be immediately adverted to; but in the meantime it is necessary to inquire into the circumstances by which the actual mean head of ten feet was reduced, when measured by the velocity of efflux at the orifices, to 8·5682 feet, showing a loss of 1·4318 feet of head-pressure incurred between the reservoir and the orifices of the machine. It was easy to perceive that this loss did not result from a single cause, but expressed the conjoined effect of several influences which it was necessary to determine individually. In the first it was obvious that there would be a certain amount of head-pressure absorbed by the friction of the water in passing through the supply-pipe. This was regarded as a known quantity, which could be represented in character and amount by

$$2f. \frac{C}{A_{,}} L. \frac{u^2}{2g}$$

in which C denotes the internal perimeter, $A_{,}$ the cross-sectional area, and L the length of the pipe: u the velocity with which the water descends through it, and f an empirical coefficient $=$ ·0035. If therefore S denote the sum of the areas of the orifices, V the velocity of efflux, and D the diameter of the pipe (all in feet), this equation may be put under the form

$$8f. \frac{L}{D} \cdot \frac{S^2}{A_{,}^2} \cdot \frac{V^2}{2g} = \alpha \frac{V^2}{2g}$$

Another small but permanent influence, tending to diminish the pressure, is the acceleration experienced by the water in passing from the supply-pipe into the interior of the machine through the neck formed by the mouth-piece and central opening, and which are commonly less in diameter than the supply-pipe. This was likewise known from established data to be represented in form by

$$\frac{A_{\prime\prime}^2}{A_{,}^2} \left(\frac{1}{m} - 1\right)^2 \frac{\text{υ}^2}{2g} = \beta \frac{V^2}{2g}$$

in which $A_{,,}$ is the area of the central opening, and υ the velocity of the water passing through it: m a coefficient, determined by a very extensive series of experiments directed exclusively to that object to be $=$ ·9378.

A third, though very small loss of pressure would obviously result from the resistance encountered by the water in traversing the arms of the machine. The effect of this resistance, were the channels uniformly contracted from their base outwards, would be represented by

$$8 f. S^2. \frac{V^2}{2g} \int_0^L \frac{C_{,}}{A_{,,,}} dx$$

in which $C_{,}$ and $A_{,,,}$ are respectively the transverse perimeter and area of the channel at a distance x from its origin. But the unequal section of the channels renders it impossible to assign exactly the value of the integral $\int \frac{C_{\prime}}{A_{\prime\prime\prime}} dx$. This is of little moment, as the quantity itself being very small, will not differ sensibly from the mean of the resistance which the water would encounter in passing through the machine if the areas had throughout their length the mean cross-sectional area of the orifice and origin, and may therefore be expressed by

$$f L \left(\frac{C_{\prime}}{A_{\prime\prime\prime}} + \frac{C_{\prime\prime}}{S}\right) \frac{v_{\prime}^2}{2g} = \gamma \frac{V^2}{2g}$$

$v_{\prime}$ being the corresponding velocity of the water in channels of the mean transverse area assumed.

These are direct and evident causes of loss of head-pressure in the machine; but we have yet to take into account another influence small indeed in amount, but still appreciable in its effect. This is manifested in what is denominated the *contraction of the vein.* Reverting to our suppositious example of an orifice being formed in the side of a vessel in which the water is maintained at a constant level, it was left to be inferred that the velocity of efflux would be that of a heavy body falling through a space equal to the head of water; and if the orifice be *very small,* compared with the horizontal area of the vessel, this will be nearly true. And, in general, the velocity of discharge can be closely assigned when the ratio of these quantities is known. But although the velocity with which the particles of the fluid issue may be found from data, which are always attainable, it does not follow that we thereby know the volume of liquid discharged. Although invariably proportional to the area of the orifice and to the square root of the head of water, its value is not found to depend, except in a minor degree, upon the ratio $\frac{\text{area of orifice}}{\text{area of vessel}}$, but upon the form of orifice through which the jet issues. If the side of the vessel in which the orifice is made, be of very thin material, as tin-plate, the discharge q, in cubic ft. per second, will be very nearly expressed by

$$q = \cdot 625\, a \sqrt{2g\, H}$$

in which a is the area of the orifice, and H the head of water under which the discharge takes place.

If the jet from an orifice of this kind be closely observed, it will be perceived to converge through a short distance from its origin, forming, when the orifice is circular, a conoid, of which the area of the least section is $\frac{5}{8}$ of the area of the orifice. If advantage be taken of this circumstance to apply an ajutage to the orifice of the form assumed by the jet, the discharge will be found to approximate very closely to that assigned by the formula $q = a \sqrt{2g H}$.

This difference of discharge of the two kinds of aperture, is usually ascribed to the inclined directions which the molecules of the fluid assume previous to their exit, and which they tend to retain after passing the thin parietes of the simple orifice. For greater clearness let us assume that the aperture is horizontal, circular, and of small area in comparison with the area of the containing vessel; under these conditions a large portion of the fluid will be put in motion, and will slowly approach the orifice during the efflux, in the form of an inverted cone, of which the orifice is the apex. The particles, as they come opposite to the orifice, are therefore impressed with motions converging to an axis; but these motions, in consequence of the mutual cohesion of the particles, must tend to a common velocity in that axis: and the length of the external conoid will express the time in which the oblique motions are converted into motions parallel to the axis of the jet. It is therefore only at the point of least section that the molecules of fluid have attained the effective velocity due to the head under which they issue; and it is therefore only in reference to that point that the hydraulic pressure of the jet is equal to a column of the fluid of double the *actual head*. By adopting an ajutage to the orifice of the shape indicated, the oblique motions of the particles are corrected in passing through it, and reduced to parallelism with the axis at the moment of efflux into the atmosphere. There still, however, remains to depreciate the discharge assigned by the formula $q = a\sqrt{2g\,\mathrm{H}}$, the imperfections of workmanship in the construction, and the adhesion of the fluid to the perimeter of the ajutage, with possibly a slight atmospheric influence not yet defined. But assuming the ajutage to be made with all possible care—both as to form and finish—if we call the area of the orifice 1000, that of the contracted vein will be 975: and these numbers taken inversely will express the velocity of the jet at the two points measured by the discharge. The value of q for an orifice of this form will therefore be

$$q = \cdot 975 a\sqrt{2g\,\mathrm{H}}$$

showing a loss of head-pressure, as measured by the discharge, of

$$(1 - \cdot 975^2)\,\frac{\mathrm{U}^2}{2g} = \cdot 049375\ \mathrm{H}$$

when $\mathrm{U} = \sqrt{2g\,\mathrm{H}}$ the theoretical velocity due to the head H. And generally, if V be the actual velocity of efflux, and k the practical coefficient of discharge for any orifice, so that $\mathrm{U} = \frac{\mathrm{V}}{k}$, the head-pressure *not realized* in the measure of q, will be $\left(\frac{1}{k^2} - 1\right)\frac{\mathrm{V}^2}{2g} = \delta\frac{\mathrm{V}^2}{2g}$ And the pressure *not realized* in the measure of the reaction, will be expressed by

$$\mathrm{Sin}\ \varphi\left(\frac{1}{k^2} - 1\right)\frac{\mathrm{V}^2}{2g} = \delta_{\prime}\,\frac{\mathrm{V}_2}{2g}$$

in which φ denotes the mean angle formed by the filaments of water of the jet with the axis.

But betwixt this the least contraction of the fluid vein, and that which takes place when the orifice is formed in a thin plate, we may evidently have a series of any number of terms expressing successive degrees of approximation of the ajutage to the theoretical form of least contraction. This is obvious, as regards the discharge from a fixed ajutage, and it is equally obvious, that if an ajutage be constructed to fulfil the conditions of least contraction when the vessel is at rest, it will no longer answer that condition when it moves in the line of the jet with any given velocity. If its motion be in the direction of the jet, its length will manifestly be virtually increased, and the contraction will approach to that of a jet issuing from a parallel pipe, the coefficient for which is ·8; and if the movement be in the contrary direction, the length of the ajutage will be in effect diminished, and the contraction will approach that from an orifice in a thin plate. This last is the actual case which falls to be considered in the reaction machine; the ajutages have a determinate velocity, in an opposite direction to that in which the fluid issues, and accordingly have their length virtually reduced. This must necessarily be provided against in the construction of the machine, and a length and form of the ajutages determined, which shall exactly correspond, at the given angular velocity of the machine, to the proper dimensions at which, if stationary, they would yield their maximum discharge. This is a problem which requires to be resolved for every machine.

But with a machine thus constructed, it is easy to perceive that the contraction of the jets will greatly exceed the minimum just assigned, when motion is prevented; and, therefore, in those experiments made for the purpose of determining the measure of the reaction, it might be predicted that the coefficient of discharge would fall considerably below ·975. By calculation of the valves of α, β, γ, and, taking into account the difference of the atmospheric pressure at the higher and lower levels of the water-surfaces, it was found that $k = \cdot 942$, and that the loss of head due to the contraction of the jets, measured by the discharge, was therefore ·112636 H, instead of the minimum, ·049375 H.

If to those absorbing influences we add $\epsilon \dfrac{V^2}{2g}$ comprehending the loss of atmospheric pressure due to the head H, and the effect of the cohesion of the water to the perimeter of the orifices, (not valued,) we shall have as the total calculated loss

$$(\alpha + \beta + \gamma + \delta + \epsilon)\,\frac{V^2}{2g} = 0\cdot 1421\ \text{H},$$

and, therefore, upon the mean head of 10 feet employed in these experiments, the loss = 1·421 feet. This result is sufficiently near the actual quantity to warrant us in assuming the measure of the reaction assigned to be practically correct for the particular case; and, therefore, we may assume that wherever the values of the coefficients can be determined with exactness, the motive force derivable from any given head will be known. Generally the value of that head will be expressed by

$$H - (\alpha + \beta + \gamma + \delta_{,} + \epsilon) \frac{V^2}{2g} = \frac{V^2}{2g}$$

and, therefore if, for simplicity, we put $\alpha + \beta + \gamma + \delta_{,} + \epsilon = K$, we shall have

$$V = \sqrt{\frac{2gH}{1+K}}.$$

This being the velocity of efflux, the expenditure of water in a second will be indicated by

$$Q = S\sqrt{\frac{2gH}{1+K}} \text{ cubic feet.}$$

S being the sum of the areas of the two orifices; and if w be the weight of a cubic foot of water, and P the weight which would be sufficient to balance the reaction due to that discharge, we shall have

$$P = \frac{wS}{1+K} \times 2cH$$

in which c is the coefficient of reaction depending upon H and S, and which in the experiments before referred to, was found to give $2c = 2{\cdot}1105$.

Theory of the Action of the Machine.—From what is here stated, it is clear that if a weight p, less than P, be applied to the machine, a certain amount of the reaction will remain to generate velocity. But when motion is induced, a new order of things will arise. Centrifugal force will be immediately produced in the water occupying the arms of the machine, and the pressure at the orifices being thereby increased, the expenditure of water will be correspondingly augmented.

A common expression for the centrifugal force referred to a unit of mass revolving in a circle is $\theta^2\chi$ when $\theta =$ the angular velocity of the body, and χ its distance from the centre of rotation. Now, if the unit of mass advance in the direction of the radius outwards through the element of space $d\chi$, in the time dt, the force developed in that direction by the centrifugal force, will be $\theta^2\chi\, d\chi$; and if this be integrated for the space $R - r$, the length of the arm of the machine, we shall have

$$\int_r^R \theta^2 \chi\, d\chi = \tfrac{1}{2}\theta^2 (R^2 - r^2)$$

And putting v for the absolute velocity of the machine in feet per second, at the distance R, from the axis of rotation, we have $\theta = \frac{v}{R}$. Substituting this value of θ in the equation just found, and taking the weight of the element of fluid $= 1$, we have as the increment of pressure due to the velocity v,

$$\frac{v^2}{2g}\left(1-\left(\frac{r}{R}\right)^2\right)$$

which added to the pressure due to the actual head, gives as the total effective head,

$$H+\frac{v^2}{2g}\left(1-\left(\frac{r}{R}\right)^2\right)=H+n\,\frac{v^2}{2g}$$

when n is put for $1-\left(\frac{r}{R}\right)^2$. But under this new condition, the coefficients α, β, γ, δ, ϵ, will pass to the new values α', β', γ', δ', ϵ', and $1+K$ will be changed to $1+K'$. We might proceed to determine the values of these coefficients in terms of v; but, for our present purpose it is sufficient to observe that they can always be assigned, and may therefore be regarded as known. It will not, however, be out of place to observe that, although α, β, γ, continually increase as v, the coefficient of contraction δ, will decrease till that value of v is attained, at which the power of the machine is a maximum, and will continually increase afterwards. The small quantity ϵ, may be considered constant; but, in order to justify its change to ϵ', we shall suppose it to include the resistance which the atmosphere offers to the motion of the machine; and which, at very high velocities, becomes an appreciable quantity.

These conditions being established, we shall have under the increased head-pressure, an increase in the expenditure of water by the machine, as

$$\sqrt{\frac{2g\,H}{1+K}} \text{ to } \sqrt{\frac{2g\,H+n\,v^2}{1+K'}}$$

and, therefore, in the unit of time we shall have

$$Q=S\sqrt{\frac{2g\,H+n\,v^2}{1+K'}} \text{ cubic feet.}$$

And supposing the permanent head H, to become $\frac{1}{1+K'}\left(H+n\,\frac{v^2}{2g}\right)$ by merely elevating the reservoir: it is clear, from what has been before stated respecting the measure of the reaction, that

$$P=\frac{w\,S}{1+K'}\times 2\,c\left(H+n\,\frac{v^2}{2g}\right)$$

This is the measure of the whole pressure of reaction at the orifices; but it is to be observed that the part $n\,\frac{v^2}{2g}$ being obtained, in consequence of the motion of the machine, with a velocity of v ft. per second, a portion of the reaction must have been consumed in communicating that velocity to the volume of water discharged in that second of time, equivalent to raising it to a height $n\,\frac{v^2}{2g}$ feet. The pressure thus consumed will be measured by the mass multiplied into the velocity, and is therefore expressed by

$$\left\{\frac{w\,\mathrm{S}}{g\,(1+\mathrm{K}')}\,\sqrt{2g\,\mathrm{H}+n\,v^2}\right\}v$$

and this subtracted from the whole pressure of reaction, there remains as the whole effective pressure,

$$\frac{w\,\mathrm{S}}{g\,(1+\mathrm{K}')}\left\{c\,(2g\,\mathrm{H}+n\,v^2)-v\,\sqrt{2g\,\mathrm{H}+n\,v^2}\right\}$$

And putting for $w\,\mathrm{S}$, its equivalent $\dfrac{\mathrm{W}\sqrt{1+\mathrm{K}'}}{\sqrt{2g\,\mathrm{H}+n\,v^2}}$ we have as the pressure with which the machine moves,

$$\frac{\mathrm{W}}{g\sqrt{1+\mathrm{K}'}}\left\{c\,\sqrt{2g\,\mathrm{H}+n\,v^2}-v\right\}$$

This will therefore be a measure of the burthen, p, which the machine can carry at a velocity of v feet per second; and the pressure multiplied into the space moved through, that is $p\,v$, being the measure of the labouring force, we have as the expression of the total efficiency of the machine,

$$p\,v=\left\{\frac{\mathrm{W}}{g\sqrt{1+\mathrm{K}'}}\left(c\,\sqrt{2g\,\mathrm{H}+n\,v^2}-v\right)\right\}v$$

And taking, $\mathrm{W\,H}=1$, the whole mechanical value of the water expended, the ratio of the efficiency of the machine will be represented by

$$\frac{1}{g\,\mathrm{H}\sqrt{1+\mathrm{K}'}}\left(c\,\sqrt{2g\,\mathrm{H}+n\,v^2}-v\right)v$$

From this reasoning it appears that the whole pressure expended in giving motion is,

$$\frac{w\,\mathrm{S}}{g\sqrt{1+\mathrm{K}'}}\left\{\sqrt{2g\,\mathrm{H}+n\,v^2}\right\}v$$

and the entire reaction due to the volume of water expended, being

$$\mathrm{P}=\frac{w\,\mathrm{S}}{1+\mathrm{K}'}\,c\left(2\,\mathrm{H}+n\,\frac{v^2}{g}\right)$$

the limit of velocity which the machine can attain when moving without burthen, will be such, that

$$\frac{w\,\mathrm{S}}{1+\mathrm{K}'}\,c\left(2\,\mathrm{H}+n\,\frac{v^2}{g}\right)=\frac{w\,\mathrm{S}}{g\sqrt{1+\mathrm{K}'}}\left\{\sqrt{2g\,\mathrm{H}+n\,v^2}\right\}v$$

And resolving this equation, we find as the limit,

$$v=c\sqrt{\frac{2g\,\mathrm{H}}{1+\mathrm{K}'-c^2\,n}}=\frac{c\,\sqrt{2g\,\mathrm{H}}}{\sqrt{1+\mathrm{K}-c^2\left(1-\frac{r^2}{\mathrm{R}^2}\right)}}$$

when n is replaced by its equivalent $1-\left(\frac{r}{R}\right)$

From this, it appears that the maximum head-pressure which can be created in the machine by centrifugal force $=\dfrac{c^2 H}{1+K-c^2\left(1-\frac{r^2}{R^2}\right)}$

and the ratio $\dfrac{v}{\sqrt{2g\,H}}=\dfrac{c}{\sqrt{1+K'-c^2\left(1-\frac{r^2}{R^2}\right)}}$

A question of much more importance in practice is the value of v, which will render

$$p\,v=\frac{W}{g\sqrt{1+K'}}\left\{c\sqrt{2g\,H+n\,v^2}-v\right\}v$$

a maximum. But at this point calculation fails to be satisfactory, and we must have recourse to experiment to determine the relation which v bears to the velocity $\sqrt{2g\,H}$ of the water due to the initial head H. Euler in his elaborate investigation of the general problem, (Berlin, Trans. 1750 and 1754,) misled by the symbols resulting from his attempt to determine the maximum value of the function analytically, announced the hypothesis that the power of the machine increases with the velocity *ad infinitum*. In taking experiment as the guide, it did not, however, require any lengthened investigation to discover that the symbols of calculation do not in this case represent the true conditions of the question, and that v has in practice a limit which can be represented in terms of $\sqrt{2g\,H}$, and of the coefficients K′ and n. In order to ascertain that relation with the necessary degree of exactness, a series of values of $p\,v$, taken near the maximum, was interpolated by La Grange's theorem, and the value of v thereby determined, was found to have the relation

$$v=\sqrt{\frac{2g\,H}{1-\frac{r^2}{4\,R^2}+K'}}$$

which in practice does not differ materially from $\sqrt{2g\,H}$. If then we substitute that value in the expression for $p\,v$, we find after reduction,

$$p\,v=W\times 2\,H\left\{\frac{c\sqrt{2-\frac{5\,r^2}{4\,R^2}+K'}-1}{1-\frac{r^2}{4\,R^2}+K'}\right\}=\cdot 8223\,W\,H$$

when $\frac{r^2}{R^2}=\frac{1}{9}$ and $K'=\frac{1}{10}$, and $c=1\cdot 05$ as before determined. The highest value obtained experimentally under circumstances which admitted of positive accuracy in the measurement of the water, was ·80375 W H; but in that instance the fall was variable, and the proper velocity could not be maintained during the time of an experiment. It is therefore not probable that the maximum effect was obtained. A smaller model, still in my possession, yields as a maximum, under like circumstance, $p\,v = \cdot 79873$ W H.

Literal References to the Drawings, Plates III. and IV.

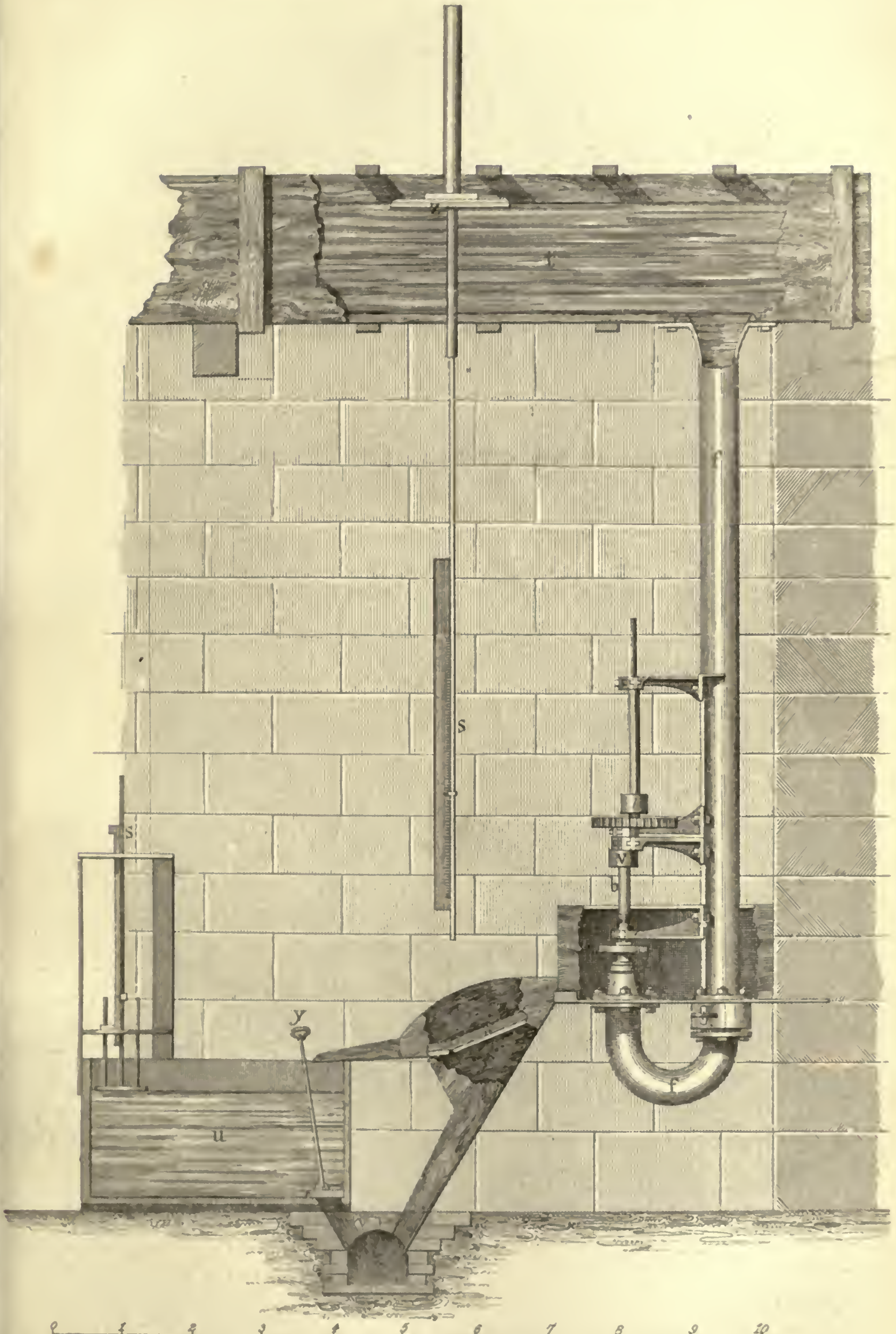
The same letters indicate the same or corresponding parts in all the Drawings.

a, the machine; and *b* its vertical spindle.
c, the water-joint, formed by the coincidence of the edge of the central opening in the machine with that of the rising-ring *d*.
e, the collar-ring, bolted upon the foundation flange of the supply-pipe *f*.
g, saucer-shaped disc, to take off a part of the hydrostatic pressure, and forming a water-tight joint with the upper plate of the machine.
h, waste-pipe, to convey the water escaping into the hollow disc *g*, into the atmosphere.
i, traversing-rod of the governing apparatus.
k, vanes on the extremities of the same.
l, endless-screws on the rod *i*, connecting the wheels *m* with the eccentrics *n*, inside of the valves.
p, *q*, parallel-cheeks, between which the valves slide.
r, spiral-spring on traversing-rod *i*.
s, indices, for height of fall and quantity of water in the cistern *u*.
t, reservoir for applying the experimental apparatus with water.
u, cistern into which the water discharged by the machine is delivered.
v, pulley for the friction-brake, used to test the power of the machine.
w, clack-valve in the bottom of the water-course, between the machine and the cistern *u*.
x, culvert for waste water.
y, handle of the valve for emptying the cistern *u*.
z, float in the reservoir, attached to the head-valve and scale of fall *s*.

15th April, 1846.—*The* President *in the Chair.*

Dr. R. D. Thomson presented an additional donation of plants, from Northern India, collected by Dr. Thomas Thomson, junior, for which the thanks of the Society were voted. The Council reported that Mr. Liddell had intimated to the meeting of this evening, that the town Council had agreed to the Report of the Joint Committee of the Town Council and the Society, as to the exhibition of models—an important provision being, "that the Philosophical Society guarantee against loss, in equal proportion with the Town Council, to the extent of £100; and that if the loss should exceed this sum, the excess to be borne exclusively by the Town Council, provided that the gross expenditure shall not exceed £500."

EXPERIMENTAL APPARATUS.

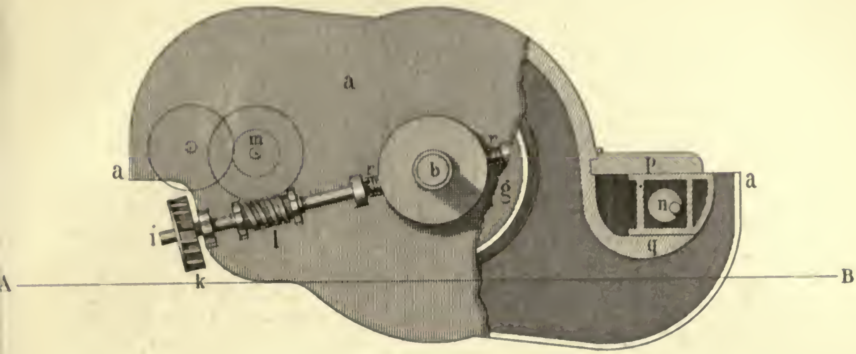


Scale of Feet.

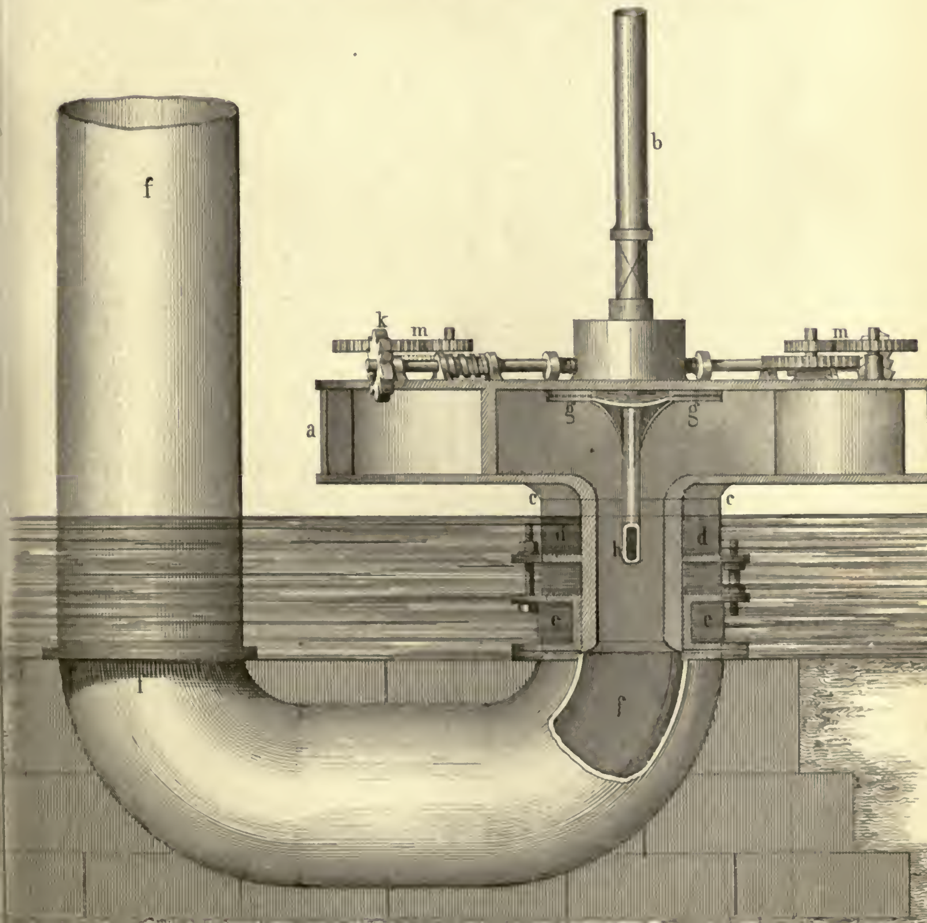
Maclure & Macdonald Lith. Glasgow.

REACTION WATER WHEEL.

PLAN OF WHEEL.



VERTICAL SECTION ON THE LINE A.B. OF PLAN.



The Joint Committee were intrusted with discretionary power as to details. The following communication was read:—

On Caries, or Decay of the Teeth.—By F. Hay Thomson, M.D.

The teeth, which are composed of enamel, bone or dentine, and a substance which has received various names, such as corticle, crusta petrosa, and cement, possess the following composition. The enamel contains phosphate of lime, 88·5; carbonate of lime, 8·; phosphate of magnesia, 1·5; membrane, alkali, and water, 2·. The dentine contains phosphate of lime, 64·3; carbonate of lime, 5·3; phosphate of magnesia, 1·; soda with chloride of sodium, 1·1: while the cortical part, or crusta petrosa, consists of organic matter, 42·18; phosphate of lime, 53·84; carbonate of lime, 3·98. These analyses show that the enamel is almost destitute of organic matter. The dentine scarcely differs from true bone, and as such, is highly organized. The crusta petrosa contains more organic matter than the dentine. Hence, we see, that writers on the subject of diseases of the bones have every reason to suppose that disease of the teeth may be similar in its origin to caries in other bones, since it happens that in some kinds of caries the result is much the same in external appearance, although analysis shows that a deficiency of earthy matter in diseased teeth is not always a symptom of caries of other bones.

According to Mr. Fox, the cause of the decay of teeth appears to be an inflammation in the bone of the crown of the tooth, which, on account of its peculiar structure, terminates in mortification. The membrane which is contained within the cavity of the tooth is very vascular, and possesses a high degree of nervous sensibility; and inflammation of this membrane is liable to be occasioned by any excitement which produces irregular action; and as the bone of the tooth is very dense, and possesses little living power, death of some part of it may speedily follow.

Mr. Bell considers the proximate cause of caries to be an inflammation of the external surface of the bone immediately under the enamel. He thinks that, when from cold or any other cause a tooth becomes inflamed, the part which suffers most severely is unable, from its possessing comparatively but a small degree of vital power, to recover from the effects of inflammation, and mortification of that part is the consequence.

Mr. Hunter appears to have come nearer the true cause of caries than any other writer, as, although he states that caries is a disease arising originally in the tooth itself, he evidently had a strong idea that the different articles containing powerful menstrua, exercised an influence in the production of caries. He remarks, "if it had always been in the inside of the cavity, it might have been supposed to be owing to a deficiency of nourishment; but as decay begins most commonly externally, in a part where in a sound state the teeth receive little or no nourishment, we cannot refer it to that cause." He was of opinion, however, that caries is a disease arising originally in the tooth itself.

The author, however, considers the cause of caries to be external, and not to depend upon inflammation. To make his views apparent, it is necessary to give a short sketch of the development of the teeth, from the pulp upwards.

The teeth differ much in formation from the bones in general, having for their basis a pulp similar in shape to the tooth to be produced, instead of the usual base, cartilage. We can trace the formation of these pulps so early as the fourth month of animal existence; and as the formative process goes on, they are each gradually enclosed in a cell produced by small processes of bone, which may be observed shooting across from each side of the groove in the jaw in which the pulps are first found, and which gradually form these cells. Each pulp is covered by a membrane firmly attached to the gum and to the pulp at its base. When the pulps have been injected, we find that they are filled with vessels, as also the membrane by which they are enveloped. The pulps derive their vessels from the artery which passes through the jaws and the membranes, from the gums. The bone of the tooth is formed from the pulp, and the enamel from the investing membrane. The bony portion is formed in the following manner; when the ossification commences, the bone is deposited in the extreme points of the pulp from the vessels. In the incisors it begins upon their edges, and in the molars upon the points of their grinding surfaces, usually four in the lower jaw, and in the upper five. These soon extend over the surface, and eventually the whole pulp is covered. The deposition of the bone continues from without inwards, and this goes on till the tooth becomes complete. When the body is formed, the pulp elongates and takes the form of the fang proper to each particular tooth. Bone is then deposited, and it becomes smaller till it terminates in a point; when there are two or more fangs, the pulp divides, and the ossification proceeds accordingly. The cavity gradually decreases, till at last it contains merely nervous and muscular matter, which is afterwards to give life and sensation to the tooth. The enamel is collected from the investing membrane, and is deposited on the ossific points in the shape of a fluid. This is at first of a consistence, not firmer than chalk; it, however, soon grows hard, and seems to undergo a process similar to that of crystallisation, for it takes a regular and peculiar form. The enamel, when broken, appears to be composed of a great number of small fibres, all of which are arranged so as to pass in a direction from the centre to the circumference of the tooth, or to form a sort of radii round the body of the tooth. This is the crystallised form which it acquires sometime after its deposit. Now, as the process of formation goes on, new particles being deposited, the lamellæ thus formed, meet at last, in the centre, and should a child, for example, be of an unhealthy constitution, we find invariably that these plates do not join in the centre, but leave minute divisions of a crucial nature on the crowns of the teeth, thereby giving access to any acid matter that may have an affinity for the bony portions of the teeth. In the author's opinion, all simple decay arises from the action of the saliva, which becomes impregnated with acid of different kinds, either from the food we occasionally indulge in, or from a morbid state of the stomach, arising from scrofula or other causes. The saliva, according to M. Donne, is in its normal state purely alkaline, and this conclusion is now followed by most physiologists. The pathological condition of the stomach, indicated by an acid state of the saliva, is irritation of its mucous membrane, and he contends that this condition of the stomach uniformly induces or is accompanied by acidity of the saliva. Besides giving the result of his experiments in arriving at these conclusions, he has narrated a large number of cases illustrative of the corresponding change from acidity to alkalinity, as the patient recovered from disease.

In compound decay where the disease appears between the teeth, more particularly in the incisors and bicuspides, and exhibits itself as a mere point, gradually increasing till absolute destruction of the organs takes place, the author considers that the disease never takes place till actual contact takes place, and when from the pulp being unhealthy, the enamel has not been properly developed. Hence the apparent cause of further decay is from without, a view which is confirmed by the fact derived from experience, that in nine cases out of ten, compound decay is developed before manhood, at a time when the teeth are very highly organized, and consequently more likely to suffer from any obstruction of the circulating medium.

The morbid states of the saliva which produce this decay, often arise from a weak constitution, thus laying the foundation of decay in after years; for although a child may become healthy, and apparently the decay may not be distinctly developed, yet a minute investigator will detect it at once. The disease, it is true, may not as yet be active, still the slightest attack of fever or ill health of any kind, by increasing the acidity of the saliva, will be sure to induce a further development of decay.

A life protecting frame for cleaning windows, made by John Bailie, Edinburgh, was exhibited to the Society by Mr. Liddell, and described by Mr. W. M. Buchanan.

29th April.—The PRESIDENT *in the Chair.*

Mr. Liddell read a paper on the statistics of pauperism, crime, and state of education of the juvenile portion of the poor of Glasgow. The following table is drawn up from data furnished by the Sunday-School Teachers, by Mr. Alexander Phimister, jun.

TABLE,

SHOWING THE STATE OF EDUCATION IN THE CITY OF GLASGOW

IN 1846.

Districts Bounded by	Population as taken at the Census in 1841.	1. Number of Children above 6 and under 16 years.			1. Proportion of Children to Population.	2. Number of Children above 6 and under 16 years, at Week-day Schools.			2. Proportion to Population.	2. Proportion to Number of Children.	3. Number of Children above 6 and under 16 years, not at School, and who cannot read.			3. Proportion to Number of Children.	4. Number of Children above 6 and under 16 years, who can write.			4. Proportion to Number of Children.
		Male.	Female.	Total.	Pr cent.	Male.	Female.	Total.	Pr cent.	Pr cent.	Male.	Female.	Total.	Pr cent.	Male.	Female.	Total.	Pr cent.
District A Bridgeton,	14547	1418	1366	2784	19·13	546	400	946	6·50	33·98	321	334	655	23·52	434	226	660	23·93
B Calton,	32690	3340	3476	6816	20·85	1287	1140	2427	7·42	35·60	816	942	1758	25·79	1063	755	1818	26·67
C Gallowgate, &c.	8991	770	851	1621	18·03	385	424	809	8·99	49·90	122	191	313	19·30	315	296	611	37·69
D East of Barracks,	11059	1184	1227	2411	21·79	371	337	708	6·40	29·36	278	374	652	27·04	345	214	559	23·18
E Duke-Street, &c.	15527	1341	1451	2792	17·98	531	562	1093	7·03	39·11	311	419	730	26·14	361	280	641	22·95
F North of Duke-Street, &c.	5878	611	538	1149	19·54	249	217	466	7·92	40·55	101	91	192	16·71	211	136	347	30·20
G North of Stirling's-Road,	9188	975	1009	1984	21·59	552	531	1083	11·73	54·58	107	112	219	11·03	465	351	816	41·12
H South of Stirling's-Road,	10899	1051	1043	2094	19·21	562	552	1114	10·22	53·19	131	149	280	13·37	488	368	856	40·87
I South of George-Street,	12217	828	919	1747	14·30	450	492	942	7·71	53·92	137	164	301	17·22	379	319	698	39·38
J South of Trongate, &c.	23470	1773	1878	3651	15·55	674	691	1365	5·81	37·38	520	569	1089	29·82	591	498	1089	29·82
K South of Canal,	22688	2088	1988	4076	17·96	1026	963	1989	8·76	48·79	274	320	594	14·56	814	646	1460	35·81
L Blythswood Hill, &c.	10732	787	819	1606	14·96	741	767	1508	14·05	93·89	8	12	20	1·28	592	562	1154	71·98
M South of Gordon-Street,	16168	1346	1400	2746	17·99	743	769	1512	9·35	55·06	191	182	373	13·58	594	529	1123	40 89
N Anderston,	17974	1637	1486	3113	17·31	780	698	1478	8·22	47·48	280	271	551	17·70	573	353	926	29·74
O Laurieston and West,	22948	2042	2090	4132	18·00	1116	1092	2208	9·62	53·43	248	319	567	13·69	992	870	1862	45·06
P Gorbals and East,	23857	2256	2395	4651	19·49	1064	944	2008	8·41	43·17	510	626	1136	24·42	979	723	1702	36·59
	258833	23447	23936	47383	18·30	11077	10579	21656	8·36	45·70	4355	5075	9430	19·90	9196	7126	16322	34·46

PROCEEDINGS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

FORTY-FIFTH SESSION.

4th November, 1846.—*The* Vice-President *in the Chair.*

Messrs. Dawson and Griffin were appointed Auditors for the past year.

The Treasurer reported that the Committee appointed on the 23d March last, to make arrangements for a public exhibition of models, &c. during the holidays at the new year, was now in active operation. The Vice-President stated, that the President, from domestic causes, was under the necessity of spending the winter on the Continent.

Mr. Liddell having taken the chair, Mr. Crum read a paper on the Constitution and Properties of Gun Cotton, the recent discovery of Professor Schönbein, which he showed to be a new and distinct compound of nitric acid and cotton. His observations were illustrated by some beautiful experiments.

18th November, 1846.—*The* Vice-President *in the Chair.*

The following gentlemen were elected members of the Society:—Messrs. John Finlay, Alexander Miller, Francis Liesching, John Carrick, and Hugh Carswell.

Mr. Griffin presented from the Chemical Society, the 18th and 19th parts of their Proceedings, and from Dr. R. D. Thomson a continuation of the Registrar General's Weekly and Quarterly Reports of Mortality in the Metropolis.

The Treasurer presented his account for the past year.

1845.			
Nov. 18.—To Cash in Bank, at beginning of Session,	£220 0 0		
— Interest on do.	6 10 8		
		226 10 8	

Brought up,				£226	10	8
To 14 New Members,	£14	14	0			
— 15 Original Members, @ 5s., Annual Payments,	3	15	0			
— 166 Annual Payments,	124	10	0			
— Arrears,	3	0	0			
				145	19	0
				£372	9	8
1845.						
Nov. 4.—By Fixtures, Furniture for Hall,	£118	6	0			
— 600 vols. purchased,	45	0	0			
— Printing Catalogue,	6	5	0			
				169	5	6
— Ordinary Outlay for Printing Books, Rent, &c.				116	12	5
— Balance in Bank,	80	0	0			
— In Hands of Treasurer,	6	12	1			
				86	11	9
				£372	9	8

Examined, (Signed) THOMAS DAWSON.
JOHN JOSEPH GRIFFIN.

From a note by the Treasurer, it appears, that no names fall to be dropped from the list for non-payment of dues. At the commencement of last session, there were on the list 178 members, and during the sitting of the session, 14 were admitted, making the number at the end 192. The number at the present date (1st Nov.) is reduced by ten, viz., 3 by death, and 7 by non-residence, making the number on the list 182.

The Society then proceeded to the forty-fifth annual election of office-bearers, when the following were chosen:—

President.

DR. THOMAS THOMSON.

VICE-PRESIDENT,..WALTER CRUM.
TREASURER,........ANDREW LIDDELL.
SECRETARY,.....ALEXANDER HASTIE.
LIBRARIAN,.....JOHN J. GRIFFIN.

Council.

A. ANDERSON, M.D.
A. BUCHANAN, M.D.
J. FINDLAY, M.D.
PROFESSOR GORDON.
WM. GOURLIE, JUN.
ALEX. HARVEY.
WILLIAM KEDDIE.
WILLIAM MURRAY.
JOHN STENHOUSE.
R. D. THOMSON, M.D.
GEORGE WATSON.
ALEX. WATT, LL.D.

2d December, 1846.—*The* VICE-PRESIDENT *in the Chair.*

The following members were elected:—Messrs. William Thomson, B.A. Professor of Natural Philosophy in the University of Glasgow, James

Bryce, Jun., M.A., F.G.S., Thomas Callender, Robert Wylie, George Buchanan.

Mr. William Murray stated, that the shock of an earthquake which was experienced in Perthshire on the night of the 24th ultimo, was distinctly felt in Athol Place, in this city, by three members of his family. The tremulous motion was accompanied with noise. Mr. Cockey stated that he also observed the motion, but heard no noise, about 12 o'clock, P.M.

Mr. Liddell reported that the arrangements for the exhibition of models and manufactures in the City Hall were making satisfactory progress.

Dr. R. D. Thomson made a communication *on the Chemistry of Food.* The views announced were founded on the idea that the destination of the food is two-fold: 1st to repair the waste of the system of animals; and 2d, to produce heat. All food, therefore, consists of nutritive and calorifiant elements in addition to the salts. The author showed that animals when placed in different circumstances, required these elements to exist in different proportions to each other in the food. For example, in milk, the food of grown animals, viz., of the young of mammiferous animals, the relation of the nutritive or azotized to the calorifiant food, is from 1 to 2, to 1 to 6; while by experiment he found that a full grown animal at rest, a cow, for example, consumed 1 part of nutritive to 8 or 9 parts of calorifiant food. Arrow root, and other substances of this class, where the relation of nutritive to calorifiant matter is as 1 to 24 or 25, in addition to the absence of the proper salts, which have been washed at neither preparation, are therefore improper food for children. He considered that the use of food not constituted according to such natural laws, as food which was in a state of decay, predisposed to disease more readily than the mere inhalation of gases from impure atmospheres.

Mr. Smith, late of Deanston, in illustration of the views of Dr. Thomson, mentioned that he had fed a number of calves with sago, in order to save milk; that the animals throve well for a time on this diet, and became fat; but that, as their food contained too little of the nutritive, and too much of the calorifiant elements described by Dr. Thomson, they all died, some from inflammation of the brain, and pleura, and all exhibiting symptoms of plethora.

Professor Gordon stated some reasons for doubting that water can be decomposed by heat.

Mr. Smith exhibited a series of thermometers arranged for the purpose of determining how far the atmospheric heat penetrates soils which have been thoroughly drained, soils which have not been thoroughly drained, but where water is present, and more especially peat-moss soils. Mr. Smith made some observations on the importance of this investigation in an agricultural point of view; and stated, that the observations made by means of this instrument would probably settle a dispute among practical men as to the depth to which draining should be carried in the soil.

16th December, 1846.—*The* Vice-President *in the Chair.*

The following gentlemen were elected members:—Messrs. Archibald B. Harley, Robert Johnston, Hugh Bartholomew, John Erskine, John M'Haffie, John Houston, J. B. Sebright, and James Clark.

Mr. Gourlie reported that the arrangements for the Exhibition were making most satisfactory progress.

Professor Gordon read the first part of a paper describing a series of experiments on the temperature of the earth at different depths and in different soils, and on the connexion between changes of temperature in the atmosphere and the growth of plants, by Messrs. Quetelet, Professor Forbes, Herr Dove, and others.— *Vid. 27th January*, 1847.

30th December, 1846.—*The* Vice-President *in the Chair.*

The following members were elected:—Messrs. Alexander Laing, Robert Laird, W. Brown, William Geddes, J. Young, Charles Robb, James M'Connell.

Mr. Smith of Deanston gave an oral account of the progress of mechanism in the Cotton manufacture.

13th January, 1847.—*The* Vice-President *in the Chair.*

The following members were elected:—Messrs. Thomas Macmicking, James Harvey.

The following form of application for the admission of members was adopted by the Society: "To the Secretary of the Philosophical Society of Glasgow. Sir,—I beg leave to offer myself as a candidate for admission as a member of the Philosophical Society of Glasgow; and, if elected, I bind myself to obey the laws made, and to be made, by that Society, as long as I continue to be a member. I am, Sir, your most obedient Servant."—then follow name, designation, and address. This form, when signed, to be accompanied with the following recommendation by three members of the Society, "A. B. being desirous of being admitted a member of the Philosophical Society of Glasgow, we hereby recommend him as deserving of that honour, and as likely to prove a useful and valuable member."

The following Tables were communicated by Dr. R. D. Thomson:—

XXI.—*Tables of the Fall of Rain in Glasgow and Neighbourhood.*

The first column is the result of the rain gauge observations of the late Dr. Couper, Professor of Astronomy in the University of Glasgow, made at the Macfarlane Observatory in the College Park. The second column is the mean, for a series of years, of the fall of rain at the Royal Society's apartments, at Somerset House, and is added for the sake of comparison.

GLASGOW.	Inches.	LONDON.	Inches.
1818,	25·270	1831,	16·85
1819,	23·041	1832,	12·59
1820,	20·267	1833,	11·36
1821,	22·486	1834,	8·00
1822,	23·456	1835,	16·98
1823,	24·876	1836,	22·75
1824,	22·529	1837,	17·94
1825,	21·958	1838,	19·54
1834,	21·861	1839,	24·50
		1840,	18·18
Mean,	22·860	1841,	27·37
		Mean,	17·82

Whether the small amount of rain-fall in Glasgow, as indicated by this table, depended on the position of the gauge, or upon other causes, remains to be determined by subsequent experiments. The greatest fall of rain in Glasgow in any one month, for 21 years previous to 1824, was—

	Inches.
August, 1808,	5·597
August, 1809,	5·283
October, 1812,	5·597

The following table is from the observation of Mr. John Wiseman, Schoolmaster at Gilmourton, in the parish of Strathaven, about 700 feet above the sea.

	1845. Inches.	1846. Inches.
January,	4·30	5·50
February,	2·10	3·40
March,	3·00	5·20
April,	1·80	1·50
May,	2·20	2·20
June,	4·20	4·80
July,	2·80	6·10
August,	4·10	6·30
September,	5·80	2·50
October,	11·70	5·20
November,	7·80	2·40
December,	9·80	2·20
Amount,	59·60	47·30

The following are the results of other observations near Glasgow:—

	Inches	
Greenock,................	61·8	Water-works, Mean of 7 years.
Paisley,..................	47·1	Do. do.
Carbeth,..................	43·99	Mean of 2 years

27th January, 1847.—*The* VICE-PRESIDENT *in the Chair.*

The following gentlemen were admitted as members:—Messrs. Robert Blackie, Henry M'Manus, John M'Gregor Macintosh, David Laidlaw, John M'Dowall, Alexander Ferguson.

Mr. Dawson moved that the sum of £30 be voted to the Library Committee, to defray the expense of this year's periodicals, and £50 for the purchase of new books. It was agreed that in future the Council should constitute the Library Committee.

A letter was received from Captain Boswall of the Royal Navy, placing at the disposal of the Society, for any museum or institution in which it might please to deposit them, the models of a harbour of refuge, boat with Archimedean screw, and bathing machine, shown in the Society's exhibition in the City Hall. The thanks of the Society were given to Captain Boswall, and the models deposited in the Andersonian Museum.

XXII.—*Notice of Experiments on the Temperature of the Earth at different depths and in different soils.* By PROFESSOR GORDON.

MR. SMITH of Deanston having mentioned his intention of instituting experiments to determine the temperature of the soil at different depths, as being a datum required in the practical question of drainage, the Professor proposed to give an account of the existing scientific knowledge upon this point, from the recently published papers of Professor Forbes and Herr Dove.

Having given a brief review of the history of the inquiry into this important subject, from Lambert's experiments in 1779, to those undertaken at the request of the Bristol Association in 1834, and carried on to the present time; and having described the instruments and methods of observation adopted by Professor Forbes in the Edinburgh experiments made in three different soils, and at three different heights above the sea, and at depths of 3, 9, 12, and 24 paris feet in depth; the first result of these observations was stated to be, that the mean temperature in the

Trap Rock is,..................................	46°·14
Sandy Soil,....................................	46°·60
Sandstone,.....................................	45°·95
The mean temperature of the air being	45°·28

There is this remarkable result too, namely, the mean temperature is greater as the depths are greater. The variation of temperature at the different depths throughout the five years of experiment, was shown by means of diagrams, containing the mean temperature for each week of the year, taken by the mean of five years, as the best mode of disposing of irregular fluctuations.

The upper curves (of the thermometer at three feet depth,) follow each other with singular regularity.

At increasing depths the curves systematically separate from each other, showing difference of conducting power in soils.

In reference to the thermometric range, these experiments confirmed the theory that the ranges of temperature may be represented by the ordinates of a logarithmic curve, of which the corresponding depths are the abscisses; and that the retardations, the epochs of maxima and minima, increase uniformly with the depth.

The geometrical expression of the first law being log. $\Delta = A + B\,p$, when Δ = thermometric range at depth p in French feet, and A and B are constant quantities determined by these experiments as follows:—

	Mean Value of A.		Mean Value of B.
Trap Rock,..................	1·105	......	·0545
Sand Soil,....................	1·174	......	·0477
Sandstone Rock,............	1·060	......	·0311

So that by means of this formula, we can calculate the range for any depth.

Diagrams illustrating the agreement of the experiments with this law, were shown.

The depths for which the annual range of temperature is reduced to one-hundredth of a degree of Centigrade, calculated by this formula, would be in

Trap Rock,....................57·3 Paris feet.
Sandy Soil,...................66·6
Sandstone Rock,............96·9

That is to say, at these depths respectively, there occurs a stratum that does not vary in temperature.

Another diagram was exhibited, showing the progress of heat downwards in these different soils, from which it appears that the greatest cold at the depth of 24 feet occurred in—

Trap Rock,...................13th July.
Sandy Soil,..................29th June.
Sandstone,.................. 3d May.

Such is the nature of the results obtained by Professor Forbes's experiments, confirming and confirmed by those of Quetelet at Brussels, of

Rudberg at Upsala, of Arago at Paris, of Muncke at Heidelberg, of Bischoff at Bonn, and others.

Dove's researches on the non-periodic changes of the distribution of heat on the earth's surface, published in 1838, 1839, 1842, show with great clearness and certainty, that years of failure of crops, in general, are distinguished *by a sinking of the mean temperature at each place of observation, for a considerable length of time.* Yet, when a large portion of the earth's surface is taken into view, the apparent irregularities of particular seasons counteract one another, so as to give no countenance to the idea, that more heat falls upon the earth generally one year than another.

As, however, the *mould* or *plant* soil is exposed to direct isolation and nightly radiation, and therefore under different circumstances from those of a thermometer in shade, it becomes a question, whether the temperature of the upper soil surface varies uniformly with that of the air, in its periodic and non-periodic changes, as in it the roots sink to greater or less depth—and so, whether the soil is affected by the anomalies which frequently distinguish the temperature of the air of one given year so considerably from that of another?

It is clear, that without the solution of this problem, the temperature which any plant requires for its complete development, cannot be even approximately determined.

From Dove's discussion of the Brussels, Upsala, and Heidelberg observations, it is manifest that the invariable stratum referred to *periodic changes* alone, has a determinate distance from surface, discoverable as above. Considering *non*-periodic change likewise, however, this invariable layer oscillates.

In years of "*sea climate,*" it gets nearer the surface; in years of greater difference of summer heat and winter cold, it falls deeper under the surface. What has been said of the invariable stratum, is true, in like manner, of those above it. They have a constant mean position, and oscillate in particular years up and down. This oscillation determines in each particular depth, the non-periodic change of the stratum.

Diagrams of the Brussels experiments were exhibited, projected on a different plan from those of the Edinburgh experiments; the curves of temperatures in the deeper strata cutting the curves of the temperatures of the upper strata. The points of intersection are likewise the times at which the air has its yearly mean value. It is, perhaps, for the development of life in plants, a matter by no means indifferent, that, in winter, when vegetation is interrupted, the higher temperature is found at the roots—in summer, at those parts of the plant in immediate contact with the atmosphere, that the times of awakening from the winter sleep and of falling into it again, agree with the transition of one division into the other.

When the plant seeks heat, nature leads it to go upwards for it in summer; in winter it finds it the more certainly the deeper it goes. In reference to the influences of heat, branches and roots mutually exchange the parts they play in the economy of the plant in each half of the year. If the growth of the parts be really a function of the temperature, we should arrive at the conclusion, that the roots develop themselves more powerfully in winter than in summer. This may be compared to a branch which is taken in winter from a tree in the open air into a hot-house, and which lives there a nurseling of fortune, as if it had no connexion with the dead trunk outside.

The Upsala experiments bring out, with peculiar distinctness, how the rapid increase of temperature of the surface in spring is retarded at the greater depths; and from them we learn, too, *how the deeper layers always indicate this rapid increase,* if in any given year it has been observed earlier in the layers above.

In winter, on the other hand, the under layers are much less affected by anomalies. Dove explains it in this way: that the snow-covering, then probably on the ground, being a bad conductor, prevents the soil from participating in the many changes of the atmosphere. The snow-covering has a twofold influence, inasmuch as it hinders the radiation from the ground, on the one hand, and as it prevents communication of heat by contact with the air, on the other.

The relative circumstances of the parts of plants out of the soil being the same, the *mean temperature* of the whole plant will be so much the *lower* in summer, and so much the *higher* in winter, the deeper its roots penetrate into the variable stratum. Plants with roots going deep into the soil, live, therefore, in circumstances approximating more to what is termed a *sea*-climate, than do those whose roots penetrate less deeply.

The following tables, from Quetelet's observations (on the *south* side of the Observatory at Brussels) for depths of 4, 16, 24, 32, and 40 inches depth, from May, 1840, to December, 1844, as arranged by Herr Dove, perfectly illustrate this.

TABLE I. *a.*—TEMPERATURES AT DEPTHS.

	Surface.	4 Inches.	16 Inches.	24 Inches.	32 Inches.	40 Inches.
Jan.	1·22	1·27	2·02	3·16	3·54	3·52
Feb.	1·84	1·78	2·44	3·16	3·33	3·16
March,	6·61	5·35	5·67	5·49	5·29	5·16
April,	10·07	8·07	8·54	8·25	7·81	7·92
May,	15·18	13·48	13·78	12·98	12·08	12·23
June,	17·25	15·88	16·43	16·04	15·22	15·10
July,	17·09	15·99	16·79	16·28	16·05	15·99
Aug.	17·70	16·89	17·57	17·27	16·84	16·79
Sept.	13·56	15·21	16·31	16·42	16·30	16·43
Oct.	9·76	9·89	11·27	12·07	12·50	12·91
Nov.	5·74	6·31	7·41	8·34	8·78	8·92
Dec.	1·73	2·63	4·02	5·12	5·66	5·78

TABLE I. *b.*—TEMPERATURES OF EACH SUCCESSIVE LAYER.

	Surface.	Sur. to 4 in.	Sur. to 16 in.	Sur. to 24 in.	Sur. to 32 in.	Sur. to 40 in.
Jan	1·22	1·25	1·50	1·92	2·24	2·46
Feb	1·84	1·81	2·02	2·31	2·51	2·62
March,	6·61	5·98	5·88	5·78	5·68	5·59
April,	10·07	9·07	8·89	8·73	8·55	8·44
May,	15·18	14·33	14·15	13·86	13·60	13·29
June,	17·25	16·57	16·52	16·40	16·16	15·99
July,	17·09	16·54	16·62	16·54	16·44	16·36
Aug	17·70	17·30	17·39	17·36	17·25	17·18
Sept	13·56	14·39	15·03	15·38	15·56	15·71
Oct	9·76	9·83	10·31	10·75	11·10	11·40
Nov	5·74	6·03	6·49	6·95	7·32	7·58
Dec	1·73	2·18	2·79	4·13	4·43	4·66

TABLE I. *c.*—DIFFERENCE OF TEMPERATURE OF LAYERS AND SURFACE.

	4 Inches.	16 Inches.	24 Inches.	32 Inches.	40 Inches.
Jan	0·03	0·28	0·70	1·02	1·24
Feb	0·03	0·18	0·47	0·67	0·78
March,	0·63	0·73	0·83	0·93	1·02
April,	1·00	1·18	1·34	1·52	1·63
May,	0·85	1·03	1·32	1·68	1·89
June,	0·68	0·73	0·85	1·09	1·26
July,	0·55	0·47	0·55	0·65	0·73
Aug	0·40	0·31	0·34	0·45	0·52
Sept	0·83	1·47	1·82	2·00	2·15
Oct	0·07	0·55	0·99	1·34	1·64
Nov	0·29	0·75	1·21	1·58	1·84
Dec	0·45	1·06	2·40	2·70	2·93

These differences naturally increase with the depths.

The Upsala experiments (made by Rudberg,) give the following results:—

TABLE II. *a.*—MEAN TEMPERATURES AT DEPTHS.

	Air.	2 Feet.	4 Feet.	6 Feet.	10 Feet.
Jan	–6·43	0·56	2·50	3·96	5·96
Feb	–6·73	0·95	1·50	2·97	5·03
March,	–3·75	0·87	0·97	2·21	6·24
April,	2·37	0·94	1·22	1·93	3·75
May,	9·64	7·01	4·33	3·77	3·86
June,	14·56	13·93	10·15	7·76	5·34
July,	16·03	16·07	12·98	10·65	7·51
August,	14·88	15·85	13·88	12·00	9·12
Sept	11·60	13·12	12·54	11·83	9·91
October,	4·95	7·98	9·43	10·02	9·76
November,	0·46	3·97	6·04	7·49	8·71
December,	2·55	1·78	3·73	5·30	7·28

Table II. *b.*—Difference between Air and Depths.

	2 Feet.	4 Feet	6 Feet.	10 Feet.
Jan.	6·99	8·93	10·39	12·39
Feb.	5·78	8·23	9·70	11·76
March,	2·88	4·72	5·96	8·01
April,	1·43	1·15	0·44	1·38
May,	2·63	5·31	5·87	5·78
June,	0·59	4·41	6·80	9·22
July,	0·04	3·05	5·38	8·52
August,	0·97	1·00	2·88	5·76
September,	1·52	0·94	0·23	–1·69
October,	3·03	4·48	5·07	4·81
November,	4·43	6·50	7·95	9·17
December,	4·33	6·28	7·89	9·83

The progress of heat from *above downwards*, commences in these high latitudes later in spring than in more southern climates; and in like manner the progress from *below upwards*, commences earlier in autumn. In the northern latitudes, the development of vegetation takes place within a much narrower "season," or space of time, than in the south.

10*th February,* 1847.—*The* Vice-President *in the Chair.*

The following were admitted members:—Messrs. Donald Campbell, Hugh M'Pherson, John Fyfe.

A second vote was taken on the motion for a grant of £50 to the Library Committee, and a report from that Committee recommending the purchase of certain books was approved of. The Secretary laid on the table a copy of the Biographical Memoir of the late Charles Macintosh, F.R.S., presented by his son, George Macintosh, Esq. The thanks of the Society were voted.

The following Statistical Account of the Society's Exhibition in the City Hall, during the Christmas and New-Year holidays, was then read:—

XXIII.—*Statistical Account of the Philosophical Society's Exhibition, during the Christmas Holidays.* By Andrew Liddell, Esq.

The Philosophical Society has frequently had private exhibitions of models, manufactures, &c., for the gratification of its own members and their scientific friends. The Town Council had, during the New-Year holidays of 1845 and 1846, a gratuitous exhibition of a small collection of works of art for the amusement of the public generally. It occurred to certain members of our Society, that a union of these on a grand scale, to embrace the very best objects in science and art that could be found, would be instructive and amusing, not only to the learned and scientific, but also to the public generally, and especially to the working portion of the community. It was thought that if the terms of admission were liberal, so as that all, even the very poorest, might have an opportunity of being present, they might be induced to think and converse, perhaps, for the first time, on such subjects, and desire to be better instructed in them. Accordingly, in March last, the subject was proposed almost simultaneously at meetings of the Philosophical Society and Town Council. Both these bodies entertained the proposal, and each appointed a Committee of its number to arrange the business. These committees were empowered to act jointly, and had authority to add to their number. A contract of agreement was gone into by the parties, in which each guaranteed, in certain portions, the Joint Committee against loss to the extent of £500, it being distinctly understood, that if the loss incurred should exceed £500, the Committee was personally bound for such excess,—the Philosophical Society taking the entire charge of collecting and arranging the articles for exhibition, and waiving all claim for admission to its own members or friends on other terms than the public generally. On the other hand, the Town Council agreed to charge no rent for the City Hall. No data existing, it was difficult at this stage of the business to estimate what the probable outlay might be. An approximate estimate, however, was made out, showing that at least £730 of outlay might be incurred, or perhaps it might amount to £1000. It was fixed that the Exhibition should be opened on the last week of December, on payment of a small admission fee, and that the working classes should be admitted gratis on the 1st, 2d, and 4th of January. It was feared, by a small number, that in consequence of free admission being given on so many days, the above-named outlay could not be obtained from admission dues on the days when payment was exacted, and that the Committee might incur pecuniary loss. But the great majority was of opinion, that if the exhibition was made attractive, not only the outlay would be repaid, but a reversion might be expected, even although the outlay should considerably exceed the above-named sum. It was therefore resolved to apply at the best sources for the most interesting and valuable articles for exhibition. The result has shown that the opinion of the majority was correct; for in place of a deficiency, there is a considerable reversion, as shall be detailed afterwards. In anticipation of this, and it being the desire of the contracting parties to perpetuate such exhibitions, special provision was made as to what purpose any surplus should be applied. The fifth clause in the contract is as follows;—"If it should happen that in place of a loss there should be an overplus of moneys received, said overplus to be laid aside as a fund for future exhibitions of a similar nature."

The Joint Committee being thus constituted assumed into its number representatives from the University of Glasgow, Anderson's University, the Mechanics' Institution, and the Sheriffs of the county, to aid them in collecting articles for exhibition. And for the same purpose appointed Corresponding Committees in most of the large cities in the empire.

In order to embrace the various arts and sciences, the Committee appointed of its own number five Sub-Committees, viz.:—1st, Chemistry and Mineralogy; 2d, Mechanics and Engineering; 3d, Manufactures; 4th, Natural History; and 5th, Works of Art.

A printed circular, containing general instructions to all the Committees, was extensively circulated early in June. In it special request was made that the articles selected should be rare and valuable. In November, a clerk was appointed to conduct the correspondence, and take charge of the articles which then began to arrive. About the same time a commissioner was sent to England to aid the Corresponding Committees in forwarding the various articles which they had selected. Possession of the City Hall was obtained on the 14th of December, and the Exhibition was opened on the evening of the 24th, with a promenade, and continued open till the evening of the 31st, admission being granted on payment of 5s. for season tickets, 2s. 6d. for admission to promenade, 1s. on other days; and on the 1st, 2d, and 4th of January, there was free admission to the public. Although at this date upwards of 71,000 had been admitted, yet it was evident that the desire of the public was not satisfied. The Exhibition was accordingly kept open for the five remaining days of the first week of January, on payment of 1s. till five o'clock evening, and 3d. after that hour. During these five days, upwards of 28,000 more were admitted, making the total number 99,444.

The Acting Committee had great satisfaction from the ready manner in which their friends, and even public institutions, placed at their disposal for exhibition the valuable articles of their museums and private collections. In every case their application was responded to, with two exceptions. In one of these the Directors expressed regret that the laws of their Society prevented their lending any article of the museum; from the other, a public trust in Edinburgh, no reason for the refusal was given. Although the principle laid down by the Committee, of selecting only rare and valuable articles, was rigidly adhered to, yet the quantity received or offered, was far beyond what the City Hall, with all its various apartments, spacious as they are, could contain; the consequence was, that many very valuable articles were refused, and others which arrived from a distance at a late period were returned in their packing cases unopened.

On receipt of so much valuable property, for which, of course, the Committee was responsible, it became a matter of serious consideration to guard it against injury from being exposed, or from loss by accidental fire. Every article of value that would have been injured by exposure, was placed under glass covers, and the whole was secured against risk from fire, by insurance to the amount of £20,000, this being the ascertained value of articles received. Although the intrinsic value was thus guaranteed, yet as many of the articles received were unique of their kind, highly prized by their owners, and could not be replaced at any price, it was thought advisable still further to take precautionary measures to guard against fire, which, if once begun, would have spread with fearful rapidity, from the walls being almost wholly covered with cotton cloth, suspended from the ceiling downwards; and, if this had happened when the place was crowded, the personal injury and loss of life might have been great. Accordingly, two leather pipes, attached to fire plugs, were introduced through a private entrance to the east gallery beside the statuary, where two firemen were stationed, who could see every point of the hall, and in a moment's notice, project large streams of water into any corner of the building. Fortunately these precautionary measures were not required.

It would lengthen this paper far beyond the prescribed bounds, were I to attempt giving a detailed account of the various articles exhibited, the manufactures carried on, or the electrical and chemical demonstrations made. The catalogue gives the names of the articles and contributors; and the "Daily Exhibitor," a paper printed in the hall, describes a small portion. On this point, I have to state that the principle laid down of selecting for exhibition only the very best article of its kind, was, as far as possible, strictly adhered to. These articles, many of them of the most splendid description, were exposed to view on tables, and on the floor of the halls, and also on the walls, nearly the entire of which were covered with pictures, many of them by the best masters, together with woven fabrics of silk, cotton, and woollen. In addition to this, there were upwards of fifty workers producing the articles of their manufacture, at fifteen different trades. If to all this we bear in mind the continuous busy throng, moving in regular order, guided by upwards of forty officers in uniform, several gentlemen of the Committee, bearing staves of office, being always present,—we have some idea of what was every day seen by the visiter, on entering the large Hall by the west gallery. The spacious area of the Hall, measuring 145 by 60 feet, with a lofty ceiling of 31 feet, contributed much to the splendour of the scene. It will be recollected that the premises were lighted with gas, by day as well as at night, thus allowing the windows to be closed, leaving the entire surface of the walls for pictures, woven fabrics, prints, plans, &c. Over the pictures and fabrics, thus suspended on the walls, was carried all round a massive cornice, with drapery of coloured cotton or woollen cloth, and every empty space between the articles exhibited, was also covered with cloth of the same colours. The effect of the whole, when seen from the west gallery, heightened as it was by the massive sculpture tastefully displayed in the east gallery, was, to use the language of an intelligent visiter, more like the romance of Eastern tale, than what we are accustomed to see, at least in this country. A print, giving a very correct view of the interior of the Hall during the Exhibition, has been lithographed by Messrs. Mack and Smith, Buchanan-Street, the firm which had its lithographic press in operation in the Hall during the Exhibition.

NUMBER OF PERSONS ADMITTED AND MONEY RECEIVED.

DATE.	Season Tickets at 5s.	Promenade Tickets at 2s. 6d.	Daily Visiters at 1s.	Children 6d.	Evenings at 3d.	FREE.	Money Received.
DECEMBER.							£ s. d.
Thursday 24,......	675	1187	...	...	...	...	317 2 6
Friday 25,..........	...	...	953	71	...	...	49 8 6
Saturday 26,.......	...	...	1243	72	...	...	63 19 0
Monday 28,........	...	...	1600	117	...	...	82 18 6
Tuesday 29,........	...	...	2388	139	...	...	122 17 6
Wednesday 30,....	...	...	3151	219	...	...	163 0 6
Thursday 31,......	...	...	3090	197	...	...	159 8 6
JANUARY.							
Friday 1,............	...	...	...	...	...	16217	......
Saturday 2,.........	...	...	...	...	...	18600	......
Monday 4,..........	...	...	...	...	...	19476	......
Tuesday 5,.........	..	...	1031	32	2780	...	87 2 0
Wednesday 6,.....	...	...	1053	44	3576	...	98 9 0
Thursday 7,........	...	...	1536	61	4154	265	130 5 0
Friday 8,............	...	...	2439	89	4343	...	178 9 3
Saturday 9,........	...	...	2697	189	3760	...	186 11 6
	675	1,187	21,181	1,230	18,613	56,558	1639 11 9

Total number admitted, 99,444.

The charges against the Exhibition cannot yet be reported, as the carriers' accounts in England, and one or two others, have not yet been received; but, from what is known, I estimate the total outlay at £1180; thus leaving a balance of, say £460, to be laid aside, according to agreement, for future exhibitions of a similar kind. The outlay now reported is considerably more than was expected; but the receipts have also exceeded anticipation, even in a much greater ratio. It may be proper to mention that the outlay was increased upwards of £200 by the Exhibition being kept open for fifteen days, the period originally intended being only eight or ten days; but during this extended period receipts were obtained amounting to £680.

It is well known to many, that the primary object of the original projectors of this Exhibition, and of the Philosophical Society and the Town Council in promoting it, was to amuse and instruct the working classes during the New-Year holidays; and by giving gratuitous admission, insuring a numerous attendance, to determine the disputed point as to whether they would conduct themselves with propriety when admitted indiscriminately, and in large numbers, to such a place, where valuable articles must necessarily be laid out openly, and comparatively unprotected. The result has shown that they can conduct themselves with propriety in such circumstances; and that they are worthy of the trust we put in them, for not one article, during the entire period of the Exhibition, was displaced or injured by the visiters. And after it was closed, and an inventory was taken, I am able to state, that not one article was found wanting.

The number of persons admitted was at the rate of 2000 per hour during the days when free admission was given; and on the evenings, when the charge was threepence, nearly the same number. On these occasions admission was given at one door and exit by another; and during those times all present were crushed and pressed on every side, while they were carried along by the stream before they could possibly have even a slight inspection of many of the articles presented to view. It frequently happened, also, that they were carried past the article which they had come on purpose to examine, and there was no possibility of return. All these things were calculated to ruffle the temper, yet scarcely an angry word was heard. It was matter of much regret to the Committee that the great number who were admitted on these days precluded a deliberate examination of the objects in the Exhibition by the visiters. Of all parts in the Hall, that which excited the most attention, and at which all were most disposed to linger, was that where the process of manufactures was carried on; and of the various descriptions of manufactures or machinery in motion, most assuredly, that of the potters and tobacco-pipe makers were the most attractive. The clean, tidy appearance of the workmen, and the rapidity with which they did their work, seemed to please every one. Next to them were the models of steam-engines, of which about half-a-dozen, of various sizes and descriptions, were always in motion. The largest, being fully one horse power, gave motion to card-making machinery; and the smallest, having a cylinder of only one-fourth inch diameter, was moving at the rapid rate of nearly 300 strokes per minute. The splendid display of pictures and statuary was much studied by all who had a taste for the fine arts. The series of illustrations of the various processes of manufacture from the raw material to the finished article, on the chemistry and manufactures table, were likewise examined by many with interest.

I should state that, at the request of Major-General Fleming, all the military in barracks, and the recruiting parties in Glasgow, had admission gratis on the 7th January; and on the 9th the officers of the 74th Regiment gratified the visiters with music from the very superior band of that regiment. On other days, Thomson's band of music was in attendance. On the 8th, the children of the Deaf and Dumb Institution had free admission. The cotton and woollen cloth which decorated the Hall, and which cost £40, has, since the close of the Exhibition, been made into garments, and distributed amongst the poor—a boon opportunely given at this inclement season of the year.

Having now, as requested by the Acting Committee, shortly described the Exhibition which has just passed away, I cannot conclude without referring to two classes of individuals, without either of which no such display could have been accomplished. To the great liberality of the one, and to the zeal and untiring diligence of the other, we are mainly indebted for the Exhibition which I have attempted to describe. The first are, the contributors, who so generously lent articles for exhibition. I have already stated that, with the exception of one or two cases, our calls were cordially responded to,—in many instances to a much greater extent than we could render available. The number of parties who thus contributed was about 290; to every one of whom a letter of thanks has been sent, subscribed by the Lord Provost, the President of the Philosophical Society, and the Chairman of the Exhibition Committee. Intimation has been received that every one has got back the articles he sent, with one trifling exception, which is being inquired after. And letters have been received from many, intimating the great satisfaction felt at their having been able to aid in the success of our experiment.

The second class is the Committee of Management. It must be evident to every one, that the scale and style in which the concern was produced must have entailed immense labour. Such was the case. I could easily give the names of various members of Committee who cheerfully gave their time, almost exclusively, for weeks together; but to mention names would be invidious.

I have already noticed the immense number who attended during the days of free admission, and the evenings when the charge of 3d. was made. It is evident that this overpowering number could not reap the advantage which they could have got from a careful survey of the objects in a less crowded assembly. So far the original object of the projectors has not been obtained, which is certainly matter of regret. But from the great desire for admission, evidenced by many waiting for hours at the door, and from their correct deportment when admitted, it is proved that this numerous class appreciate and will take advantage of such modes of amusement and instruction when they are placed within their reach;—the experiment now made has established this fact. It becomes us, therefore, to consider if such displays cannot be more frequently given, or if they cannot have a permanent place amongst us, so that the working man might have a resort where he could exhilarate his spirits and improve his mind by viewing beautiful objects of nature and art, and occasionally, perhaps, seeing and hearing demonstrations on the same subject. It must be allowed, that all who are confined in factories, or work shops, or warehouses, for ten or twelve hours every day, require relaxation and amusement in the evening. If they cannot find this of an innocent, an amusing, and at the same time, instructive kind, many of them will betake themselves to amusements of a different and injurious description. To have an exhibition annually, in style and extent corresponding to the one now brought to a close, need not be expected. You would not easily get a committee or contributors, who would undertake the work so frequently as once every year. One, however, on a smaller scale, conjoined, perhaps, with organ music, might be a source of rational amusement and instruction. And, I am of opinion, that were the public voice to bear on the subject, we might have an organ of suitable power in the City Hall by next New-Year holidays. A Committee for collecting subscriptions towards this object exists, of which Mr. Andrew Orr, one of the magistrates of the city, is Convener. Only three or four hundred pounds is now required to complete the object. This king of musical instruments, when placed in the Hall, may be used for the amusement of the people, on many other occasions than the New-Year holidays. It is well known that a good toned powerful organ, under the hands of a skilful performer, can produce sweet sounds, little inferior to that of a full band. But what would be most desirable is a gallery, a museum, or a polytechnic institution, of a comprehensive and instructive description, permanently fixed amongst us, and which would be thrown open to the public on the evenings and holidays, gratuitously, or at a trifling admission fee. I am of opinion, that such an institution, if started free of debt, could support itself from admission fees of a reasonable amount exacted at other times than those mentioned. The exhibition opened by the Local Committee of the British Association, for six months previous to the meeting of that body in 1840, paid all expenses from admission fees of 3d., 6d., and 1s., although the concern, with the exception of Perkin's steam gun, had little novelty. To be attractive, such an institution must bring to the public view every new discovery. By arrangement with inventors, designers, manufacturers, and others, this could be done at a comparatively small outlay. In this way, novelty could be maintained by a change of many of the objects, perhaps every month. Were such an institution resolved on, suitable apartments would be required. These could be erected at a small expense, adjoining the City Hall, where the Corporation have vacant ground which might be applied to that purpose. Money also will be required at starting. The overplus or receipts of the late Exhibition cannot, in accordance with the clause just quoted, be applied to this purpose. It amounts to nearly £500. And I have authority from a wealthy and liberal citizen to say, that so soon as it can be made apparent that an exhibition similar to the one lately got up by our Society, can be established on a permanent footing—admission being given to the working classes, either free or on the payment of a very small sum—he will cheerfully subscribe £500. We have thus, from these two sources alone, a sum of about £1000. This amount, if placed under the fostering care of a competent committee, may, in my opinion, at no distant period, be quadrupled—which would be quite sufficient to get up an institution of the kind proposed. The Exhibition we are now describing, may thus have laid the foundation of a museum which may become gigantic in extent, and more useful to the great bulk of the community, than even the Philosophical Society itself, which being purely scientific in its aim, must necessarily communicate instruction or amusement direct to a comparatively small number.

RECEIPTS.

To Cash received for Tickets of Admission,	£1,639	11	9
— for Catalogues, &c.	68	4	4
	£1,707	16	1

DISBURSEMENTS.

By Cash paid, Fitting up Hall, Hanging Pictures, &c.,	£265	8	9
— Workmen in Hall during Exhibition,	108	13	2
— Printing and Advertising, including Catalogues,	164	17	2
— Lithographing,	33	1	0
— Insurance against Fire,	47	10	0
— Refreshments to Workmen and Police,	66	15	7
— Salaries to Exhibitor, Clerk, and Commissioner,	137	1	2
— Wages to Porters, Door-keepers, &c.,	75	8	5
— Freights, Packing, and Carriages,	142	18	10
— For Music,	45	0	0
— Glass Covers,	18	0	0
— Collecting Articles in Edinburgh,	5	0	0
— Cleaning Hall,	5	3	9
— Stationery,	7	9	4
— Firemen,	5	2	0
— Gas Company,	64	19	0
— Miscellaneous,	54	3	9
— Postages,	7	15	4
By Cash in Union Bank of Scotland,	453	8	10
	£1,707	16	1

22d February, 1847.—*The* Vice-President *in the Chair.*

Mr. William Henry Long was admitted as a member.

Professor Gordon described a simple contrivance which he had devised for smoky chimneys. The following paper was read:—

XXIV.—*Physiological Effects of the Inhalation of Ether.* By Andrew Buchanan, M.D., *Professor of the Institutes of Medicine in the University of Glasgow.*

The Council of the Society having thought that the discussion of this subject might prove both interesting and useful, and having applied to me to bring it forward, I complied solely from the desire to render to the Society any service in my power; but certainly not from thinking my knowledge of the subject so exact, or my opinions upon it so matured, as to entitle me to bring it forward spontaneously; but I hope to meet with indulgence for the imperfections you may find in the performance of a duty not sought for, but imposed upon me.

It has long been a desideratum in the medical art, to lessen the pain of surgical operations—for as to removing it altogether, no rational man, even in his most sanguine moments, ever dreamt of it. It was at one time attempted to deaden the pain by means of opium; but the attempt was abandoned, because it was found impossible to administer the drug in sufficient doses to blunt sensibility without risk of more serious consequences. I need scarcely mention the more recent attempts, by means of animal magnetism; for I hold the abandonment of an object so important by the professors of the mesmeric art, to be a tacit acknowledgment that they know themselves unable to attain it—that their boasted power is a deception, or, at most, has no influence but over the minds of a few hysterical females. Were it otherwise, the charge I make against them is a light one, compared with the moral charge implied in their deserting so many sufferers, whom they have the power to relieve.

I confess that when I first heard of the marvellous efficacy of ether in deadening the sensibility of the nerves, I received it with distrust, and thought it was to turn out just such another imposition as animal magnetism. I am not ashamed to say this, because I think that every rational man ought to receive in a spirit of scepticism, statements made to him in opposition to all antecedent experience. But I should have thought myself a very unworthy member of this Philosophical Society, had I refused to inquire further, and shut my mind against the authority of facts. I have carefully examined the subject, by actual observation and experiment, and I have now to state as the result, that I am fully satisfied that the statements originally made to me were in no way exaggerated: that the inhalation of ether really has the power of suspending, for a time, the sensibility of the nerves; and that, during the period of suspended sensibility, the most formidable surgical operations may be performed—amputation of the limbs, the dissecting out of tumours, and cutting for the stone—without any perception of pain by the person operated upon, and without reason to apprehend any bad consequences, either immediate or subsequent. I can honestly declare that I have seen all these, and many other operations performed; and that the patients, when put fully under the influence of the ether, gave no indications of feeling pain during these operations, and declared afterwards that they had felt none, which is the whole evidence that the case admits of. So great a triumph of the medical art I never expected to witness; but it should not excite feelings of exultation merely, but should be received with gratitude and with thankfulness, as a great boon which it has pleased the Giver of all good to bestow, in his compassion for the sufferings of mankind.

When our wonder at results so unexpected has in some degree subsided, it becomes our duty to inquire in what way they are produced; because it is only when we come to understand the nature of this important agent, and the laws which regulate its action upon the human body, that we can expect to derive from it all the benefits which it is capable of imparting; to direct and modify it according to circumstances, and to avoid the dangers which, in the hands of the incautious and ignorant, it may, most unquestionably, occasion. It was to attain these important ends, and not to gratify a mere vulgar curiosity, that the Council of the Society started this subject; and I am not without hopes that good may be done by the mutual communication of opinions, and that even the collision of them may serve to strike out some useful light.

That we may be better able to appreciate the new facts recently ascertained, let us first inquire what was previously known of the action exercised by ether upon the human body. I could state this in few words, if I were addressing a body of medical men, fully conversant with the subject; but I am persuaded that, in addressing a general audience on such a subject, it will not be thought out of place for me to premise some general remarks as to the mode in which medicines operate on the human body, so that the place which ether occupies as a physiological agent, may be the more readily understood.

Medicines, then, may be divided into four classes, according to the mode in which they affect the human body:

Those of the first class act altogether locally. We have familiar examples of them in mechanical agents applied to the surface of the body, in the diluted and strong acids, liquid ammonia, mustard, and cantharides, all of which produce inflammation and other local effects on the parts to which they are applied, but do not necessarily implicate parts at a distance. Ether, and many other substances, have a local irritant power of this kind, combined with a power of a more general nature.

The medicines of the second class operate by local sympathy. They are, in so far, local agents, that they must always be applied to the same spot; but the local impression influences distant organs sympathetically. Tobacco and other irritants applied to the nostrils operate in this way; the local impression they produce on the membrane of the nose is propagated, through the nerves, to the diaphragm and abdominal muscles, which are thus made to contract, and produce the act of sneezing: whence we name them *sternutatories*. Many important medicines operate in this way—many emetics, for instance, such as mustard, and the sulphates of zinc and copper, which, exercising an irritant action on the stomach, call into play, sympathetically, the muscles concerned in the act of vomiting. Almost all purgatives also, such as castor and croton oils, jalap, senna, and aloes, act in this way. They irritate the mucous membrane of the bowels, and the impression is propagated, by sympathy, to the expulsive muscles. It is a most erroneous idea, which some medical men entertain, that such medicines will operate when applied to the skin, for they can only operate when applied to the membrane of the bowels. Croton oil, for instance, when used as a liniment to the skin, or even applied to an abraded surface, never operates but as a local irritant.

The medicines of the third class require to be absorbed by the blood vessels, in order to produce their effects, which are thereafter exerted on the organs of nutrition and secretion. Iodine is a good example of the former; nitre, squill, and turpentine, of the latter. Such medicines produce the same effects, to whatever part of the body they are applied, provided it be an absorbing surface. Iodine and mercury act in the same way, whether applied to the skin or to the stomach.

The medicines in the fourth class act on the nervous system, either after absorption, or directly. The former may be said to be their general mode of action; but there are some substances, such as the prussic acid, of which the effects are manifested so instantaneously, that we can scarcely but suppose, that the nerves transmit the impression, with the rapidity of thought, to the heart and brain.

It is to this class of substances that ether belongs. They are readily distinguished from all other medicines, by possessing the four following characters:—They do not act locally, like the substances of the first class, but on parts at a distance. They act in the same way to whatever part of the body they are applied. They are thus distinguished from the substances of the second class. From the substances of the third class they are distinguished, by acting on the nervous system, and the organs most intimately connected with it—the brain, the organs of sense, the heart, and the voluntary muscles. Lastly, they are all of them, with a few exceptions, poisonous substances, if improperly administered.

The substances belonging to this class are known by the name of narcotics, or stupefiants, from their producing confusion of intellect, and deadening sensibility. They were, at one time, supposed all to operate in one way; first, as excitants, and then as sedatives. But a more accurate knowledge of them has shown, that is impossible to refer their multifarious effects to so simple a principle. There are, indeed, some of them to which the name of narcotics is altogether inapplicable, for instead of diminishing, they exalt the sensibility of the nerves. Such, for instance, are the nux vomica, and the other substances containing the alcaloids, strychnia, and brucia; for an animal, under the poisonous influence of these substances, instead of being rendered insensible, feels a touch of the finger like a shock of electricity.

But the great majority of the substances in question really act on the brain as stupefiants, but they affect other important organs too seriously to permit us to derive any advantage from the stupor they induce. Hellebore is the most powerful stupefiant we know, but it acts as a poison to the system. Camphor, while it induces stupor, brings on frightful convulsions of the muscular system, and prussic acid and fox-glove exert a deleterious influence over the action of the heart.

The section of the narcotics to which ether belongs, instead of exerting a deleterious influence over the heart, have for their character, to excite and sustain the action of the heart, while they produce upon the brain at first exhilaration, and at length stupefaction.

To this section belong, *first,* alcohol, the distilled spirits, the wines, and other fermented liquors; and *second,* ether, and some of the compound substances, now named salts of ether, such as the nitrite and the chloride of ether, more commonly called nitrous and muriatic ether. I say some of these bodies, for the effects of all of them on the animal economy have not been ascertained.

It simplifies our subject very much to observe that alcohol is the active ingredient in the first series of these bodies, and ether in the second; so that we have merely to consider and contrast the effects of these two agents, alcohol and ether, on the animal economy.

The effects of alcoholic liquids are too well known to require minute description, but their more prominent effects are, in the first place, an exhilaration and excitement of mind, which gradually passes into a state of narcotism or stupefaction: and in the second place, excitement and invigoration of the action of the heart, which seems to continue throughout; for the feebleness in the heart's motions, which comes on in deep intoxication, is, probably, the consequence of the narcotised state of the brain.

The effects of ether may be described in the very same words. This the identity of composition of the two substances might have led us to anticipate; for alcohol is just the hydrate of ether, or ether *plus* an atom of water—the two bodies not differing in composition more than oil of vitriol does from anhydrous sulphuric acid. The moment the dry acid comes into contact with water, it is converted into oil of vitriol; and ether, when kept long in contact with water, (*Liebig*,) is converted into alcohol.

There is, however, a difference in the physical qualities of the two substances, which renders each of them only adapted to a certain mode of administration.

Alcohol is miscible, in all proportions, with water, and forms a palatable and too insinuating beverage. It is thus well adapted for administration by taking it into the stomach—while it is far less volatile than ether, and, therefore, is less adapted for inhalation.

Ether, on the other hand, is not miscible with water, unless the latter be in great excess (1 ether to 10 water.) Hence it is not adapted to be administered by taking it into the stomach; for its hotness cannot be overcome by dilution, and it acts as a violent local irritant. How much less alcohol would be consumed, if it could only be drunk in the form of a highly rectified spirit, and its fiery qualities could not be corrected by dilution! Physicians seldom prescribe more than from one to two drachms of ether—a quantity quite insufficient to develope any narcotic effects. I have known seven drachms of it taken; but it produced, at the pit of the stomach, a most uneasy sensation of heat and pain, which only the callous stomach of a dram-drinker could stand. As a dram, ether might answer very well; and it is for a similar purpose that it is usually prescribed in medicine—as a carminative, and not as a narcotic.

Ether, on the contrary, from its high volatility, is admirably adapted to be administered by inhalation. It boils at 96° Fahr. The heat of the hand is sufficient to make it fly off in vapour. Alcohol, again, is far less adapted to this mode of administration. Even when rectified to the uttermost, it only boils at a temperature of 173° Fahr.; and if less strong, the temperature must be higher. Still, however, the inhalation of the vapour of alcohol will produce narcotism, although with less rapidity than ether.

It is, I believe, to this difference of physical qualities, in the two substances, and in the mode of administering them which is the consequence of it, that the differences in the physiological effects of alcohol and ether are mainly to be ascribed; and not to any actual difference in their modes of action upon the human body.

The most remarkable peculiarities in the action of ether administered by inhalation are, 1st, the suddenness with which it induces complete narcotism; 2d, the transiency of the narcotic state; and, 3d, the very small quantity of ether necessary to produce the effect. I shall endeavour to show, that these peculiarities depend altogether on the mode of administering the ether, by inhalation; and would not be observed if it were administered in any other way: and in doing this, I shall assume as principles, that ether only acts as a stimulant to the heart, and as a narcotic on the brain, after being absorbed; and that the energy of its action, is proportionate to the degree in which the blood applied to the tissues of the heart and brain is impregnated with it.

The suddenness of the effect produced depends, in the first place, on the volatility of the ether, and on its being thus brought, at once, into contact with a very extensive and highly absorbent surface—the mucous membrane of the lungs.

Another circumstance which favours much the speedy development of the narcotism is, that the blood, fully charged with the absorbed ether, is at once poured, undiluted, and in a continuous stream, on the heart and brain. The ether is no sooner absorbed, than the blood, charged with it, passes on to the cavities of the left side of the heart; and immediately thereafter it circulates through the coronary vessels, and the carotid and vertebral arteries, and thus pervades the tissues of both sides of the heart, and every part of the brain. It is far otherwise with respect to substances applied to the surface of the stomach, and absorbed by the stomachic veins; for the blood in these veins is necessarily diluted, by intermingling with many currents larger than their own, before reaching the heart and brain. Suppose, to take an extreme illustration, that the blood were capable of absorbing as much ether as water can combine with, or one-tenth of its own weight; if, then, we suppose that the blood in the lungs were impregnated to this extent, it would be applied in that state to the heart and brain, whereas, if the blood in the stomachic veins were impregnated with the same quantity of ether, before reaching the liver, it would have mingled with more than its own mass of pure blood from the splenic and mesenteric veins; the tenth would thus become a twentieth; and, on the blood leaving the liver, and joining the larger current of inferior cava, the twentieth would become a fiftieth or sixtieth. A further dilution would take place at the confluence with the superior cava, so that the blood, on reaching the heart and brain, instead of containing one-tenth part of absorbed ether, could not contain so much as one-hundredth. Whenever, therefore, the same quantity of ether, or of any other absorbible substance, is taken up from the lungs and from the stomach, it must, in the former case, be applied to the tissues of the heart and brain, in a state of concentration at least ten times greater than in the latter; and will, therefore, act on these organs with more suddenness and energy.

I would explain, also, by referring to the laws which govern the circulation of the blood, the evanescence of the effects produced, which is the most extraordinary part of the whole phenomena, and the most difficult to explain. During the inhalation, which is usually continued from five to seven minutes, blood, highly charged with ether, is applied to the heart and brain; while the blood, circulating in the lower parts of the body, contains a much smaller proportion of it. Now, on stopping the inhalation, the blood, circulating in the heart and brain, speedily passes off by the veins, and is succeeded by the comparatively pure blood coming from the lower regions of the body; and so the narcotic symptoms disappear.

It is far otherwise, when alcohol is absorbed from the stomach, for the whole mass of blood must be impregnated with it, before a highly charged blood can be applied to the heart and brain; and then, the effect continues for many hours till the alcohol has been thrown out of the system by the skin and lungs.

It must not be supposed, with respect to the ether, that, on the subsidence of the narcotism, it disappears from the body; for it is merely weakened in its effects, by being diffused equably over the whole mass of blood; but, that it remains within the body is obvious from the smell of the breath for many hours afterwards, and from its frequently causing copious perspiration.

The small quantity of ether, necessary to produce narcotism when inhaled, depends on the principle above stated, that the ether is applied directly and continuously to the tissues of the heart and brain. It is difficult to determine the actual *dose* of the ether, or the quantity of it absorbed into the blood. The first step is to determine what quantity of it is inhaled into the lungs; and this inquiry is the more important as there is a necessary connection between the quantities of air and of ethereal vapour which are simultaneously inhaled, and by determining the one we determine also the other. Now, if at any given temperature, the chamber of the inhaler be saturated with vapour, since there is a free communication between the chamber and the external air, it is obvious that the tension of the ethereal vapour, added to that of the air within the chamber, must just balance the pressure of the external atmosphere. We know the tension of the vapour of ether at all ordinary temperatures from the experiments of Dalton. Supposing, therefore, the barometer to be at 30 inches, we have only to ascertain from Dalton's table the height of the column of mercury indicating the maximum tension of the vapour at any given temperature, and also the difference between that column and one of 30 inches high, and we then have two numbers which express the relative volumes of ethereal vapour and air existing in the chamber of the inhaler. Thus, at the temperature of 64°, the maximum tension of ethereal vapour corresponds to a column of mercury 15 inches high, and the difference between that column and one of 30 inches is also 15 inches, so that equal volumes of ethereal vapour and of air are contained in the chamber of the inhaler. At the temperature of 96°, again, the tension of the vapour is equal to that of the atmosphere, or to a column of mercury 30 inches high, so that the whole air is expelled from the chamber, which is entirely filled with pure ethereal vapour. But such an atmosphere could not be respired without immediately causing asphyxia from want of oxygen. Even at the temperature of 64° the proportion of air in the atmosphere of the chamber is reduced to one half, whence we may infer that during the inhalation of ether, the application of artificial heat is both unnecessary and dangerous, for by increasing the tension of the ethereal vapour the proportion of common air in the atmosphere of the chamber is proportionally diminished, and the risk of asphyxia made greater accordingly.

To determine the weight of the ethereal vapour we assume that the relation of 1 to 2·583 between the specific gravity of atmospheric air and that of ethereal vapour is constant whenever they are at the same temperature and subjected to the same pressure. Taking, therefore, the weight of a cubic inch of atmospheric air, when the barometer is at 30 inches, to be ·310117 of a grain at 60° F. it becomes ·307695 gr. at 64°, and ·289595 gr. at 96°, whence we deduce the weight of a cubic inch of ethereal vapour at 64° to be ·397388 gr., and at 96° to be ·748023 gr.

To find the weight of the vapour inhaled in five minutes, we assume that 18 respirations are made in the minute, and that 15 cubic inches of gaseous fluid are taken into the lungs at each inspiration. We thus find by calculation, that if it were possible for any person to breathe, for five minutes, an atmosphere of ethereal vapour at 96° F., he would inhale 1010 grains of the vapour, or 2 *medicinal ounces* + 50 grains; and that at the temperature of 64° there would be inhaled, in the same time, 536 grains, or *an ounce* + 56 grains.

It thus appears, that at the temperature at which ether is commonly inhaled, if the air in the chamber of the inhaler were fully saturated with ethereal vapour, an ounce of it would be introduced into the lungs in five minutes; but of that quantity at least three-fourths would be again thrown out with the expired air, so that only two drachms would remain to be absorbed. There is, however, a still further reduction to be made, for during the inhalation, the atmosphere of the chamber is undergoing a continual renovation, and as the external air rushes into it with far greater rapidity than the ethereal vapour is generated, there is not time enough for the latter to attain its maximum tension. The deficiency thus occasioned may probably be estimated at about one-half. It must obviously be the greater the smaller the chamber of the inhaler, and we may therefore infer that there is an advantage in employing an apparatus of which the chamber is of large size.

Taking, then, into account the whole of the circumstances above mentioned, it appears to me probable, that by the inhalation of ether during the space of five minutes, not more than a drachm of it is introduced into the blood; and yet that quantity has been found to induce such a state of narcotism, that the most severe operations in surgery occasion no feeling of pain. Now it has been stated above, that a quantity of ether, seven times greater, has been administered by introducing it into the stomach. This dose, though largely diluted with water, excited a violent sense of heat and pain in the region of the stomach, and at length passed off by a profuse perspiration, without having occasioned any narcotic symptom, except a slight giddiness. It is obvious, therefore, that the recent important discovery of the influence of ether over the sensibility of the nerves, depends entirely on the mode in which the ether is administered, and not on any hitherto unknown power possessed by it as a physiological agent.

The preceding observations, with respect to ether, are confirmed by the fact familiarly known with respect to alcohol, that persons employed in bottling spirits, if not habituated, are readily intoxicated; and that this kind of intoxication is almost immediately relieved by going into the open air.

[*The remainder of this paper will appear in an appendix, as the wood-cut by which it is to be illustrated is not yet in readiness.*]

10*th March*, 1847.—*The* VICE-PRESIDENT *in the Chair.*

Messrs. Charles Watson, and J. H. H. Lewellin were admitted members.

Mr. Smith of Deanston finished his oral account of the progress of mechanism.

31*st March*, 1847.—*The* VICE-PRESIDENT *in the Chair.*

Dr. Peter Stewart was elected a member.

The Vice-President read the following letter from Professor Clark of Aberdeen:—

XXV.—*On a method by the late John Wilson, Esq. of Thornly, of facilitating the Arithmetical Calculation of the Contents of Solids.* By THOMAS CLARK, M.D., *Professor of Chemistry, Marischal College, Aberdeen.* (*Communicated in a letter to the Vice-President.*)

I HAVE been sorry to observe in the newspapers the death of Mr. Wilson of Thornly. The event recalls to my mind an important discovery of his in calculation, which is extensively applicable to most of the ordinary operations of mensuration. It was made by Mr. Wilson many years ago, but it lies buried, and, I fear, unnoticed and unknown in his Survey of Renfrewshire.

The following is the form of statement that makes most obvious the practical bearing of Mr. Wilson's discovery:—

1 Cubical Foot = 1728 cubical inches.
" = 2200 cylindrical inches.
" = 3300 spherical inches.
" = 6600 conical inches.

True, the result is not strictly accurate; for, indeed, no finite number can give with strict accuracy the relation between rectilinear and circular dimensions. The cylindrical, spherical, or conical dimensions, will be too much, by one in 13,931 of cubical dimension, corresponding to one in 41,792 of linear dimension. This would be an eighth of an inch on the height of St. Rollox chimney. Such minuteness must, more than ten times, exceed the accuracy that is attainable in the ordinary operations of measuring, in subservience to manufacture and the arts; and, therefore, for all ordinary purposes, it were idle to apply for any correction. My recollection leads me to doubt whether minuter accuracy has been reached in the most scientific measurements, where measurement itself is a primary object, instead of being, as it commonly is, a subsidiary one; for example, in the comparison of standard measures of length. But it is important that the correction be such as can be made without calculating the results over again. Now, this is what can be done most easily. Subtract one-14,000th, and you get a remainder, that is one in about 2,800,000 of cubical content, still above the truth. If we choose again to subtract one-200th of the former correction, we shall get a remainder that is now too low by 3 of cubical dimension, corresponding to one of linear dimension, in 1,000 millions, or, more correctly still, 999 millions. These are very simple and easy corrections. Were they less easy, the objection to them, as corrections, would be of little practical weight, for the application of any correction can but very seldom be needed. Subject to the foregoing corrections, 1728 is the fourth part of the circumference of a circle whose diameter is 2200. This remarkable numerical coincidence, you will perceive, is the foundation of the table.

Such a table as the foregoing should find a place, not only in every book of mensuration, but in every book of common arithmetic. I need not point out to you how much, by the aid of it, the most generally required parts of mensuration might be taught in ordinary schools, as part of the course of arithmetic.

By making so useful a discovery generally known, there is the reality of the diffusion of useful knowledge without the cant; there is honour to the worthy dead, and such advantage to the living as he felt delight in conferring.

Under this impression, it has occurred to me that the subject will probably appear to you a proper one to submit to the Glasgow Philosophical Society, not only as likely to be grateful to many of the members, so recently after the departure of the venerable author of the discovery, but in the view of making it more useful, as they will be able, and, I have no doubt, they will be disposed to make it more widely known.

In all questions relating to the simplification of weights and measures, a subject much studied by Mr. Wilson, his discovery has long appeared to me to have an important bearing; for he seems by this discovery to have conclusively determined that the inch, as the twelfth part of the foot, must ever be retained, for the sake of its convenience, in computing cubical dimension, whenever the circle is an element of that dimension.

This important practical consideration had escaped all the men of science that had previously investigated the same subject.

Professor Gordon gave an account of the viscous theory of Glaciers, illustrated by models and drawings from Professor Forbes.

XXVI.—*Analysis of a Slag, from a Lime-kiln.* By MR. JOHN BROWN.

THIS Slag presented itself in the form of a congeries of black fused masses, with a resinous fracture, in a lime-kiln at St. Rollox. It dissolved in acids, and gelatinised on evaporation. Its composition was found to be

	Experiment.		Atoms.		Calculated.
Silica,	36·47	......	7	......	38·62
Lime,	28·89	......	3	......	28·96
Protoxide of Iron,	12·68	......	1	......	13·79
Alumina,	18·88	......	3	......	18·62
	96·92				100·00

It consists approximately of simple silicates, with an excess of silica, the formula being—

$$FeO\ SiO + 3\ (CaO\ SiO) + 3\ (AlO\ SiO.)$$

The powder emitted a few bubbles of gas when heated with an acid.

7th April, 1847.—*The* VICE-PRESIDENT *in the Chair.*

Dr. Nicol made an oral communication on the relation of the science of Astronomy and Geology.

14*th April,* 1847.—MR. LIDDELL *in the Chair.*

The following paper was read:—

XXVII.—*On a Method for the Analysis of Bodies containing Nitric Acid, and its application to Explosive Cotton.* By WALTER CRUM, ESQ., F.R.S.

AT the first meeting of the present Session of the Philosophical Society, I gave an account of some experimental inquiries into the nature of gun-cotton, a body whose composition was then little known. I had at that time chiefly occupied myself with its nitrous contents, and described a method by which some approximation could be made to a quantitative result for nitric acid. On resuming the subject, I found that much was wanting to render the method a rigorously accurate one; and I shall now relate what I have since done to simplify and complete it. I shall first, however, give an account of its application to nitrate of potash,—a body of known composition, and easily obtained in a state of purity,—to which I had recourse as a means of proving the accuracy of the method, and detecting any fallacy to which it might be liable.

Nitric Acid in Nitrate of Potash.—The salt I employed was purified by repeated crystallization, and fused at little more than its melting heat. A glass jar, eight inches long and an inch and a quarter in diameter, is filled with, and inverted over mercury. A single lump of the fused nitrate, weighing about six grains, is let up into it, and afterwards fifty grains of water. As soon as the nitrate is dissolved, 125 grains of sulphuric acid, ascertained to be free from nitric acid, are added. By the action of the mercury upon the liberated nitric acid, deutoxide of nitrogen soon begins to be evolved, and usually in about two hours, without the application of heat, the whole of the nitric acid is converted into that gas. Occasional agitation is necessary, and it is easily performed by giving a jerking horizontal motion to the upper part of the jar. The surface of the sulphuric acid is then marked, and three-fourths of a cubic inch of solution of sulphate of iron, recently boiled, let up into the jar. The gas is rapidly absorbed, except a small portion at last, which must be left several hours to the action of the solution, or be well agitated in a smaller tube with a fresh portion of it. No correction of the nitric oxide has to be made for moisture; for the mixture of acid and water which I employed, as I ascertained by direct experiment, has no perceptible force of vapour. In one experiment,

5·40 grains nitrate of potash yielded

4·975 cubic inches of gas, at 60° Fahr., and bar. 30 inches.

The residue not absorbable by sulphate of iron, was

0·015 cubic inch; leaving

4·96 cubic inches of nitric oxide, =1·594 grains NO_2, and which correspond to

2·869 grains nitric acid, or 53·13 per cent. of the nitrate of potash.

Four consecutive experiments made in this manner yielded—

53·13
53·14
53·73
53·29

Mean, 53·32

Or leaving out the third experiment—

53·19

The calculated per centage of nitric acid in nitrate of potash, the acid being represented by 6·75, and the potash by 5·8992, is—

53·36*

In order further to determine whether the presence of organic matter

* By Thomson's numbers, the per centage of nitric acid in nitre is 52·94. By Berzelius, 53·44.

would interfere with the liberation of the nitric oxide, the experiment was repeated with the addition of three grains of cotton wool, which was first dissolved in the sulphuric acid; the result was—

53·24

Other nitrates are analysed in the same manner. For salts in powder, which it is difficult to pass through mercury without loss, I cut a quarter-inch glass tube into little cylinders for them, of half an inch long, and closed up the ends with thin paper fastened with gum. In the analysis of numerous samples of crude nitrates, the residue, which is azote, may be taken as a constant quantity, and the jar graduated in such a manner that the volume of gas may be read off at once as the per centage of nitric acid.

PREPARATION OF GUN-COTTON.—The cotton I employed was fine Sea Island. It was first thoroughly carded, and then bleached, by boiling in caustic soda, and steeping in solution of bleaching powder; then caustic soda again, and afterwards weak nitric acid. It was well washed and beaten in a bag with water after each operation. When burnt, 10,000 parts left 9 of ashes. It was considered to be lignin, nearly pure.

The cotton, dried and carded after bleaching, was exposed in parcels of ten grains each, for several hours, to the heat of a steam-bath, and each parcel was immersed, while hot, in one ounce measure of the following mixture:—

One measure Sulphuric Acid, spec. grav., 1·840.
Three measures of pale lemon coloured Nitric Acid, of 1·517.

After one hour it was washed in successive portions of water, till no trace of acid remained, and dried in the open air.

Thirty grains of bleached cotton wool, dried at 65° Fahr. became, after being some hours in a steam-bath, 28·32 grs., and lost, therefore, 5·6 per cent. of water. It increased to 51·08 grs. when made into gun-cotton, and dried in the open air. Dried further in vacuo, over sulphuric acid, it was reduced to 50·40 grs., and lost therefore 1·33 per cent. of water.

100 of dry cotton produced
177·9 of dry gun-cotton.

The gun-cotton thus prepared is whiter, but less transparent, than the original bleached wool. It appears to be little liable to change, but a slight elevation of temperature causes a commencement of decomposition, and the colour becomes more or less brown. It is much less tenacious than cotton wool. Dissolved in nitric acid, and tested with chloride of barium, it gives no indication of sulphuric acid.

The increase of weight above stated is the greatest I have been able to obtain; and I had completed its analysis in the manner I shall describe, when I found reason to believe that it still contained a portion of unaltered cotton. With a view to saturate that portion, it was immersed the second time, and for twenty-four hours, in the same mixture of acids, but without yielding any greater quantity of nitric acid.

An immersion of one hour in nitric acid alone gave a better result. It lost in weight by this second process 0·47 per cent. It was little altered in appearance, but after being dried in the open air, it lost in the air-pump only 0·69 per cent., instead of 1·33, as in the former case. It is this substance of which I will now relate the analysis.

Ashes in Gun-Cotton.—Sixteen grains of gun-cotton were dissolved in nitric acid. The solution being evaporated by degrees, and burnt to ashes, left 0·035 gr. of a reddish ash, or 0·22 per cent.

Nitric Acid in Gun-Cotton.—In this process the same apparatus is employed as for nitrate of potash. About six grains of the gun-cotton, containing a known quantity of water, is collected into a ball—squeezed between the finger and thumb to free it as much as possible from air—and let up into the jar, over the mercurial trough. 125 grains of sulphuric acid are added to it. Nitric acid is liberated, and, being acted upon by the mercury, produces nitric oxide. After one hour, when about three-fourths of the whole gas has been evolved, and the gun-cotton is entirely dissolved, fifty grains of water are added. In another hour the increase of gas ceases; in a few hours more its boundary is noted, then treated with sulphate of iron, and the residue measured. It consists of azote from the common air introduced with the gun-cotton, and a minute portion also, which is always accidentally entangled between the mercury and the glass. Its oxygen is absorbed by the mercury, when in the state of nitrous acid.

In one experiment—

6·02 grains of gun-cotton = 5·978, after being dried over sulphuric acid in vacuo, and =
5·964 grains, after deducting ashes, produced
5·513 cubic inches of gas, bar. 30 in., therm. 60°, of which
0·08 was left by sulphate of iron.
5·433 cubic inches, therefore, were deutoxide of nitrogen =
1·746 grains NO_2, which represent
3·143 grains of nitric acid, or 52·70 per cent.
Another experiment gave 52·68 per cent.

The gun-cotton prepared by a single immersion gave only 51·42 per cent. of nitric acid.

Carbon in Gun-Cotton.—Having failed to obtain good results by burning this substance with oxide of copper, I used chromate of lead, precipitated from the nitrate, and heated to redness. I employed for the combustion an apparatus which I used many years ago for the analysis of indigo, and I still find it very convenient for substances which do not require a strong red heat. It consists of a tube of hard glass, eight inches long and three-eighths of an inch in diameter; the gases from which are led by a small bent tube under the receiver in a mercurial trough.

1 inch at the closed end of the tube is filled with eight grains chlorate of potash, ground with chromate of lead.

4½ inches are filled with chromate of lead, among which is ground to powder three grains of the gun-cotton.

1½ inches contain chromate of lead that has been used to wash out the mortar.

A glass plug separates these materials from the perforated cork which joins the two tubes. The materials are gradually heated with broad-wicked spirit lamps. Carbonic acid comes over, mixed, when in the receiver, with nitric oxide and the azote of the apparatus; and when all the gun-cotton is consumed, the lamps are extended to the chlorate of potash. The oxygen gas thus liberated, which in other cases is useful to consume carbonaceous matter that may have escaped the chromate, expels in this case all remains of carbonic acid, and passing itself into the receiver, mixes there with the nitric oxide, and causes its entire absorption by the mercury. Oxygen and azote are then the only gases left along with the carbonic acid, and as those are not absorbable, an addition of half a cubic inch of solution of caustic soda indicates exactly the quantity of carbonic acid present.

In one experiment, 2·993 grains of gun-cotton (after deducting water and ashes,) yielded 7·952 cubic inches of gas, of which 5·733 was carbonic acid, = 0·739 grains carbon, or

	24·69 per cent.
A second experiment gave	25·16
Mean,	24·92

ELEMENTS OF WATER IN GUN-COTTON.—To burn gun-cotton for the purpose of collecting its oxygen and hydrogen in the state of water, I ground up ten grains of it with pounded flint, and used the combustion tube already described, having attached to it a chloride of calcium tube, and afterwards a tube with asbestus moistened with sulphuric acid. But, along with the water, ammonia and other matters were obtained, which destroyed the result. I next used a thin glass tube of a foot and a half long, bent so that a foot in the middle of it could dip into cold water. Such water as would condense at 65° Fahr. was collected. The gas was led through it into a mercurial trough, and measured. A trace of cyanogen appeared in the last portions of gas, while the oxygen from the chlorate of potash was burning a quantity of charcoal that had escaped the nitric acid.

After the experiment, the refrigerating tube was found studded with large crystals of bicarbonate of ammonia. It contained very little water in the liquid state. The crystals and the liquid were washed out with more water, converted into muriate of ammonia, and found to contain 0·675 grain $NH_3\ 2\ CO_2$, the hydrogen of which represents

0·299 grain of water. There was besides

2·025 grains water in the tube. And in the 22 inches of gas which were obtained, assuming it to be saturated with moisture, which is doubtful, there was

0·088 grain of water—making in all

2·412, from which must be deducted

0·160 grain hygrometric water in the gun-cotton and in the flint, leaving

2·252 for the water in 9·92 grains of dry gun-cotton, or 22·70 per cent.

In a second experiment, where the only difference was in having moistened cotton for the gas to pass through before entering the mercurial trough, the water obtained only amounted to 20·61 per cent. I did not proceed farther. These were the two last of a number of experiments, and the determinations of nitric acid and carbon are so much more satisfactory, that I prefer resting the water contents upon their results.

Purified cotton wool (lignin) is composed of $C_{12}\ H_{10}\ O_{10}$. During its transformation into gun-cotton, there is no indication of change in the proportions of its oxygen and hydrogen. The difference, therefore, between the weight of the substance employed and that of the nitric acid and carbon found by experiment is oxygen and hydrogen in the proportions which form water.

The experiments I have related give the following for the composition of gun-cotton:—

52·69	nitric acid,
24·92	carbon, and leave
22·39	for water.
100·00	

These numbers are nearly in the proportions of 12 C, 7 HO, 3 NO_5.

Found.	Calculated.
52·69	52·69 = 3 NO_5.
24·92	23·41 = 12 C.
22·39	20·49 = 7 HO.
100·00	96·59

Leaving a remainder of 3·41 per cent., consisting of 1·51 carbon, and 1·90 water. These, however, are nearly the proportions which form lignin.

Found.	Calculated.	
1·51	1·51 = 12 C	= lignin.
1·90	1·88 = 10 HO	

Gun-cotton, from the form in which it is produced, is not one of those substances we can expect to obtain in absolute purity. Every previous improvement in its preparation had diminished this excess of unaltered cotton, and I had no reason to suppose the last portion perfect, considering the difficulty with which some of the previous stages of improvement had been attained.

The specimen I have thus examined consists, therefore, of—

$$\begin{array}{rl} 96{\cdot}59 & \text{gun-cotton } (12\ C,\ 7\ H,\ 7\ O,\ 3\ NO_5.) \\ 3{\cdot}41 & \text{lignin } (12\ C,\ 10\ H,\ 10\ O.) \\ \hline 100{\cdot}00 & \end{array}$$

And pure gun-cotton consists of—

$$\begin{array}{rl} 24{\cdot}24 = & 12\ C. \\ 21{\cdot}21 = & 7\ HO. \\ 54{\cdot}55 = & 3\ NO_5. \\ \hline 100{\cdot}00 & \end{array} \qquad \begin{array}{rl} 24{\cdot}24 = & 12\ C. \\ 2{\cdot}36 = & 7\ H. \\ 14{\cdot}14 = & 3\ N. \\ 59{\cdot}26 = & 22\ O. \\ \hline 100{\cdot}00 & \end{array}$$

It is lignin in which three atoms of water are replaced by three atoms of nitric acid.

21st April, 1847.—*The* VICE-PRESIDENT *in the Chair.*

On the motion of Mr. Liddell, the Society agreed to request Dr. R. D. Thomson to undertake the duties of interim Librarian, in room of Mr. J. J. Griffin, who resigns in consequence of his being about to remove to London.

XXVIII.—*Notice of Stirling's Air Engine.* By WILLIAM THOMSON, B.A., *Professor of Natural Philosophy in the University of Glasgow.*

PROFESSOR WILLIAM THOMSON gave an account of Stirling's Air Engine, and exhibited a working model.

Attention was called to the circumstance that, in accordance with Carnot's theory,* of which an explanation had been given by Professor Gordon at a previous meeting of the Society, the mechanical effect to be obtained by an Air Engine, from the transmission of a given quantity of heat depends on the difference between the temperatures of the air in the cold space above and the heated space below the plunger; as this difference is considerably greater than that which exists between the boiler and the condenser in the best condensing Steam Engines, it appears that, if the practical difficulty in the construction of an efficient Air Engine can ever be removed to nearly the same extent as already has been done in the case of the Steam Engine, a much greater amount of mechanical effect would be obtained by the consumption of a given quantity of fuel.

* An account of this theory is given in a paper by Clapeyron on the Motive Power of Heat, of which a translation is published in Taylor's Scientific Memoirs, vol. i.

Some illustrations, afforded by the Air Engine, of general physical principles, were also noticed. If the Air Engine be turned *forwards*, by the application of power, and if no heat be applied, the space below the plunger will become colder than the surrounding atmosphere, and the space above hotter. Expenditure of *work* will be necessary to turn the engine, after this difference of temperatures, contrary to that which is necessary to *cause* the engine to turn forwards, has been established. If, however, we prevent the temperature in one part from rising, and in the other from sinking, the engine may be turned without the expenditure of any work, (except what is necessary in an actual machine for overcoming friction, &c.) One obvious way of retaining the two parts at the same temperature, is to keep the machine immersed in a stream of water; but there is another way in which this may be done, if we can find a solid body which melts at the temperature at which it is required to retain the Engine. For instance, let this temperature be 32°; let a stream of water at 32° be made to run across the upper part of the Engine, and let the lower part of the vessel containing the plunger, which is protected from the stream, be held in a bason of water at 32°. When the Engine is turned forwards, heat will be taken from the space below the plunger and deposited in the space above. Now, this heat must be supplied by the water in the bason, which will, therefore, be gradually converted into ice at 32°. Hence we see that water at 32° may be converted into ice at 32°, without the expenditure of any work. This may also be very easily proved in the following manner:—

Let a syringe be constructed of perfectly non-conducting materials, except the lower end of the cylinder, which is to be stopped by a solid plate, a perfect conductor. The syringe being at first full of air, at atmospheric pressure, and at the temperature of 32°; let the lower end be dipped in a stream of water at 32°, and the piston be pushed down. Let the syringe be then placed with its lower end in a bason of water at 32°, and the piston be allowed to rise. The mechanical effect given out in this part of the operation will be equal to the work spent in the former, and a portion of the water in the bason will be turned into ice.

Note.—To avoid perplexity, in the account which was given, it was supposed that the temperature of the air is always the same as that of the vessel in which it is contained, which will only be strictly true, even were the action of the plunger perfect in altering the temperature of the air, when the motion is very slow.

April 28th, 1847.—The Society met for the last time this Session.—
The Vice-President *in the Chair.*

Mr. Liddell made his concluding report on the winding up of the affairs of the Society's exhibition at the beginning of the year. All the accounts were paid, leaving a balance of receipts over expenditure, now in the Union Bank, of £453 8s. 10d., which, with £7 2s. 10d. of interest to the 20th of April, current, leaves an available balance of £460 11s. 8d., to be laid aside for future exhibitions of a similar kind, in conformity with article 5 of contract agreement betwixt the Town Council and the Philosophical Society, of date 1st April, 1846, which runs thus—"If it should happen that, in place of a loss, there should be an overplus of money received, said overplus to be laid aside as a fund for future exhibitions of a similar nature." Mr. Liddell moved, agreeably to a recommendation contained in the Acting Committee's report to the General Committee on the exhibition, and adopted by the latter on the 20th April, "that this money, in the meantime, be lodged with the Corporation of the City, at the current rate of interest, in name of the Lord Provost and Senior Bailie of Glasgow, *ex officio*, and of the President and Vice-President of the Philosophical Society, also *ex officio*, as trustees for the application of this sum; and that the Treasurer of the Philosophical Society for the time being, be the custodiers of the bill or other voucher for the debt; and that he be requested to see that the interest be added to the principal sum twice every year, at the usual terms of Martinmas and Whitsunday, commencing at the term of Martinmas 1847. And further, that the Treasurer be required to report to the Philosophical Society at least once every year the state of the fund, and that the Philosophical Society see that this report to them is regularly given in." Which motion was unanimously approved of by the Society.

The two following papers were communicated by Dr. R. D. Thomson.

XXX.—*On the Chemical Composition of the Substances employed in Pottery.* By Mr. R. A. Couper.

Most kinds of pottery are composed of two parts, viz., the body and the glaze.

The body is the principal part of the vessel, being the base or foundation, as indicated by the term itself.

The glaze is a thin transparent layer of glass which covers the body and fills up its pores, giving it a smooth surface, with a polished and a finished appearance.

I. The substances principally employed to form the body of earthenware are, clays of different kinds, flint, and Cornish stone or granite.

Clay, which constitutes the base of the body of earthenware, is distinguished from silicious earth by becoming plastic when mixed with water, and being very soft and not gritty to the feel; also, when burned it keeps its form, and becomes firm and solid, whereas silicious earths crumble into a powder when burned. Clay, when intensely heated, as in porcelain manufactories, does not regain its plasticity, which it loses in the burning, although pounded very fine, in which state it is technically termed potsherd.

Clay is obtained naturally from Cornwall, Dorset, and Devonshire, and is the finer particles of decomposed feldspar, deprived of its alcali.

(1.) The finest clay (termed *China Clay*) used in Britain is obtained artificially from Cornwall, by running a stream of water over decomposed granite, which carries with it the finer particles of feldspar, and is then received into catch-pools or ponds, where it is allowed to subside. The water is then run off, leaving a fine sediment, which is removed and exposed to the atmosphere for four or five months, when it is ready for export. By analysis of this clay, previously dried at 212°, I found it to consist of—

	I.	II.
Silica,	46·32	46·29
Alumina,	39·74	40·09
Protoxide of iron,	·27	—
Lime,	·36	·50
Magnesia,	·44	—
Water,	12·67	—
	99·80	

For the second analysis I am indebted to Mr. John Brown.

The more common clays, which are found naturally deposited, are supposed to have been produced in a similar manner to the China clay; the rains having washed from the hills the decomposed rock into a lake or estuary, where it has subsided and gradually displaced the water, and become in the course of time perfectly firm and solid, forming fields of clay. The clay is found in layers or strata lying over each other; each layer possessing some distinctive property from the other, which renders each clay fitted for a peculiar purpose.

(2.) *Sandy Clay*, (stiff or ball clay,) is the upper layer of clay, and is used by itself for making salt glazed ware; it is well adapted for this kind of ware, in consequence of the considerable quantity of silica or sand which it contains. By analysis of this clay I found it to be composed of—

Silica,	66·68
Alumina,	26·08
Protoxide of iron,	1·26
Lime,	·84
Magnesia,	a trace.
Water,	5·14
	100·

Being previously dried at 212°, spec. gravity = 2·558.

(3.) *Pipe Clay* is the second layer, which is used in making tobacco pipes. This clay is not employed for manufacturing earthenware, owing to its possessing the property of contracting more than sandy clay. It was analysed by Mr. John Brown, who obtained—

Silica,	53·66
Alumina,	32·00
Protoxide of iron,	1·35
Lime,	·40
Magnesia,	a trace.
Water,	12·08
	99·49

(4.) *Blue Clay* is of a greyish colour, and is considered the best layer of clay in the whole series, owing to its burning perfectly white, and approaching in character nearest to the China clay. As analysed by Mr. John Higginbotham, it was found to consist of—

Silica,	46·38
Alumina,	38·04
Protoxide of iron,	1·04
Lime,	1·20
Magnesia,	a trace.
Water,	13·57
	100·23

Also previously dried at 212°. There is a variety of other clays obtained from these fields which are of less value, and need not be enumerated here, as they are similar in appearance to those already noticed.

(5.) *Red or Brown Clay*, which is very abundant in the neighbourhood of Glasgow, is a surface clay, and contains a large quantity of peroxide of iron, which gives it a deep brown colour. It is of this clay that common black ware, flower-pots, and red bricks are made, which do not require a very high temperature, else they would fuse. The analysis gave

Silica,	49·44
Alumina,	34·26
Protoxide of iron,	7·74
Lime,	1·48
Magnesia,	1·94
Water,	5·14
	100·

(6.) *Yellow Clay* is obtained from various parts of the country, and is so called from possessing a yellow colour both before and after being burned, owing to the presence of iron.

By mixing sandy clay and red clay together we gain an artificial yellow clay, which is often employed.

Yellow clay, as analysed by Mr. John Brown, was found to contain—

Silica,	58·07
Alumina,	27·38
Protoxide of iron,	3·30
Lime,	·50
Water,	10·30
Magnesia,	a trace.
	99·55

(7.) *Fire Clay* is also very abundant in this country, and occurs both on the surface and several fathoms under ground. It is termed marl, and is used principally in potteries for making saggars, or vessels for placing the ware previous to burning, to protect them from the flame; and, owing to its coarse particles, which cause the body to be very porous, is well adapted for strong heats. Crucibles or large pots for glass works, in which the glass is fused, are also made from fire clay, as well as bricks known under the name of fire bricks. This clay was analysed by Mr. John Brown, who obtained—

Silica,	66·16
Alumina,	22·54
Protoxide of iron,	5·31
Lime,	1·42
Magnesia,	a trace.
Water and Coal,	3·14
	98·57

(8.) *Flint*, as used in potteries, is first calcined, then water ground, in which state it is used for mixing with clays, and is called slop flint; but for glazes, it is evaporated to dryness, and used in the dry state with other articles which constitute the glaze.

(9.) *Cornish Stone* or granite, is water ground, then evaporated to dryness for mixing in glazes, and is used in the slop state for mixing with clays.

(10.) *Plaster of Paris*, or gypsum, which is employed in forming the moulds in which certain kinds of pottery are cast, is a native sulphate of lime, and is a very important article to the manufacturer of earthenware, owing to its singular property of parting easily with the clay, by the application of a slight heat. Plaster of Paris requires to be dried at a high temperature before using it; but if it is over dried it will not set for making moulds; the drier the stucco the harder are the moulds that are made of it, and they will stand more readily a greater degree of wear. Plaster of Paris casts, as commonly prepared, cannot again be used for the same purpose.

II. The colours used for printing are similar to those employed in painting on ware, excepting that the colours for painting may not be so expensive as for printing; both, however, form an important and extensive part of the materials of a pottery. The manufacturers of earthenware are much occupied with the improvement of the variety and beauty of the colours, as well as of the patterns or styles that are produced, and hence a great emulation exists among those employed in the trade.

(1.) The blue colour in printing is produced from cobalt, which is used with flint, ground glass, pearl ash, white lead, barytes, China clay, and oxide of tin in reducing its strength.

(2.) The brown colour, by ochre, manganese, and cobalt.

(3.) The black colour, by chromate of iron, nickel, ironstone, and cobalt.

(4.) The green colour, by chrome, oxide of copper, lead, flint, and ground glass.

(5.) The pink colour, by chrome, oxide of tin, whiting, and China clay, which are mixed in various proportions, fused together at a high temperature, then pounded and mixed with oil when it is ready for the printer's use.

For the following analysis of a blue cobalt calx, I am indebted to Mr. John Adam—

Silica,..	17·84
Peroxide of cobalt,..............................	19·42
Peroxide of iron,................................	25·50
Water,...	8·41
Carbonate of lime and magnesia,..................	28·45
	99·62

The oil that is used for mixing with the colours is made by boiling the following substances together, viz.,—linseed oil, rape oil, sweet oil, rosin, common tar, and balsam copaiba in various proportions.

III. It is but recently since a new method has been applied to cause the colours to flow or spread over the surface of the ware. This object is effected by washing the saggars in which the ware is placed previous to its being fired in the glost kiln, with a mixture of—

(1.) Lime, common salt, and clay slip. Dry flows are also used, which answer equally well, the mixture being sprinkled on the bottom of the saggar. The following are some of those flows:—

(2.) Lime, sal ammoniac, and red lead.

(3.) Lime, common salt, and soda.

(4.) Whiting, lead, salt, and nitre.

(5.) But there is a wash made of lime, clay slip, lead, in general use for washing all the saggars employed in the glost kiln, which fuses on the inner surface of the saggar, making it perfectly close and not porous, otherwise the gloss required on the surface of the ware could not be obtained.

IV. The colours used in producing the dipt ware are of a very cheap kind, as it is only for common purposes that they are employed. The colours when used for dipt ware are put on the ware before it is burned. The following are some of those colours:—

(1.) A black dip is made from manganese, ironstone, and clay slip.

(2.) A drab dip, by nickel and clay slip.

(3.) A sage, or a greenish blue dip, by green, chrome, and slip.

(4.) A blue dip, by cobalt and clay slip.

(5.) A yellow dip, by yellow clay alone, or a compouud of white and red clay, natural, which produces the same results.

(6.) A red dip is produced from the red or brown clay, but it is not every quality of this clay that will answer, as it requires to burn red.

The first four of these dips are prepared by mixing a little of the colouring agent with a quantity of clay slip, while the two last mentioned dips are mixed with water to produce the slip state, in which condition they are employed.

V. There are several kinds of bodies manufactured, but they may be all classed under two heads, viz., porcelain and earthenware.

(1.) *Porcelain or China*, is a rich, very smooth, and transparent ware, and is the finest quality that has yet been manufactured. It is a fused body, and owes its transparency to this circumstance; it also requires a very high temperature to burn it, and is manufactured in this country from flint, Cornish stone, (granite,) China clay, and bone earth; the phosphate of lime employed acting as a flux partly fusing it. By analysis of two pieces of china from different manufactories in Staffordshire, I found them to be differently composed. The last of these species was also analysed by Mr. William Crichton; the three analyses being as follows:—

Silica,	39·88	40·60	39·685
Alumina,	21·48	24·15	24·650
Lime	10·06	14·22	14·176
Protoxide of iron, Phosphate of lime,	26·44	15·32	15·386
Magnesia,	—	·43	·311
Alcali and loss,	2·14	5·28	5.792
	100·	100·	100·

No. 1, by R. A. C.; No. 2, by R. A. C,; No. 3, by W. C.

(2.) Foreign manufacturers do not employ bone earth; but instead of it they use feldspar, the alcali of which supplies the place of the phosphate of lime; the Germans make the best porcelain for chemical purposes, as that body is more vitrified and less liable to be acted upon by acids, as well as being capable of standing a very strong heat; hence it is extensively used by chemists. By the analysis of some specimens of foreign porcelain, I obtained the following results:—

	Berlin.	Chinese Porcelain. superior.	Chinese Porcelain. inferior.
Silica,	72·96	71·04	68·96
Alumina and protoxide of iron,	24·78	22·46	29·24
Lime,	1·04	3·82	1·60
Alcali and Loss,	1·22	2·68	—
	100·	100·	99·80
Specific gravity,	2·419	2·314	2·314

VI. *Earthenware* is a very porous and less compact body than china or porcelain, owing to its containing little or no alkali, which is the great difference between these bodies. I had a piece of ware manufactured, resembling in appearance porcelain, as regards its porosity and compactness, slightly transparent, and capable of standing a very strong and sudden heat; it was produced by mixing soda to the extent of 3½ per cent. in a little clay prepared for the common white body, and was then fired in the biscuit kiln. The clay employed having been previously well dried, so as to weigh it without water, the proportional quantity of soda requisite was then calculated and weighed out; the clay was again mixed with water along with the soda; it was then formed into capsules, which, after being fired, and then broken, presented the appearance of a vitrified or fused body.

(1.) The common white ware, or earthenware, is made from flint, Cornish stone, China clay, and blue clay, and does not require such a high temperature in burning as the porcelain does. By analysis of a piece of white ware, manufactured in this city, it was found to contain—

Silica,	68·55
Alumina and protoxide of iron,	29·13
Lime,	1·24
Magnesia,	a trace.
	98·92
Specific gravity,	2·36

Coloured ware is also manufactured from the same substances, but mixed with a colouring agent which stains the body.

(2.) The toqua, or blue coloured ware, is coloured by cobalt, chrome, and oxide of zinc.

(3.) The sage, or greenish blue coloured ware, by nickel and cobalt.

(4.) The drab, or buff coloured ware, by chromate of iron, or nickel.

(5.) The body for the cane, or yellow coloured ware, is produced by a mixture of sandy clay and common red clay, the same as is used for red bricks, but is generally produced from the natural yellow clay found in particular localities.

(6.) The last mentioned body is also employed for making Rockingham ware, which only varies from the cane ware by possessing a different glaze.

(7.) The common black ware body is made from the red clay alone.

(8.) The Egyptian ware body is made from ironstone, stiff clay, manganese, and red clay.

These four last-mentioned bodies do not require nearly such a high temperature to burn them; therefore, they are, comparatively speaking, soft bodies.

(9.) Salt glazed ware is made from sandy clay, and a little sand to keep the body open, or make it less compact; but for large salt glazed ware, potsherd, which is ware that has been fired and then ground, is employed to render the body still more open or porous, and also to give it a greater capability of standing sudden heats or colds. This ware is much used in public works for chemical purposes; it is exposed to the action of the flame during burning, whereas other kinds of ware are protected by saggars from the flames.

VII. The glaze vitrifies the surface of the body, rendering it generally capable of withstanding acids. It is a very important point with the manufacturer to obtain a glaze which will adhere to the body without crazing or peeling off, as he may discover a good body, but not find a glaze to answer it, since every glaze will not adhere to the same body; and hence every manufacturer has a glaze of his own composition.

(1.) The substances used in the preparation of the glaze for the white ware are—borax, China clay, flint, Cornish stone, Paris white, and white lead. In preparing the glaze, a substance technically termed frett, is first made, consisting of borax, China clay, flint, Cornish stone, and Paris white, which are fused together in a kiln, and, when ready, allowed to flow into water, which shortens it, owing to the water being mechanically lodged in it and keeps it from adhering to the bottom of the vessel, rendering it much easier to pound. Frett is a beautiful glass, coloured by a little iron, and is pounded, and water ground along with Cornish stone, flint, and white lead. This constitutes the glaze for white ware.

	Analysis of white glaze.	Of Frett.
Silica,	43·66	55·98
Lime,	·52	2·52
Alumina and protoxide of iron,	9·56	10·38
Borax,	20·08	31·12
Carbonate of lime,	10·88	—
Carbonate of lead,	15·19	—
	99·89	100·
Specific gravity,		2·345

A piece of earthenware was brought lately from Wisconsin territory, N. America, having been discovered several feet under ground, the glaze of which was tested and found to be composed of silica, iron, alumina, lime, sulphate of lime, and antimony, which was a beautiful rich white glass, concealing a common red clay body.

(2.) The glaze of Rockingham ware possesses a beautiful brownish metallic lustre, and is made from Cornish stone, flint, manganese, red lead, and clay slip, the latter substance being a little clay mixed with water until it becomes of the consistency of milk.

(3.) The glaze for common black ware is made from the same materials, in different proportions, and has a brilliant black appearance.

(4.) The glaze used for cane, or yellow coloured ware, is made from flint, red lead, and Cornish stone.

(5.) The Egyptian ware owes its value to the beautiful and rich tinted black glaze, made from flint, Cornish stone, red lead, and manganese, with which it is covered. These four last mentioned glazes are made by stirring the substances together with a certain quantity of water, and passing it through a very fine sieve or search. Glazes do not require such a high temperature to fuse them on the surface of the ware as the body does to be burned.

(6.) The glaze for salt glazed ware is common salt, which is thrown in at the top of the kiln through a number of small apertures in the crown of it, and diffuses itself through all parts of the kiln, giving the ware the required glaze. The action that is supposed to take place when the salt is thrown into the kiln, is owing to its decomposition; the chlorine of the salt combines with the hydrogen of the water, which is mechanically lodged in the salt, forms muriatic acid gas, which passes off, while the sodium, with the oxygen of the water, then unites with the silica in the ware, forming a silicate of soda, which fuses on the surface. The salt is not thrown in until the kiln has been raised to its greatest necessary temperature.

TABLE OF THE COMPOSITION OF CLAYS AND PORCELAIN WHEN FREE FROM WATER.

	Silica.	Alumina.	Protoxide of Iron.	Lime.	Magnesia.	Phosphate of Lime and Peroxide of Iron.	Alcali and difference.	Specific Gravity.
Cornish China Clay, ...	53·16	45·61	·31	·41	·51	...	...	...
Cornish China Clay, ...	53·12	46·00	·31	·57	...	...	...	...
Sandy Clay, ...	70·29	27·47	1·33	·90	trace.	...	...	2·558
Pipe Clay, ...	61·39	36·61	1·54	·46	trace.	...	...	...
Blue Clay,.	53·52	43·89	1·20	1·39	trace.	...	...	...
Red Clay, ...	52·04	36·19	8·17	1·56	2·04	...	...	...
Fire Clay, ...	69·33	23·62	5·56	1·49	trace.	...	...	...
Yellow Clay, ...	65·06	30·68	3·70	·56	trace.	...	...	...
English China Ware, No. 1,...	39·88	21·48	...	10·06	...	26·44	2·14	...
English China Ware, No. 2,...	40·60	24·15	...	14·22	·43	15·32	5·28	...
English China Ware, No. 2,...	39·68	24·65	...	14·18	·31	15·39	5·79	...
Berlin Ware, ...	72·96	24·78		1·04	trace.	...	1·22	2·419
Superior Chinese Ware, ...	71·04	22·46		3·82	trace.	...	2·68	2·314
Inferior Chinese Ware, ...	68·96	29·24		1·60	trace.	...	...	2·314
Common White Ware, ...	68·55	29·13		1·24	trace.	...	...	2·360

XXIX.—*On the Analysis of Molybdate of Lead.* By Mr. John Brown.

Molybdate of Lead was first analysed by Klaproth, who proceeded in the following manner:—*

100 grains of the mineral, finely pounded, were treated with dilute hydrochloric acid, and the whole of the silica was thus separated. Upon cooling, the greater part of the chloride of lead was deposited in fine crystals. The clear supernatant liquor was then drawn off, and when sufficiently concentrated, the remaining chloride of lead was deposited. The whole of the chloride was then carefully collected together, dried, and weighed. Its weight was 74·5 grains. From this, the quantity of oxide of lead was ascertained, which was 64·42 grains. Every 100 grains of molybdate of lead contain, therefore, 64·42 grains of oxide of lead. When the solution had thus been freed from lead, it was concentrated by evaporation. Nitric acid was then added to the solution, which immediately became of a fine blue colour; when sufficiently concentrated, a quantity of molybdic acid separated. The solution was then evaporated to dryness, and the molybdic acid remained in the form of a fine citron-yellow powder, which when completely dried weighed 34·25 grains.

The constituents, therefore, of 100 parts of the purest crystals of Carinthian molybdate of lead, are, according to Klaproth:—

Oxide of lead,	64·42	59·59	corrected from
Molybdic acid,	34·25	34·25	the chloride.

As Klaproth did not know the true composition of chloride of lead, the quantity of oxide of lead given above is wrong. Calculating the quantity of oxide from the quantity of chloride which he obtained, we get 59·59 per cent. of oxide of lead, which is near the theoretical quantity, or 60·87. But the great error is in the molybdic acid. What Klaproth considered as silica, was very probably molybdic acid, as that acid is not entirely soluble in hydrochloric acid, and as he apparently deducted this as impurity, he gets too little molybdic acid. He also does not mention how he washed out the molybdic acid from the chloride of lead. It could not well have been done with water, for chloride of lead is soluble to a great extent. This is a point of imperfection in the analysis.

II. This mineral was next subjected to a close examination by Charles Hatchett, Esq. whose analysis is recorded in the Philosophical Transactions (vol. xviii. abridgment), from which the following is an extract:—

250 grains of the ore, freed from as much impurity as possible, were put into a glass flask and digested for some time under a strong heat with dilute sulphuric acid. When the solution cooled, the clear liquor was drawn off, and the residual sulphate of lead washed by subsidence. This process was repeated several times. The acid solutions were then filtered,

* Beiträge zur chemischen Kentniss der Mineral Körper. I. 265.

and the filtered liquid neutralised by caustic ammonia. After standing for twenty-four hours, a pale yellowish coloured precipitate fell down, which was collected on a filter, washed, and dried. Its weight was then 4·20 grains. It had a yellowish colour, and when dissolved in hydrochloric acid, gave a blue precipitate with yellow prussiate of potash.

Part of the clear blue solution, which was composed of sulphate and molybdate of ammonia, was then put into a retort and evaporated down, the rest of the solution being added as the liquid in the retort evaporated. The whole was then dried and strongly heated. In this manner all the sulphate of ammonia was driven off, while the molybdate of ammonia was decomposed into molybdic acid and ammonia—the former of which remained in the retort. The molybdic acid then weighed 95 grains. The sulphate of lead formerly obtained was then treated in the following manner:—It was boiled with 4 ounces of carbonate of soda in solution; the powder was then washed, and nitric acid, much diluted, was poured on it. The whole dissolved, except a small quantity of silica, which was thrown on a filter; this, when washed and dried, weighed ·7 grain. The acid was then exactly neutralised with caustic potash, which precipitated the lead as oxide. This, when washed and dried, weighed 146·00 grains.

The oxide of lead was then dissolved in nitric acid, and sulphuric acid was added. After standing for some time, the solution was filtered, and the filtered liquor saturated with caustic ammonia; after standing, a small quantity of peroxide of iron was precipitated, which, when filtered and dried, weighed 1·0 grain. This, when added to the former quantity of peroxide of iron, makes the quantity 5·2 grains, and the quantity of oxide of lead 145· grains.

The composition of 250 grains of molybdate of lead is therefore—

Oxide of lead,	145·0	58·00,	per cent.
Molybdic acid,	95·0	38·00	—
Peroxide of iron,	5·2	2·08	—
Silica,	·7	·28	—
	245·9	98·36	

If the iron and silica be subtracted as impurities, this analysis is very correct. But the method is very tedious and inconvenient, and requires very great care.

III. The next person who turned his attention to this mineral was Göbel.*

100 grains of the mineral were digested with dilute hydrochloric acid, with the assistance of heat. Upon cooling, the lead was deposited in the form of chloride. These crystals were then collected together and dried. The weight was found to be 72·5 grains, which is equivalent to 59 grains of oxide of lead. The solution, freed from lead, was evaporated to

* Schweigger's Journal fur Chemie und Physik, xxxvii. 71.

dryness; when perfectly dry, a small quantity of nitric acid was added, and the solution was again dried. The residue was then heated to redness in a close vessel, and weighed; its weight was found to be 40·5 grains.

100 grains contain therefore—

Oxide of lead,	59·0	58·0	corrected from
Molybdic acid,	40·5	40·5	the chloride.
	99·5	98·5	

This method is essentially the same as that used by Klaproth. The result, however, is much nearer the truth; but Göbel gets too much molybdic acid, and too little oxide of lead; this was probably owing to some of the chloride of lead not being obtained, as it is soluble to a great extent in water, (1 in 152 of water,) * and the analyst does not state how he washed the chloride of lead free from molybdic acid.

IV. The methods hitherto employed being liable to very great objections, the molybdate of lead was analysed by another method, which had proved successful in the hands of Mr. William Parry last year, in the College Laboratory.

26·84 grains of the mineral, finely pounded, were boiled for a considerable time with nitric acid, and filtered. The undecomposed mineral, along with a quantity of molybdic acid, remained on the filter. This was then completely washed; ammonia was then poured into the filter. The molybdic acid was thus dissolved, and the insoluble matter remained on the filter. This was then washed, dried, ignited, and weighed. The weight of the insoluble matter in 26·84 grains was 1·15 grains.

The solution containing the molybdate of ammonia was then evaporated to dryness, and heated to redness in a close vessel. The greater part of the molybdic acid was thus obtained. Its weight was 6·76 grains.

The first washings from the molybdic acid and insoluble matter were then concentrated. Caustic ammonia was added, in order to neutralise the excess of acid, and afterwards sulphohydret of ammonia was added in excess. In this manner the lead was precipitated in the form of sulphuret, while the tersulphuret of molybdenum was re-dissolved by the excess, giving the solution a deep red colour. The sulphuret of lead was then thrown on a filter and washed with water containing sulphohydret of ammonia. When completely washed, the sulphuret of lead was dissolved in muriatic acid, and after boiling for some time was filtered to get rid of the sulphur. The filtered liquor was then concentrated, and the lead precipitated by means of oxalate of ammonia; the precipitated oxalate of lead was then thrown on a filter, washed, and dried. By ignition the oxalate of lead was converted into the oxide; the quantity of which in 26·84 grains was thus found to be 16·20 grains, which is equivalent to 60·35 per cent. of oxide of lead.

* In two experiments 3963 grains of water at 60°, dissolved 26·2 grains $PbCl$, = 1 in 151 grains; and 4260 grains of water dissolved 27·6 grains $PbCl$, = 1 in 154 grains of water.

The next thing to be obtained was the rest of the molybdic acid. This was contained in the washings from the sulphuret of lead in the form of tersulphuret of molybdenum. When the solution was sufficiently concentrated, it was made slightly acid by means of hydrochloric acid, a brownish coloured precipitate fell down, which was tersulphuret of molybdenum. This was then thrown on a filter and washed. It was then dried at 212° and weighed. Its weight was 3·37 grains. From this and the previous quantity of molybdic acid, the quantity per cent. was calculated, which was 39·30 grains.

According to this analysis the composition of molybdate of lead is—

Molybdic acid,	39·30
Protoxide of lead,	60·35
	99·65

V. In the course of the preceding analysis it was observed that the sulphohydret of ammonia exercised a powerful solvent action on the mineral itself. The following new method of successfully analysing this mineral was therefore adopted:—

23·00 grains, after being reduced to a very fine powder, were digested with the aid of gentle heat in sulphohydret of ammonia. The solution became immediately of a deep red colour, owing to the tersulphuret of molybdenum which is held in solution by the sulphohydret of ammonia, while the lead was precipitated as sulphuret and fell to the bottom in the form of a black powder. The clear supernatant liquor was then drawn off, and a fresh portion of sulphohydret of ammonia was added. This after standing for some time, was thrown on a filter, and washed with water containing sulphohydret of ammonia. The tersulphuret of molybdenum passed through in solution while the sulphuret of lead remained on the filter. When this was completely washed, it was dissolved in dilute muriatic acid, which takes up the lead and leaves the undecomposed matter along with the sulphur. These were then thrown on a filter and washed. The whole was then burnt. The sulphur was thus driven off while the insoluble matter remained. The insoluble matter in 23 grains amounted to ·24 grains, while in the former analysis it amounted to 1·15 in 26·84 grains.

When the washings from the sulphur were sufficiently concentrated, the lead was precipitated by means of ammonia and oxalate of ammonia. The oxalate of lead was then thrown on a filter and washed. The quantity of oxide of lead in 22·76 grains amounted to 13·71 grains, which is equivalent to 60·23 grains per cent.

The next point was to precipitate the tersulphuret of molybdenum. This was done by making the solution in sulphohydret of ammonia slightly acid by means of muriatic acid. The tersulphuret went down in the form of a brownish coloured precipitate. This was then thrown on a filter, dried, ignited, and weighed. The quantity in 22·76 grains was thus found to be 9·91 grains, which is equivalent to 39·19 per cent. of molybdic acid.

The constituents, therefore, of molybdate of lead, according to this analysis, are,—

Molybdic acid,....................................39·19
Lead protoxide,...................................60·23

99·42

Phosphates and arseniates of lead were decomposed in the same manner; and it is evident this process would also do with antimoniates, vanadiates, and selenicts, &c.

	Klaproth	Hatchett	Göbel	Parry.		J. Brown.			Theory
Molybdic Acid,.........	34·25	38·00	40·50	*40·40	39·88	39·30	*40·64	39·19	39·13
Protoxide of Lead,.....	59·59	58·00	58·00	59·60	59·56	60·35	59·36	60·23	60·87
Peroxide of Iron, ...	...	2·08	...	...	...	...	...	...	...
Silica,...................	...	·28	...	...	...	...	...	...	...
	93·84	98·36	98·50	100·00	99·44	99·65	100·00	99·42	100·00

The two last analyses were made by means of sulphohydret of ammonia; the three preceding analyses by nitric acid.

Physiological Effects of the Inhalation of Ether. By Andrew Buchanan, M.D., *Professor of the Institutes of Medicine in the University of Glasgow.*

(Continued from page 161.)

The narcotic effects above described do not always follow upon the inhalation of ether. The operation, as at present practised, must be admitted to be uncertain and not devoid of danger. If too little ether be inhaled we fail in our object of stupifying the nerves; if too much be inhaled, excessive narcotism may be induced; and if atmospheric air be not supplied freely enough, or the same air be respired more than once, there is danger of asphyxia. The source of this uncertainty and danger, is the difficulty of determining the exact quantity of ethereal vapour which is inhaled, and the proportion of air which is mingled with it. To resolve these problems is, therefore, a matter of great importance, and fortunately the solution of them is not difficult. It only requires that the inhaling apparatus be of a proper size and structure, and that it be always employed at the same, and that a fit temperature. The proportion of ether and ethereal vapour is certainly known from the temperature, and if the chamber of the inhaler be of sufficient size that proportion will vary very little during the period of inhalation. If again the apparatus be so constructed, that there is no impediment to the free ingress and egress of the elastic fluid to and from the lungs, the quantity of air, and of course also of ether inhaled in a given time may be determined with considerable accuracy. Now, as the quantity

* In these analyses the lead only was ascertained, and the deficiency was taken as molybdic acid.

of ether absorbed will, in the same circumstances, be always nearly in the same proportion to the quantity inhaled, we are enabled to measure, or at least adjust, the dose of ether by the sure and simple standard of the time during which the inhalation is continued. The only other criterion of the quantity of ether administered is the physiological effects resulting from it, such as the appearance of the eye and the state of the sensibility; but these, although worthy of being noted, are too vague and difficult of estimation to be relied upon alone.

It follows from what has been just said, that the form of the inhaling apparatus is of the utmost importance, and should not be regarded as a matter of mere taste and convenience, as if there were no more stable principles to regulate it. Much risk is incurred by the diversity of instruments at present in use. It is, moreover, clear that no comparable results can be expected so long as an indiscriminate use is made of instruments differing so much, that one produces full narcotism in from five to ten minutes, and another can be employed from two to four hours with impunity. Admitting fully the influence of idiosyncracy, we cannot, without abandoning all faith in the uniformity of the laws of living nature, explain such discrepancies on that principle, and a little consideration will show that an obvious explanation of them is to be found in the mere difference of size and structure of the instruments made use of.

In constructing an inhaling apparatus, and in making use of it, every other consideration should be made to give way to the vitally important object of administering a definite quantity of ether in a given time, and having it mingled with such an unvarying proportion of atmospheric air as may be sufficient to support respiration. Now, to attain that object, the apparatus should always be employed at the same temperature; the chamber in which the vapour is contained should be of large size; the apertures into it, and the tubes connected with it, should be at every point somewhat larger than the human wind-pipe, and kept carefully free from all obstructions; and, lastly, there ought to be valves, or some similar contrivance, to direct the course of the gaseous fluid to and from the lungs.

The temperature of 60° Fahr. is the most convenient that could be selected. At that temperature, if the size of the chamber be large enough to admit of the vapour retaining its maximum tension while the inhalation is going on, the gaseous fluid consists nearly of equal volumes of air and ethereal vapour; and experience seems to have shown that air of that degree of tenuity, or of one half its ordinary density, may be respired for a short period without any bad effects—although this cannot be considered as fully ascertained, since probably even the largest inhalers now in use are too small to fulfil the conditions above-stated. If the temperature be higher than 60° we must either lower it artificially to the proper standard, or we must admit air into the chamber so freely as to prevent the vapour from attaining its maximum tension, which it could not do without expelling so much air from the chamber as to render the remainder too highly rarified to be respired without danger of asphyxia. In cold weather again, the apparatus must be maintained by artificial heat at 60°, for it is only by a scrupulous attention to the influence of temperature, that the time of inhalation of the ether can be rendered a measure of its physiological effect.

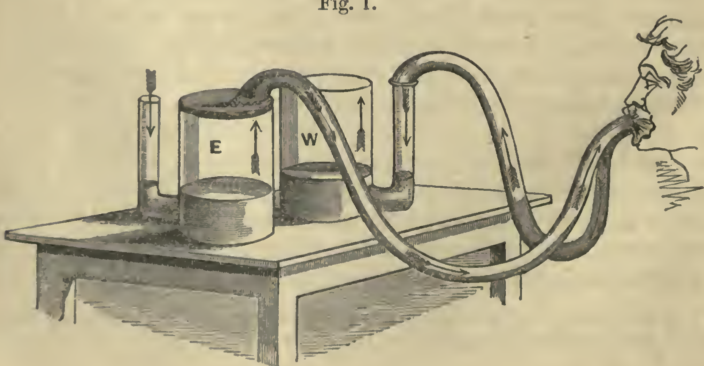
The reason why the chamber of the instrument should be large has been already pointed out. The larger it is the more complete will be the uniformity between the successive quantities of ether drawn into the lungs at each inspiration. It should probably not be of less capacity than from 1300 to 1400 cubic inches, the volume of air consumed by respiration in five minutes. A cubic foot is a simpler measure, and, if adopted as a minimum standard for the size of the chamber, would render all observations made with instruments so constructed comparable with each other. It is true that such an instrument will not go into the surgeon's pocket, but this is probably no disadvantage, for an agent so energetic as the vapour of ether should not be employed on light occasions, but only after deliberate consideration.

The tubes and apertures of the chamber should not be less than an inch in diameter, for when they are narrower, especially if the tubes be long, the difficulty of respiration is much increased. Care should be taken to keep the apertures perfectly free, instead of choking them up as is often done with sponges soaked in ether.

The valves are a frequent source of difficulty. As they are fitted on narrow apertures, they impede the respiration to a certain extent, even when they are in good working order; but they are very liable to derangement, and may then readily occasion asphyxia.

Having frequently witnessed how imperfectly the valves perform their office, it occurred to me that an apparatus might be constructed without any valves; or, to speak more correctly, substituting for the *solid valves* now in use, *liquid valves*, which require no contraction of the tubes, and, from their simplicity of structure, are not liable to go out of order. The principle of this contrivance will be understood by reference to fig. 1.

Fig. 1.



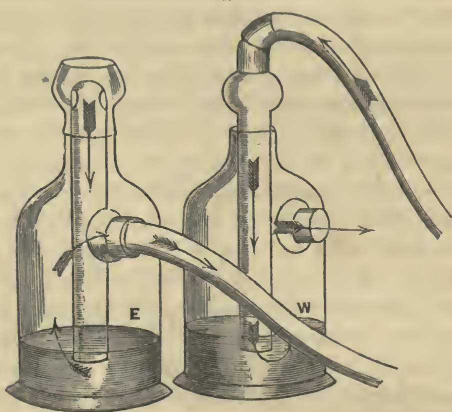
E and W are two glass vessels, the one containing a small quantity of ether, and the other of water. They are shaped somewhat like the letter U, having one limb or tube very narrow and the other wide. They are placed with these tubes in opposite directions—the one internal and the other external, in reference to the person who is to inhale the ether. In the vessel E, the narrow tube is external and open at the top, while the wide or internal tube is shut, and has an elastic pipe attached to it. In W, again, it is the wide tube which is external and open, while the narrow or internal one is shut, and has the pipe attached to it. The two elastic pipes terminate together at the mouth-piece. The effect of this arrangement is, that when the person begins to breathe, the air inhaled into the lungs can only gain admittance through the vessel E containing the ether, and the air expelled from the lungs can only make its escape through the vessel W containing the water. A current of air is thus kept up in the direction indicated by the arrows from E to W, and the air, as it enters at E and passes through the ether, is mingled with ethereal vapour, and carries it along to the lungs. The mechanism by which this is effected is of the simplest kind. The liquid in the vessels E and W stands at the same level in the tubes of each vessel, so long as the pressure of the air upon it is equal from within and from without. But no sooner does the person begin to breathe, than, by expanding his chest, he rarefies the air within, and thus diminishes the pressure upon the surface of the liquid in the internal tubes. The consequence is, that the liquid being forced inward by the pressure of the air from without, rises in the internal and is depressed in the external tubes. But owing to the small diameter of the external tube of E, only a very trifling elevation of the liquid in the broad internal tube can take place before the whole liquid in the external tube is exhausted, and the air rushes in to restore the equilibrium. On the other hand, no air can enter through the vessel W, owing to the reversed position of the two tubes, the broad one being external, and the narrow one internal. These mechanical conditions are just reversed during expiration; for when the chest contracts, the air within is condensed and acquires a greater tension, so that the liquid in the two vessels E and W is now pressed more powerfully from within than from without. It therefore rises in the external tubes, and is depressed in the internal, till the whole liquid in the narrow internal tube of W being exhausted, the air rushes out in that direction, and the equilibrium is restored.

Mr. Young of this city * suggested to me an improvement on the apparatus just described,—that of putting the small tubes in the inside of the large ones,—and had the kindness to construct for me an apparatus of the kind. On trying it at the Infirmary, it was found to answer perfectly so long as the patient breathed calmly; but when he coughed, the

* Now resident in Manchester, formerly assistant to Professor Graham, and well known for his ingenuity in the construction of chemical apparatus.

ether spurted out through the narrow tube of E. To remedy this defect, the narrow tube was made shut at the top and with two apertures at the sides, and a round capital made to fit upon it at the level of these apertures, so that any liquid poured into the capital or projected upwards, might flow down thence into the vessel below. Mr. Young constructed for me an apparatus so improved, which is shown in fig. 2. It has been

Fig. 2.



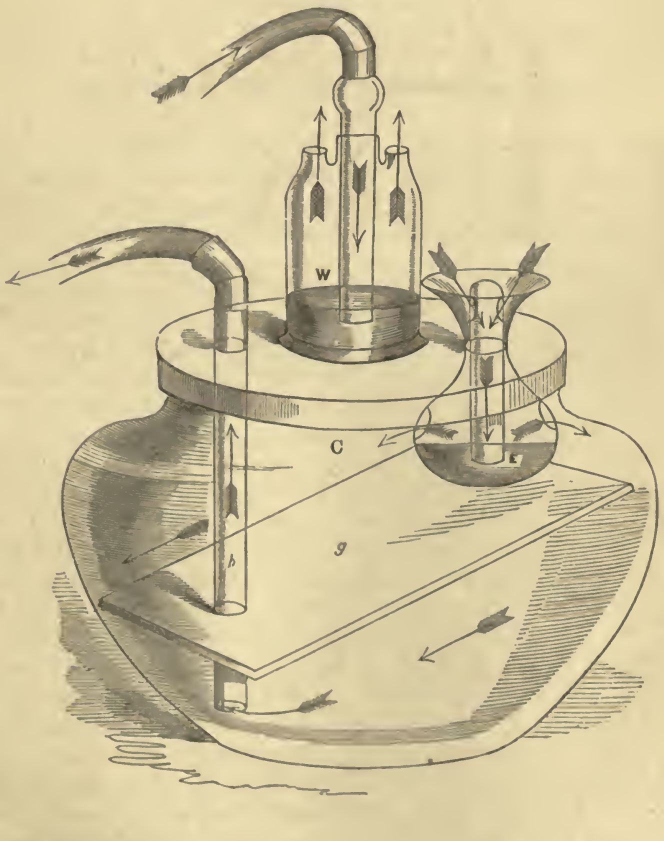
found to answer the purposes in view exceedingly well, inducing narcotism with great rapidity. It might probably, however, be still further improved, by enlarging the chamber containing the ethereal vapour; for, at the time it was made, I was not fully aware of the importance of having the chamber of large size. I would now prefer to it an instrument constructed in the following way, as seen in fig. 3:—

The vessel W is much the same as in fig. 2; but the vessel E has been converted into a mere valve, regulating the admission of air to the chamber C, which is a globular glass vessel of the capacity of a cubic foot, having a wide mouth, to which a wooden cover is accurately fitted, and on that the other pieces of the apparatus rest. E consists of a glass vessel, having a wide funnel-shaped mouth, a narrow neck by which it is attached to the wooden cover, and two openings below by which it communicates with the chamber C. To the neck of it there is fitted by grinding a tube, an inch in diameter, shut at the top, but having two lateral openings, through which the ether poured in at the wide mouth descends to the bottom of E, where there should be as much of it as to rise a little above the level of the lower orifice of the tube. Another tube *h* conveys the ethereal vapour and air out from the chamber. It has attached to it an expanded linen cloth, *g*, placed obliquely, and serving to receive any drops of ether which may descend from above: and before commencing the inhalation a slight excess of ether should be poured into

E, so that it may run over and moisten the linen cloth inside. An expanded cloth seems to me much better adapted to promote evaporation than the sponges now in use, for a sponge is more fitted to retain liquids that to promote the exhalation of vapours.

Lime water may be substituted for the common water in the vessel W, when the carbonic acid in the expired air renders the liquor milky. Whether the degree of decoloration produced will have any correspondence with the degree of narcotism I have not tried, but it is worthy of attention, as Dr. Prout's experiments on the effect of alcohol on the quantity of carbonic acid exhaled, render such a result not impossible. An apparatus of this kind might be advantageously employed in many physiological experiments on respiration.

Fig. 3.



BELL AND BAIN, PRINTERS, ST. ENOCH SQUARE, GLASGOW.

PROCEEDINGS

OF THE

PHILOSOPHICAL SOCIETY OF GLASGOW.

FORTY-SIXTH SESSION.

3d November, 1847.—*The* President *in the Chair.*

The Librarian read a report on the Library, from which it appeared that, since last Session, various periodical works have been completed by the addition of 66 Nos. and 63 vols., in pursuance of a decision of the Committee. Many of these were obtained with great difficulty, in consequence of their scarcity, but by applying in the proper quarters, a remarkable degree of success has attended the attempts made to render the series of periodicals perfect. The Library can now boast of a perfect copy of Agassiz' Work on Fishes. The American Journal of Science is now complete, from the year 1831 to the present time. The Annales de Chimie, by the purchase of 46 vols. at £12, and 2 Nos., is complete from the year 1816. The Edinburgh New Philosophical Journal, by purchasing 9 or 10 Nos., is also rendered complete from the year 1819, the date of its commencement. The Philosophical Magazine, by the purchase of 4 vols. and 3 Nos., is now perfect from its commencement, in the year 1798, to the present date. The Reports of the British Association have also been completed by the addition of 6 vols. In consequence of the Repertory of Patent Inventions being a work which is very much consulted in this Library, it was considered proper to make every effort to procure the absent Nos., and now the series, with the exception of 3 vols., is complete from the year 1794—the absent vols. are 28, 29, 45 of the second series. The first two published in the year 1816, and the last in 1824. The report suggested that the Council of the Andersonian University should be requested to enter on their minutes the titles of the 600 volumes purchased by the Philosophical Society, and that the Philosophical Society should preserve a similar document, to prevent any dispute in future, in consequence of these books being marked with the Andersonian stamp. It was also suggested, that as the Repertory of Patent Inventions is so valuable for reference, and is consulted perhaps more than any other work, and that as many Nos. and vols. have been lost in consequence of their being lent out, in future the work should not be taken from the Library, except by special permission, but should be consulted in the Library room. The same recommendation was advised should be extended to Brewster's Encyclopedia.

The report was unanimously adopted.

Mr. Robert Graham presented, from his Grace the Duke of Northumberland, a copy of Results of Astronomical Observations by Sir John Herschel at the Cape of Good Hope, made during 1834—38. The Secretary was requested to return a letter of thanks to his Grace.

XXX.—*Notice of the Geology and Climate of Nice.* By Dr. Thomas Thomson.

The President, Dr. Thomas Thomson, read a paper *on the Geology and Climate of Nice*, where he resided during last winter. Nice was described as being surrounded on all sides except the south, where the sea serves as a boundary, by mountains. Of these there are three ranges. The range nearest Nice is the lowest, and the mountains composing it are covered to the summit with olive trees. The mountains of the second range are a good deal higher than those of the first, and are also covered with wood to the top. The trees at lower levels are olives, but the summits are covered with a beautiful pine, which Dr. Thomson considered to be the *Pinus Maritima.* The cones of this tree are much larger than those of our pine, and are highly combustible. The third range of mountains constitute the Alps, which are at a great distance, and are constantly covered with snow. The mountains of the inner circle are separated from each other by valleys, which run towards the sea, and becoming broader as they descend. It is in one of these valleys that the city of Nice is situated. The most abundant tree in the neighbourhood of the town is the olive, which indeed may be said to cover the country. It is often small, and its dull green is unpleasing to the eye; but when allowed to grow to its full size it becomes a magnificent tree. One which Dr. Thomson measured was 40¾ feet in circumference at its base, just above the surface of the ground; at 4½ feet high its circumference was 20½ feet. An olive must be twenty years old before it comes into full bearing. The range of mountains nearest Nice is composed of limestone, which is regularly stratified; the limestone strata are separated by a yellow ochry looking substance, varying from one inch to several feet in thickness. From the fossils contained in this limestone, there can be no doubt that these mountains belong to the oolite formation. The fossils are similar to those which are so abundant in the neighbourhood of Bristol, intermixed with the oolite fossils and others belonging to the green sand and the chalk; from whence it was concluded, that beds of green sand and chalk must still exist or have existed there. The sea-coast from Nice to Genoa is mountainous, and the mountains are composed of limestone. It was thought not improbable that the oolite continues throughout, although no opportunity occurred of verifying this opinion. The limestone round Genoa is often slatey and dark coloured, having much the aspect of mountain limestone, but the great abundance of white marble every where conspicuous in Genoa, indicated that this ornamental article of architecture must be near and plentiful.

From accurate meteorological tables kept at Nice for thirty consecutive years, by M. Roubodi, it appears that the mean temperature of Nice (which is situated in N. lat. 43° 40′, and E. lon. 7° 15′,) is 60°·62, while that of Naples, 3° to the south, is 61°. Hence it appears to possess a higher temperature than it ought to have from its position. In winter, the lowest point to which the thermometer has been observed to fall is, 27°·5, but it has never remained at this point more than a few hours In two out of three years it does not freeze at all, and even when frost occurs at night, the thermometer at two p.m. always rises to at least 43°·25. The mean temperature of the winter three months is 48°·25, of the spring three months 48°·62, of autumn 54°·375 and of summer 68°. The highest point to which the thermometer has been observed to rise in summer, is 88°·25.

The atmosphere at Nice is generally dry, especially in winter and spring, when the wind blows from the north. It is driest near the sea-shore, and becomes moister as we go to the interior. The humidity is greatest by the Paillon and the Var, two torrents which come from the mountains, the last constituting the boundary between France and the country of Nice.

In summer the south-east wind usually blows from nine in the morning till five in the afternoon. This wind, coming from the sea, preserves a temperature varying from 73° to 82°.

The most common winds are the south-east, the north, and the north-east.

In winter the north-east and north-west, in summer the south-east wind most commonly blows.

The clear, cloudless winter sky is owing to the north wind. The south-east brings good weather. In winter it raises the thermometer, in summer it moderates the heat.

The quantity of rain which falls at Nice is very various. The greatest annual quantity during the last thirty years is forty-five inches, the least sixteen inches, and the mean quantity amounts to twenty-six. The most rainy season is the autumn, the fall during that season varying from six to ten inches. In summer it varies from two to seven inches, in spring from three to eight, and in winter from four to seven.

The rain is often very heavy; five inches have fallen in twenty-four hours. But this is small compared to what falls in India. At Mahabuleshwar, on the west coast of Indostan, latitude about 18°, there fell in one year 302·21 inches of rain, or as much as would have covered the earth to a height of twenty-five feet. During the month of August, 1843, there fell at Cananore, on the same coast, 130 inches of rain.

The variation in the quantity of rain which falls at Glasgow and its neighbourhood is not less remarkable. The annual fall in the College Garden, according to a register kept by the late Dr. Couper, Professor of Astronomy, averages 21·331 inches. A register was kept with great care for several years of the fall of rain at Greenock, by the late Mr. James Leitch, from which it appeared that the fall in Greenock was very nearly double that in Glasgow. The mean fall at Stocky Muir, only about twelve miles distant, is 42·6 inches, or double the fall in Glasgow.

Snow falls at Nice once in four or five years. We had it last winter to the depth of half an inch. In places screened from the sun it lay three days, but where the sun acted on it, it melted in a few hours.

In the year 1837 the fall of snow at Nice was the greatest ever known. It lay to the depth of six inches.

About a century ago, it was the universal opinion that when sea water was evaporated the vapour carried with it a portion of the salt, and therefore that fresh water could not be obtained by distilling sea water.

Vogel and some other chemists examined the air over the Baltic, and found it to contain common salt. And the late Dr. Dalton observed the panes of his windows in Manchester incrusted with common salt after a violent storm of wind and rain. From these and similar observations, it has been pretty generally supposed that the atmosphere over the sea, and in its neighbourhood, contains common salt in solution. The question was decided some years ago at Nice by M. Brunner, Professor of Chemistry at Berne, and M. Roubodi of Nice.

A large globular glass vessel, filled with a mixture of snow and sulphuric acid, was suspended a few feet above the ground, and six paces distant from the sea, when the sea was calm and no wind was blowing. Abundance of aqueous vapours were collected and condensed on the outside of the vessel, and a colourless liquid was collected exactly similar in appearance to distilled water. After being kept for six months, its appearance was not altered. When evaporated to dryness it left no residue. It was not precipitated by nitrate of silver nor nitrate of mercury, and therefore contained no muriatic acid nor common salt. Chloride of barium occasioned no precipitate, showing that sulphuric acid was not present. The absence of lime was indicated by oxalate of ammonia, occasioning no muddiness when dropt into it.

With solutions of barytes and lime it became slightly nebulous, and after some hours a very slight deposit fell, soluble in nitric acid. These phenomena indicate the presence of a trace of carbonic acid.

This experiment was repeated when the sea was in a state of agitation, great waves dashing impetuously against the beach. When the liquid collected was tried by reagents, the results were very different.

Nitrate of silver made the liquid opal, and after some hours a precipitate fell possessing all the characters of chloride of silver, thus showing the presence of chlorine in the liquid.

In like manner nitrate of mercury formed white clouds in it, which precipitated to the bottom.

Barytes and lime water made it muddy, and the precipitate was dissolved in nitric acid, showing the presence of carbonic acid.

Litmus paper was not altered. Chloride of barium, nitrate of barytes, ammonia, potash, diacetate of lead, oxalic acid, and oxalate of ammonia occasioned no change, showing the absence of sulphuric acid and lime, and of any uncombined acid.

When the waves were high but no wind blowing, which often happens with the Mediterranean, the balloon was placed about fifty paces from the sea, and the liquid condensed examined by reagents, it was found perfectly pure, without the smallest trace of common salt or chlorine; but when the wind blew from the sea to the balloon, placed at the same distance from the beach, the liquid collected exhibited distinct traces of muriatic acid.

A tube bent in the form of a syphon was got, and a quantity of water, holding nitrate of silver in solution, was put into the bent part of the tube. One of the extremities of the tube was open, the other was luted into the mouth of a very large glass vessel, having a stop cock, and filled with water. The stop cock being opened, the water ran out, and its place was supplied by air, which made its way by the syphon tube, and consequently passed through the nitrate of silver solution. When the large vessel was exhausted of water it was filled again, and the experiment renewed. Air in this way was made to pass through the nitrate of silver solution for six hours. In this way a prodigious quantity of air was made to pass through a small quantity of nitrate of silver solution. This experiment was tried when the sea was calm and no wind blowing, in a boat at some little distance from the shore, and a few paces from the beach. No precipitate appeared, nor was there the least symptom of the presence of common salt. But when the sea was agitated and a wind blew from it, the solution became muddy, and chloride of silver was precipitated, indicating the presence of common salt.

These experiments leave no doubt that the common salt, occasionally observed in the atmosphere of the sea, is not dissolved in that atmosphere, but proceeds from a little sea water mechanically suspended, and which of course is speedily deposited. In calm weather the sea atmosphere is quite free from salts; it is, therefore, not in the least injurious to invalids, as some medical men have supposed it to be.

17*th November*, 1847.—*The* Vice-President *in the Chair.*

The Librarian intimated that the library had been valued and recommended to be insured for £500, and also that the first thirty-one volumes of the Mechanics' Magazine had been purchased. A minute of Council was read recommending the Society to abolish the office of Assistant-Secretary, and to elect two Secretaries, and that Article I. of the Rules should stand thus—"The business of the Society shall be conducted by the following office-bearers, constituting together the Council of the Society, viz.:—A President, Vice-President, Treasurer, Librarian, two Secretaries, and twelve Councillors, elected annually, as hereinafter prescribed," the remainder of the Article to be as at present. In conformity with this regulation, the Council recommend further that Article VI. be expunged, and that Article V. be changed as follows:—"*Secretaries*—The Secretaries shall record in the minute-book the transactions of the Society, and give an abstract of the papers that are read at the Ordinary Meetings. They shall also conduct the Society's correspondence, and act as Secretaries to the Council."

The Society then proceeded to their forty-sixth annual election of office-bearers:—

President.

DR. THOMAS THOMSON.

VICE-PRESIDENT,..WALTER CRUM.
TREASURER,........ANDREW LIDDELL.
LIBRARIAN,.....DR. R. D. THOMSON.

Secretaries.

ALEXANDER HASTIE, M.P. | WILLIAM KEDDIE.

Council.

A. ANDERSON, M.D.	PROFESSOR GORDON.	JOHN STENHOUSE.
G. A. WALKER ARNOTT, LL.D.	WM. GOURLIE, JUN.	PROF. WM. THOMSON.
A. BUCHANAN, M.D.	ALEX. HARVEY.	GEORGE WATSON.
J. FINDLAY, M.D.	WILLIAM MURRAY.	A. K. YOUNG, M.D.

The Vice-President took occasion to refer to the recent death of Dr. Alex. Watt, and observed, that the Society had much cause to regret the loss which they had sustained by that event, especially in the statistical department.

The Treasurer presented an abstract of his account for Session 1846–47.

1846.							
Nov. 21.—To Cash in Bank, and in Treasurer's hands, at beginning of Session,...	£86	11	9				
— Interest from Bank,.................	6	11	8				
					93	3	5
1847.							
41 Entries (New Members,) 21s.....................					43	1	0
15 Annual Payments @ 5s..........................					3	15	0
193 Do. Do. @ 15s.........................					144	15	0
Arrears of Payment from 1 Member,...............					0	15	0
Balance due the Treasurer,........................					2	0	0
					£287	9	5

1847.			
Nov. 3.—By Books,..	£88	16	3
— Binding Books,..	16	10	0
— Printing Proceedings,..	16	10	0
— Stationery, &c..	15	19	6
— Rent of Hall,..	15	0	0
— Sundries for Postages, &c.	14	18	6
— Cash in Union Bank,..	119	15	2
	£287	9	5

At the beginning of last session the members on the roll were 182, and during the session 41 were admitted members; 2 of these have died, and several have removed from Glasgow, leaving the number on the roll 213. The Treasurer also reported that the amount of overplus from the Philosophical Society's Exhibition was now £471 1s. 11d.

Mr. Gourlie gave in the following report from the botanical section:—

"1st Nov. 1847.—The section recommenced its meetings this evening —Mr. W. Gourlie in the chair. Dr. Walker Arnott was elected President, Mr. Gourlie Vice-President, Mr. Francis Leeshing Curator of the Herbarium, Mr. W. Keddie Secretary. Dr. Arnott presented specimens of Schizaea pusilla from Quaker's Bridge, New Jersey, being the only station in the world where this fern has been found; also specimens of Phylloglossum Drummondii, from New Zealand, a plant allied to Lycopodium, not having a bulbous root. A small collection of Fungi were received from Mr. James Davis, Edinburgh. Mr. Leeshing reported on the state of the Herbarium, and presented some German plants."

Mr. Gourlie moved for a grant of £5 to be expended on the Herbarium of the botanical section, and, in the absence of Mr. Smith, described a living plant of the *Tussack* grass, or *Dactylis cæspitosa*, from the Lews. The seed was brought from the Falkland Islands, and sown in the spring of 1845 in pure moss simply delved, with a small quantity of guano thrown upon the surface. The specimen shown was one of the most perfect yet produced in this country. Thirty-seven plants have come to maturity, two of which carried seed last year. They grew in an inclosure fourteen yards square, formed by a turf wall six feet high, and situated within thirty yards of the sea.

Dr. R. D. Thomson exhibited a specimen of chrome iron ore, on the surface of which was a green crystalline body, which had been mistaken for oxide of chrome, but which, on being analyzed last winter in the College laboratory by Mr. Brown, was found to be a carbonate of Nickel. The specimen was from North America, and was presented to Dr. Thomson by Mr. John Tennent of the Bonnington Chemical Works.

Mr. Gourlie exhibited several star fishes dredged by him last summer off the Island of Bute.

1st *December*, 1847.—*The* Vice-President *in the Chair.*

A living land tortoise, belonging to Mr. Forrester, Gordon-Street, was exhibited; also a specimen of *Epiphyllum truncatum* in flower, from Mr. Wardlaw, gardener, Ibroxhill.

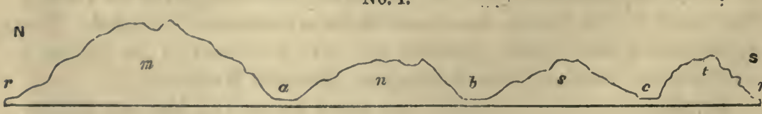
The following paper was read:—

XXXI.—*Notices of the Geology of the Island of Bute.* By James Bryce, Jun., M.A., F.G.S.

1. The only account which we possess of the geology of Bute, is that given by Dr. MacCulloch, in his "Description of the Western Islands of Scotland." During the thirty years that have elapsed since the publication of that work, no observations, that I am aware of, have been put on record, either supplementary to this account, or in correction of it. Indeed, the island seems to have been entirely overlooked;—the superior grandeur and interest of the sister isle of Arran having wholly absorbed the attention of geologists. Yet Bute has many points of great interest in itself; and phenomena, which in Arran are but obscurely shown, are here fully exhibited. During a residence on the island for a part of last summer, I had frequent opportunities of testing the accuracy of Dr. MacCulloch's account; and it is but justice to the memory of that distinguished geologist, to say, that both in this island, and in other islands, and adjoining portions of the mainland, which I have been in the habit of carefully examining from time to time for a considerable period, I have found the description of the phenomena to agree very closely with my own observations, and the work to be an accurate and safe, as well as most pleasant guide. I have not, therefore, in the present communication attempted a new history of the strata of Bute; but adopting the arrangement and descriptions of Dr. MacCulloch, I merely propose to supplement his account by such other observations as seem worthy of being put on record. In order, however, to make the remarks which follow more easily understood, it may be well to state, briefly, a few particulars respecting the general structure of the island.

2. The island of Bute is naturally divided into four portions, by three deep depressions or valleys, which traverse it in a direction perpendicular to its greatest length, as illustrated in the accompanying sketch.

No. 1.

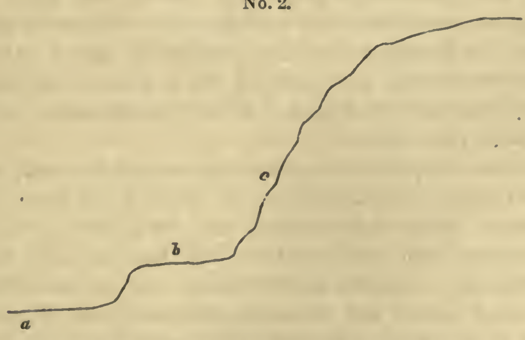


a, *Kaimes bay;* b, *Rothesay;* c, *Kilchattan;* m, *mica slate;* n, *clay slate;* s, *sandstone, old red;* t, *trap:* r, *the terrace.*

These low tracts terminate on either side of the island in deep bays, or indentations of the land, between which, there can be no doubt, as well from the lowness of the ground, as from the marine character of the materials of which these tracts are composed, the sea once flowed, thus forming three straits or narrow channels, dividing Bute into four islands. I have no means, either from a personal survey or otherwise, of stating with even tolerable precision, what amount of elevation was required to convert these narrow straits into dry land; it is probable that it was the same as that which was realized when Loch Lomond was placed at its present level above the Clyde; not, however, by one sudden movement, but by a succession of slow and gradual movements, such as there is reason to think may be still going on in some parts of Scotland, and as are well known to have been long in progress, to a great extent, in the Scandinavian peninsula.*

Another interesting feature in the structure of Bute, and one intimately connected with the origin of the low tracts referred to above, is the terrace which surrounds almost the whole island, at a considerable height above high water mark, and along which the road is conducted throughout almost the whole extent of the coast. The cliffs which in many parts rise above the terrace are often worn into caves, and bear other obvious marks of the action of the waves. This terrace is, no doubt, the former beach.

No. 2.



a, *present sea level;* b, *terrace with road;* c, *inland sea-worn cliff.*

It is well marked along the opposite coast from Gourock to Largs, in the Cumbrays, in Arran, and upon most of the estuaries in the firth of Clyde. Taking this along with other evidence, accumulated by Mr. Smith of Jordan-hill in various papers, we cannot hesitate to admit, that at a comparatively recent period such a change of level has been effected in Bute as to convert a detached group of islands, separated by narrow and not very deep straits, into continuous land.

3. The valleys which have been now described are the boundaries

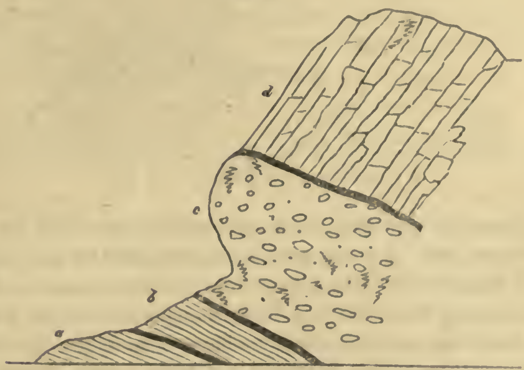
* Loch Lomond is about 22 feet above the Clyde. It is specially referred to because we have, in the country between it and the Clyde, the evidence derived from shelly deposits,—which is much more satisfactory.

between contiguous and dissimilar strata. The line of junction seems to run about the middle of the valley, but it is usually wholly concealed; now by marshy ground, and again by deep accumulations of shingle and other rolled and transported materials. On opposite sides, however, the rocks are perfectly distinct. The northern portion between the Kyles on one side, and Kaimes and Ettrick bays on the other, is composed of mica slate. The district south of this, and which has the valley behind Rothesay for its southern boundary, is composed of siliceous and common clay slate. The portion reaching from this valley to that of Kilchattan, is occupied by a coarse sandstone, usually conglomerate; and, finally, the southern portion is composed of various rocks of the trap family, which have been erupted through the sandstone, and overlie it in a nearly conformable position. The connexion of these strata with the mainland is most intimate. The slate and sandstone are, in fact, the terminal portions of those great bands of sedimentary strata which stretch from Angus to the Clyde, being parallel throughout to the granitic axis of the Grampian chain; while the erupted rocks in the south of the island are a prolongation of the great outburst of the igneous formations, which, affecting a general parallelism with the same axis, extends from sea to sea in considerable ranges, as the Kilpatrick and Campsie hills, the Ochills, and some minor ridges in the south-east of Perthshire. The valleys intersecting the island seem obviously a part of that great system of parallel fractures, which run in a north-east and south-west direction on both sides of the Grampians, and are probably due partly to the original upheaval of that chain, and partly to the subsequent eruption of the igneous rocks just mentioned through the old red sandstone, and the coal formation which rests upon it.

4. The strata of sandstone are fully exposed on the shore, and in the inland cliffs from Rothesay to Ascog. A little to the south of Bogany Point, limestone appears interstratified with the sandstone, the two rocks gradually passing into one another at the junction. Dr. MacCulloch describes one bed—I noticed several others; but the beds being thin, of small horizontal extent, and containing generally much siliceous matter, the rock is of no great economical importance in this place. On the north side of the small rocky promontory, south of Ascog mill, the limestone assumes the nodular structure, and several thin courses of it are seen to traverse beds of a crumbling, brown-coloured shale, subordinate to the sandstone. This shale is of considerable thickness, and appears in the banks above the road.

The south side of the promontory presents the following section, (No. 3.) The lower bed, *a*, is a fine-grained bluish-grey nodular limestone, often intermixed with, and undistinguishable from, the adjoining sandstone. This is succeeded by black, slightly bituminous shale, containing a few very thin veins of coal, less than a quarter of an inch thick. A bed of concretionary limestone, *c*, rests on the shale, the base or paste being an impure dark-coloured limestone, and the concretions rounded lumps of the same rock, often of considerable size. The upper part of the cliff is occupied by trap, in various prismatic forms. An interesting

No. 3.



a, *limestone;* b, *shale, with thin coal seams;* c, *limestone breccia;* d, *trap.*

change has been produced by the contact of the trap. The base of the concretionary limestone has been so much altered from its original state as closely to resemble the trap itself. So complete, indeed, is the metamorphosis, that the two rocks cannot be distinguished but by the action of a strong acid. The imbedded lumps have undergone a similar change, particularly in the upper part of the bed. This trap rock occupies a considerable area, inland; and is 100 to 200 feet thick. Speaking of it, Dr. MacCulloch says,—"When examined on the shore it appears rather to pass through the sandstone than to lie over it; but there is considerable obscurity in this place, as the lateral junction of the two is concealed by a cavity filled with earth." The section of the coast is better exposed at present, probably in consequence of the continued action of the sea; and there can be no doubt that the relative position of the strata is such, throughout, as is given in the preceding section, (No. 3.) The trap reposes upon the sandstone, and does not pass through it.

5. The most considerable mass of limestone on the island is that which occurs on the south side of Kilchattan bay. Its characters are accurately described by MacCulloch, but he has fallen into a slight error with respect to its position. "This bed seems to lie above all the sandstone strata at this place, and to be the rock immediately in contact with the superincumbent trap." The annexed cut, (No. 4,) shows the true position of this bed of limestone, ascertained by a careful examination of the ground.

At some distance above the limestone quarry, near the ruins of the ancient castle of Kelspoke, the beds of sandstone, *b*, are distinctly seen dipping towards the trap, both the dip and the inclination being the same as below the limestone; and it hence appears that the limestone is here, as in other parts of the island, subordinate to the sandstone, and of cotemporaneous origin.

No. 4.

a, b, *sandstone;* c, *limestone;* d, *trap.*

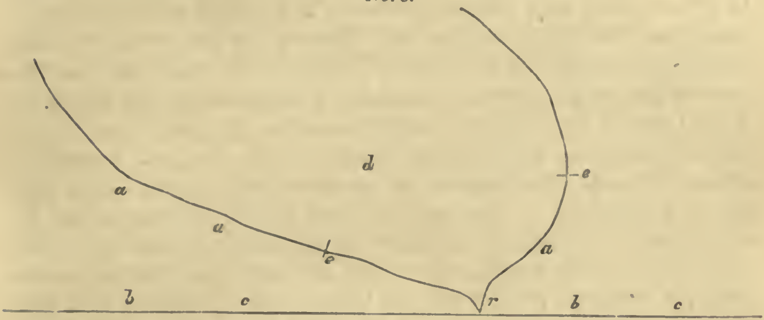
6. The limestone and shale which are interstratified with the sandstone in several places, and at Ascog are also accompanied by very thin veins of coal, bear a considerable resemblance to true coal measures; it is therefore not surprising that coal has been thought to exist in or under this sandstone, and that several attempts have been made to discover it. These, however, have been fruitless, and must always prove so; since there can be no doubt that this sandstone is the old red, and therefore subjacent to the whole coal formation. Such undertakings should never be entered upon without the sanction of a geologist or scientific miner. As the matter is one of some importance economically, I shall briefly state the reasons which have led me to this conclusion.

(1.) Since in the adjoining tracts the series of rocks, successively superimposed on the central granite, is complete, and old red sandstone occupies in these its proper place, we may fairly infer that the sandstone, which in Bute succeeds the slate series, must be the old red. (2.) This sandstone, if continued out on the line of its bearing, would coalesce with that which forms the Cumbrays, and with that which, rising to the west from beneath the great mineral basin of Ayrshire, skirts the coast from Ardrossan to Gourock, and from Toward Point to Dunoon, and appears again, on crossing the firth, in Dumbartonshire and Stirlingshire, forming the lower portions of the Kilpatrick and Campsie hills,—and thus constituting a well marked boundary between the coal basins of Lanarkshire and the primary ranges of the Highlands. (3.) The true coal formation, associated with carboniferous limestone, exists in Arran, separating distinctly the old red sandstone from the new. This old red sandstone of Arran encloses beds of limestone which are similar to those of Bute, and contain the same fossils as those limestones termed cornstones, which in England are subordinate to the old red system. Thus the red sandstone of Bute seems to be identified with the old red series of Arran and England. The evidence drawn from fossils is unfortunately not applicable; as I was unable to find a trace of any organic body, either in the limestone, sandstone, or shale, and the same statement has been made by Dr. MacCulloch. I have no doubt, however, that organic remains will yet be found, on a more extended and careful search.

7. The extent of the trap at Ascog has been already hinted at, (Art.

4.) The lower limit is a projection or tongue, running off from the principal mass, and descending to the shore, where it rests on a limestone breccia, as already noticed. At other parts it rests on sandstone, the line of junction ascending rapidly as it retires from the shore on either side, to the south and west. The manner of this approach is shown in the annexed cut, which is a map or ground plan, and not a section. The extent inland is somewhat less than a mile.

No. 5.

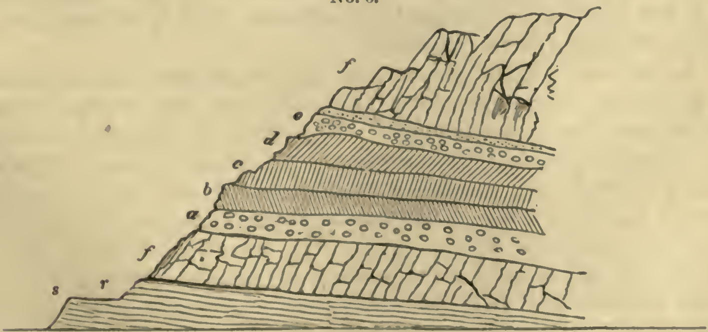


a, *sandstone;* b, c, *shale and limestone;* d, *trap;* e, e, *beds of lignite;* r, *road cut through the projecting mass of trap.*

These trap rocks derive their chief interest from being the repository of beds of lignite,—a substance so rare in Scotland that I believe no well marked beds occur on the mainland, and only two or three on the other islands; and these far up on cliffs nearly inaccessible, in Mull and Skye. I was led to a careful examination of this carbonaceous deposit, and the associated beds, by the statement of Dr. MacCulloch, that some of the strata which occur at this place were unlike any he had seen in his survey of the western islands.

The principal bed is situated in the face of the cliffs above the road, a little to the south of Ascog mill, as shown in the annexed section, (No. 6.)

No. 6.



s, *sandstone;* r, *terrace and road;* f, f, *greenstone;* a, *trap-tuff;* b, *red ochre;* c, *lignite bed;* d, *pisolitic ochre;* e, *porphyritic amygdaloid, the upper portion much altered.*

A little above the road, a small-grained, rudely columnar greenstone rests upon the sandstone, but the exact junction is concealed. To this succeeds an ironshot concretionary greenstone, or species of trap-tuff, the base being greenstone, and the imbedded portions being spherical lumps of the same substance. This is followed by a bed of red ochre, of coarse texture, traversed by numerous black iron seams, which have been produced, no doubt, from a change in the oxidation of the component iron. Over this is the lignite bed. It is three feet thick, and consists of a hard stony coal, interstratified with a yellowish-white shale, both being much intermixed with pyrites. The coal has been so much altered throughout its whole thickness by the contact of the trap rock, that Mr. Rose of Edinburgh, to whose examination I submitted the best specimens I could find, in order that he might determine the species of wood, but without mentioning the geological situation of the coal, was "unable to obtain a slice, in consequence of the structure being altered by the contact of a whin dike." The coal has been worked to some extent by driving an adit inwards on the line of the dip, which is about 20° to the westward; but the workings have been for some time abandoned, and the inner and lower portions are now full of water. It is said that they would be most likely soon resumed, if too high a rent was not demanded. Beds, indeed, so situated, and of such a character, can never be expected to yield much profit, or to be of any considerable economical advantage.

The floor of the coal has been already described: the roof, *d*, is a peculiar rock. In consists of a base or paste of an ochreous steatite, with imbedded round pieces of the same substance, and may hence be called a pisolitic ochre; it is 3½ yards thick. The bed above this is of the same character, but the base contains less soapstone, and with the imbedded steatite it contains also imbedded calcareous spar. The base effervesces briskly with an acid; and hence we may call the rock a calcareous amygdaloid. The upper portion of this bed, to the thickness of a few inches only, is very hard, and has a semivitreous appearance, and thus closely resembles a porphyry. In common with the trap above—and, indeed, all the beds in this locality—it contains much disseminated iron. The rest of the cliff is occupied by greenstone, which is the same as the lower bed resting on the sandstone.

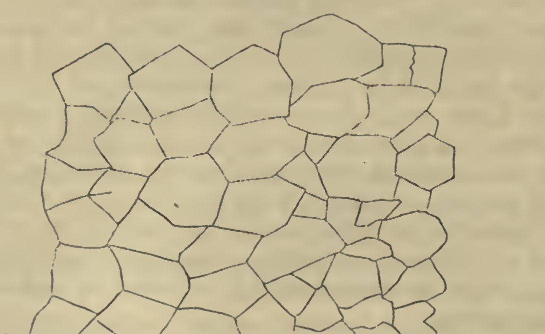
Another bed of lignite occurs on the opposite, or north-west side of the trap district, overlooking Ascog lake. The coal dips to the interior of the area, that is, nearly south. It is of about the same thickness, and is accompanied by beds of steatite and red ochre very similar to those above described; but the nature of the ground is such that a complete section cannot be had, and the precise number, therefore, and order of the beds cannot be exactly stated. The association, however, of the lignite with ochres and steatites here also is sufficiently distinct, and it is even probable that these beds are persistent throughout the whole of this district. It is to these ochreous and steatitic beds that Dr. MacCulloch refers, when he says, that he "has met with no similar substance among the numerous trap rocks examined in the course of the survey of the western islands." He has not, indeed, described any such strata; yet casual mention is made (vol. I., p. 376) of an iron clay and jaspery substance, forming extensive beds in the trap of the cliffs of Talisker, in Skye,—the same in which the lignite also occurs—and that these are often variegated with red, grey, and purple colours. No further description is given, nor is the precise position of the coal mentioned, the cliffs being very difficult of access. But even by such a brief notice the steatitic beds and variegated ochres are easily recognised; and though these characters are not very distinctly marked in the beds we have been describing in Bute, yet they apply exactly to the red and variegated ochres which occur as members of the trap series of the north-east of Ireland. This class of rocks attains there a much more complete development than in this country, both geographically and in relation to the number and variety of the beds. They extend continuously over an area of upwards of 1000 square miles; and while the thickness is, on an average, about 300 feet, in very many cases it reaches to 1100 or 1200 feet. The whole series reposes upon the chalk formation, while the corresponding rocks of this country rest upon the old red and carboniferous systems. Now in this series the lignites occupy a determinate place, they occur in the middle region, associated with the steatites and variegated ochres, which are always largely developed wherever the series approaches to completeness. Instances may be seen at various points in the cliffs at the Giant's Causeway, at Ballintoy, at Glenarm, and at numerous places in the interior of the district. Similar beds are associated with the lignites of Bute and Skye, and most probably also of others of the Western isles, though the notices are too vague to be relied on. We are thus led to the interesting conclusion, that such association is not accidental, but has been determined by the prevalence, over a considerable area, of certain similar and fixed conditions, regulating the succession of the igneous eruptions, the mode of their consolidation, and the periods of repose during which the productions of the adjoining dry land were swept down and entombed.

8. The dikes of Bute are composed of greenstone or basalt, and are extremely numerous. They traverse the different strata in every possible direction, and are well seen upon the rocky parts of the coast. All the usual phenomena are remarkably well exhibited by them, and can be studied together in a small space. The dikes can in some instances be traced continuously for several miles, preserving the same direction, and the same width,—two or more are sometimes seen to meet and to coalesce for some distance, and again to separate,—a narrow dike branches off into several filaments, which unite again,—portions of the rock which is traversed are frequently found entangled in the dike; and these, as well as the contiguous strata, present the usual alterations now universally acknowledged to be the result of igneous action. It is unnecessary to enter into any detail respecting these changes; but there are two

instances which require special mention, as presenting phenomena somewhat unusual.

Between Ascog and Kerrycroy, a greenstone dike, five yards wide, which has run parallel to the shore for some distance, gradually retires from it, toward the latter place, and striking the inland cliff already mentioned, whose direction here coincides with that of the dike, it forms the perpendicular face of the cliff in front of the sandstone, rising like a wall to the height of 20 or 30 feet. The direction of the cliff soon changes, however, and the dike then enters the hill behind, and is lost. By this fortunate coincidence of the two directions, the largest surface that I have ever seen exposed in the case of a dike is completely laid bare, and thus the structure is revealed in the most satisfactory manner. These dikes, as is well known, are usually prismatic across, not vertically, as the overlying trap. The reason is obvious enough; the sides of the dike acted as the cooling surfaces to the fused and liquid mass within; the imprisoned caloric of course passed off in a direction perpendicular to these surfaces, and hence the divisional planes are also perpendicular to the sides—or the dike is prismatic across. The following sketch will help to convey some idea of this interesting dike; the prisms are mostly pentagons and hexagons.

No. 7.



Side view of whin dike between Ascog and Kerrycroy.

The other dike, which deserves special notice, traverses the Kilchattan limestone. Its direction is very nearly that of the dip, and the effects are well seen at the eastern side of the quarry. Along the plane of contact the limestone is altered to the state of a granular saccharine marble, which, on the application of a slight pressure, crumbles into a fine powder. This is succeeded by a hard crystalline marble, the crystals appearing in distinct flakes. Between this and the last change, which is one of simple induration, there are many gradations. Similar effects are common at the contact of limestone with plutonic rocks; in some localities they are accompanied by other singular changes of a chemical nature. Magnesia, and sometimes silica and alumina, are introduced into the composition of the limestone, so that simple carbonate of lime becomes a double carbonate of lime and magnesia. The question whence this magnesia has been derived, has occasioned much difference of opinion among geologists. Some imagine that it has been transferred from the plutonic rock to the limestone; while others hold that, as fractures and dislocations of the earth's crust accompanied the cruption of these plutonic rocks, gaseous exhalations might find their way from beneath, and introduce carbonate of magnesia and other substances into rocks near the surface. In confirmation of this view, Mr. Phillips has shown, in his Geology of Yorkshire, that "common limestone is dolomitized by the sides of faults and mineral veins far away from igneous rocks of any kind;" and some distinguished chemists have expressed their belief that carbonate of magnesia may be sublimed by the action of great heat. (Rep. Brit. Assoc. for 1835, trans. sect. p. 51; Phillips's Geology, vol. II. p. 98.) Much doubt, however, still hangs about this subject. Cases occur in which magnesia has been introduced, although the limestone could not have been subject to such a pressure as would confine its carbonic acid when the rock was softened by heat.

Being anxious to elucidate, if possible, this obscure subject, I submitted two specimens of the rock to Mr. John Macadam, lecturer on chemistry, 60 High John-Street, for examination with reference to the presence or absence of magnesia. The following is Mr. Macadam's report; the specimen referred to as No. 1 is the saccharine marble from contact with the dike; No. 2 is the unaltered limestone from the western part of the quarry; both were average specimens.

"I have carefully subjected to chemical analysis the specimen of limestone No. 1, with special reference to the presence or absence of magnesia; and I find from the indications given, that carbonate of magnesia constitutes about 2½ per cent. of the whole mass. The mineral is not, therefore, a double carbonate of lime and magnesia. Its other and principal ingredients are carbonic acid and lime, besides which silica is present, as also, traces of oxide of iron, and alumina.

"In the specimen No. 2, I find magnesia in great abundance; the amount present being equivalent to 33·72 per cent. of carbonate of magnesia. The other constituents present are similar to those reported in No. 1. From the large proportions of carbonate of lime and carbonate of magnesia present in specimen No. 2, it would appear to be a species of dolomite. It may be noticed that the physical characters of No. 2 are very different from those of No. 1; the former is difficult to pulverise, the latter is extremely susceptible of division.

"The action of strong hydrochloric acid on both specimens causes a portion of gelatinous silica to appear, showing the presence of a silicate, which may be that of magnesia, since the quantity of gelatinous silica is about sufficient to combine with the 1·28 per cent. of caustic magnesia existing in the specimen No. 1. There is a less quantity of this gelatinous silica in No. 2. The greater portion, however, of the silica present in both specimens remains undissolved, in the gritty or pulverulent condition;

and is hence in a state of mere mechanical mixture with the other constituents of the limestone. It would require a minute quantitative analysis to determine whether the 1·28 per cent. of magnesia exists as a carbonate or silicate, or partly as both."

The phenomena are thus of a contrary character to what I had anticipated,—the unaltered rock is a dolomite, and contains nearly 34 per cent. of carbonate of magnesia, while the altered rock contains less than 3 per cent. What has become of the constituent magnesia? Has it been driven off by the heat to which the limestone was exposed? Most chemists are unwilling to admit that this is possible; and it may reasonably be objected that if the limestone had been exposed to so high a temperature as to vaporize its magnesia, the silica would not be mechanically present, but would have entered into chemical combination with the lime or the magnesia, and have formed a silicate.

That whin dikes have sometimes been the means of producing such a combination has been shown by an eminent chemist. In a valuable paper by Dr. Apjohn on the dolomites of Ireland, published in the Dublin Geological Journal, vol. 1st, the details of an analysis of the white chalk of Antrim, altered to the state of a saccharine marble, are given (p. 376); and it is remarked in conclusion, that "the stone under consideration consists of silica, combined with the mixed oxides of calcium, magnesium and iron, (the carbonate of lime being mechanically present); and is therefore a mixture of trisilicates, very analogous in its composition to olivine. We are thus enabled to understand why olivine should be so very frequently found in trap-rocks, and to refer its origin to the contact of silex at a high temperature with an excess of the basic oxides; and we have in some degree a demonstration that the dolomites which contain siliceous sand could not have been exposed at any time to a heat sufficiently high to account for the introduction into them of magnesia in the vaporous state; for by such a heat a silicate of lime or magnesia, or of both, would have been produced."

The presence of these silicates in both our specimens is shown by the gelatinous silica appearing; yet a greater quantity of silica is present mechanically; which, as already stated, seems inconsistent with the exposure of the rock to intense heat; unless, indeed, we could suppose that the silica has been introduced by infiltration, or the magnesia removed by the solvent power of free carbonic acid, at a period subsequent to the consolidation of the dike from a state of igneous fusion. It is unnecessary, however, to pursue the subject farther with our present limited knowledge of facts; it is one of great interest both to the chemist and the geologist, and as no instance of similar changes on dolomitic rocks has, so far as I am aware, ever been put on record, the subject is deserving of a full investigation. I hope to be able, in the course of next session, to lay before the society complete quantitative analyses of a suit of specimens illustrative of the structure of the limestones of Bute, and the nature of the metamorphic action to which they have been subjected.

15*th December*, 1847.—Vice-President *in the Chair.*

Mr. Keddie gave in the following report from the botanical section:—

"The President, Dr. Walker Arnott, in the chair. The President presented to the Herbarium a collection of exotic ferns, chiefly from the southern part of the peninsula of India and Ceylon.

"Mr. Gourlie presented 105 species of British and Foreign mosses and jungermanniæ, and exhibited the fruit of Maclura aurantiaca, from the neighbourhood of Philadelphia, sent by Mr. Gavin Watson.

"Dr. Walker Arnott gave an account of the characters adopted for the distribution of ferns into genera, accompanied with an historical sketch of this branch of botany.

"Among the ancients there appeared to be no distinctions except such as *Filix mas* and *Filix fœmina.* Bauhin was the first to make any attempt of the kind, and Tournefort in his *Institutiones rei herbariæ* did little more than give figures of Bauhin's genera, which depended chiefly on the form of the fronds. Linnæus, as in every thing else, laid down new principles, with which at this present day we are still working. Sir Jas. E. Smith, in the Turin transactions for 1793, extended Linnæus's views, and added several new genera indispensable from the multitudes of species discovered since the time of Linnæus.

"By none of these was the subject of venation attended to, either to assist in specific or generic characters. The first whose mind seems to have been directed to this subject was Mr. R. Brown of London, who, in one or two genera in his *Prod. floræ Novæ Hollandiæ* published in 1810, distinctly announced the necessity of introducing new elements; and these were afterwards brought out more clearly in 1830, in the first volume of Wallich's *Plantæ rariores,* in the description of *Matonia,* and a short time after in the first part of Horsfield's *Plantæ Javanicæ rariores;* but Brown, with that degree of caution which marks the true botanist, is far from asserting that the venation affords in all cases a good generic auxiliary. Presl, however, in Germany, and Mr. John Smith of Kew Gardens, have carried the doctrine of venation to excess; and finding it useful in some instances for distinguishing genera with a different appearance or habit, have applied it as an universal principle throughout this group of plants.

"Dr. Walker Arnott then pointed out some genera, to characterize which the venation might be employed with the utmost advantage; and others, in which the simple and reticulated venation was to be found in the same species, and even in the same specimen. The great error, he observed, lay in forgetting the Linnæan maxims—'Quæ in uno genere ad genus stabiliendum valent, minime idem in altero necessario præstant,'—(*Fund. Bot.* § 169); that the character that may suffice for defining one genus may not be good for any other; and the neglecting the equivalent one, "character fluit e genere, non genus e charactere." He concluded by indicating some genera, in which the presence or absence of the involucre was of less consequence than the venation, and the presence or absence of a central receptacle; others in which it was the reverse, and others in which the position and shape of the sori and form of the involucre were chiefly to be depended on. The whole he illustrated by specimens."

Dr. R. D. Thomson read a communication from Dr. Thomas Thomson, jun., giving an account of his travels into Thibet, of which a full account has since been published in *Sir William Hooker's London Journal of Botany.*

5th January, 1848.—*The* PRESIDENT *in the Chair.*

The following members were elected:—Messrs. George Robins Booth, James King, Andrew Fergus, John Moffat. The Librarian intimated that John Macgregor, Esq., M.P. for this city, had presented a copy of his works to the Society.

The following paper was then read:—

XXXII.—*Some Peculiarities in the Native Agriculture of the Lews.* By JAMES SMITH ESQ.

ABOUT two years ago, I had the honour of laying before this Society some account of the Island of Lews, and of the condition of its inhabitants.

By the activity of its wealthy and generous proprietor, extensive operations are in motion, which will progressively lead to an improved condition of the people, whilst it is to be hoped that an ample pecuniary reward will result to the proprietor, in addition to the pleasure which will arise to his benevolent feelings, by having promoted industry, and with it the increasing comforts and comparative riches of the people.

Whilst these great changes are going on, it is but justice to the people to record some excellences in their primitive agriculture, fitted for the peculiar circumstances in which they have been placed—exhibiting an extraordinary acuteness in their observation of natural causes. It is a curious fact, that many of the practices now recommended by the most forward improvers of the present day, as new and important discoveries, have been in universal practice by those islanders from time immemorial.

I shall first speak of their treatment of their cattle and their manure.

In a country so exposed as the Lews is to much rain, and to heavy gales of wind from the Atlantic, and where there are no trees and no mountains to afford shelter, it becomes essential to provide house covering for their cattle in winter, and, at the same time, a constant covering for their manure, so that none of that precious and essential aid to their cultivation may be wasted by the winds and the water which prevail so plentifully. I speak now of the small tenantry, who possess from one to five acres of cropping land, with a wide range of very indifferent moorish pasture. Their houses consist of a rather long, low, building, the walls of which are, in some cases, three or four feet thick, composed of stones and turf, to give at once strength and imperviousness to the wind and rain. The cattle and the people are together in the same apartment, which, to those who have been accustomed to a better system of lodging, may appear objectionable, but to these people, in their primitive condition, it has many points of convenience and economy to recommend it, although it is to be hoped that in the improvement of their condition, the chief points of economy may be retained, whilst their household condition shall be vastly improved.

In this long apartment, the space which is provided for the cattle occupies the greater portion. The earth is taken out to a depth of two or three feet below the level of the surface of the end occupied by the people, and the space serves to contain a large quantity of manure—indeed it holds the whole manure of a year's making, and is exactly upon the principle of the box-feeding system now being recommended by the English Agriculturists.

The dung is never removed from its site, until it is taken to be put into the ground at seed time, consequently, it is never exposed to the weather, to the winds, and to the rain, until it is deposited in the soil.

The cattle are tied to their respective positions by ropes made of heather, attached to stakes of timber driven into the ground or into the wall, and they are arranged with plenty of room, so that they can move around freely in all directions within the walls. A bed is prepared for them all over the floor, consisting, sometimes, of turf and broken peat-moss, with heather, and coarse grass pulled from the moor, and with such straw of the crops as may, by casual damage, have been rendered unfit to eat as fodder. Layer upon layer of this material is added as may be required, so as to form a clean dry bed as the dung accumulates; and from the freedom of motion allowed to the cattle, their droppings, both liquid and solid, are pretty equally distributed through the body of the litter. The moisture descending through the manure, becomes generally absorbed—keeping the whole mass moist, which prevents that dry fermentation and rapid change, which is so destructive to ordinary dung heaps. All the slops and refuse from the dwelling end of the apartment are likewise thrown into the general receptacle, so that not an atom of the debris of the domestic economy is lost.

The floor of the living division is formed of clay, and being so far above the level of the floor of the cattle portion, is at all times dry. The fire, which is of turf, is placed in the middle of the floor, which keeps the clay floor always warm, and as the clay is a non-conductor, only a small portion of the heat escapes into the earth; whilst it is diffused all around, and affords a comfortable warm circle for the family, however large; and in a country where the people are constantly walking through the wet mossy ground around their dwellings, it affords the immediate means of drying their clothes and warming their bodies.

There is generally an inner room, apart from the living one, in which there are beds for a portion of the family—the guidman and his wife, with the small bairns, generally sleeping in that portion where the fire is. There is no vent for the escape of the smoke, and consequently there are no drafts around the fire. The roof is so constructed as to permit the smoke to sift through at all parts, so that when fresh fuel has been added to the fire, you see the smoke escaping like steam all over the roof. There is generally an opening at the farther end of the cattle portion, so that some part of the smoke finds an escape in that direction, and carries a sheet of warm smoke all along over the cattle, thereby imparting a considerable degree of warmth.

The winter keep for cattle in the Lews is extremely scanty; and it is well known to the scientific agriculturist that external warmth saves food, which is equally palpable by observation to the simple Lewsman, who, knowing no language but the Gaelic, in which there is no literature —no magazine of ancient lore, save the traditionary stories of his chiefs —no science—no knowledge of the practical facts constantly arising in this age of improvement—he is left entirely to his own observations, and to the practices gathered from the experience of generations of his ancestors. On all these points the Lewsmen have ready reason for what they do practise. They say that their cattle do not thrive unless they see the fire, and smell the smoke.

On the approach of the cholera, in the year 1832, they were compelled to build up walls betwixt their cattle and the domicile; but as soon as the dread of the disease had fled, they pulled down the walls, that the cattle might have the benefit of the fire. We shall yet see, in a more improved system of agriculture in the low country, the application of artificial heat, with a good ventilation for the general warmth of the homestead, substituted for the present destructive mode of obtaining warmth by the pent up atmosphere of a crowded stable or byre. Thus taking another leaf from the typeless book of the Lewsman.

There are a few small openings at the bottom of the roof to admit the poultry, and a little day-light, through which a portion of the smoke escapes, when the wind blows on the opposite side of the house. The roof is composed of a scanty portion of timber, to maintain its form and position, and the bulk of the covering is made up of the stubble and roots of the grain crops, laid loosely on and thatched over similar to a stack. When the crops are reaped, they are generally pulled so as to gather the roots and stubble with the grain; and after it has been fairly winnowed, the roots and stubble are cut off with a knife, to be placed on the roof as I have described. There the straw is subjected to the fumes of the peat fire, and before the summer season, when it is to be used as manure, it is thoroughly impregnated with the different volatile products of the peat combustion, and forms a very valuable manure. The Lewsmen have here anticipated another of the important discoveries of the present time. A patent has just been taken out for an improvement in the purification of gas, where, by the passing of the gas through saw-dust, chopped straw or other similar material, the gas is purified, whilst the material through which it has been passed, is converted into a very valuable manure. In these singular adaptations of natural circumstances by the Lewsmen, we have an example of the openness with which nature divulges to the untutored mind, those qualities of matter which are essential to the sustenance and comfort of man; whilst a knowledge of them is only reached by the man of science through a long course of varied experiment and laborious induction.

This impregnated manure is seldom dug into the ground, but is generally applied upon the surface, when the plants of potatoes, or grain, have made some advancement; and the rush of growth, after the application, is truly astonishing.

The bulk of the soil of the Lews is deep peat moss; but the cultivated parts have a soil composed of the debris of the granitic rocks, in all conditions and mixtures of gravel, clay, and sand; but so scanty is the available soil, that the cultivation is generally on the lazy-bed system—the trenches, in many instances, occupying nearly as much space as the ridges. The active soil is seldom moved more than four or five inches in depth, and the sub-soil is never moved at all, yet, on this scanty soil, good crops have been raised from time immemorial, with the simple and never varying rotation of potatoes, bere, or bigg, and oats; and there is no more appearance of its exhaustion now, than there was a hundred years ago. Almost the whole of the crop is consumed at home, and the bulk of the debris is carefully kept and returned to the soil, with the addition of the products of the turf fuel, and a portion of the debris of the material gathered by the people, and by the cattle from the vast extent of muirland.

There is one great source of manure which the cultivators near the coast avail themselves of, and that is the sea-weed, which is a vast advantage, as containing elements greedily devoured by the plants. Still, without the peculiar management of their cattle manure, and the debris of their household, with the addition of the peat fuel products, it is not possible that they could maintain the energies of their thin and ill-worked soil, so as to enable them to maintain continuously so large a population on so small an extent of arable ground.

In prosecuting the improvement of the Lews, care will be taken so to engraft the desirable improvements in domestic economy, and in agriculture, of the more advanced countries, without disturbing the peculiar excellencies at present practised by the natives, whilst they advance in all the essentials of an improved civilization. There is ample room, both in the extent of country and in direct proportion of its unoccupied labour, to afford to every family a comfortable and independent subsistence, and to ward off those starvations which have hitherto periodically visited the regions of the north.

19th January, 1848.—*The* President *in the Chair.*

The following members were elected:—Messrs. James Hudson, Ph. D., John Knox, John Smith.

Mr. Stenhouse described some proximate principles of lichens, and exhibited specimens.

The following paper was read:—

XXXIII.—*Notes on the Proportions of the Pyramids of Egypt.* By G. A. Walker Arnott, LL.D., Regius Professor of Botany.

Perhaps there are no monuments of antiquity that have created such general interest as the pyramids of Egypt, enumerated by some among the seven wonders of the world; and although much has been written on the subject, it must be confessed that, at the present day, we have no sufficient evidence, indeed, nothing but conjectures, either of the era in which they were erected, or of the specific purposes for which they were built, any more than we have of the kind of machines by which the enormous stones were piled together. Some trace them to a period coeval with, or antecedent to, Moses; others refer them to a much more modern age. Some consider them merely as the splendid mausolea of the Egyptian kings; others as having been primarily devoted to the religious rites and ceremonies practised by the priests; and as in those days all branches of literature and science were confined to the priests, or to such few others whom they permitted to participate in them, so we have two subsidiary hypotheses; one, that the pyramids were erected on general scientific principles; the other, solely for astronomy, with which their religion was intimately connected.

About six or eight years ago, having occasion to enter upon the investigation of some allied topics, it therefore appeared to me that if any additional light was ever to be thrown on the rise of these artificial mountains, it might be derived from something connected with their construction. As the kings of Egypt had other burying-places much farther up the Nile, and the bones found in the pyramids are those of a bull, I felt very unwilling to give credence to that theory which viewed them only as tombs; and on the other hand, if raised for the use of the priests, as the bones of the bull would imply, that animal being connected with their religion, there would, in all probability, be some remarkable peculiarity displayed indicative of astronomy, geometry (I use this term in its widest sense), or numbers.

The pyramids, or at least the most celebrated of them, are situated in the neighbourhood of Cairo, in the lat. of 30°; and what seems to indicate their astronomical character is, that the entrance is on the north side, and the passage slopes downwards at an angle almost directly pointing to the pole star. Belzoni states the angle to be 26°, consequently the north pole star must have had a still further elevation of 4°; but others say the angle is 27°, and I have heard it mentioned that this angle was 30°, so that perhaps we are not yet in possession of decisive information on the subject; at all events I know of no explanation so good of the northern entrance and its peculiar declivity, as its referring to the elevation of the pole star. Having observed it somewhere stated or conjectured that the pyramids were so constructed as to cast no shadow at noon, from the vernal to the autumnal equinox, my attention was directed to this point, and consequently to the precise proportions of the pyramids.

It is curious and amusing to glance over the different measurements recorded of the base and height. Herodotus makes the height and base the same; Strabo makes the height more than the base, and in the proportion of 25 to 24; but both of these measurements being widely at variance with those given by all other writers, may be safely put out of view, unless with the explanation I shall presently give. M. Savary considers these ancient estimates correct, and that the true base is now covered deeply by sand; but then the *proportions* of the present base and height ought to be the same as given by Herodotus, which they are not.

All indeed must be aware of the great difficulty experienced in modern times in taking accurate measurements, in consequence of the quantity of sand and rubbish now collected around the base; while, again, ancient observers had not very correct instruments for ascertaining the altitudes of solid bodies of such magnitude. On that account a difficulty arose in my mind if the measures given by ancient writers of the height actually referred to the true or perpendicular altitude, and consequently such modern authors as trusted to those old ones, or made their own to tally nearly with them, must be placed in the same predicament.

Of all who have pretended to give the measurements from their own observations, the one in whom most confidence seems to be placed is Belzoni: his observations were not made on the Pyramid of Cheops (a Greek corruption of Kopts), or the Great Pyramid, but on what is called the second one, or the Pyramid of Cephrenes. According to Belzoni, each side of this second pyramid is 684 feet, and the perpendicular height 456. Now these numbers happen to be precisely in the proportion of 3 to 2. Farther, Trench makes the side of the base of the Great Pyramid and its height 704 and 670 feet* respectively, or if these be French feet, his measures will be 750·3 and 500·9 feet English; or, in round numbers, 750 and 500 feet English, which numbers are also as 3 to 2.

Among the ancient writers, or such of the moderns as give proportions very different from these, may be mentioned Diodorus Siculus, Le Bruyn, and Prosper Alpinus; and assuming the base to be 704 French feet, or

* Not having access to Trench's original memoir, I do not know whether these feet be French or English: I suspect the former, from their being made to enter into the average with what are known to be so, in the seventh edition of the Encyclopædia Britannica, article *Egypt*.

750 English, its proportion to the height as given by these individuals will be in round numbers:—*

	Base.		Height.
Diodorus,	750	....	643
Le Bruyn,	750	....	656
Prosper Alpinus,	750	....	625
Sum,	2250	....	1924
Average,	750	....	641

and this proportion is nearly as 6 to $5\frac{1}{10}$, or in round numbers as 6 to 5, instead of 3 to 2, or 6 to 4, as in what are deemed the more correct observations.

But if, instead of the perpendicular height, we suppose these dimensions to refer to the slanting height from the middle of one of the sides of the base to the top, and this was the only way in which a measuring line or rod could be actually applied, and the height most easily ascertained, we shall find that the above average slanting height will correspond to an average perpendicular height of 520 feet,† which, although still too great, is much nearer the truth.

That Diodorus gave the slanting height from the base to a supposed sharp apex, I have little doubt; there is more difficulty about the two others mentioned above, as they may have deduced the height by a method similar to Thevenot's; if so, their measurements ought to be entirely rejected: but their introduction does not much disturb the proportions given by Diodorus.

Among the more modern observers, Thevenot makes the base 682 French feet, which may possibly be not much under the truth, and the height 520; but this latter was obtained by counting the number of steps, measuring the thickness of a few of them, and thence averaging the whole at $2\frac{1}{2}$ feet, French measure; the result would appear to be too great by almost a tenth part. Indeed, the average thickness of all the steps does not seem to exceed 27 or 28 inches English, or scarcely 27 French inches. All attempts, however, at ascertaining the exact height in this way, must yield erroneous and very contradictory conclusions, and unless confirmed by some other method, may be disregarded. In the Encyclopædia Britannica, seventh edition, article Pyramid, it is said "the breadth of each step is equal to its height," but this is absurd.

* Having no other works at hand, I have deduced the proportions adopted by me from the dimensions given in the article *Egypt* alluded to in the above note, and in the article *Pyramid* of the fifth edition of the same Encyclopædia, and which are chiefly copied from M. Savary. In the two latter works, the actual measures are distinctly stated to be in *French* feet, and hence require to be augmented by almost a fifteenth part to convert them into English feet.

† Were the 641 to indicate the slanting height only up to the present platform, the height of the platform would be 531, which is much too great.

Other modern observers, such as Niebuhr, Greaves, Davidson, and Trench, do not by any means agree with each other, and, as M. Savary says, "to determine the precise dimensions is still a problem." But we may arrive at a somewhat satisfactory conclusion by taking the average of their measurements reduced to a supposed base of 750 English feet. Thus:—

	Base.	Height.
Niebuhr,	750	465
Greaves,	750	514
Davidson,	750	464
Trench,	750	500
Head,	750	484
Approximation in Ency. Brit., art. Egypt,	750	477
Sum,	4500	2914
Average,	750	485

At the summit of the greater pyramid is at present a platform of about 32 feet square. Supposing the height in the above average to be that of the platform, it will be requisite to add about 21 feet to get the height, if the pyramid were carried up to a sharp point;* this gives the extreme height, if the pyramid were complete, of about 506 to the base of 750, numbers not very remote from the proportion already derived from Belzoni's measurements, by which the base and height are as 3 to 2, or as 6 to 4.

These, then, I conceive may be assumed as the true proportions, or rather perhaps, the proportions originally contemplated; and consequently, the right angled triangle formed by the half base, the perpendicular height, and the slanting height, exhibits the remarkable numbers 3, 4, 5, the lowest integers that indicate a right angled triangle, and which made these numbers be looked on with great veneration centuries before Euclid became acquainted with the properties of right angled triangles, and which, with many other portions of his geometrical knowledge, he derived from the Egyptian sages.

I have said that Herodotus states that the base and height of the pyramid are equal. He may have arrived at this conclusion in two ways; either by supposing that the phenomenon of the pyramid casting no shadow at noon, was limited to the precise period between the two equinoxes; in which case, as the latitude was 30°, a vertical section would exhibit an equilateral triangle, the height he gave being thus the slanting height; or he may have given the length of the ridge formed by two contiguous faces of the pyramid, and it is to this, as I conceive, he refers, although in reality this ridge is a few feet shorter than the base, or in the proportion of 31 to 32 nearly. And if we suppose that, in Strabo's

* Some of the above do not require this correction, but in others it may not suffice: it may be allowed to the average.

account, the proportions are accidentally inverted, and that instead of the height being 625 and the base 600, he meant to say that the base was 625 and the height 600, we shall find the proportion to be almost quite correct, on the supposition that by the height was intended likewise the sloping line along the angle or ridge of the pyramid.

I have therefore no hesitation in assigning the following proportions to the pyramids:—Half side of the base 3, perpendicular height 4, sloping height from the middle of a side of the base to the top 5, and the line along the ridge or angle $\sqrt{34}=5{\cdot}83$ nearly. Each face of the pyramid is thus not very different from an equilateral triangle, but still sufficiently so as to indicate that such a construction was not intended.

The angle of elevation of each face of the pyramid is about $53^\circ\ 7'\ 9''$, and hence the pyramid casts no shadow from about the 3d March to the 11th October, so that the hypothesis of this being limited to the equinoxes is not correct. Other considerations, too, have now rendered it doubtful to me, if these buildings were proportioned solely for astronomical purposes, although there can be no question as to astronomy, and the arkite worship being intimately connected with the worship of Isis and Osyris.

As the pyramids differed in size from each other, it is unnecessary to speculate on what was the actual length of the sides of the base, or the height. In all probability they were not the result of chance, but referred to some scale of measures (either square or lineal) adopted by the ancient Egyptians, but now scarcely known.

The subject is of more importance than at first sight it would appear, because the angle of elevation and the proportions are more easily determined now than the actual dimensions, and when they are once satisfactorily obtained, the true magnitude of the pyramids will cease to be a problem of difficulty. Moreover, the size of the great pyramid has been attempted to be ascertained, by converting the length of the base and height given by different authors, ancient and modern, into an uniform standard of feet, French or English, and taking the average of the whole; but if, as I have endeavoured to show, the height spoken of by some could not be the perpendicular height, we must either reject them, or assume that either the sloping height or the length of the ridge was intended, these alone tallying with the proportions ascertained by Belzoni in the second pyramid; and then it is obvious that, before taking the average, we must reduce the different kinds of height to the perpendicular or true height, as I have done. We ought also to determine, if possible, whether the observers supposed the pyramid complete, or reckoned only the height of the platform. By not adverting to these, we find in the Encyclopædia Britannica, seventh edition, article Egypt, (vol. viii. p. 568,) that the mean of the observations, since the time of Pliny, gives the base 693 feet and height 510; while the mean derived from the ancient writers is 702 feet for the base and 675 for the height, the average of these being 697 and 592; these measures are, as I have said, in French, not English feet, as the author would lead one to suppose. In Murray's excellent Encyclopædia of Geography, p. 1165, the measures may have been obtained somewhat in this way, as the base is said to be 693 feet (the above average of the modern observations), but the height is stated to be 599 feet, greater than the average of the observations, both ancient and modern, and is so exaggerated that it seems to be copied from Diodorus; and that corresponds to the slanting height.

Although the writer in the Encyclopædia Britannica deduces the side of the base and height by taking the mean of all observations, he does not appear to place much confidence in that method, for he himself adopts, as a nearer "approximation," (whence obtained is not clearly indicated,) 750 feet for the base, and 480 for the height; while Capt. Head makes the base about 780, and the height 503. Now, as already supposed, each of these heights mean the height of the platform; so, before getting the proportions of the complete pyramid, we must add 21 feet, making the height, in the one case, 501, and in the other, 526; and even in Capt. Head's estimate, the proportion is nearly the same for 780 : 826, or 750 : 501 nearly, or 3 to 2. On the whole, 750 and 500 English feet, will probably represent these with tolerable accuracy, agreeing with Trench's estimate, on the supposition that the 704 feet given by him, are French feet, and that the height was the height of the supposed pinnacles; and if the ancient Egyptian Schoenus, consisting of 19,800 (or nearly 20,000) English feet, were divided into 160 equal parts or units, the length of the base would be 6, or half base 3 of these, and the height 4. It may also be noticed, that this base is almost exactly the one-seventh of an English mile, or nearly seven and a half seconds of a degree of an arch of the meridian, in the latitude of the pyramid; and that the sloping height, (625,) obtained from this base, and these proportions, accords well with the proportional height given by Prosper Alpinus; while, as already said, the perpendicular height coincides with that assigned by Trench, when converted from French into English feet.

XXXIV.—*On the Preparation of Chloroform.* By JAMES KING, ESQ.

CHLOROFORM was discovered about the same time by Soubeiran (1831) and Liebig (1832.) Soubeiran, in its preparation, made use of 5 parts of hypochlorite of lime, or bleaching powder, 30 parts of water, and 1 of alcohol of spec. grav. ·852. He states that no carbonic acid was given off during the distillation, and the residue in the retort he found to be water with a little alcohol, carbonate of lime, and a little caustic lime. Leibig prepared it from 1 lb. of hypochlorite of lime, 3 lbs. of water, and from 2 to 3 ounces of alcohol.

It was analyzed by Dumas in 1835, and found to be composed of 2 atoms of carbon, 1 of hydrogen, and 3 of chlorine. Its symbol is C_2 H Cl_3, or Fo Cl_3. In its preparation he recommends the proportions of 4 lbs. of hypochlorite of lime, 12 ounces of alchohol, and 12 lbs. of water.

In the preparation of chloroform, 4 atoms of the hydrogen of the alcohol are replaced by 4 of chlorine, and 2 atoms of oxygen by 2 atoms of chlorine; thus,

$$\begin{array}{l} C_4\,H_6\,O_2 \\ C_4\,H_2\,Cl_2 = 2\,C_2\,H\,Cl \\ \quad Cl_4 \end{array}$$

And in the same way with pyroxilic spirit; the oxide of methyle being acted on, 2 atoms of hydrogen are replaced by 2 atoms of chlorine, and 1 atom of oxygen is replaced by 1 atom of chlorine.

$$\begin{array}{ll} \text{Oxide of methyle,} & C_2\,H_3\,O \\ \text{Chloroform,} & C_2\,H\,Cl = C_2\,H\,Cl_3 \\ & \quad Cl_2 \end{array}$$

Its relation to formic acid is represented by the replacement of 3 atoms oxygen by 3 atoms chlorine; as follows,

$C_2\,HO_3$ = formic acid, or peroxide of formyle.
$C_2\,HCl_3$ = chloroform, or perchloride of formyle.

The following table exhibits a few trials which I made of the preparation of chloroform by distillation with various proportions of alcohol, pyroxilic spirit, and brewers' wash.

Experiments.	Bleach. Powd. by weight.	Water.	Alcohol, by measure.	Chloroform, by measure.
1	8 oz.	20 oz.	1 oz.	2 dr.
2	8 "	24 "	1 "	1½ "
3	8 "	20 "	1½ "	3¼ "
4	8 "	24 "	1½ "	4 "
5	8 "	32 "	1½ "	3 "
6	8 "	20 "	2 "	2½ "
7	8 "	24 "	2 "	5 "
8	8 "	32 "	2 "	3¾ "
9	8 "	24 "	2½ "	5 "
			Pyroxilic spirit.	
10	8 "	24 "	1½ "	⅜ "
11	8 "	24 "	3 "	1 "
			Fermented wash.	
12	8 "	4 "	20 "	1 "

The spec. grav. of the alcohol was ·837. The spec. grav. of the pyroxilic spirit ·833.

The substances were first mixed in a glass vessel, and then introduced into a retort of the capacity of half-a-gallon. The following specimens were submitted to the meeting:—

No. 1, chloroform which has not been washed, but in the condition in which it was distilled. Its spec. grav. is 1·226.

No. 2, chloroform which has been washed with distilled water, until the water with which it was washed gave no precipitate with nitrate of silver. Its spec. grav. is 1·446.

No. 3, chloroform which has been washed with distilled water, agitated with chloride of calcium, and distilled with sulphuric acid. Its spec. grav. is 1·4995.]

I find it an advantage to remove the liquor which has been distilled with the chloroform as soon as possible. 16 drs. of the distilled liquor generally absorbed ½ dr. in 12 hours. If there has been a large amount of alcohol distilled with the chloroform, it absorbs more. From these trials the proportions of 8 oz. of hypochlorite of lime, or bleaching powder, 24 oz. of water, and 1½ oz. of alcohol, give the best results. If 1½ give 4, 2 ought to give 5⅓; it only gives 5.

Chloroform is a colourless oily liquid, having an agreeable ethereal smell and sweet taste. It is very slightly soluble in water, but soluble in alcohol and ether. It boils at a temperature of about 141°. Its spec. grav. is 1·4995, or 1·5.

There are several substances which, when inhaled into the lungs, cause stupor or insensibility. We have nitrous oxide, (the stupifaciant effect of which gas was discovered by Sir H. Davy,) composed of 1 atom of nitrogen and 1 of oxygen. We have sulphuric ether; composed of 4 atoms of carbon, 5 of hydrogen, and 1 of oxygen.

In October last, Dr. Simpson applied to Mr. Waldie of Liverpool, when in Edinburgh, to recommend an agent that possessed the properties of sulphuric ether. Mr. Waldie advised the use of chloroform, which Dr. Simpson tried, and found to be successful. At a meeting of the French Academy, held on the 29th of November, 1847, it was stated that at the time the stupifaciant influence of ether was observed, several attempts were made to find some other agent capable of producing the same effect; and at that time M. Flourens, Secretary to the Society, having made some trials on animals, found that chloroform possessed the same power of rendering them insensible. Chloroform is supposed to act on the system in the same way as sulphuric ether. For an account of the action of sulphuric ether, I refer to a paper read by Dr. Andrew Buchanan, at a meeting of this Society on the 22d of February, 1847.

Dr. Simpson says the superiority of chloroform over sulphuric ether consists in its requiring a less quantity to produce the same effect,—its action being much more rapid and complete,—its inhalation being much more agreeable,—its perfume not being unpleasant,—and its odour not remaining attached to the clothes.

February 2.—*The* President *in the Chair.*

Messrs. John Smith and John Knox were admitted members.

The following paper was read:—

XXXV.—*On the Fall of Rain in the Neighbourhood of Glasgow, and Description of the Gorbals Gravitation Water Company's Works.* By ALEXANDER HARVEY, ESQ.

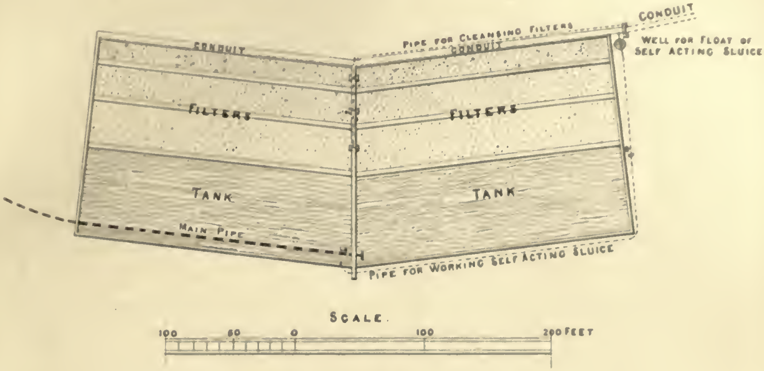
THE valley of the Clyde is estimated by Dr. Thomson, in his work on Heat and Electricity, to drain about 1-30th part of Scotland, or about 1-83d part of Great Britain. He also states that the district drained by the Clyde is not nearly so rainy as many other tracts both in England and Scotland. The estimate, however, which he makes of the annual fall of rain over the whole of Great Britain, as not less than 36 inches, must be exceedingly near the truth, if we take into account many of the districts, both in England and Scotland, where the fall of rain is considerably under that quantity, along with the other districts which rise considerably above it.

I will not take up your time with any detail of the quantity of rain falling in other districts, but will confine myself, as far as I have ascertained it, to the fall of rain in different places situated in the strath or valley of the Clyde, where of late rain guages have been kept, and observed with considerable accuracy, and shall, for that purpose, present you with a tabular view of the results obtained by the different observers:—

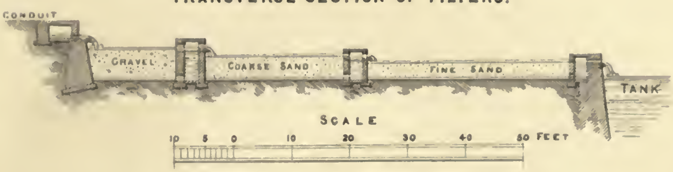
	Maximum.	Minimum.	Mean.
Parish of Strathaven, Gilmourton, by Mr. John Wiseman, ...	59·60	47·30	53·95
Parish of Mearns, by Mr. Mather,	71·00	40·30	55.65
Near Paisley, Mr. Stirrat,.........	72·00	42·00	57·00
Ibroxholm, Mr. Gardner,.........	35·91	33·33	34.64
Glasgow, Dr. Couper, from 1818 to 1834, ...			22 86
Largs,................................			43·50
Mean,......	59·64	40·73	44·60

It is difficult to account for the fall of rain at Glasgow being so much less in quantity than at other places in the immediate neighbourhood, as, for instance, at Ibroxholm, only two miles to the west of Glasgow, and upon a lower level than even the college grounds where the rain guage was kept. The guage at Ibroxholm shows a fall of rain of about one-half more than the record kept by Dr. Couper shows at Glasgow. It is now pretty well established that more rain falls upon high grounds than upon low and level plains; and this may be accounted for by the direction given to the currents of air, by the hills causing an intermixture of the different strata of hot and cold air, thereby giving rise to a precipitation of rain from the hotter stratum; but why such a difference should exist within so short a distance, at nearly the same level and in the same strath, is, as I have already said, difficult to account for, unless we sup-

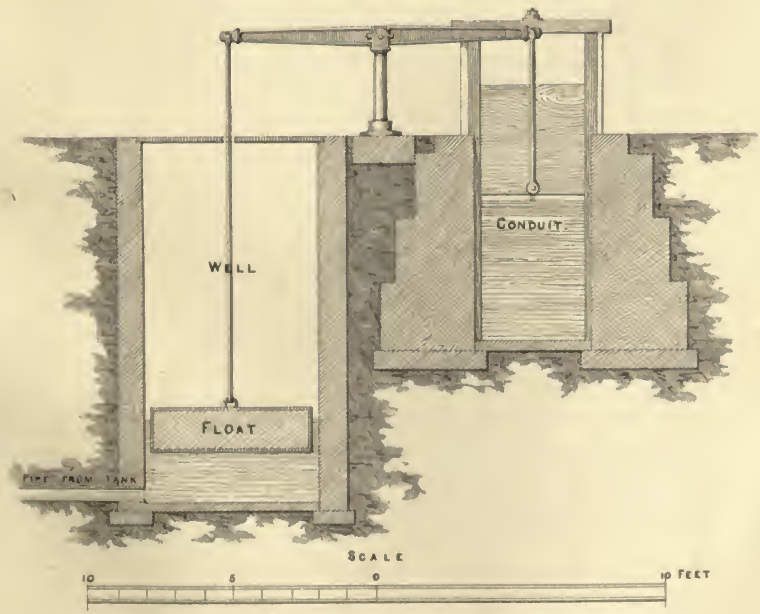
PLAN OF FILTERS AND TANKS.



TRANSVERSE SECTION OF FILTERS.



SELF ACTING SLUICE.



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pose that the heat of the city, or some other local cause, occasions an absorption of the rain-drops as they are falling through the stratum of air immediately above the city.

Of the quantity of rain falling in this neighbourhood, about one-third part is lost by evaporation, absorption, and other causes; the other two-thirds can be retained and made available for useful purposes, such as water-power, or the supplying of large towns with water. This is now so well understood, that water-works for the supply of the public are erecting in many places throughout Great Britain, upon the principle of collecting, and making available, the quantities of rain which fall throughout the year, and which would otherwise pass off in floods direct to the sea.

In 1846, an Act of Parliament was obtained by the Gorbals Gravitation Water Company, for supplying the inhabitants of Gorbals, Govan, and other places in the neighbourhood, with water, by gravitation, from works to be erected on the estate of Upper Pollock, in the parish of Mearns; and since then these works have been progressing with great rapidity towards completion; during a great part of last summer, no fewer than from eight hundred to one thousand men have been employed upon them, in raising the embankments, building the tanks and filters, and in other departments connected with the works. The works, I am happy to say, are now very nearly completed, and in a very short time the inhabitants of the south side of the river will have an abundant supply of pure water.

The source from which this water is to be obtained is the Brock Burn, which drains an area of about 2800 acres, and the annual fall of rain in that neighbourhood, for the last ten or twelve years, has been ascertained by Mr. Mather to be 55 inches, two-thirds of which, or 37 inches, could be made available; but supposing that we can only collect 30 inches out of the 55, it is easy to ascertain what quantity a depth of 30 inches of water over an area of 2800 acres would be. It amounts to about 305 millions of cubic feet, or 1906 millions of gallons, which is a sufficient supply for a population of 270,000, allowing each individual to consume twenty gallons daily. For the purposes of the company, however, it is not at present necessary to construct more than two reservoirs, which will contain about fifty millions cubic feet. On the supposition that these will be filled three times in the year, (which is considerably below what may be expected,) that would give 150 millions cubic feet, or a supply of twenty gallons daily to each of a population of 133,000 or about double the present number of the inhabitants of Gorbals.

These calculations are not hypothetical, and are rather under than over the result to be expected; sufficient proof of which we have from Paisley, and other works of a similar kind already erected, and which have been in operation.

Through the kindness of Mr. Stirrat of Paisley, who was, I believe, the originator of the Paisley Water Works,* and who has, both during and since their erection, devoted much of his time and attention to them, I have been furnished with a few details of the practical results obtained at these works.

The extent of the contributing ground to the Paisley works is 793 acres, or considerably less than a third of that of the Gorbals Company. These works are capable of supplying 70 million cubic feet of water annually, and the actual consumpt by a population of 42,000 is about 25 millions cubic feet. There are, however, a number of dyeworks, printworks, breweries, distilleries, and others of a similar kind, supplied with water from these works, and consuming about 25 millions cubic feet annually also.

The whole water from which the company thus derive their revenue is, therefore, about 50 millions cubic feet, out of 70 millions collected; 20 millions cubic feet of water must thus be allowed to run to waste from the reservoirs after it has been collected.

It has been ascertained, that out of the 70 millions cubic feet collected in the reservoirs in one year, 65 millions of this quantity was collected during twenty-five rainy days throughout the year.

Mr. Stirrat has also furnished me with details of the expense of erecting and keeping up these works, also the revenue derived from them; but I consider it unnecessary to detain you with these. It is sufficient to know that the inhabitants of Paisley are now supplied with abundance of pure water, at a cheap rate, and have been so for the last ten years, during which period the pressure has never been taken off the pipes either at night or throughout the day.

With these facts before the Gorbals Company, I think that they need have no fear of having an abundant supply of water for double the present amount of the population of Gorbals; and were they to extend their works to a higher level, and draw their supply from ground farther to the south and west of their present works, they could obtain a supply of water sufficient for a population of 700,000, or more than double the number of the present inhabitants of Glasgow.

The water of the Brockburn has been analysed by Dr. Thomson, Professor Penny, and Dr. Gregory of Edinburgh, all of them concurring in pronouncing it a very pure water. The maximum quantity of saline matter found in an imperial gallon, or 10 lbs., amounting to only 8·1 grains, while the minimum quantity obtained was only 6·5 grains. The Clyde water, which, when properly filtered, is considered a very pure water, contains from 10 to 16 grains of saline matter in the imperial gallon. The water of the Brock Burn is, therefore, much purer than that of the Clyde, which contains nearly double† the quantity of saline matter.

* The credit of originating these works is usually ascribed in Paisley to the late Dr. Kerr.—Edit.

† The water of the Clyde contains from 10 to 16 grains of saline matter in the gallon, according to the state of flood in the river. The statement, therefore, that the water of the Clyde contains *nearly* double that of the Brock Burn is pretty correct.

Analysis of the water of the Brock Burn, by Professor Penny:—

Organic matter,	1.150
Carbonate of lime,	3.610
Sulphate of lime,	0.870
Common salt,	0.881
Sulphate of potash and soda,	0.299
Magnesia,	0.120
Oxide of iron,	0.070
Silica	0.150
	7.150

Mr. Stirrat of Paisley, on being invited to give his opinion on this subject, spoke in the strongest terms of the capabilities of the works. In regard to the rain-guage commonly in use, he stated that it did not show one-half of the quantity of rain falling. When it was set on a height, like the one in the College, the rain falling during a storm was not correctly indicated. He had kept one for fourteen years, and set up one beside it at a height of four feet; and he found that, in a storm, there was a difference of 30 per cent. in favour of the lower one. He had no doubt that the rain falling in this part of the country averaged 56 inches. This opinion he formed from three years' measurement of the reservoir at Paisley, which showed 52 inches for each year, while the rain-guage indicated only 33. He considered that, as the works of the Gorbals Company now stood, they could afford an abundant supply of water to 270,000 of a population.

EXPLANATION OF PLATE—The conduit which conveys the water from the reservoirs is from 400 to 500 yards in length, and constructed of arched masonry. At the end of the conduit next the reservoir, there is situated a self-acting sluice, differing in construction from the one shown in the plan, but acting in concert with it. The self-acting sluice shown in the plan is placed at the end of the first filter, and is connected by a lever with the float in the well. The water from the reservoir passes along the continuation of the conduit at the upper end of the series of filters, and flows in a regular and thin stream into the first filter, which consists of gravel, through which it percolates, and then rises within the double wall which separates the first from the second, or coarse sand filter, and so on till it reaches the tank, as shown in the transverse section of filters.

The use of the self-acting sluice is to prevent the continued flow of water into the filters after the tank has been filled, and it acts in the following manner:—at the bottom of the well containing the float there is a pipe connecting the well with each of the tanks, whereby the water in the well and that in the tank, which may be in use at the time, is always kept at the same level, as the float rises with the water in the well it acts upon the sluice, by shutting it, thus preventing the water from passing onward. The water being prevented from passing into the filters, accumulates in the conduit, until it begins to act on the self-acting sluice at the reservoir, which in turn shuts off the supply of water from that source. It is evident from this that the supply of water from the reservoir must be regulated by the demand at the distributing tank.

Mr. Robert Montgomery of Johnstone exhibited and explained his new Self-Acting Railway Break.

The friction or break wheel, which was nearly of full working size, was 17 inches in diameter and 2½ broad; the full-sized wheel would be 18 inches diameter and $3\frac{1}{2}$ inches broad. The break wheel is fixed upon the axle, between the carriage wheels. From axle to axle of each carriage there is a frame or shears, on which all the break apparatus is fixed, this being quite detached from the body of the carriage. The break is self-acting, being governed primarily by the drag-bar of the carriage, on the forward end of which is a strong spiral spring, which gives ease to the carriages at the starting of the train, and allows the break to act the moment that any stoppage takes place, from whatever cause produced. Mr. Montgomery, by means of a train of four model carriages, with breaks to each, illustrated the value of his invention in a series of interesting and satisfactory experiments. These model carriages, of about half a hundred-weight each, were mounted on a model railway of about twenty-feet long, at one end of which was an upright rod, with a pulley at its upper extremity, over which passed a cord, bearing a ball of metal, which supplied the motive power. The carriages were drawn to the extreme end of the railway, and allowed to approach the opposite terminus, with the full amount of momentum which the descending ball gave, and showed what might be supposed to take place upon a railway when the breaks were not applied. The breaks were next applied to two carriages when at the highest rate of speed, and when about three-fourths of the road was passed; the effect was an immediate slowing, until the train stood still at about ten inches from the end of the railway. The railway, which, in the above experiment, was level, was now altered to an inclination of one foot in fourteen; and here the power of the breaks, when applied to all of the carriages, was so great, that they stood firm upon the rails; and with breaks on two carriages, came down at a slow, easy, and perfectly safe rate of progression. The break only acts upon the forward motion of the carriages. This was shown by the carriages being easily drawn backward up the incline by a cord attached to the hindermost one, and all the breaks applied; and when the cord was suddenly cut through, the carriages did not run down the line, but stood still instantaneously, and one or more breaks had to be put out of action before the train again acquired any motion.

February 16, 1848.—*The* PRESIDENT *in the Chair.*

Messrs. John Macadam, John Barclay, and William Watt, were admitted members.

A vote of £24, for book-cases, was finally passed.

The following paper was read:—

XXXVI.—*On the Mode of Preparing Manila Hemp.* By THOMAS M'MICKING, ESQ.

DURING a two years' residence as a merchant at the town of Manila, I availed myself of every opportunity to visit the interior of the Island

Luzon, the chief of the Philippine group, of which Manila is the capital town and the seat of government.

The Philippine Islands form a colony of Spain, second in importance only to Cuba.

One map, now exhibited, shows their position and extent in the Eastern Archipelago; the other map, which was constructed at the town of Manila, shows the political subdivisions, like our counties, each under a governor, or alcaldé. The districts in which the substance known in this country as "Manila Hemp" is produced, are designated on the map as Albay-Camarines, N. and S., Batanyas, and the Islands of Panay and Marinduque.

While on a visit at a sugar-producing establishment in Laguna district, having expressed a wish to see hemp prepared, my host, an accomplished Spanish naturalist, desired some of his workmen from the hemp district to gratify me. This was easily done by going into the woods, cutting down the first tree, or rather large herbaceous plant, of the proper sort, and speedily putting up the simple apparatus necessary.

The hemp plant is described in the Flora de Filipinas, a botanical work in Spanish, by a most estimable man, Manuel Blanco, an Augustine friar, with whose acquaintance I was honoured during my residence at Manila. This book—now produced—is interesting as a specimen of Manila printing and binding; and possesses the higher value of being the only correct and complete account of the botany of a little known part of the world. It is the result of a lifetime, from manhood to old age, spent by the worthy friar, so far as he felt free to intermit civilizing labours in his clerical vocation, and give time to his darling science of botany.

He thus describes the hemp plant, the native name of which is Abaca:—

Musa Trogloditarum textaria.

Corolla—the lower lip almost entire.

Stamens—five, without the rudiment of the sixth.

Fruit—three-ribbed, and with many perfect seeds.

He considers it a variety of the Musa Trogloditarum errans, a rare plantain which grows spontaneously in the woods, with fruit of about a finger's-length, bitter, and non-edible; and the fibres from which plant appear to be fully as strong as those from the cultivated variety.

In the districts already named and pointed out on the map, the hemp plant is cultivated with care, and is of much utility. The fruit is eaten, but is small, hardly exceeding two inches in length. The seeds arrive at complete ripeness. The sap of the tree is sometimes used medicinally by the natives.

When hemp is to be made, a tree is cut down by the root, close to the ground. This is an easy process, as it is not timber or woody fibre, but compact successive layers of vegetable substance. In girth, it is about equal to the common plantain, say eight to twelve inches in diameter.

The plant is felled at the time when it is about to produce fruit; the upper extremity or head is also cut off, and the leaves removed. The layers of the tree, or herbaceous plant, are torn off one by one, and the fine skin from the inner surface removed with the knife, which every Manila man carries in a sheath in the waist-string of his trousers, like many of our sailors. The layer, or roll, when stript of its skin on the inner surface, is torn into strips, of about two fingers'-breadth. One of these strips is placed on a plank, or rude table, the inner skinless surface next the table, on which it is pressed by the sharp edge of a knife. Of course, the knife may be held by the hand, but an easier way, and which was done when the process was shown to me, is to fasten the knife to the table by a string, where the blade joins the handle, and the outer end of the handle being pressed upwards, by a piece of bent bamboo doing the work of a spring, the sharp edge presses down against the outer surface of the strip on the table, with sufficient force to penetrate the soft pulpy substance, though not with such force as to wound or cut the stringy fibre. The workman grasps an end of the layer or strip thus held to the table by the knife edge, and pulls it towards him. I can best explain the degree of force necessary, by saying, that, when I tried it, I had to exert my strength, an easy pull did not suffice. The pulpy substance remains on the side of the knife away from the workman, who pulls the clean fibres towards him. When entirely pulled through, he changes it end for end, grasping the clean fibre, and pulling towards him underneath the knife the portion first held in his hand, which, in like manner, on being pulled through, becomes cleaned fibre. If not sufficiently cleaned, the process is repeated a second time; but this is unusual in practice. The specimen of hemp now produced is long and well cleaned, consequently of good quality. It is part of what was made when the process was shown to me. The hemp of commerce is sometimes shorter, from the stem of the musa plant being cut into lengths, for convenience of lifting it from the place in which it is felled to where the workmen are. The hemp is also sometimes matted, from portions of the pulpy substance or skin adhering to the fibres, when the workmen are careless or unskilful.

The portions, as cleaned, are hung up for an hour or two to dry, if in the open air, on any branch of a tree at hand; or, if in a house, on a peg in the wall. No further preparation is necessary for the ordinary Manila hemp of commerce. The product of a day's—probably not hard work—of three persons, is about 14 lbs.

Of the fibres thus prepared, some are fine, and fit for being woven into cloth of considerable fineness and beauty. Such fibres the women pick out, and roll up tightly into a ball, as big as a child's head. This is placed in the wooden mortar, of which there is one in every house for husking rice, and pounded for some time with the wooden pestle. This operation renders the fibre flexible, and less liable to break. The ends are then knotted together by women and girls, to form a continuous thread. The weaving process is the same as for cotton fabrics. In weaving very fine hemp cloth, the wind is apt to break the threads if not under shelter. I believe, also, that the threads are kept moist in weaving from both the hemp and the pine-apple fibre; and it is an occasional mode of the sellers to praise the fineness of the cloth, by saying, that it was "woven under water;" implying that the threads were so fine, that ordinary moistening would not suffice to enable the weaver to work them up.

The hemp cloth, when woven, is placed for a day and night in water, with a little lime made from sea-shells, and afterwards washed and stretched out. It is hard and rough, more so than our linen or than China grass cloth. It is, however, a favourite material for shirts with the Philippine islanders of both sexes. Those now exhibited are a man's and a woman's, and constitute the only covering in common use by both sexes of the labouring class for the upper part of the body.

When to be woven, the hemp is easily dyed of blue and pink colours. To dye it blue, the natives employ the leaves of the Marsdenia ocar, which gives blue colour in abundance. This plant is described at page 118 of the Flora de Filipinas. To dye hemp pink, they boil the bark of the root of Morinda citrifolia, (described at page 150 of the Flora de Filipinas,) with a little lime or alum, till the desired colour is obtained; or it may be more easily done by the same process as used for cotton thread, which is by solution of wood ashes, and oil of Sesamum Indicum. (See Flora Filipina, p. 507.)

The price paid to the actual producers of the hemp must be very low, as it has to be collected in small quantities from house to house, and transported chiefly on horseback through a country where roads are few and bad. Its selling price is commonly about 11s. or 12s. per cwt. at the outports, from which it is conveyed by coasting craft to Manila.

At Manila, the hemp is packed into well-shaped bales, measuring ten cubic feet, and weighing 280 lbs. each, which is the shape in which it appears as merchandize, and in which state the price is usually about 20s. per cwt. The packing-press is a worm screw, worked like the capstan of a ship, which, in descending, forces the hemp into a strong wooden box, the upper portions of which are taken to pieces, and removed as the hemp is pressed down.

The quantity exported from Manila annually is about 5000 tons weight, of which about two-thirds or three-fourths go to the United States, and remainder chiefly to this country, where its consumption appears to be increasing. A considerable quantity is also made into rope in the districts where it is produced, to supply coasting vessels, and for other purposes; and at Manila, the manufacture of rope from the hemp for domestic use, and for exportation, or sale to shipping visiting the port, is a considerable branch of industry.

Dr. Walker Arnott mentioned, that, although the Manila hemp possessed great tenacity, the fibre always gave way when knotted. Mr.

Harvey mentioned that it could not be bleached by chlorine, the fibre being reduced to a pulp by that agent. Mr. Gourlie exhibited a fine specimen of manufacture from Manila hemp, and also of the prepared fibre of the pine-apple plant.

The Librarian produced a copy of the Commercial Statistics and Progress of America, by John Macgregor, Esq., M.P. for Glasgow, presented to the Society by the author. The thanks of the Society were voted for the valuable donation.

1*st March,* 1848.—*The* President *in the Chair.*

Messrs. James H. M'Clure and John Craig were admitted members.

The following communication was made :—

XXXVII.—*List of Zoophytes found in the West of Scotland.* By the Rev. David Landsborough, Saltcoats. Communicated by William Gourlie, Jun.

Class Anthozoa. Ehrenberg.

Anthozoa Hydroida.

I. TUBALARINA.

Family—Corynida.

1.—Clava. Gmelin.

1. Clava *multicornis.* Found, at times, on seaweeds; but it is rather rare in the west. It has been found at Saltcoats, Largs, and in Arran.

2. Hydractinia. Van Beneden.

1. Hydractinia *echinata.* This I had long known under the names of *alcyonium* and *alcyonidium echinatum.* It is not rare here; on old univalve shells, and is found in Arran.

3. Coryne. Gærtner.

The name is from *Coryne*, a *Club.*

1. Coryne *pusilla.* Seldom found here. Found at Largs, on seaweeds.

4. Tubularia. Linnæus.

1. Tubularia *indivisa.* Not found here, as we have no muddy shores; but found at Cumbraes, and in Rothesay Bay, and dredged in Arran. It is very pretty when in a live state, with flowery heads.

2. Tubularia *Larynx.* This I have got from Cumbraes; but it is very rare.

II. SERTULARINA.

Family.—Sertulariada.

5. Halecium. Oken.

The name is from *Halec*, a herring; and it is called the *herring-bone* coralline.

1. Halecium *halecinum.* I have not found this on the coast of Ayrshire, but I have repeatedly dredged it in Arran.

2. H. *muricatum.* I have not found this on the Ayrshire coast; but I have got it on oysters from Stranraer.

6. Sertularia. Linnæus.

1. Sertularia *polyzonias.* This is not uncommon with us, and it is still more common at Troon. It is almost always found on *Halidrys siliquosa.*

2. S. *rugosa.* This is very rare with us. I have found it only once or twice on seaweeds.

3. S. *pumila.* Very common here, and all along the coast, and in Arran. It is generally on the larger seaweeds, such as *Fucus serratus*, *vesiculosus*, and *nodosus*. The finest and largest specimens, however, I have ever seen of it, were between Leith and Portobello, on young plants of *Laminaria saccharina.*

4. Sertularia *abietina.* I have at times got specimens of this, though rarely, amongst *rejectamenta*, on the shores of Ayrshire. It is found abundantly in Lochryan, at Port-Patrick, and at Little Ross Island, near Kirkcudbright.

4. S. *filicula.* This is rare with us. It is at times, however, found on seaweeds, and about the roots of *Laminaria digitata.*

5. S. *operculata.* This is not uncommon. It is found on the stout stems of *Laminaria digitata.* I once found it intermingled with the stems of *Furcellaria fastigiata.* It is seldom three inches in height; whereas I have seen specimens from Lough Swilly, measuring upwards of four inches.

We are not rich in *Sertularia*, as we have only five of the seventeen that have been observed.

7. Antennularia. Lamarck.

The name, from *antennula*, a diminutive of *antenna*, a *feeler.*

1. Antennularia *ramosa.* I have not found this more than once on the coast of Ayrshire; but I have got it in the Kyles of Bute, and off Cumbraes, and very fine specimens, by dredging in Arran, and also from fishermen.

It has been made a question whether this be more than a variety of *Antennularia antennina*, and there are many of high authority on each side of the question. I am disposed to join the minority, and to say that I think it a distinct species. I have now seen a considerable number of specimens found in the west. They are very branching; and not one of them approaches the form of *antennina.*

Antennularia *antennina.* Largs, Mr. Adamson.

8. Plumularia. Lamarck.

The name from *plumula,* dim. of *pluma.*

1. Plumularia *falcata.* This is very rarely found on that part of the Ayrshire coast with which I am best acquainted. It is found in Islay, Arran, Kyles of Bute, Lochryan, Portpatrick, and Little Ross Island, near Kirkcudbright.

This is the sickle-coralline. When it is so common in so many parts of Great Britain and Ireland, a person is rather surprised that it should be so rare in the west of Scotland.

2. P. *cristata.* Podded-coralline. This is very beautiful, and though not common, it cannot be called very rare in the west. With us, it is found only on *Halidrys siliquosa,* and it is generally in company with *Cellularia reptans* and *Sertularia polyzonias.* When fresh from the deep it is generally of a fine yellowish straw colour, though occasionally some of the fronds are pink. It is attached to the seaweeds by flexuous, horny, root-like fibres. The finest plumes with us are between two and three inches in height. The podded vesicles are large and curious.

3. P. *pinnata.* I have dredged very fine specimens of this in Lamlash bay. They are found on *Pecten opercularis,* adhering by root-like fibres. The largest specimens were about four inches in height, by three-fourths of an inch in breadth. They were of great beauty, purely white, and very delicate. I have seldom found it with vesicles.

4. P. *setacea.* This, though beautiful, is less so, and smaller than *P. pinnata.* It is rather rare on the west coast. It is generally found on univalve shells, but sometimes on *Halidrys siliquosa.* The main stem is often clothed with vesicles. The finest and largest specimens I ever saw, were got in Lochfine when I was aboard the *Raven,* with Mr. Smith of Jordanhill and Professor John Fleming. They were rich in reddish vesicles.

5. P. *Catharina.* This is a very elegant *Plumularia,* which I have dredged in Lamlash-bay, adhering to *Pectens* along with *P. pinnata,* from which it differs in several respects. The *pinnæ* of the plumes are opposite, and more sparse. I was the more pleased to fall in with this species, because it bears the specific name *Catharina,* in honour of Mrs. Johnston, a lady to whose pencil natural science is so much indebted.

6. P. *myriophyllum.* Pheasant's tail coralline. I have never found this very handsome zoophyte on the Ayrshire coast. It is found in Arran, where it does not seem to be very rare. I have twice found it with vesicles, which had not been seen before, and which are very remarkable. They are figured by Dr. Johnston, in his History of Zoophytes. It grows to a great size. One specimen I got was eighteen inches in length. The Arran specimens do not seem to have the *pinnæ* leaning to one side, like specimens from other places.

See Johnston, I. page 118.

CAMPANULARIDÆ.

9. Laomedea. Lamour.

The name is from Λαομεδεια, one of the Nereids.

1. Laomedea *dichotoma*. Sea-thread coralline. Small specimens of about three inches in height are at times, though rarely, found on univalve shells on the Ayrshire coast. It has been dredged in Arran, and in the Kyles of Bute, of larger size.

2. L. *geniculata*. This is very common with us. It is found during the winter and spring months on *Laminaria*, on *Halidrys*, and very often it covers more than a yard of *Chorda filum* with a thick fringe. It is very phosphorescent.

3. Laomedea *gelatinosa*. This is common with us; but the specimens are diminutive. It is found on the underside of stones and shelving rocks, within tide-mark. It is seldom above an inch in height.

10. Campanularia. Lamour.

1. Campanularia *volubilis*. This takes its name from *campanula*, a *bell*. It is not rare with us. I have found it on *Fucus nodosus*, on *Halidrys*, with vesicles, and on *Polysiphonia elongata*. I have often observed it on *Sargassum*, from the Gulf Stream, along with a pretty little *Plumularia*. It is beautiful with a lens, but too small to appear beautiful unless magnified.

2. C. *dumosa*. This, though found at times on seaweeds, is rare here.

HYDRINA.

11. Hydra. Linn.

The name is from Ὕδρα, a *water serpent*.

1. Hydra *viridis*. This is very common, especially on aquatic plants from a pond near Stevenston, which once formed part of the first navigated canal in Scotland.

I have never tried to multiply them by using the knife, but I have seen many produced by buds, almost equalling the parent in size in a few days, and dropping off to lead an independent life.

2. Hydra *vulgaris*. This is much rarer here than the former, but I have got it in the same pond.

ANTHOZOA ASTEROIDA.

Family.—Pennatulidæ.

12. Pennatula. Cuvier.

1. Pennatula *phosphorea*. This is the sea-pen, or, as fishermen call it, the Cock's-comb, which, from its colour and substance, it resembles. It is an interesting creature. I have never got it but once. It was brought to me by a fisherman, on a frosty morning, and it seemed stiff and dead; but on being put into sea-water, it recovered, and lived with me several days; when, as a reward for the pleasure it had given me, it was returned

to its native element, the sea. It seems to be rare in the west. The fisherman said he had got it only once before; but fishermen, in general, see only what will bring them money in the market. Even when they have the promise of good pay for curiosities, few of them can be at the trouble to preserve what they class under the generic term of "Vermin." It does not appear that it has been found in Ireland.

13. VIRGULARIA. Lamarck.

1. Virgularia *mirabilis.* This takes its name from *virga*, a *rod.* It is called in some places the *sea-rush*, and it is thought that it stands erect with one end in the mud. I have never dredged it, but it has been dredged by Mr. Smith of Jordanhill, in Gareloch and in the Kyles of Bute.

14. PAVONARIA. Cuvier.

1. Pavonaria *quadrangularis.* This remarkable species was discovered by Mr. M'Andrew, who dredged it near Oban. It lives erect, its lower extremity being sunk in the mud, like *Virgularia ;* and, like *Virgularia*, it is phosphorescent. One specimen got was forty-eight inches in length. It has been got only in one locality, but in that locality it is probably not rare, as a friend of mine dredged it there without any guidance, except verbal instructions.

Family.—Alcyonidæ.

15. ALCYONIUM. Linnæus.

1. Alcyonium *digitatum.* The name is from *Alcyon*, the King's-fisher; the word itself signifying sea foam, of which the Halcyons were thought to build their nests. Dr. Johnston says—"This is one of the most common marine productions." I wondered at this, because it was long before I ever saw a specimen of it. When I began to dredge, however, I got many. At the same time, it does not seem to be so common here as in the east country. At Leith, I got abundance of it, driven out by an eastern breeze. I have very seldom found it on the shore in the west.

2. A. *glomeratum.* I have got this only once. It was sent to me by a fisherman, who had got it on his long lines in the deep sea near Saltcoats. The colour being fine vermilion red, I did not know what it was, as I had not at that time heard of this species. On plunging it in sea-water, it soon sent forth its tentacula, showing me that it was an Alcyonium, and when I afterwards read the description of this species, I saw what it was.

16. SARCODICTYON. Forbes.

1. Sarcodictyon *catenata.* I had a specimen of this dredged off Cumbraes. It was on a stone from deep water. There were inequalities on the surface of the stone, and it had wound itself in a meandering way around it, selecting the hollow places that it might be safer in them The name is from σαρκος, *flesh*, and δικτυον, a *net.*

ANTHOZOA HELIANTHOIDA.

17. Zoanthus. Cuvier.

1. Zoanthus *Couchii?* I write this with some doubt. The specimen I got from deep water was named *Z. Couchii* by a well-skilled friend to whom I showed it, and comparing it with a true specimen received from Mr. Bean of Scarborough, I had no doubt that it was the same; but I was not then aware of the existence of *Sarcodictyon*, and as, when dried, they resemble each other, it is possible that there may be a mistake in this.

18. Adamsia. E. Forbes.

1. Adamsia *palliata*. This is very common in many places on our coast. The first time I observed it was in Arran, where a little stream falls into the sea, near Brodick. It was very abundant on *Trochus magus*. As at that time I had not paid much attention to zoophytes, I thought that it was the inhabitant of the shell that had turned out to enjoy itself in the summer evening; and I thought the pretty spots corresponded with the finely-tinted spots of the shell. I was still more interested in it, however, when I learned what it was, and that it was thought to be in copartnership with the hermit crab that took possession of the inside of the shell.

19. Actinia. Linn.

1. Actinia *mesembryanthemum*. This is not uncommon with us, and it is very pretty. The name of the genus Actinea is from *ακτιν*, a *ray*.

2. A. *crassicornis*. Very common, and large.

3. A. *Dianthus*. Beautiful, found on the pier, Millport.

4. A. *Bellis?* Found, I think, at Saltcoats.

I am sure that many more kinds are found on this coast, but I dare not try to name them.

20. Anthea. Johnston.

The name is from *ανθος*, a flower.

1. Anthea *Tuediæ*. This is found in deep water at Cumbraes, and also as far up the Clyde as Gourock, where a friend of mine kept one for more than two years in a vase of sea-water. In winter it shrunk very much, and lay dormant, but in spring it blew itself up to great size, and became active again.

Family.—Lucerniadæ.

21. Lucernaria. Müller.

1. Lucernaria *fascicularis*. This is not rare in the west, and yet it had not been noticed till Mr. Alder came to stay some weeks at Ardrossan, in June, 1846. His well-trained eye soon observed it on seaweeds. It has often been found by my son David since, here and in Arran.

2. L. *cyathiformis*. This was discovered by my son David, in Arran, in July, 1846. It was in great plenty at one place, among the trap

dykes near the natural harbour at Southend, Arran. He brought a specimen along with him, and showed it to Mr. Alder, who was then in Arran. He thought that it was a Lucernaria, but he could not give the specific name till Sar's *Fauna Littoralis Norvegiæ* came into his hands, and then he saw that it was the above-named. It had not before been observed in Britain. It is not so showy as L. *fascicularis*, which proves to be the same as L. *quadricornis* of Müller.

CLASS POLYZOA. J. V. THOMPSON.

POLYZOA INFUNDIBULATA.

Family.—Tubuliporida.

1. TUBULIPORA. Lam.

The name is from *tubulus*, a tube, and πορος, a *passage*.

1. Tubulipora *patina*. This is occasionally found on seaweeds and shells. It often lurks among the strong fibrous roots of *Laminaria digitata*

2. T. *hispida*. Under this name Dr. Johnston includes two varieties, which are so different, that I would be disposed to regard them as distinct species. The more common one, I would call *T. verrucaria*, corresponding with Dr. Fleming's *Discopora verrucaria*, which, however, included *T. patina* also. The other I would call *T. hispida*. It is from deep water, much rarer, and much more hispid than the former, without any of those smooth vallies that mark *T. verrucaria;* and the border is a little cupped, which is not the case in the other.

Tubulipora orbiculus is now by Dr. Johnston regarded as a variety of *T. hispida*. It is very common here on *Laminaria saccharina*. It is much smaller than either of the preceding, and I think distinct. However, I readily give way to higher authorities.

3. Tubulipora *phalangea*. This is not common here. I have dredged it in Lamlash Bay on *Laminaria saccharina.*

4. T. *Flabellaris*. This is rare. I found it at Whiting bay, Arran, inside of a broken valve of Solen siliqua; and I once found it here inside of a valve of Modiola. It is very beautiful, like a Prince of Wales' feather.

5. Tubulipora *serpens*. This is very common. It is got on old shells, but more frequently on seaweeds, especially *Desmarestia aculeata*, and *Furcellaria fastigiata*.

Pustúlipora deflexa. Dredged in Lamlash Bay, on *Maia horrida*. This is inserted, as it was not observed till the list was finished.

2. DIASTOPORA. Lamour.

The name is from διαστημα, an *interval*, and πορος, a *passage*, intimating some distance between the pores.

1. Diastopora *obelia*. This is rare; I have got it on shells here and at Millport, in Cumbrae; but the finest specimens I have of it are from the Island of Tiree, where it is pretty common on *Pinnæ*.

3. ALECTO. Lamour.

The name of this genus is from *Alecto*, one of the Furies.

1. Alecto *major*. It seems I was the first to find this in Britain. I got it on a fine large *Pinna* sent to me from Tiree, with no other wrapping than a cotton pocket-handkerchief. I remember sending it to my friend Dr. Johnston, saying, as he mentions, that it was like a trickling tear.

2. Alecto *dilatans*. Dredged by Mr. Hyndman, off Sana Island, and by Professor Edward Forbes, off the Mull of Galloway.

4. CRISIA. Lamour.

1. Crisia *eburnea*. This is very common, particularly on the smaller *Algæ*, and on none of them more than *Dasya coccinea*.

2. C. *denticulata*. This, which was formerly C. *luxata*, is often met with, though not at all so frequently as C. *eburnea*.

3. C. *aculeata*. Found by Mr. W. Thompson at Ballantrae, and found, though rarely, by us here.

4. C. *geniculata*. This was sent by me, in an early stage of my zoophytical studies, to Dr. Johnston, from whom I learned that it had not before been found in Scotland. It is most abundant here, but seldom on any thing except *Desmarestia aculeata*, which is often quite hoary with it.

5. CRISIDIA. Milne, Edwards.

1. Crisidia *cornuta*. This is not at all rare with us, being found on *Delesseria sanguinea*, and oftener on *Phyllophora rubens*. It is the Goat's horn coralline.

II. CELLEPORINA.

Family.—Eucratiada.

6. EUCRATEA. Lamour.

This is from Eucrate, one of the Nereids.

1. Eucratea *chelata*. This is the Bull's horn coralline. When Dr. Johnston states, on my authority, that it is frequent on the Ayrshire coast, it must be from some mistake on my part. I must have meant *Crisidia cornuta ;* for though this is found on seaweeds at times here, it is rather rare. I observed it on *Delesseria* sent to me by Lady Emma Campbell, got by her in the Island of Islay.

7. ANGUINARIA. Lamour.

This takes its name from *anguis*, a *serpent*.

1. Anguinaria *spatulata*. This is very rare here. I have got it only once or twice on *Dasya coccinea*. My friend Dr. Fleming desires me to be on the look out for it on *Bryopsis plumosa*, saying that it is found on that alga on the coast of Devon, and *what for no* should it be found on the same on the coast of Ayrshire ? I shall attend to this.

8. HIPPOTHOA. Lamour.

1. Hippothoa *catenularia.* The Hippothoæ are very beautiful, but very minute, and therefore little apt to be observed by unpractised eyes. This species, though the most common, is rare here. I have, however, found it on shells. It seems to be pretty common on Pinnæ from Coll and Tiree.

2. H. *divaricata.* This elegant little zoophyte has been got, though rarely, on *Phyllophora rubens,* here and in Cumbrae. I have got it also on Pinnæ from Coll and Tiree. It is synonimous with *H. lanceolata.*

9. GEMELLARIA. Savigny.

1. Gemellaria *loriculata.* *Coat-of-mail* coralline, and synonimous with *Notamia loriculata.* I have never found the smallest fragment of this on the coast of Ayrshire, or in Arran; but when, in 1846, I visited the Little Ross Island, near Kirkcudbright, I got as many specimens floating in a quarter of an hour as will supply my friends for many days to come.

Family.—Celleporidæ.

10. CELLEPORA. O. Fabricius.

1. Cellepora *pumicosa.* This is one of our most common corallines, on other corallines or seaweeds.

2. C. *ramulosa.* I am not sure that I have got this pretty branching coralline here, but I have got it from Cumbrae, and I have dredged it in Lamlash bay. The fine specimens are about two inches in height, and branched somewhat like an antler. It is found attached to old shells from deep water.

11. LEPRALIA. Johnston.

This is sea-scurf, a pretty tribe, in which there is much variety.

1. Lepralia *hyalina.* This is very common on the Ayrshire coast, and also in Arran and Cumbrae. It is found most frequently on Laminaria saccharina, but it is found also on shells and other algæ. The variety with the punctured cells is not uncommon with us.

2. Lepralia *Hassallii.* This I found on *Patella cœrulea,* on the shore at Saltcoats, and sent to Dr. Johnston, as new to me, and it seems that it has turned out to be *L. Hassallii.*

3. L. *tenuis.* This I have never seen, but it has been got within my range, having been dredged by Mr. Hyndman, off Sana Island, near the south end of Kintyre.

4. L. *simplex.* The same may be said of this, which has been dredged by Mr. Hyndman off the Mull.

5. L. *ventricosa.* Do. do. do.

6. L. *Hyndmannii.* Do. do. do.

7. L. *granifera.* This I found on the Ayrshire and Arran coasts, on old shells.

8. L. *Landsborovii.* Dr. Johnston has done me the honour of dedi-

cating this Lepralia to me. I sent the first specimen I got of it to him, and I have lost the only other specimen I got, so that I would scarcely know my namesake were I to meet him. The one was got on a shell on Lochfine side, and the other was got on the coast of Ayrshire.

9. L. *pertusa*. This is very common at Saltcoats, on the underside of stones, within tide-mark. It is as common at Arran, at Whiting bay. It has been dredged by Mr. Hyndman, off the Island of Sana, near the Mull.

10. L. *annulata*. I found this at Saltcoats, many years ago, when it was new to Britain. As I had not then seen L. *nitida*, I thought it was that species; but Dr. Johnston, to whom I sent it, told me that it was L. *annulata* of Fabricius, and a discovery. It is found pretty abundantly on *Laminaria saccharina*. I once found it on a shell with two spines. It has been dredged by Mr. Hyndman, off the Mull of Kintyre.

11. L. *biforis*. This is rather rare with us. I once found it on a piece of floating bark.

12. L. *pediostoma*. This beautiful Lepralia is one of the most common at Saltcoats, and in various parts of the Island of Arran, on the underside of stones.

13. L. *variolosa*. This is not uncommon on shells in Arran. It is also found here, though but seldom.

14. L. *nitida*. This is a most beautiful Lepralia, and very rare both here and in Arran. Dr. Johnston says, "I would say of it what Fabricius says of his *Cellepora annulata*, (that is, Lepralia annulata, which I mistook for this, which marks both its beauty and similarity,) '*pulcherrima et perfectissima hæc omnium visorum.*'" The most beautiful specimen I ever saw of it, I found on the Ross-shire shore, when waiting for the ferry-boat to take me over to Fort-George, in Inverness-shire.

15. L. *unicornis*. This, which used to be called L. *coccinea*, is very common on the west coast, particularly on the roots of Laminaria digitata.

16. L. *Ballii*. I have never seen this, but it has been dredged by Mr. Hyndman, off Sana Island.

17. L. *coccinea*. This is not uncommon with us, on the underside of stones. It has spines when it is entire.

18. L. *ciliata*. This is not uncommon on seaweeds of various kinds, but chiefly such as *Delesseria sinuosa*. The variety *insignis*, of Hassall, is more generally found on Laminaria saccharina.

19. L. *immersa*. This is common on shells, and stones, and seaweeds.

20. L. *punctata*. On *Pinna ingens*, from Island of Coll.

12. Membranipora. Blainville.

1. Membranipora *pilosa*. This is very common on the large seaweeds. The variety M. stellata, of Thompson, is very common on *Fucus serratus*. The normal kind often completely invests the smaller algæ.

2. M. *membranacea*. This is pretty common, especially lining the inside of specimens of *Buccinum undatum*.

Family.—Escharidæ.

13. Cellularia. Pallas.

1. Cellularia *ciliata.* Very beautiful, but very rare here. This, also, I found in great beauty on the shore opposite to Fort-George.

2. C. *reptans.* Very common here. It is most frequently found on Halidrys siliquosa. The finest and largest specimens I have got were at Troon. It is very brittle when dry.

3. C. *plumosa.* This is not found here. I think I dredged a little of it in Arran. It is found in Lochryan on oyster shells. It was formerly *Acamarchis plumosa.*

14. Flustra. Linnæus.

The name is from the Saxon word *flustrian*, to *weave.*

1. Flustra *foliacea.* Common as this *sea-mat* is in many places, it is very rarely that the smallest fragment of it is found on the shore here. I have a specimen which was dredged in Lamlash bay some months ago, and it has still a little of that sweet fragrance, like heliotrope, which it had when fresh. I think this flavour is different at different places. At Leith, where it is abundant, it seemed to me to have the flavour of *Verbena triphylla.*

I never saw even the smallest portion of *Flustra truncata* on our western shores, though it seems so nearly allied to *F. foliacea.* Dr. Johnston says that "it is very common on the shores of Scotland." The western shores must be excepted.

2. F. *membranacea.* This is very common on large seaweeds, especially *Laminaria digitata.* I have seen a web of this beautiful lace six feet in length by eight inches in breadth. The polypes in this one colony were almost equal to the population of Scotland. At times the Flustra is roughened by little compressed linear projections, rising about a quarter of an inch above the surface, the use of which I did not know; and I got it once on one of the smaller algæ, where, for want of room to expand itself on the alga, it mounted up, and was, to a certain extent, free.

3. F. *coriacea.* This I have not seen, but it has been dredged adhering to shells, by Mr. Hyndman, off Sana.

4. F.? *lineata.* Very common with us, and especially on *Laminaria saccharina.* I have at times been disposed to think that this was an imperfect state of *Leparalia nitida.* The rigid varieties with the spines met, come very near it. Mr. Peach thinks it a good species.

15. Salicornia. Cuvier.

1. Salicornia *farciminoides.* This is a very beautiful zoophyte. The first specimens I saw of it were from Lochryan and Portpatrick. I never met with it on the Ayrshire coast. A month or two ago, I got a specimen of it that had been dredged by a fisherman off Arran.

VESICULARINA.

Family.— Vesiculariadæ.

16. Vesicularia. J. V. Thompson.

Vesicularia *spinosa*. This is never found here, but I have got it from the oyster-beds in Lochryan.

17. Valkeria. Fleming.

Valkeria *cuscuta*. Dodder coralline, named in honour of Dr. Walker, Professor of Natural History, Edinburgh. This pretty little zoophyte, for several years, was got abundantly here, but of late it has been rare. It was got on *Halidrys*, also on *Poly. byssoides*, and *Rhodomena bifida*. It is phosphorescent.

18. Bowerbankia. Farre.

1. Bowerbankia *imbricata*. This is found occasionally here on the small seaweeds. I have seldom seen it of late.

POLYZOA HIPPOCREPIA.

19. Plumatella. Bosc.

1. Plumatella *repens*. This was at one time found in great abundance on the underside of stones, in a quarry pool at Parkend, Saltcoats; but the pool having been pumped dry on one occasion, the *Plumatellæ* perished, and I have not seen any in the pool since. I found, what I suppose is a variety of this, on the underside of water-plants, in another quarry pool, and I saw the same alive in the possession of Mr. Brown of Lanfine, who had got it in a pool near Lanfine House. It is much smaller than those found on stones, and I would almost think another species.

Thuiaria *articulata*. Sea-spleenwort. One specimen of this beautiful zoophyte has been found in Arran since the list was made up.

15*th March*, 1848.— *The* President *in the Chair.*

Messrs. C. R. Collins and Thomas L. Patterson were admitted members.
The following paper was read:—

XXXVIII.—*History and Description of the Kelp Manufacture.* By Charles F. O. Glassford, Esq.

History of the Kelp Manufacture.—The history of the kelp manufacture, if we could now get at all the details connected with it, would be an extremely interesting one. Recent, however, as we may justly suppose its origin to have been, it would require much labour and research to draw together all the facts connected with it, so as to show this question in all its manifold bearings. The subject is intimately associated with our social and commercial progress as a people; and being so, deserves some of our attention. I have endeavoured in the remarks which I will lay before this Society, to bring forward those details which will be of immediate interest, and also the most important facts connected with its history.

The burnt ashes of plants have been long used and manufactured under a variety of names, and for a variety of purposes. On the shores of the Mediterranean, barilla, varec, salicor, and blanquette have been prepared by burning the plants which grow on or near the shores, and applied to such uses as soda is at present. Kelp has likewise been manufactured on the shores of Ireland, Scotland, and the North Sea, and was chiefly of value in former times from the soda it contained. Potashes are likewise formed from the ashes of large timber, and are applied to purposes where potash is required. The variety of the composition of those products depends on their source, whether obtained from land or sea plants, or from plants growing contiguous to the sea. I shall have occasion to allude to this more particularly again; kelp, which is entirely made from plants growing in the sea, at present demands our attention. It is upwards of a century since this article was first prepared as a regular object of commerce on the shores of Ireland, and subsequently in Scotland. But it was not until the beginning of this century that it became an object of very great importance, or was extensively made on our own shores. The elevation of the price from a comparatively small sum of about £3 to £4, to £20 and £22, caused the proprietors of our island shores to exert themselves, and devote some share of their attention to its produce. The result was a great increase on the quantity made, and in many instances a vitiated article. The demand was raised by the gradual increase in number and extent of our manufactures requiring soda or alkali, which followed the troubled and warlike times of last century, and from improvements resulting in these manufactures from the combined influence of talent and capital then exerted. Glasgow, then as now, exerted herself to the utmost, and became the cradle of Scottish manufacturing industry. Manufactures, chemical and mechanical, were then established, and these have since increased and prospered with astonishing rapidity. Soda and potash being largely required—and the demand increasing with our wants, and with our energetic trading propensities—the kelp manufacture flourished. The manufacture was pushed to the furthest limits by the makers, and for years their prosperity continued. From the high price, however, which it then attained, it was doomed—like almost every other manufacture—to meet with competitors. Barilla then entered the market, and notwithstanding the very high duty imposed on it, entered into successful competition with kelp. This product having once reached our shores, and found out the nature of its opponent, and the uses to which it was applied, continued steadily to oppose and increase in quantity, and latterly to reduce the price of kelp considerably, so much so, indeed, that for the 22 years ending 1822, the average price was only

£10 10s. per ton. Barilla at the same time, being an article richer in alkali, that is, in soda, than kelp, commanded a higher price and a preference. The value of these commodities being then entirely dependent upon the soda or alkali they contained, and this alkali being in the form of carbonate, the kelp trade was yet doomed to greater changes; for on the reduction of the duty on barilla in 1822 from £11 6s. 8d. to £8 10s. per ton, and in 1831 to £2 per ton, and also on the removal of the salt duty in 1823, the price of kelp gradually fell to £2 10s. and £3, at which point it may be almost supposed it would have been extinguished. Not so, however; a considerable quantity was yet prepared by a few of the Highland proprietors, and annually sent into the soap and glass manufacturers and bleachers of Glasgow and neighbourhood. It may be supposed that at this very low price it ceased to be an object of any interest. Not so, however, for many of the landlords found it their interest to maintain the manufacture among their tenants, even although the price realized barely covered the cost of the support of the kelpers. In this way a great responsibility was removed from the shoulders of the landlord, the poor tenants were enabled to pay their rents, and probably a portion of their food, while the landlords, besides the removal of the possible responsibility, profited somewhat at the same time. From 1822 till 1845, matters remained in this position, but immediately thereafter a new and important aspect was to be presented by kelp,—it had again to experience a change, a temporary increase in value and in the quantity produced, and a new feature was to be presented. The value of iodine and its demand was the new cause, and from the sudden and unexpected, almost unexplained cause of a great increase in the value of that curious substance, the kelp was for a time seriously influenced. The value of iodine rose from 6s. 8d. per lb. to about 40s. per lb. The attention of our chemical manufacturers and speculators was drawn to it, and the result was a considerable increase in the value of kelp. But this increase in value being now determined by the value of iodine, the worth of the kelp was stamped upon it by the quantity of that substance which it contained, and not by the soda as before. It was now found that the kelp made and sent into market, contained very variable quantities of iodine, depending on the manner in which it was made, but more especially upon the peculiar weeds employed. That prepared in Ireland, and on the north and north-eastern shores of that island, was the richest in iodine. So much was this the case that the manufacturers of the salts from kelp, and particularly of iodine, found it frequently better to pay £10 10s. for good Irish kelp, than to pay £4 4s. or £5 for Highland kelp. Indeed, generally speaking, the Irish kelp contains more than twice as much iodine as ordinary Highland kelp. The increase of price on the Highland kelp—from £2 5s. to £4 5s., and occasionally to £5 5s.—caused many of the proprietors of kelp shores to turn their attention to the subject, and to increase its manufacture. This they did, however, without the slightest reference to the cause of the increased value of kelp, and without any attempts whatever at improving the usual process. I have here appended a list of the variations in price of iodine during the period of its rise and fall. Comments on it would be almost superfluous;—it will remain an interesting document, illustrative of the fluctuation in value of this commodity, dependent upon the combined influence of demand and speculation.

COMMERCIAL PRICES OF IODINE,

From January, 1843, *till March,* 1848, *showing the comparative values, compiled from a list of actual purchases made by an extensive Commission house in Glasgow, and other sources. The Prices quoted are those given to the makers of Iodine, the London Price may be assumed at from* 1s. *to* 2s. *per lb. higher.*

In January, 1843, the price of iodine was 4s. 8d., and was with difficulty disposed of at that price, the seller being obliged to take 6 months' bills. In June, or thereby, of the same year, it rose, however, to 6s., at which price it continued till, at the close of 1844, it had reached the price of 12s. per lb. cash; from which it will be seen that an improvement had taken place, and that the value of iodine was slowly but steadily augmenting.

1845.	Per Lb.
January,	@ 12s. 0d.
And little doing.	
April to Dec.,	@ 35s. to 40s.
And at 42s. in London.	
1846.	
January,	@ 34s. 8d. to 30s.
And now begins to decline till	
May,	@ 23s. 0d.
June to July,	" 22s. 0d.
August,	" 21s. 0d.
September 5th and 12th	" 21s. 0d.
" 14th,	" 20s. 0d.
" 18th,	" 16s. 0d.
This was a large purchase rather under the market price, and sales were difficult to effect.	
October and November,	@ 16s. 0d.
December 5th and 6th,	" 16s. 0d.
" 31st,	" 20s. 0d.
A temporary rise.	

1847.	Per Lb.
January,	" 16s. 0d.
Small parcels bought at this.	
May,	" 16s. 0d.
Large purchases made at this price.	
June and July,	" 9s. 0d.
Small parcels.	
August,	" 10s. 6d.
Small parcels.	
Sep., Oct., Nov., & Dec.,	" 6s. 0d.
Average price for the 4 months. This was for small parcels, and bought under the market price, owing to the depressed state of trade at this time.	
1848.	
January,	@ 8s. to 9s.
February,	@ 10s. to 11s.
March 1st,	@ 11s. 8d.
" 7th,	" 10s. 0d.
The tendency at present is rather upwards, and will probably improve.	

I think it not uninteresting to append also a Table of the quantity of kelp which entered the port of Glasgow for the following years, as recorded at the Glasgow Tonnage Office:—

TABLE OF KELP IMPORTS AT BROOMIELAW,

as per the Glasgow Tonnage Office.

From July, 1841,	to July,	1842,	2565	tons.
" 1842,	"	1843,	1887	"
" 1843,	"	1844,	1965	"
" 1844,	"	1845,	3263	"
" 1845,	"	1846,	6086	"
" 1846,	"	1847,	3627	"

In addition to the above, there were about 300 tons landed at Dumbarton, from 1845 to 1846, and about 600 tons at Greenock, making altogether, about 7000 tons which entered the Clyde. During the same year, (and over a period of nine months,) a manufacturer consumed about 700 tons, on the Irish shores; and it is asserted, that 3000 tons were consumed at Borrowstowness, on the Forth, during the same year; from which it would appear, that considerably upwards of 10,000 tons of kelp were manufactured on our British shores, during that year.

It cannot fail to be observed that the large quantity of kelp brought into Glasgow during the latter end of 1845, and beginning of 1846, was somewhat connected with the elevation in price of iodine. This was the case. Numerous chemical manufacturers turned their attention to the business; persons were despatched to the shores of Ireland and our Scottish isles, to increase the quantity of kelp made, to buy it up at low prices; and for a time much excitement prevailed. The Irish kelp rose in some instances to £10, although the average about this time might be £8 10s. The kelp from our Highland shores rose from £2 or £2 5s. to £4, and in a few instances to £5 5s, and the *make* on our own shores was considerably increased in consequence.

Within the last six or eight months, the muriate and sulphate of potash from the kelp, which previously had been almost entirely consumed in the manufacture of alum, having been applied to new purposes, namely, to the manufacture of saltpetre (nitrate of potash) and pearlash, (carbonate of potash,) has increased the demand and consequently the value of the former potash salts. This has resulted from the late high price to which saltpetre and potashes, as derived from the usual sources, have risen, and will most probably cease on a larger introduction of the foreign articles. This has to some extent influenced the slight elevation in the price of kelp which has taken place within the last half year, and which will continue until the decline in value of the muriate and sulphate of potash. It is however to the value of iodine chiefly that we must now look for any modifications which take place in the value of kelp, and at present it is impossible to predict which direction may be taken.

These fluctuations in the value of kelp have been productive of many changes in the fortunes of our Highland shore proprietors, whose properties, during the last fifty or sixty years, have alternately been utterly worthless, and, productive of considerable wealth. When Pennant, who visited the Hebrides in 1772, visited Collonsay, he states that these islands "annually produced from 40 to 50 tons of kelp, which was sold at the rate of £3 10s. to £4 per ton." When kelp was at £22 per ton, the same islands produced upwards of 200 tons per annum, realizing clear to the proprietors the very handsome sum of £4000, or thereby, annually. During 1846 the same islands produced about 90 tons at about £4 per ton, but would have easily yielded 120 tons, with the same hands employed, had the season been at all favourable.

Wilson, in his "Voyage round the Coasts of Scotland and the Isles," in 1842, says "that in 1812, in the island of North Uist, the clear proceeds from kelp alone, after deducting all expenses, was £14,000, and fell little short of that sum for several years after. It has been calculated that the alteration of the law regarding the duty on barilla reduced the income of the island and its dependencies from £17,500 to £3500," and that "the value of the island of South Uist to the proprietor has fallen from about £15,000 to £5000." The district called Long Island, which includes the two Uists and several others, during the palmy days of kelp, produced about 4000 tons of kelp annually from their shores, and realized about £80,000 annually. The same district at present yields little more than half the quantity, and that, at about £2 per ton (= £4000), the greater portion of which is paid to the kelper in wages. Macculloch, when he visited the Hebrides in 1818, estimated the total product of kelp from the Scottish islands at 6000 tons annually, which, if we value at £20 per ton, must have realized to these islands the sum of £120,000 annually for a number of years. At present I have good reason to believe that not much over 3000 tons are annually manufactured, and if we estimate this at the present average price (for Highland kelp) of £2, it appears that only about £6000 are realized, comparatively little of which can go into the pockets of the proprietors, nearly the whole being required for the maintenance of the kelpers and necessary apparatus.

In the beginning of the year 1845, there were only four chemical manufactories engaged in the lixiviation of kelp, and manufacture of iodine, in and about Glasgow, and these not very extensive. During the following year these were increased to twenty establishments, several of which were very extensive indeed, and capable of working up from 50 to 60 tons weekly. During this year the leys of the soap-boilers using kelp were eagerly sought after, and three of the above number of manufacturers were engaged in the extraction of iodine from soap leys solely, and other three parties partially occupied with this source. At present there are nine manufacturers in and about Glasgow engaged with the lixiviation of kelp, working up about 85 tons weekly, (= 4500 tons per annum.) I estimate, however, that about 1500 tons of this quantity is consumed at Borrowstowness, leaving about 3000 tons for the Glasgow chemical manufacturers.

From estimates made from information which I have collected as carefully as possible, I should say that there are about 600 tons of kelp at present annually employed in the manufacture of soap, but even this is getting slowly reduced, from the use of soda-ash in that manufacture. A few years ago (6 years) I have estimated that not less than 1100 tons of kelp were annually employed for this purpose. The chief disadvantage resulting from the use of kelp in soap-boiling, is the very extensive set of vessels required, to furnish leys even for a very small manufactory.

The estimates which I have here made of the quantities of kelp manufactured and worked up in our chemical works, can only be considered as an approximation to the truth. This occurs from the difficulty of procuring correct information from almost any party connected with the trade, —the utmost jealousy and suspicion being immediately excited by the most distant query. Every one connected with the manufacture in any shape is aware of this.

Mode of collecting the Sea Weeds.—The observations which I have now to make regarding the collecting and burning of sea weeds, were the fruit of a four months' residence in the Hebrides, in the islands of Collonsay and Oronsay, the property of Captain M'Neill, and my remarks apply more particularly to the practice there followed. I was sent out there by the Messrs. Turnbull & Co. of this city, during the year 1846, to prosecute the manufacture of the kelp, and if possible, to make any improvements which might suggest themselves to me. I beg to lay a few of the details of my experience before you at present, reserving for another opportunity all the chemical part of the subject and other details which would render this communication of too great a length.

The methods of collecting and burning the sea weeds now demand our consideration, and although it is a subject upon which much might be said, my remarks shall be as brief and concise as possible. The methods of collecting the weeds, and of burning in kilns, are differently conducted upon the Hebridean and Irish shores; but the former demands our attention at present. The kelp of commerce is known in the market under the terms *Cut-weed* and *Drift-weed* kelp, the Cut-weed kelp being solely prepared from weeds growing upon the shores, and alternately immersed and left dry by the flow and ebb of the tides. The Drift-weed kelp, upon the other hand, is prepared from wreck which is torn from the rocks, and driven upon the beaches by the currents and swell of the sea. The plants comprising this wreck grow always in deep water, firmly attached to the sunken and shelving rocks, and are constantly submersed. They possess different properties from the more landward plants, and are usually detached by the roots from the rocks on which they grow, and thrown upon the beach during the flow tides which succeed violent storms. The cut-weed kelp, which is that chiefly prepared on our Highland shores, is made chiefly from two plants of the same order, from the yellow wreck and from the black wreck (technically speaking). The former, or yellow wreck, from its property of being able to float in water when cut or detached from the rocks, is differently and more easily managed than the other weed, which does not float. Less extensive apparatus, and less labour is required to collect and burn the yellow wreck, and for this reason it is mostly used in the Highlands of Scotland. And because it is more of a land plant—of a more amphibious nature than the drift-weed and deep sea plants—it is much less valuable as a source of iodine and of potash. The method of cutting and collecting the yellow wreck, or *Fucus nodosus,* called bladder-wreck by the Irish, is peculiar, and merits our attention now. The men designed for this purpose are arranged into a company, which may consist of almost any number, but most usually and conveniently of six or eight men. These are headed by one who takes charge of all their operations, who is termed the master. He, however, participates in all their labours, and requires to find his company in their full complement of tools and materials, points out the shore which is to be cut, and takes a general supervision, for which he receives an extra payment at the end of the season. Each of these companies are provided with a small rowing boat, having an anchor, painter, and oars—with three or four common hay pitchforks—with one or two spades or shovels—with two or three handbarrows, or with a horse and car if they can be got. Each man is provided with a stout rope 30 yards long, and with a reaping hook. The operation of cutting the wreck is conducted only during the days of *spring* tides, when the greatest quantities of weed are exposed, and may be carried on for eight successive days in fine weather, during every alternate tide, when at the lowest. The hours of low and full tides must be carefully watched by the companies, as on this the success of their operations depends. The cutting operations usually commence three days before the day of highest *spring* tide. About two hours previous to low water, (that is, while the tide is still ebbing,) the men proceed *en masse,* with their ropes and hooks, towards the shore where their operations are to be conducted. They range themselves along the water edge, at a distance of six to eight yards from each other, and begin to cut the weeds in a somewhat similar manner to the reaping of corn or wheat, and when cut, throwing the weeds behind them with the left hand. In this manner they proceed cutting—following the water as it recedes or ebbs, until they have cleared the whole ground allotted to them. The ropes are then brought to the beach, their ends tied together, and laid along the water edge. Each man then wraps a portion of the weed round the rope, so as to encase it completely. This is necessary to give the rope sufficient buoyancy, otherwise it would not rise with the weeds when they float, and the wreck would thus become scattered. In some parts of the Highlands ropes made of birch are used, which swim readily, and do not require this covering process. When this operation is securely effected, the men proceed towards the point where they began, and with their faces in the opposite direction, (*i.e.*, to the shore,) cut the remaining weeds before them until they have cleared the whole shore, and secured all the available wreck. By this time the tide is rapidly advancing upon them, and the weeds are beginning to float, enclosed within the swaddled rope, the extreme ends of which are drawn up as far as possible upon the shore, and securely fastened to a rock or stone. The company are now at liberty for a couple of hours or so, and with the exception of one or two men who may be left in charge of the *rope*, if considered insecure, they proceed towards their temporary hut or cabin, situated within a short distance of where they have been working. Their fire is rekindled, the pot with water is soon boiling, and the meal stirred in; when ready, the whole, which is usually pretty thick, is turned out into a wooden cog, and when cold enough, supped. This, with sour milk or treacle and water, followed with a bit of bannock and a drink of spring water, constitutes the chief ingredients of their diet. On this simple fare these men live for two, three, or four months almost uninterruptedly without experiencing any disease—with the occasional exception of *boils* upon their legs or arms—and always apparently in good health and spirits. For many hours each day they are exposed to all weathers, wet to the skin with salt or rain water, mostly always with salt water, and yet with few or no bad results; on the contrary, it is said they improve in health while so engaged, and if I may judge from my own experience, I should certainly say, they do. For the most part these men are tough and sinewy, possess great strength, and when they choose evince much agility. There are few or no corpulent men amongst the islanders.

When the tide is full, the men proceed again to the shore, and draw the rope as far in as possible upon the beach, or if it is not a convenient spot for landing, the boat is put in requisition, and the *rope*, with the encircled wreck, is hauled into *port*. The boat is manned with four men —one man at each oar, with one at the bow and one at the stern. The end of the rope attached to the wreck is securely fastened to the stern of the boat, and hauled along. If, however, the tide or current be against them, different tactics are necessary. The boat shoots ahead of the rope as far as its painter will allow, the man at the bow throws out his anchor, and when securely fixed the whole body haul in the rope towards the boat, the same operation is repeated until they reach their destination or "port." This is usually, if possible, a gently sloping beach, free from large stones and gravel, where easy access can be had to the inland, and where there is ample free room to dry and sort the weeds for burning. The rope is now secured at the highest of tide, and when the tide recedes the wreck is left dry. During the next ebb tide the weeds are carried higher up on the beach or upon the grass, and if there be sufficient time, spread out to dry in the sun's rays. The time of the company is thus pretty much taken up with the various operations, which are conducted with considerable regularity and system. The weeds which have been cut during the spring tides, and which may be nearly dried, are fully dried and burned during the days of *neap* or small tides. It is of the utmost importance for all their operations that they should have clear and dry weather, but more so especially for the drying and burning operations. When the weeds get wet from rains, or even have to remain moist from the want of sun heat, fermentation ensues. The weeds then become quite soft and pulpy, run together in masses, and finally disappear. If even dry weather should interrupt this waste, the decomposing wreck is with difficulty saved, and the kelp prepared from it is inferior.

The process of drying and burning this weed is identically the same as that for the black and other sorts of wreck, and will be described afterwards.

The proceeds of the operations of a company are for the benefit of that company, each member participating alike in the labour and in the proceeds of their toil. The master of the company alone is remunerated extra by the receipt of 10s. 6d. at the end of the season. The company receives 27s. per ton of $22\frac{1}{2}$ cwt. for all they produce. This is all they receive in money. There is an allowance of 1 stone ($= 17\frac{1}{2}$ lbs.) of oatmeal allowed to each man per week, and 1 to 2 oz. of tobacco per week; but these items, together with a few others in connection with this subject, we will again return to.

The black wreck, or *Fucus serratus*, (from the saw-teeth-like leaves,) is also a shore weed, and is cut with the hook. This plant does not swim like the other, and requires therefore to be at once carried inland. This is done with large boats capable of holding four or five tons of the wet weeds, and each boat, according to its size, is manned with two or three men. The boats must be strong for this purpose, and as tight as possible, and having good strong oars and a sufficient painter. It is always kept ready for service, moored in deep water, and in a sheltered position. When the tide is about half-ebb the boat is manned, and they proceed to the rocks intended to be bared; the boat is moored, and they begin to cut the wreck from the rocks, throwing it into the boat when cut. The boat is frequently supplied with a plank, on which the men walk when loading and unloading, and the weeds, when lying at a distance from the boat, are carried to it by means of a handbarrow. When the boat is full it is rowed home to the shore, where the wreck is intended to be dried, and landed at full tide with the handbarrow. The succeeding operations with this weed are identical with those for the yellow wreck. The labour, however, of cutting and throwing the wreck into the boats, and carrying it again to shore, involves a greater amount of time, or what is the same thing, produces less kelp per man. This is adjusted, however, by the payment to the company of 35s. per ton of $22\frac{1}{2}$ cwt. for this kelp; and although the labour is more severe, it often happens that the "boat companies," as they are termed, realize more remuneration for the season than the "rope companies." The kelp produced from this plant is richer in iodine and potash (generally speaking) than that from the yellow wreck. This Fucus is much more a sea plant than the other, it seldom or never being found high up on the shores. This kelp, although by mere inspection it cannot be distinguished from the yellow wreck kelp, is yet superior in some respects, and should command a higher price.

Process of drying and burning the Sea Weeds.—The drying and burning processes for both these kinds of sea wreck are, as I have said, identical, and I will briefly describe the operation. The plants are spread out in the rays of the sun, as thin on the ground as their quantity and the extent of surface will admit. This is usually done early in the morning, and as they get warmed by the sun, they are turned over and over until quite dry. Two days of strong unclouded sunshine will dry the weeds sufficiently for burning. They must not be too much dried, else they burn too easily in the kiln, and by *flaming* carry off a portion of the salts. The proper degree of drying requires skill and experience. To prevent them from getting wet during the night by the heavy dews which fall at this season, they are collected together into *quoils* or little heaps, and again spread out in the morning. When sufficiently dried they are collected into large heaps, and carried by the horse and car, or by the handbarrow, to the point where the kiln is to be erected, and there burned. When the weather is favourable, the whole of the wreck which has been cut during the six or eight days of spring tides, is dried in two days in this way, and is ready for burning. The building of the kilns is the next operation, and is a very simple one. A convenient and level spot on the green sward (if possible) is selected and measured out. The kiln may be any size in length and breadth, but the size preferred is from 14 to 16 feet long, and 2 feet to 2 feet 3 inches broad. This parallelogramic patch of earth is then surrounded with a wall of stones—collected in any way and from any where, the shores usually supplying abundance of materials—as perpendicular as possible on the inside, but sloping on the outside so as to give it strength. These walls may be 8 to 10 inches high. The stones require to be carefully placed on each other, not ready to roll out of their places, and not too large. It will be readily supposed that there will be plenty of air spaces between the stones to supply the burning weeds with air; this is quite necessary, and their proper adjustment requires some nicety and understanding in the architect.

It is essential that the ground on which the kilns are built be level, and also of great importance that the side of the kiln be presented to the wind, *i.e.*, at right angles to its direction, otherwise the burning proceeds with tardiness, and the smoke may be the source of annoyance to the burner. When the wreck is dry the burning commences, and the attention of the whole company is directed towards it. Two men are required for every kiln, one of whom constantly superintends the burning, the other brings the wreck from the scattered clumps which are lying about, and performs any other little duty which may be required; the attention of both men, however, is pretty exclusively taken up with the proper management of their kiln. The burning commences at four or five o'clock in the morning, and may terminate with day light. In this way from 14 to 16 hours of unremitting attention is required from each man. The kiln is kindled with a layer of dry heath or straw, which when in full blaze is slightly and carefully overlaid with the dry wreck, which speedily takes fire and burns. As this is being consumed it is again covered with fresh wreck, and thus the operation proceeds during the whole day. The burner—from whom a considerable portion of nicety and tact is required—spreads the wreck carefully over the burning mass with his hand or with a pitchfork, leaving the ends of the wreck lying over the walls of the kiln, which prevents the fresh weeds from crushing down the burning mass beneath, and permits the air to enter easily through the sides of the kiln. As the mass burns it is very apt to burst into flame. This is to be carefully avoided by the burner, who knows that this wastes and dissipates the kelp salts. It is also apt to *fall into holes*, and present the appearance, on a small scale, of volcanic craters, this is caused by the partial fusion of the ashes of the wreck, which runs into a liquid mass, and must also be avoided if possible. This is caused by too much air entering the sides of the kiln, to prevent which, a number of firm grass sods are ranged along the side of the kiln, next the wind. In this way the kiln is *kept warm*, the ash is not so apt to fuse and run into kelp, nor to be cooled down by the access of too much air. The burning of a kiln is divided into two periods, which are termed *floors*, when the kiln has been in operation for six to eight hours, the burner carefully levels the surface of the ashes, throws in the half consumed wreck which may be lying along the sides and on the walls of the kiln, and allows it to remain in this way for ten to fifteen minutes. In the meantime, he has pulled down a portion of the kiln ends, or end walls, and mustered the assistant burners from the other kilns, each of whom is provided with a small iron *clât*, or rake, (called a corag in the Gaelic,) about two feet long, and having a wooden handle or shaft six feet long, or thereby, fastened into its hose. The corag is similar to the common hoe, but the mouth piece, or clât, is only about three inches square, and is widest at the lower edge, for the purpose of drawing the ashes more effectually together; they are made very strong and of good iron, as they are quickly consumed by the hot kelp. The men (three or four) range themselves closely together, at the one end of the kiln, they plunge their corags into the porous ash and begin to knead and work it rapidly; it quickly melts or runs together, and as it does so, more of the ash is drawn into the fused magma and worked up with it, until the half of the ash in the kiln is thus drawn together and kneaded into liquid kelp; it is then carefully spread over the bottom of the kiln, and the men then proceed in a body to the other end of the kiln and perform the same operation there. When this is done, they proceed to the other kilns of the company and work them up in the same way. This is termed the first floor, and it forms a cake of kelp of from three to six inches in thickness, which floors the kiln, and forms the basis for the next floor; the burner proceeds with his operations as before, laying on fresh weeds and tending them carefully again till the evening, when the second floor is made, and the labours of the day are finished. The material of the second floor generally becomes fused into the surface of the first, and forms one undistinguishable mass or cake. These cakes are of various thickness according to the number of floors, and to the rapidity or slowness of the burning. In Collonsay they seldom burn more than two floors in the same kiln, but in the Uist Islands, and elsewhere, they frequently have four or even six floors: I prefer the latter plan, as it ensures the cleanliness of the kelp. It is obvious that much of the soil, earth and stones which form the bed of the kiln, and which is generally unprotected, gets unavoidably raked up by the corags into the fused kelp, and mixes with it; this can only take place, however, with the first floor, the succeeding floors resting on the top of which, must, unless vitiated by the throwing in of sand, earth or stones, be quite pure and clean. I am sorry to have to remark that these injurious and unjust practices are often—too often—deliberately and regularly had recourse to; it is done by the companies merely for the purpose of adding weight to the kelp and increasing their returns, under the impression that as they are not seen doing so, the fraud cannot be discovered. To the honour of the men of Collonsay, I have to say, that although the fraud is well known, and occasionally attempted by a few, this practice is held in detestation amongst them, the men vieing with each other in producing clean and good kelp. The operations of drying and burning being necessarily performed out of doors, it will be evident that warm and dry weather is essential; indeed the success of the season entirely depends on this, for when rain sets in at any of these periods, and continues for a length of time, the wreck wastes and sometimes becomes totally useless, and the kelp, which is already made, unless carefully secured and covered from air and moisture, gets destroyed. None of the operations can go on except the cutting and collecting, but even this is abandoned with the prospect of wet weather, and the men are reluctantly obliged to retreat homewards. It will be evident how materially a few wet days interrupt and retard their operations, when we recollect that it is only during the days of high spring tides that the weed is collected, and, that without weeds, none of the other processes can follow. A few wet days at any time of the kelp season, materially affect the produce of kelp, and injures the prospects of the kelpers, for little else can be done by them at this season, and wet weather is too frequently accompanied in the Hebrides, with squally winds and a swelling sea.

The materials of the structure of to-day's kilns, are taken for the erection of succeeding kilns; they are generally too hot for the succeeding day's operations. The kelp after lying a day or two, and when able to be handled, is broken up into lumps, piled up together, and covered, first with a mass of fern leaves or straw, and finally, with a good layer of light grass sods, which shields it from the rain, and protects it from the air; it lies here until it is required for shipping. As it is of the greatest importance to all parties concerned, that the kelp be carefully excluded from rain or moisture, I will say a few words here on this topic, believing that the present careless and injurious manner of keeping the kelp before it is shipped, is entirely the result of their ignorance of its consequences. The value of kelp at present, and for many years back, has almost entirely depended upon its iodine, and the potash salts; the proportion of these constituents determining its commercial value. From the potash salts,—and more especially the muriate of potash (which is the most valuable salt of potash)—and the iodide of sodium, being the most soluble of all the constituents of kelp; it follows, that if we expose kelp to moisture, in any way, that these salts will dissolve out, and will ultimately leave the kelp an almost valueless mass. Kelp, which occasionally contains caustic soda, and salts of magnesia, attracts moisture in any position, and gets deteriorated from the loss of its valuable salts. In this way a cargo of excellent kelp, which had lain in a damp store near the Broomielaw, for upwards of a year, when lately brought out and exposed for sale, only brought a few shillings per ton, to the great loss of the parties to whom it belonged. To prevent this source of loss to the kelper, it is necessary that it should be immediately removed, whilst still warm, to a dry shed, safe from rain and damp, and there preserved until ready for shipping The intelligent kelper, when he understands the nature of the source of loss, will easily find out the means best adapted to prevent such, and unhesitatingly adopt them.

Wages of the Kelpers.—I have already mentioned that the kelpers receive at the rate of 27s. per ton for the "rope," or yellow wreck kelp, and 35s. per ton for the "boat" or black wreck kelp, this is for the ton of 22½ cwt. In addition to this, every man employed, especially if he is a *crofter*—or is possessed of a house and portion of ground, for which he has a rent to pay—is allowed £2 for the season, which sum is deducted from his rent, or if he refuses to work at the kelp, he is forced to pay this sum to the landlord. By this ingenious method, the remuneration is apparently increased to a considerable sum, and the kelper is forced to pay this as a *fine*, if unwilling to contribute his labour. It is only the 27s. or 35s. per ton which he actually receives, and on which he depends for the payment of his food, the support of his family, and for the liquidation of his rent, &c. Each kelper, during a good and dry season, will produce on an average 2 tons to 2½ tons of kelp, or at the rate of ½ a ton per spring tide. This shows 2½ tons at 27s. = £3 7s. 6d., or about 8s. 6d. per week for each man of a rope company: and 2 tons at 35s. = £3 10s., or about 9s. per week per man for the boat companies. The landlord or proprietor, supplies each kelper with meal, tobacco, and one or two other trifling things, which amount to about 3s. to 3s. 6d. per week, this is deducted from the above sums; the remainder is for the support of the family at home. Not so very poor nor unprofitable, when we take all the accompanying considerations into thought, and reflect, that the time occupied by the kelpers in kelp making, during the two or three hot summer months, would, if not engaged in this, be spent in the most trifling manner.

In South Uist, Wilson says, "the rate of wages is about £2 per ton,—that the young and old, of both sexes, are engaged during two months of summer, and that each family may clear upon an average £4." Each individual ought to clear this as their wages, but then his living has to be deducted from this sum.

Plants Supplying the Kelp.—The drift-weed, and drift-weed kelp next requires our consideration. The drift-weed, as I have already explained, is the deep sea weeds, which become detached from the rocks by the violence of the swell, and by the rolling and striking of small pebbles and stones against them; they are hurled from their rocky hold, and swept by impetuous currents or eddies toward the shore. As billow follows billow, the mass of wreck accumulates, and is borne upon their crests towards the beach, where it frequently gets piled into gigantic ridges, where the retiring tide leaves them. This happens usually during the days of highest spring tide, when evidently the increased force of the tidal current is the more immediate cause of this curious phenomenon. A single flow tide generally completes the work of destruction, and leaves the shores lined, at the highest water mark, with a ridge of wreck, six, eight, and sometimes ten feet high. The beaches on which the wreck is thrown, are mostly, what may be termed, inland, *i.e.*, deeply indented in the shore, gently sloping towards the sea, and unencumbered with rocks at the entrance. The wreck is almost entirely confined to deep sea weeds, chiefly the common tangle, or *Laminaria digitata*, but with a great variety of other plants of the same order, adhering to their leaves and stems.

It would be impossible to do more here than allude to the family of sea plants termed *Algae*. I have mentioned those chiefly employed in the kelp manufacture, because they are the most prominent and largest; but there are a numerous and most beautiful class of minute and various coloured plants, which, being parasitical to the larger algae, are also employed in kelp making. Dr. Harvey in his beautiful collection of marine plants, pictured in the Phycologia Britannica, has figured nearly the whole of these, and added information upon the habitudes, residences, and appearances of these beautiful plants. He divides them into four classes, which he terms,

I. The *Fuci*, or *olive coloured sea weeds*, which are generally of large size, and leathery texture; sometimes membranaceous and leafy, and more rarely of a gelatinous or filamentous nature.

II. The *Florideæ*, or *red coloured sea weeds;* cartilaginous and fleshy, membranaceous or gelatinous sea weeds; often filamentous; of a red, purple, brown red, or livid greenish-red colour.

III. The *Chlorosperms*, or *green sea weeds:* membranaceous or filamentous; rarely somewhat horny plants, of a green colour, and simple structure.

IV. The *Corallines;* vegetables coated with a crustaceous epidermis, composed of carbonate of lime, either red or green when fresh, becoming white and brittle on exposure to the air. (These must not be confounded with the true *Zoophytes*, which often assume the appearance of plants.)

The plants which furnish kelp belong to the two first groups, and include *Fucus nodosus*, *F. serratus*, and *F. vesiculosus*; *Laminaria digitata*, and *L. saccharina; Halidrys siliquosa; Alaria esculcuta; Rhodomenia palmata*, &c. &c.

The *tangle* or *staffa*, as it is termed in the Gaelic, is, from its size and value, the most prominent, and is the especial object of attention. In Ireland, where the kelpers confine their attention, in some places exclusively, to the making of drift-weed kelp, it is entirely prepared from the stems of the tangle, which are carefully separated from the wreck, carried to their houses, and laid on the tops of dikes, &c., to dry. The more leafy portions of the wreck are carried up and spread on the ground in the winter months, for manure. On the Irish shores, it is said, that the drift-weed comes in mostly during the end of April, and beginning of May, when, it is believed by the people, that the plants are shedding their leaves; this they term the *Scawee*, a name indicative of *great plenty*, in their language. It is at this period that all hands are congregated on the shores for the kelp making. Horses and carts, or cars, donkeys with creels slung on their backs, men, women and children, are busily engaged collecting and saving the drift-wreck. Enormous quantities are in this way thrown in, collected, and burnt into kelp, or taken for manure by the small farmers on the shores of Ireland. The method of burning there, is somewhat differently practised. A large, and nearly square, hole of eighteen inches deep, being dug in a convenient place, and the wreck there burned. It is similarly managed for the *coraging* or fusion, but is always in larger masses than our Highland kelp, it is generally sophisticated with sand, gravel, and stones, to a large extent, and its value much deteriorated; occasionally this is so deliberately done, that one workman is constantly adding those foreign materials, while the others are raking them into the fused mass, so as to mix the whole well and intimately together. In this way the kelp gets as much as it will *stand*, as they term it, and as such goes into market. The Irish drift-weed kelp, when carefully and honestly prepared, as it sometimes is on the Irish shores, is a very valuable article, and so very rich in iodine, that during the high price of that article in 1845, the kelp, in some cases, brought £10 per ton. Drift-weed kelp can be readily distinguished from the Cut-weed kelp, by its appearance. The former contains masses of the charred portions of the stems of the tangle through its broken surface, while the latter is full of the charred cells and vesicles of the *Fucus vesiculosus*, and *nodosus*. In this way, by a careful inspection of broken masses of kelp, the weeds from which it is made are easily discerned, and its value may be readily decided upon. In ordinary years the Irish kelp is almost exclusively made from drift-weed, but during the year 1845, when the demand for kelp was so much increased, and its value rose, a considerable quantity was made from cut-weed, and a large per centage of foreign matters added, which reduced its value and materially hurt the trade. Indeed, several of our Glasgow manufacturers, who bought Irish kelp upon the simple assurance that it was pure drift-weed, and without properly inspecting the article, or probably, from a want of knowledge in the discrimination of the good and the bad, suffered very severe losses. Honesty in this, as in other things, is the best policy, and let our Irish and Highland friends look to this, the honest manufacturer will almost be the first and the last patronized, and must inevitably, in the long run, make the best of it.

In the Highlands of Scotland comparatively little kelp is ever made from the drift-weed. Last year, however, I have been told, by a Glasgow kelp worker, a considerable quantity of drift-weed kelp was manufactured in the islands of Uist, where it is occasionally made, and with great care, if we may judge from the large quantity of iodine (upwards of 12 lb. per ton) which it yielded. The drift-weed which is thrown in on the beaches during the winter months, is either taken for manuring their fields, or is suffered to lie on the beach and either rot, or get washed away: they have, as yet, little idea of the causes of the difference in the value of their kelp and the Irish kelp. When they have acquired this knowledge, I have no doubt they will pay some little attention to this point, exert themselves to the utmost, and improve the *brand* and the price of their article. All parties concerned in its production would be better satisfied, and a higher remuneration would be the result.

The kelper would, in this way, profitably occupy time, which is usually spent and squandered in the most trifling manner, he would increase his own and the comforts of his wife and family, and would at least be helping to move the fulcrum, which would elevate him as a man and as a reasonable and thinking being; a fulcrum which, in too many cases, is left entirely to the care and supervision of their lairds and landlords, and is necessarily, but too partially done. It is an old saying—a true one, and applies here, that "when you wish to be well served, serve yourself." How better can a man serve himself than by applying himself assiduously to some task.

Suggestions for Practical Improvements.—As I consider this part of the subject of great importance to our Highland friends, and as it is one which I have considered carefully, and urged much on the spot, I may be permitted to add yet a few words of direction and advice, on what I conceive to be, the best manner of conducting the operations for making the drift-weed kelp, and of availing themselves of what is thrown in during the winter months. My observations, although they have been made on the Colonsay shores, will, I have no doubt, be applicable to any portion of our Highland coast.

As the periods when the drift-weed is thrown in upon our island shores occurs most usually during the winter and spring months, it so happens, that during these months little or no employment is followed by the male population. The farming operations, which can only be carried on within doors, can easily be managed by the servants, or persons more immediately connected with the farms, so that a considerable population are almost entirely idle for months. It is the latter class of persons who could be profitably employed in collecting the drift-weed, and preparing the kelp, but to this class of men inducement must be held out by the proprietor; they will require to be shown that it is decidedly their interest to engage in the operations, and every facility must be held out for their successful prosecution of the work. That it is their interest, must be obvious to all who believe that labour rightly directed, is more profitable than idleness, but that this is not apparent to them, is obvious from their condition; the result of incessant and unmitigated bondage, of a regular system of grasping and grinding servitude. To convince them satisfactorily that it is for their interest, we must proceed upon direct and simple methods. I would suggest, that the whole proceeds or profits, remaining after payment of unavoidable expenses, (which indeed are trifling,) be paid over to the kelper, in money, without censorship and without control. With these proceeds he will be enabled to pay the debts he has contracted during the winter months, with, perhaps, something towards payment of his rent and a few other necessaries, and thus to improve the condition of himself and family. By this means he would become a more responsible individual, ascertain his own weight and individuality, and would, with a little assistance, be permanently raised in his own estimation, and in that of those around him. He would, I believe, no longer willingly and unresistingly become a burden upon the landlord, nor hang about listless and idle, in the vain endeavour of passing the day in ease and comfort. When he finds his labour productive to himself, and not merely to his landlord, he would shake off his apathy and become a man, action would be substituted for inaction, and new and better fields for industry and enterprise would be opened up. The prospect of adequate reward would induce him, not only to enter, but to proceed, and succeed. The obverse policy has been long tried, and the results have been and are, aught but satisfactory; why not try the ameliorating process, and substitute the mere aggrandizement and affluence of the few, by the bettering of the many? it will be found, I believe, that *all* would be improved.

I have already remarked, that it is only at certain beaches along the rugged shores, that the wreck is drifted up. At these points, and as convenient to the shore as possible, I would suggest the erection, by the landlord, of wooden sheds, of say 50 to 100 feet long, 20 feet wide, and with side walls, 10 feet or more high, with good and tight roofs, to prevent access of rain, and these to overlie somewhat the side walls. The side walls might be of wood, but better if of tarpauling, so as to be readily removable, and allow access upon all sides. The floor of this shed or house, to be kept dry and free from wet, by means of a drain or gutter, running round, to carry off the surface and roof water. In this shed the long stalks of the *Laminaria digitata* are to be stored. They can be easily collected from the mass of drift-wreck, carried up in suitable creels or cars by horses, to the shed, and there carefully placed in rows and tiers, crossing and overlying each other, so as to permit easy access of the air from all sides, these tiers may be raised to the roof, and, if carefully placed, would get quickly dry or winnowed, and so become ready for burning. Fermentation could not possibly occur, and loss from rains would be entirely prevented; and when dry enough for burning, they could be removed and converted into ashes, fresh room being made, in this way, for further quantities of *tangle* as thrown up. A few men, with activity and care, could, in this manner, collect the materials for many tons of kelp, and that of the most valuable kind; during the winter months, the operations would be conducted at a very small expense of manual labour, and that, during the most inclement seasons. The apparatus required is trifling, compared with that necessary for the prosecution of the cut-weed kelp, and an expensive armament of boats, ropes, oars, anchors, hooks, &c., &c., entirely dispensed with. The ashes could either be fused into kelp, or sent off as loose ash, the former method is the most preferable for transportation to a distance. The latter condition would be the most suitable, if the kelper designed to follow the sensible and practical advice of Mr. Donald M'Crummen, as recommended in his article on the kelp manufacture in the "Transactions of the Highland and Agricultural Society of Scotland," for October, 1847. The valuable constituents could thus be easily extracted and concentrated, with little or no expense for other fuel, as the burning of the dry weeds would supply the greater portion of the heat required. The operations being conducted simultaneously, much labour would thus be saved, and a much more valuable and remunerative article produced. If to these advantages we add the consideration, that the insoluble constituents of the kelp remain to them, and might be used as an excellent manure, the total improvement capable of being effected in this manner deserves the attentive consideration of the Highland proprietors. Although the usual description of kiln would answer for the production of the kelp from tangles or other drift ware, I would suggest the following modification:—Let it be constructed of fire brick laid together without mortar, for ease in the construction, of 2 to 3 feet deep, and 4 feet square, the walls being of 9 inch or *brick-length* in thickness, and with the air spaces in the third or fourth course from the bottom. In such a furnace the stalks would be consumed with much greater rapidity, from the increased draught produced by the height of the walls, and the heat issuing from the top might also, if not employed as has been already suggested, be taken advantage of to dry the tangles, by placing stout bars of iron across its mouth on which they could be placed. The heat could be easily regulated by the air-holes below. Such a kiln would have the advantage of cheapness, of easy construction, and of being readily removed to wherever it might be wanted, and also of performing this kind of work more advantageously than the ordinary kilns. If the furnace were built on a plate of iron, the kelp made in this manner and from these materials would bring the very highest market price, higher than any at present obtained, and would undoubtedly command the attention of chemical manufacturers to the exclusion of an inferior article. The salt which would be obtained by the lixiviation and concentration of such ashes would be worth from £10 to £12 per ton to the chemist, even at the present very low price of iodine.

I can only refer briefly to my concluding topic, not that I consider it by any means of minor importance, but simply because I have already occupied too much of your space. I allude to the application of kelp, or of kelp waste to agricultural purposes. Much has been already said and done on this subject, but I believe there is much still unsaid. In the Highlands the wreck is plentifully taken from the shores and spread on the grounds as a manure, where, indeed, it constitutes their main ground of hope for the success of their crops. The utility of this practice is known and acknowledged on all hands, and we cannot but suppose that the like application of kelp would be attended in many cases with success. I would press this upon the attention of farmers and agriculturists in all parts, but chiefly in inland districts, where, by a careful application of kelp for green crops, a native manufacture would be fostered, the condition of a large class of our countrymen bettered, and expensive quack manures to a great extent become extinct. The kelp for this purpose would require to be ground, and in this state, and before application to the soil, if it were mixed with 5 to 6 per cent. of a salt of ammonia, it would equal, nay surpass any guano in productiveness, and certainly supersede it in every way.

I have refrained in the present paper from entering upon the chemical composition of kelp, as it is my intention to lay a few details before you on that subject in a subsequent paper, when, I shall take the opportunity of adding what I may at present have neglected, and which would have made this communication, it may be, of an unreasonable length.

29*th March,* 1848.—*The* PRESIDENT *in the Chair.*

Messrs. William Kerr and David Burgess, were admitted members.

Dr. R. D. Thomson read his "contributions to a sanatory report on Glasgow." In this communication, the division of infectious diseases, into two classes, was alluded to. One of these classes is produced by emanations from the earth, or by particular conditions of the atmosphere. and is not contagious or communicable from one individual to another, It is typified by ague and Asiatic cholera. The second class is produced by a poison generated in the human system, and is communicated by the contact with the blood by a poison. The types of this class are small pox, measles. According to the views contained in this paper, all persons are not equally liable to be affected by these diseases. The diseases are all produced by a poison, or seed, but the seed will not take root unless it falls on a congenial soil, that is, a diseased state of the blood, generated by a defective, or impure diet. Scurvy and typhus fever are accompanied by symptoms which indicate a defect in the blood, and, therefore, an error in the equilibrium of the food. Scurvy on board ship is cured by lime juice, because in salt meat the soluble salts of the beef have been removed in the brine; and lime juice, the author found to contain the soluble salts which have been removed. Turnips, potatoes, and succulent vegetables, cure scurvy, because, from the quantity of water which they contain, they are less easily deteriorated by the variations in the climate, than the dry corn plants. The importance of pure air was insisted on in all conditions of society; but a more extensive view, it is obvious, must be taken of the cause of disease. The baneful influence of fermented fluids in undermining the constitution, and their tendency to supply congenial soil for poisonous miasmata, were referred to. The importance of pure water, and the circumstance, that the fluids in the common sewers and from churchyards, filter into the wells of large towns, were also alluded to—the constituents of the Glasgow wells being given.

The following contribution was communicated by Dr. R. D. Thomson:—

XXXIX.—*Analysis of a Mineral Water from Titwood, near Pollockshaws.* By Mr. Edward T. Wood and Mr. Thomas Coutts.

This water was discharged from a bore now making near the Titwood coal works, on the property of Sir John Maxwell, Bart., three miles south of Glasgow. The water was come upon when at the depth of 780 feet under the surface.

Specific gravity, 1008·8. Weight of an imperial gallon, 70,616 grains.

Constituents in the imperial gallon—result of several analyses.

	Titwood Water.	Airthrey Water, 1842.
Carbonate of Lime,	9·462	....
Sulphate of Lime,	1·341	16·062
Chloride of Calcium,	130·286	300·883
" Magnesium,	84·739	9·234
" Sodium,	543·743	363·825
Peroxide of Iron,	trace	....
	769·571	690·004

An analysis of Airthrey water, made by Dr. R. D. Thomson, is annexed for the sake of comparison.

12*th April*, 1848.—*The* President *in the Chair.*

Professor William Thomson read a paper on an absolute thermometric scale, founded on Carnot's theory of the motive power of heat, and calculated from the results of Regnault's experiments on the pressure and latent heat of steam.

The following paper was communicated by Dr. R. D. Thomson:—

XL.—*On the Composition of the Products of the Soda Manufacture.* By Mr. John Brown.

In the year 1736, Du Hamel proved the base of common salt to be soda. Previous to this, however, Cohausen had mentioned that salt might possibly be decomposed by means of lime; but as this observation was associated with numerous errors, it was entirely overlooked. In 1737 Du Hamel succeeded in obtaining the alkali from sulphate of soda, by fusing with charcoal, and digesting the fused mass in acetic acid, evaporating the acetate of soda thus formed to dryness, and calcining the residue.

Margraff endeavoured to decompose sulphate of soda by limestone, but without success. In 1768, Hagen showed that salt might be decomposed by means of *potash;* chloride of potassium and caustic soda being formed.

Bergmann succeeded in decomposing salt by *caustic barytes.*

In 1775, it was shown by Scheele that salt was partially decomposed by *oxide of lead.*

In 1782, Guyton and Carny decomposed salt by fusion with *felspar.*

Glauber was the first to show that salt could be decomposed by *sulphuric acid,* in 1658.

In 1781, Constantini succeeded in decomposing salt by means of *alum.**

The *sulphates of lime, magnesia, ammonia, potash,* &c. decompose salt, as also *iron pyrites.*

To convert the sulphate of soda into caustic or carbonated alkali, was, however, the process of greatest importance. The first step, viz., the conversion of sulphate of soda into sulphuret of sodium, was known to Glauber, Stahl, Du Hamel, Margraff, and others. The difficulty was to get rid of the sulphur. Du Hamel effected this by means of acetic acid. But in the year 1784, the present process was discovered by Le Blanc and Dizé; and in the beginning of 1791 it was patented by Le Blanc.†
He used carbonate of lime to convert the sulphuret of sodium into carbonate of soda.

The proportions used by him were—

* Journal des Mines, Tom. I., No. III., p. 37—69.

† Journal des Mines, Tom I., No. VI., p. 68.

2 parts dry sulphate of soda.
2 — carbonate of lime.
1 — ground charcoal.

These were intimately mixed, and introduced into a reverberatory furnace, where a strong heat was applied. After this had been continued for about an hour, the fused mass was raked out of the furnace and allowed to solidify. When this cooled, it was broken up and exposed to the action of moist air, which caused it to crumble down. In this way the caustic soda was converted into carbonate of soda, the carbonic acid being derived from the atmosphere. After being ground, it was ready for use.

The soda process, as at present carried on, will be best considered under the four following heads:—

I. The production of sulphate of soda from salt and sulphuric acid.

II. The conversion of sulphate of soda into crude carbonate of soda, or British barilla.

III. The soda ash process.

IV. The carbonate of soda process.

The first stage which thus comes under our consideration is—

I. *The Decomposition of common Salt by Sulphuric Acid, causing the formation of Sulphate of Soda and Muriatic Acid.*

The salt used in this process is obtained from the brine springs of Cheshire which exist abundantly in the new red sandstone of that county. The solution is evaporated till it reaches a certain strength, when all the salt precipitates. It is then raked out into wicker baskets and allowed to drain. The mother liquor is used for the manufacture of the salts of magnesia. The salt thus obtained, contains, as might be expected, numerous impurities, the principal of which are lime, sulphuric acid, and magnesia.

To estimate the lime, a portion of the salt was dissolved in water, and after separating the insoluble matter by filtration, the lime was precipitated by ammonia and oxalic acid, a large quantity of muriate of ammonia being added to retain the magnesia in solution.

	$CaO\,CO_2$	CaO	CaO per 1000 grs.
2000 grains of salt gave,	...15·10	8·456	4·228
2000 — —	...14·60	8·176	4·088
Average,	....		4·158

The sulphuric acid was precipitated by the addition of nitric acid and nitrate of barytes:—

	$BaO\,SO_3$	SO_3	SO_3 per 1000 grs.
2000 grains of salt gave,	... 39·85	13·738	6·869
2000 — —	... 39·50	13·620	6·810
Average,	....		6·839

The quantity of magnesia was ascertained by precipitation by ammonia and phosphate of soda, the lime having been previously separated:—

	$2 MgO PO_5$		Mg O		Mg O per 1000 grs.
2000 grains of salt gave, ...	4·65	......	1·660	......	0·830

The carbonate of lime remained as insoluble matter when the salt was digested in water, and was separated by filtration:—

	$Ca O CO_2$		$Ca O CO_2$ per 1000 grs.
2000 grains of salt gave, ...	3·000	....	1·50

By estimating the amount lost by drying the salt at 212°, the quantity of water was ascertained:—

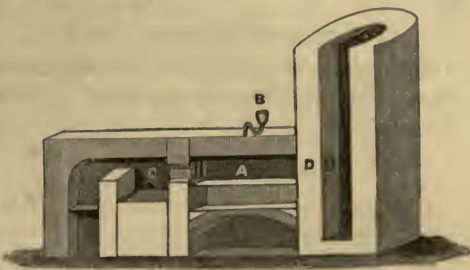
			Water, per 1000 grs.
330·2 grains of salt lost, ...	17·96	....	54·373

In order to estimate the quantity of iodide of potassium and bromide of magnesium, $1\frac{1}{2}$ lbs. of salt were put into a funnel, the lower end of which was closed with filtering paper. The salt was then repeatedly washed with boiling water. The iodide and bromide were thus taken up by the water along with a large quantity of common salt. This solution was evaporated to dryness, and the residue digested in alcohol, which dissolved the iodide and bromide, along with a little of the salt, leaving, however, the greater part of it, which was afterwards separated by filtration. The filtered solution was again evaporated to dryness, and the residue digested in water. Chloride of palladium was then added, but no precipitation of iodide of palladium took place. The palladium was precipitated by sulphuretted hydrogen; and the sulphuret of palladium thus formed separated by filtration. Upon testing the filtered solution with ammonia and nitrate of silver, no precipitate was obtained. Had bromine been present, it would have been precipitated in combination with the silver, bromide of silver being insoluble in caustic ammonia. It is therefore evident, that the common salt, manufactured as previously mentioned, does not contain iodine or bromine; although it is highly probable that these bodies are present in small quantity in rock salt, and we might therefore be able to detect them in the brine from which the magnesia salts are manufactured.

Upon treating the salt with bichloride of platinum, a slight precipitate of potash bichloride of platinum was obtained:—

		Magnesia.	Lime.	Sulphuric Acid.
Chloride of sodium, ...	931·615	—	—	—
Chloride of potassium,	trace,	—	—	—
Chloride of magnesium,	1·066	0·381	—	—
Sulphate of lime, ...	10·098	—	4·158	5·940
Sulphate of magnesia,	1·348	0·449	—	0·899
Carbonate of lime, ...	1·500	—	—	—
Water, ...	54·373	—	—	—
	1000·000	0·830	4·158	6·839

About 6 cwt. of this salt is introduced into the iron pot, A; and upon this is run, by the pipe, B, about 5½ cwt. of sulphuric acid, of about 1·750 specific gravity, (150° Twaddell). A violent action immediately takes place, and large quantities of muriatic acid gas are evolved, which pass off by the chimney, D. If, however, the muriatic acid can be made use of, the gas is absorbed either by passing it through water contained in large cylindrical vessels, or through a column of coke, which retains the gas until a considerable quantity of it is collected; a stream of water is then allowed to trickle through the coke, and in this manner all the gas is absorbed. At the expiration of about two hours, the evolution of gas ceases, and the sulphate, which is in a semifluid state, is removed to C, where it is strongly heated, in order to drive off the whole of the acid. The whole operation takes about four hours.



The foreign matters contained in the sulphate of soda thus obtained are, sand, iron peroxide, magnesia, and undecomposed salt.

To estimate the sand. This remained as insoluble matter when the sulphate was digested in water containing muriatic acid, and was separated by filtration:—

1000 grains of sulphate of soda gave,		2·82	grains of sand.
1000	— —	3·38	—
Average,........................		3·10	—

From the solution filtered from the sand, the peroxide of iron was precipitated by ammonia; muriate of ammonia having been previously added, to retain the magnesia in solution:—

1000 grains of sulphate of soda gave		2·15	grains peroxide of iron.
1000	— —	2·45	—
Average,.....		2·30	—

After separating the sand and peroxide of iron as mentioned above, the lime was precipitated by oxalic acid and caustic ammonia:—

	$CaO\,CO_2$	$CaO\,SO_3$
1000 grains of sulphate of soda gave,.....	7·100	9·656
1000 — —	7·367	10·019
1000 — —	7·000	9·520
Average, ...		9·731

The solution thus freed from lime, &c. was treated with ammonia and phosphate of soda. The magnesia was thus separated as ammonia phosphate:—

	$2\,MgO\,PO_5$	$MgO\,SO_3$
1000 grains of sulphate of soda gave,......	2·70	2·893

The quantity of chloride of sodium was ascertained by precipitating the chlorine by nitrate of silver and nitric acid:—

	Ag Cl.	Na Cl, per 1000 grs.
200 grains of sulphate of soda gave,......	4·30	8·995
1000 — —	......29·70	12·373
500 — —	......13·80	11·500
Average, ...		10·956

The sulphate of soda always contains a small quantity of free acid, the amount of which was ascertained by determining the weight lost by heating to redness:—

		per 1000 grs. Free Acid,
200 grains of sulphate of soda lost,......	1·70	8·50
200 — —	...... 1·84	9·20
Average, ...		8·85

Sulphate of soda,.........................	962·170
Sulphate of lime, ...	9·731
Sulphate of magnesia, ...	2·893
Chloride of sodium, ...	10·956
Iron peroxide, ...	2·300
Sand, ...	3·100
Free acid, ...	8·850
	1000·000

This brings us to the consideration of the second part of the process, namely,—

II. *The conversion of Sulphate of Soda into Crude Carbonate of Soda, or British Barilla.*

This is effected by the combined action of coal and carbonate of lime. The following Table shows the quantities commonly used:—

	Cwt.	Qrs.	Per cent.	Theoretical quantity.
Sulphate of soda,......	2	2	100 lbs.	100 lbs.
Ground limestone, ...	2	$2\frac{1}{2}$......	102·9 "	105·3 "
Coal dross, ...	1	3	61·7 "	33·6 "

These, after being intimately mixed, are introduced into a reverberatory furnace, and strongly heated. The mass soon becomes soft, when care must be taken to stir it frequently, in order to expose a fresh surface to the heat. When it becomes of the consistence of dough, the chemical action commences, and jets of inflamed carbonic oxide begin to issue from it. The evolution of gas soon becomes very rapid, so much so, that the whole mass appears to be in a state of ebullition. When this ceases, the operation is completed, and the fused mass is raked out of the furnace and allowed to solidify. The cake thus obtained is the crude carbonate of soda.

This process consists of two sub-processes, which might be conducted in separate furnaces; 1. The coal is consumed at the expense of the oxygen of the sulphate of soda, causing the formation of carbonic oxide and sulphuret of sodium.

$$Na\,O\,SO_3 + 4\,C = Na\,S + 4\,CO$$

2. The sulphuret of sodium thus formed is decomposed by the carbonate of lime, with the formation of sulphuret of calcium and carbonate of soda.

$$Na\,S + Ca\,O\,CO_2 = Na\,O\,CO_2 + Ca\,S$$

But if this compound was digested in water, a reverse action would immediately take place; sulphuret of sodium and carbonate of lime being again formed. To obviate this difficulty, a large excess of lime is used in the process, nearly twice as much as would otherwise be absolutely necessary. This excess of lime causes the formation of a compound insoluble in water, the composition of which is $3\,Ca\,S + Ca\,O$. This substance has no effect upon a solution of carbonate or caustic soda.

Analysis of Soda Ball, or Crude Carbonate of Soda.

An average sample was obtained by pounding a large quantity of the soda ball, and from this the specimens analysed were taken.

1. To estimate the amount of soluble and insoluble salts.

A portion of the substance was thrown on a weighed filter and washed with water at about 120° F., until a portion of the filtered liquor left no residue on evaporation. The filter and insoluble matter were then dried in a water bath and weighed:—

Soda Ball.	Insol. Matter.	Sol. Matter.
100 gave,	59·87	40·13
100 —	58·92	41·08
100 —	59·90	40·10
Average,	59·56	40·43

2. Sulphate of soda.

After saturating the soda ball with pure muriatic acid, and separating the insoluble matter by filtration, the sulphuric acid was precipitated by chloride of barium:—

Soda Ball.	$BaOSO_3$	$BaOSO_3$ p.c.	$Na\,OSO_3$ p.c.
245·20 gave,	8·50	3·466	2·147
110·00 —	1·30	1·181	0·733
78·36 —	0·76	0·969	0·601
Average,		1·872	1·160

3. Chloride of sodium.

The soda ball was digested with nitric acid and filtered, and from the filtered solution the chlorine was precipitated by nitrate of silver:—

Soda Ball.	Ag Cl.	Cl.	Na Cl.	Na Cl p.c.
98 gave, ...	5·400	1·350	2·250	2·295
100 —	3·679	0·912	1·532	1·532
			Average,......	11.39

4. Soda.

The total quantity of available soda, that is, soda existing as carbonate, sulphuret, and hydrate, was determined in the following manner:—A portion of the soda ball was thrown on a filter and washed with warm water, until all the soluble matter was taken up; the filtered solution was then exactly neutralised by dilute sulphuric acid, which was afterwards precipitated by chloride of barium. From the quantity of sulphate of barytes thus obtained, the amount formerly got from the sulphate of soda was deducted, and from the remainder the per centage of alkali was calculated:—

Soda Ball.	$BaOSO_3$	$BaOSO_3$		$BaOSO_3$ p.c.	Soda p.c.
44·60 gave,	40·60......	91·031 —	1·872 =	89·159......	24·593
100 —	88·96......	88·960 —	1·872 =	87·088......	24·024
48·50 —	42·76......	88·164 —	1·872 =	86·292......	23·800
				Average,......	24·138

5. Sulphur.

The amount of sulphur was determined in two different ways:—1st, The soda ball, after being very carefully pulverised, was intimately mixed with about four times its weight of nitrate of potash, and heated in a covered platinum crucible. The nitrate of potash was thus decomposed, and the sulphur converted into sulphuric acid by the oxygen of the nitric acid:—

$$KO\ NO_2O_3 + S = SO_3 + KO + NO_2$$

The fused mass was dissolved by muriatic acid, and after filtering the solution, the sulphuric acid was precipitated by chloride of barium. 2d, The soda ball, moistened with a small quantity of water, was intimately mixed with a quantity of finely pulverised chlorate of potash, and to this muriatic acid was added, drop by drop, until, upon a fresh addition of acid, no more gas was evolved. The flask containing the substance was then gently heated by means of a water bath, care being taken to keep the temperature below 180° F., as chlorous acid explodes with great violence at about 200° F. When all action had ceased, the solution was filtered, and the sulphuric acid precipitated by chloride of barium. From the weight of the sulphate of barytes thus obtained, the former quantity, 1·872, was deducted, and from the number thus found, the amount of sulphur was calculated:—

	Soda Ball.		$BaOSO_3$				BaOSO₃ p.c.	Sulphur, c.p.
By 1st Method.	19·34	gave,	17·90	92·554	— 1·872	=	90·682	12·507
	19·53	—	18·20	93·189	— 1·872	=	91·317	12·595
By 2d Method	28·90	—	27·00	93·425	— 1·872	=	91·553	12·627
	29·60	—	27·20	91·891	— 1·872	=	90·019	12·416
							Average	12·536

6. Magnesia.

This was precipitated by ammonia and phosphate of soda:—

Ball Soda.	$2\,MgOPO_5$	MgO p.c.
100 gave,	0·980	0·350

7. Silica and sand.

The soda ball was dissolved in muriatic acid, and the solution evaporated to dryness. The residue was then digested with strong muriatic acid, and the insoluble matter separated by filtration:—

Ball Soda.	Silica and Sand.	Silica and Sand, p.c.
56·00 gave,	4·30	7·679

The silica was separated from the sand by strong caustic potash:—

Ball Soda.	Sand.	Sand, p.c.	Silica, p.c.
56·00 gave,	2·40	4·285	3·394

8. Iron and alumina.

A portion of the soda ball was dissolved in muriatic acid, and after separating the insoluble matter, the iron and alumina were precipitated by caustic ammonia:—

Ball Soda.	AlO & Fe_2O_3	AlO & Fe_2O_3 p.c.
61·20 gave,	3·45	5·637
19·53 —	1·15	5·888
29·10 —	1·45	4·982
	Average,	5·502

The peroxide of iron was separated from the alumina by caustic potash:—

Ball Soda.	Fe_2O_3	Fe_2O_3 p.c.	Fe p.c.	AlO p.c.
61·20 gave,	2·94	4·804	3·363	0·833
29·10 —	1·20	4·123	2·886	0·859
		Average,	3·129	0·846

9. Lime.

From the solution filtered from the alumina and iron, the lime was precipitated by oxalate of ammonia:—

Ball Soda.	$CaO\ CO_2$	CaO	CaO p.c.
61·20 gave,	33·00	18·480	30·194
29·10 —	15·50	8·680	29·828
21·80 —	12·05	6·748	30·954
		Average,	30·325

10. Carbonic acid.

By the addition of muriatic acid to the ball soda, sulphuretted hydrogen and carbonic acid gases were evolved, which were passed through a strong solution of caustic barytes. The precipitated carbonate of barytes was filtered as rapidly as possible, care being taken to keep it covered with a plate of glass during the process:—

Ball Soda.		BaO CO_2	CO_2	CO_2 p.c.
45·35	gave,	28·90	6·487	14·304
90·18	—	59·20	13·289	14·736
			Average,	14·520

11. Carbon.

To determine the amount of carbon, a portion of the ball was heated with muriatic acid, and the solution evaporated to dryness. Dilute acid was then added, and the insoluble matter thrown on a filter, which had been previously dried at 212°, and weighed. The total amount of carbon, silica, and sand, was thus ascertained. The whole was then ignited and weighed, and from the loss the per centage of carbon was calculated:—

Ball Soda.	Insol. Matter.	Carbon, p.c.
100 gave,	15·941 which lost, on ignition,	7·998

12. Water.

The soda ball was dried at 212°, and the amount lost estimated:—

Ball Soda.	Water.	Water, p.c.
50·00 lost,	0·35	0·700

Whilst washing out the soluble salts, it was observed that the filtered solution was of a greenish colour, and upon boiling it a green coloured substance was deposited, after which the supernatant liquor became perfectly colourless. Upon examining this precipitate, it was found to consist principally of silica and alumina, with a little lime. From this it was concluded to be artificial ultramarine, which is frequently found in the crevices of the ball furnaces, and which, when dissolved in caustic soda, yields a green coloured solution, precisely the same as that mentioned above:—

Ball Soda.		Ultramarine.	Ultramarine, p.c.
200	gave,	0·46	0·23
100	—	0·36	0·36
		Average,	0·295

Sulphate of soda,	1·160
Chloride of sodium,	1·913
Soda,	24·138
Lime,	30·325
Sulphur,	12·536
Carbonic acid,	14·520
Sand,	4·285

Silica,	3·394
Magnesia,	0·350
Alumina,	0·846
Iron,	3·129
Water,	0·700
Carbon,	7·998
Ultramarine,	0·295

		Soda.	Lime.	Carbonic Acid.	Sulphur.
Carbonate of soda,	35·640	21·120	—	14·520	—
Caustic soda,	0·609	0·609	—	—	—
Aluminate of soda,	2·350	1·504	—	—	—
Sulphate of soda,	1·160	—	—	—	—
Sulphuret of sodium,	1·130	0·905	—	—	0·454
Chloride of sodium,	1·913	—	—	—	—
Ultramarine,	0·295	—	—	—	—
3 CaS + CaO,	29·172	—	24·024	—	10·296
Caustic lime,	6·301	—	6·301	—	—
Sand,	4·285	—	—	—	—
Sulphuret of iron,	4·917	—	—	—	1·786
Silicate of magnesia,	3·744	—	—	—	—
Carbon,	7·998	—	—	—	—
Water (hygroscopic,)	0·700	—	—	—	—
	100·214	24·138	30·325	14·520	12·536

It will be seen that, in the above analysis, I consider almost all the soda to be united with carbonic acid, there being very little caustic soda. Unger and others who have examined the soda balls, fall into the error of supposing a large quantity of the alkali to exist as hydrate, and also of always finding carbonate of lime. But if a portion of the ball soda be digested in alcohol, and the alcoholic liquor carefully examined, it will be found that it holds in solution a very small quantity of alkali, which I consider to be as sulphuret. If, on the contrary, the soda balls contained caustic soda, it would be immediately dissolved by the alcohol, and we would obtain a *strongly* alkaline solution. This however is not the case. But if the ball soda be digested in water, the liquid will be found to contain a large quantity of caustic soda, which, however, can easily be accounted for in the following way:—There exists in the ball soda a large amount of caustic lime, and whenever water is added to it, a decomposition takes place,—carbonate of soda and caustic lime becoming carbonate of lime and caustic soda,—

$$NaO\ CO_2 + CaO = CaO\ CO_2 + NaO.$$

Some analysts have also found water of combination in ball soda; that is, water united to soda or lime. But this is impossible: for where does the water come from? The materials contain none. A small quantity of water is certainly formed in the combustion of coal, but this is not sufficient to account for it. The method of analysis pursued in the determination of the amount of water combined with soda or lime was, I think, very incorrect. It was to burn the ball soda with chromate of lead, and determine the weight of the water given off. Had any undecomposed coal existed in the waste, it would have contained hydrogen, and water would consequently have been formed, the oxygen being derived from the chromic acid of the chromate of lead.

As might be expected, I found, upon trying samples taken from different furnaces, that the constituents were subject to great variations. Thus, the lime varied from 27 to 34 per cent.; the soda from 22 to 26·5 per cent.; the sulphur from 10 to 16 per cent.;—but they always stood in a certain fixed relation to one another; for when the quantity of lime was large, the amount of sulphur was proportionally increased, and the per centage of soda consequently diminished. The following table will suffice to show this:—

	I.	II.	III.
Soda,	26·480	22·000	24·138
Lime,	26·959	33·807	30·324
Sulphur,	10·527	13·820	12·436

I insert here two analyses of soda balls, the one from Cassel by Unger, the other from Newcastle by Richardson. They both get hydrate of soda and carbonate of lime, and are I think wrong in both of these, although the other parts of the analyses are probably quite correct.

The manufacture in Cassel and Newcastle is carried on almost exactly in the same way as here.

	From Cassel.	From Newcastle.
Sulphate of soda,	1·99	3·64
Chloride of sodium,	2·54	0·60
Carbonate of soda,	23·57	9·89
Hydrate of soda,	11·12	25·64
Carbonate of lime,	12·90	15·67
3 CaS, CaO,	34·76	35·57
Sulphuret of iron,	2·45	1·22
Silicate of magnesia,	4·74	0·88
Charcoal,	4·59	4·28
Sand,	2·02	0·44
Water (hygroscopic,)	2·10	2·17
	99·78	100·00

This brings us to the consideration of the third division of the soda process, namely,—

III. *The Manufacture of Soda Ash from Ball Soda.*

The first point is to extract all the soluble matter from the balls. This is done by digestion in warm water. The vessels used for this purpose are large square iron pans, five or six of which are usually worked together. They are so contrived that the water which runs into the first pan passes through the whole six in succession. In this way a very saturated solution is obtained. From the last digester, the liquor is run into a large iron vessel, where it is allowed to settle. The insoluble matter which remains in the pans is of no use, and is thrown away as waste. It is a source of great annoyance to the manufacturer, as also to the whole neighbourhood of the place where it is deposited, large quantities of sulphuretted hydrogen being evolved from it. Numerous attempts have been made to recover the sulphur from it, but without success.

The following analysis of fresh soda waste was made in the same way as that of the ball soda:—

1. Sulphuric acid.

The waste was digested in pure muriatic acid, and after separating the insoluble matter by filtration, the sulphuric acid was precipitated by chloride of barium:—

Waste.	$BaO\ SO_3$	$BaO\ SO_3$ p.c.	$CaO\ SO_3$ p.c.
28·00	2·10	7·500	4·396
30·95	2·20	7·108	4·166
		Average,	4·281

2. Sulphur.

The sulphur was oxydized by chlorate of potash and muriatic acid, and the sulphuric acid thus formed precipitated by chloride of barium:—

Waste.		$Ba\ O\ SO_3$	$Ba\ O\ SO_3$, p.c.		$Ba\ O\ SO_3$ from $Ca\ O\ SO_3$			Sulphur, p.c.
27·75	gave	27·56	99·315	—	7·304	=	92·011	12·689
30·90	—	32·40	104·854	—	7·304	=	97·550	13·455
26·95	—	27·80	103·154	—	7·304	=	95·850	13·220
							Average,	13·182

3. Silica and sand.

By dissolving the waste in strong muriatic acid, evaporating to dryness, and dissolving the residue, the silica, sand, and carbon remained as insoluble matter, the last of which was destroyed by ignition. The silica and sand were then separated by caustic potash:—

Waste.		$Si\ O$ & Sand.		$Si\ O$		Sand.	$Si\ O$ p.c.	Sand p.c.
50·00	gave	5·513	containing	2·640	and	2·873	5·280	5·746

4. Peroxide of iron.

After separating the silica and sand, the iron was precipitated by caustic ammonia. It contained a very small quantity of alumina:—

Waste.		$Fe_2\ O_3$	$Fe_2\ O_3$ p.c.
20·00	gave,	1·10	5·500
50·00	—	2·46	4·920
21·40	—	1·44	6·729
		Average,	5·716

5. Lime.

After the iron had been precipitated by ammonia, the lime was thrown down by oxalic acid:—

Waste.	$CaO\,CO_2$	CaO	CaO p.c.
21·40 gave, ...	17·10	9·576	44·747
48·90 —	39·10	21·896	44·777
		Average, ...	44·762

6. Magnesia.

After separating the lime, the magnesia was precipitated by phosphate of soda and ammonia:—

Waste.	$2\,MgO\,PO_5$	MgO	MgO p.c.
48·90 gave, ...	0·970	0·346	0·707

7. Carbonic acid.

A quantity of the waste was put into a flask, and dilute acid slowly added to it. The carbonic acid thus disengaged was passed through a solution of caustic barytes; and from the quantity of carbonate of barytes thus precipitated, the amount of carbonic acid was calculated:—

Waste.	$BaO\,CO_2$	CO_2	CO_2 p.c.
30·80 gave, ...	15·65	3·513	11·406
27·20 —	13·30	2·985	10·974
		Average, ...	11·190

8. Soluble and insoluble salts.

The whole of the soluble matter was extracted by water, and the residue dried at 212°, and weighed:—

Waste.	Insol. Mat.	Insol. Mat. p.c.	Sol. Mat. p.c.
71·2 gave, ...	52·50	73·736	26·264

9. Carbon.

The amount of carbon was determined in the same way as in the ball soda:—

Waste.	Si O Sand & C.	Carbon.	Carbon p.c.	Insol. Salts p.c.
50 gave,	11·552,	lost on ignition 6·039	12·078	61·658

10. Carbonic acid in insoluble salts.

Waste.	$BaO\,CO_2$	CO_2	CO_2 in Insol Salts.
20·30 gave, ...	15·70	3·525	10·657

11. Lime in insoluble salts.

Waste.	$CaO\,CO_2$	CaO	CaO in Insol. Salts.
23·80 gave, ...	20·90	11·704	30·448

12. Bisulphuret of calcium.

A portion of the waste was digested with muriatic acid and a large quantity of water, and heated till the whole of the sulphuretted hydrogen was dissipated. The sulphur which remained was then oxydized by chlorate of potash and muriatic acid, and the sulphuric acid thus formed precipitated by chloride of barium. But as this method does not yield very accurate results, the amount of bisulphuret of calcium given below can only be considered as an approximation:—

Waste.	$BaOSO_3$	Sulphur.	Sulphur p.c.	CaS_2 p.c.
35·8 gave, ...	11·45	1·579	2·205	3·583

13. Hyposulphite of lime.

About 100 grains of the waste were digested for twenty-four hours with a solution of oxalate of potash. A salt of the oxide of copper was then added, by which all the sulphur was precipitated. The precipitated sulphuret of copper was separated by filtration; and to the filtered solution, sulphuric acid was added. At first, no precipitation took place; but after standing for one or two hours the solution became slightly turbid. The quantity of sulphur was, however, too small for estimation.

14. Water.

Waste.	Water p.c.
100 grains lost by drying at 212°, ...	2·10

Soluble salts, ...	26·264
Insoluble salts, ...	73·736
	100·000

Sulphate of lime, ...	4·281
Sulphur, ...	13·182
Silica, ...	5·280
Sand, ...	5·746
Peroxide of iron, ...	5·716
Lime, ...	44·762
Magnesia, ...	0·707
Carbonic acid, ...	11·190
Carbon, ...	12·079
Carbonic acid in insoluble salts, ...	10·657
Lime in insoluble salts, ...	30·448
Bisulphuret of calcium, ...	3·583
Hyposulphite of lime, ...	trace.
Water, ...	2·10

			Lime.	Sulphur.	Carbonic Acid.
Insoluble Salts.	Carbonate of lime, ...	24·220	13·563	—	10·657
	3 CaS CaO, ...	20·363	16·769	7·187	—
	Carbon, ...	12·709	—	—	—
	Silicate of magnesia, ...	5·987	—	—	—
	Sand, ...	5·746	—	—	—
	Peroxide of iron, ...	5·716	—	—	—

Soluble Salts.	Sulphate of lime,	4·281	1·645	—	—
	Hyposulphite of lime,	trace	—	—	—
	Bisulphuret of calcium,	3·583	1·929	2·205	—
	Sulphuret of calcium,	8·527	6·631	3·790	—
	Hydrate of lime,	5·582	4·225	—	—
	Carbonate of soda,	1·309	—	—	0·533
	Water (hygroscopic),	2·100	—	—	—
		99.492	44·762	13·182	11·190

As might be expected, the quantity of lime, sulphur, and carbonic acid is subject to great variations—every sample varying to a considerable extent.

Upon examining a sample of waste three or four weeks old, I found the quantity of hyposulphite of lime to be much greater than in perfectly fresh waste. Another specimen which had been partially exposed to the action of the atmosphere for three years, was entirely converted into sulphate of lime, sulphite of lime, carbonate of lime, and hyposulphate of lime. Some specimens were obtained which consisted entirely of sulphate of lime, carbonate of lime, and caustic lime. These experiments are very interesting, as they show the gradual oxydation of the sulphur which the waste contains.

The waste in the soda ball consists entirely of oxysulphuret of lime (3 CaS CaO,) and caustic lime. The 3 CaS CaO soon, however, decomposes, giving rise to sulphuret and bisulphuret of calcium, and caustic lime. The bisulphuret of calcium being very efflorescent, forms on the waste heap a yellow coating of small prismatic crystals. The sulphur is then further oxydized, the first products being hyposulphite and sulphite of lime: the process still continuing, hyposulphate and sulphate of lime are formed; and this oxydation goes on till sulphate of lime remains. The caustic lime is also, for the most part, converted into carbonate.

It would be very interesting to ascertain the exact amount of each of these substances present in waste in different stages of decomposition; but there are as yet no methods known by which sulphurous, hyposulphurous, and hyposulphuric acid can be accurately determined, especially when existing along with sulphuric acid and sulphurets, as in soda waste. Under these circumstances, it would be impossible to make a series of analyses of the waste in its different stages of decomposition, upon which perfect dependence could be placed. But it is to be hoped, that as the science advances, these at present insuperable obstacles may be entirely removed.

The following is an analysis by Unger of a sample of waste from Cassel:—

Carbonate of lime,	19·56
3 CaS + CaO,	32·80
Carbon,	2·60
Silicate of magnesia,	6·91
Sand,	3·09
Iron peroxide,	3·70
Sulphate of lime,	3·69
Hyposulphite of lime,	4·12
Hydrate of lime,	11·79
Bisulphuret of calcium,	4·67
Sulphuret of calcium,	3·25
Sulphuret of sodium,	1·78
Water,	3·45
	100·31

The soda waste thus affords ample room for further researches, which, if carefully prosecuted, might yield very interesting results. But without dwelling any longer on this subject, I pass on to the consideration of the remaining part of this division of the process, viz., the manufacture of soda ash from the liquor containing the soluble matter extracted from the ball soda.

This liquor contains carbonate of soda, caustic soda, sulphuret of sodium, sulphate of soda, and chloride of sodium, with a little aluminate of soda, the greater part of which is, however, soon decomposed by the action of the carbonic acid of the atmosphere, carbonate of soda being formed whilst the alumina precipitates. This solution is boiled down in an iron pan until it is nearly dry. The analyses of this and the remaining salts were made in the following way:—

1. Carbonate of soda.

The amount of carbonate of soda was determined by ascertaining the weight of the carbonic acid, which was evolved on the addition of muriatic or sulphuric acid to the salt.

2. Sulphuret of sodium.

The amount of sulphuret of sodium was ascertained by passing the gases evolved on the addition of muriatic acid to the salt through a solution of arsenious acid in caustic potash. The sulphuret of arsenic thus formed, was precipitated by neutralising the potash with nitric acid. It was then thrown on a filter, dried at 212°, and weighed. From its weight the quantity of sulphuret of sodium was calculated.

3. Hydrate of soda.

To ascertain the quantity of hydrate of soda, a portion of the substance was heated strongly with carbonate of ammonia, in order to convert the hydrate and sulphuret into carbonate. The amount of carbonic acid was then determined as formerly, and the difference between the results of the two experiments gave the amount of carbonic acid equivalent to the quantity of soda existing as hydrate and sulphuret in the sample. The amount united to sulphur was then deducted, and the remainder gave the per centage of hydrate.

4. Sulphate of soda.

A portion of the salt was dissolved in a pretty large quantity of water, and nitric acid added to expel the carbonic acid. The sulphuric acid was then precipitated by chloride of barium.

5. Sulphite of soda.

The salt was boiled with strong nitric acid, in order to oxydize the whole of the sulphite of soda and sulphuret of sodium. Water was then added, and the sulphuric acid precipitated by a salt of barytes. From the quantity of sulphate of barytes thus obtained, the amount got by the former experiment was deducted, and the remainder showed the quantity of sulphate of barytes equivalent to the amount of sulphite of soda and sulphuret of sodium. The per centage of sulphuret of sodium being known, the sulphite of soda was easily determined.

6. Chloride of sodium.

After expelling the carbonic acid by nitric acid, the chlorine was precipitated by nitrate of silver.

7. Aluminate of soda and insoluble matter.

A solution of the salt was acidified by muriatic acid, and the insoluble matter (principally sand) separated by filtration. From the filtered solution, the alumina was precipitated by caustic ammonia.

The salt obtained by evaporation from the liqour from the keaves, after drying at 212°, yielded on analysis,—

	I.	II.
Carbonate of soda,...............	68·907	65·513
Hydrate of soda,.................	14·433	16·072
Sulphate of soda,................	7·018	7·812
Sulphite of soda,.................	2·231	2·134
Hyposulphite of soda,...........	trace	trace
Sulphuret of sodium,............	1·314	1·542
Chloride of sodium,..............	3·972	3·862
Aluminate of soda,...............	1·016	1·232
Silicate of soda, ...	1·030	0·800
Insoluble matter,.............. .	0·814	0·974
	100·755	99·961

This salt is then introduced into a reverberatory or *carbonating* furnace, where it is strongly heated. In this process the sulphuret of sodium is converted into sulphate of soda, and part of the hydrate of soda into carbonate. The salt, when removed from the furnace, is ready for the market. In Newcastle and some other places, it is dissolved and carbonated again; and when thus manufactured, it contains less caustic soda. Soda ash thus prepared contains from 48 to 53 per cent. of available alkali, that is, alkali combined with carbonic acid and water, and yielded on analysis,—

	I.		II.		Analysis of Ash from Germany, by Unger.
Carbonate of soda,	71·614	......	70·461	......	62·13
Hydrate of soda,	11·231	......	13·132	......	17·20
Sulphate of soda,	10·202	......	9·149	......	8·66
Chloride of sodium,	3·051	......	4·279	......	3·41
Sulphite of soda,	1·117	......	1·136	......	0·35
Aluminate of soda,	0·923	......	0·734	......	1·11
Silicate of soda,	1·042	......	0·986	......	2·56
Sand,	0·316	......	0·464	......	0·62
Water,	—	......	—	......	3·96
	99·496		100·341		100·00

The next stage of the process which comes under our consideration is,—

IV. *The Carbonate of Soda process.*

The carbonate of soda balls are lixiviated with water in the same way as in the manufacture of soda ash. The liquor from the settler is pumped up into a pan, where it is evaporated till it becomes nearly dry. It is then taken out of the pan in colanders, thrown up in a heap, and allowed to drain. The sulphuret of sodium and caustic soda soon deliquesce and drain out from the salt.

This salt, after drying at 212°, gave, when analysed,—

	I.		II.
Carbonate of soda,	79·641	......	80·918
Hydrate of soda,	2·712	......	3·924
Sulphate of soda,	8·641	......	7·431
Sulphite of soda,	1·238	......	1·110
Sulphuret of sodium,	trace	......	0·230
Hyposulphite of soda,	trace	......	trace
Chloride of sodium,	4·128	......	3·142
Aluminate of soda,	1·176	......	1·014
Silicate of soda,	1·234	......	1·317
Insoluble matter,	0·972	......	0·768
	99·742		99·854

This salt is then introduced into a reverberatory furnace and carbonated. The last traces of sulphur are thus oxydized, and almost the whole of the hydrate is converted into carbonate.

This salt yielded, on analysis,—

	I.		II.
Carbonate of soda,	84·002	......	83·761
Hydrate of soda,	1·060	......	0·734
Sulphate of soda,	8·560	......	9·495
Sulphite of soda,	trace	......	0·386
Chloride of sodium,	3·222	......	3·287
Aluminate of soda,	1·013	......	0·620
Silicate of soda,	0·984	......	0·780
Insoluble matter,	0·716	......	0·846
	99·557		99·909

A finer kind of soda ash is frequently made from this salt by dissolving it in water, evaporating to dryness, and carbonating. It contains very little caustic soda, and should average about 50 per cent. of alkali. It yielded, on analysis,—

	I.		II.
Carbonate of soda,	84·314	......	84·721
Hydrate of soda,	trace	......	0·280
Sulphate of soda,	10·260	......	9·764
Sulphite of soda,	trace	......	—
Chloride of sodium,	3·480	......	3·140
Aluminate of soda,	0·632	......	0·716
Silicate of soda,	0·414	......	0·318
Insoluble matter,	0·250	......	0·498
	99·350		99·437

It is from this salt that the crystallised carbonate of soda is manufactured. The ash is dissolved in boiling water until the solution has a specific gravity of 1·255, (50° Twaddell). It is then run into a cistern, where it is mixed with sufficient cold water to reduce the specific gravity to 1·21, (42° Twaddell). This occasions the deposition of a quantity of earthy matter. A small quantity of bleaching powder is then added to the liquid, which causes another deposition. After this has been allowed to settle, the solution is carefully decanted into another pan, and evaporated till it attains a specific gravity of 1·27, (54° Twaddell). From this it is run into another cistern, from which it passes into the crystallising pans. The average time taken in crystallisation is eight days; but it of course varies very much with the season of the year and the state of the atmosphere. The crystallisation is very much assisted by placing a few bars of wood, two or three inches broad, on the top of the liquor.

The crystallised carbonate of soda yielded, on analysis,—

	I.		II.
Carbonate of soda,	36·476	......	36·931
Sulphate of soda,	0·943	......	0·542
Chloride of sodium,	0.424	......	0·314
Water,	62·157	......	62·213
	100·000		100·000

As it contains 10 atoms of water of crystallisation, its formula is $NaO\,CO_2 + 10\,HO$; and the per centage calculated from this formula gives,—

Carbonate of soda, ...	37·500
Water, ...	62·500
	100·000

By driving off the water from these crystals by heat, a very pure carbonate of soda is obtained, which is used by the glass makers. It yielded, on analysis,—

	I.		II.
Carbonate of soda, ...	98·120	......	97·984
Sulphate of soda,.................	1·076	......	1·124
Chloride of sodium, ...	0·742	......	0·563
	99·938		99·671

Table exhibiting the Composition of Salt and Products of the Soda Manufacture.

	Salt.	Sulphate of Soda.	Soda Ball.	Waste.	Soda Ash before Carbonating.	Soda Ash.	Carb. of Soda before Carbonating.	Carbonate of Soda.	Refined Ash.	Crystallyzed Carb. of Soda.	Carb of Soda, Theory.	Ash made from Cryst. Carb. of Soda.
Chloride of sodium,............	931·615	10·956	1·913	—	3·917	3·665	3·635	3·254	3·310	0·369	—	0·652
Chloride of potassium, ...	trace.	—	—	—	—	—	—	—	—	—	—	—
Chloride of magnesium, ...	1·066	—	—	—	—	—	—	—	—	—	—	—
Sulphate of lime,................	10·098	9·731	—	4·281	—	—	—	—	—	—	—	—
Sulphate of magnesia,...........	1·348	2·893	—	—	—	—	—	—	—	—	—	—
Carbonate of lime, ...	1·500	—	—	24·220	—	—	—	—	—	—	—	—
Water, ...	54·573	—	0·700	2·100	—	—	—	—	—	62·135	62·501	—
Sulphate of soda,..................	—	962·170	1·160	—	7·415	9·676	8·036	9·027	10·012	0·742	—	1·100
Sulphite of soda, ...	—	—	—	—	2·182	1·126	1·174	0·386	—	—	—	—
Iron peroxide,......................	—	2·300	—	5·716	—	—	—	—	—	—	—	—
Free acid, ...	—	8·850	—	—	—	—	—	—	—	—	—	—
Sand,................................	—	3·100	4·285	5·746	—	—	—	—	—	—	—	—
Carbonate of soda, ...	—	—	35·640	1·309	67·210	71·037	80·279	83·881	84·517	36·703	37·499	98·052
Caustic soda, ...	—	—	0·609	—	—	—	—	—	—	—	—	—
Caustic lime,........................	—	—	6·301	—	—	—	—	—	—	—	—	—
Hydrate of soda,....................	—	—	—	—	15·252	12·181	3·318	0·897	0·280	—	—	—
Aluminate of soda, ...	—	—	2·350	—	1·124	0·828	1·095	0·816	0·674	—	—	—
Sulphuret of sodium, ...	—	—	1·130	—	1·428	—	0·230	—	—	—	—	—
Hyposulphite of soda, ...	—	—	—	—	trace.	—	—	—	—	—	—	—
Silicate of soda,....................	—	—	—	—	0·915	1·014	1·275	0·882	0·366	—	—	—
Ultramarine,........................	—	—	0·295	—	—	—	—	—	—	—	—	—
3 CaS CaO, ...	—	—	29·172	20·363	—	—	—	—	—	—	—	—
Sulphuret of iron, ...	—	—	4·917	—	—	—	—	—	—	—	—	—
Silicate of magnesia, ...	—	—	3·744	—	—	—	—	—	—	—	—	—
Carbon, ...	—	—	7·998	12·078	—	—	—	—	—	—	—	—
Hyposulphite of lime, ...	—	—	—	trace	—	—	—	—	—	—	—	—
Hydrate of lime, ...	—	—	—	5·582	—	—	—	—	—	—	—	—
Bisulphuret of calcium, ...	—	—	—	3·583	—	—	—	—	—	—	—	—
Sulphuret of calcium, ...	—	—	—	8·527	—	—	—	—	—	—	—	—
Insoluble matter, ...	—	—	—	—	0·894	0·390	0·870	0·781	0·374	—	—	—

26th April, 1848.—The concluding meeting of the Session was held this evening.—*The* President *in the Chair.*

Mr. William Clark was admitted a member. Mr. William Connell was elected and admitted a member.

Dr. Gregory of Edinburgh read a paper "On the Preparation of Creatine, with remarks on the Composition of the Juice of Flesh," and exhibited several beautiful specimens of creatine, creatinine, inosinic acid, &c. The thanks of the Society were voted to Dr. Gregory for his kindness in coming to Glasgow to read this paper.

The following paper was read:—

XLI.—*Note on the Composition of Shea Butter and Chinese Vegetable Tallow.* By Dr. R. D. Thomson and Mr. Edward T. Wood.

Shea Butter.—This substance is a vegetable product of Western Africa, and was first brought into notice by the celebrated Mungo Park, during his first journey in 1796. The tree from which it is procured, he describes as very much resembling the American oak, and the fruit (from the kernel of which being first dried in the sun, the butter is prepared by boiling the kernel in water,) has somewhat the appearance of a Spanish olive. The kernel is enveloped in a sweet pulp under a thin green rind, and the butter produced from it, besides the advantage of its keeping the whole year without salt, is whiter, firmer, and, according to Park, of a richer flavour than the best butter he ever tasted made from cow's milk. The growth and preparation of this commodity seem to be among the first objects of African industry, and it constitutes a main article of their inland commerce. This butter is abundantly produced not only towards the Gambia, but also in the countries adjoining the Niger, as it is mentioned by the Landers and other recent travellers. Mr. John Duncan, who penetrated by Dahomey, describes the tree as resembling a laurel, and growing to the height of eighteen or twenty feet. The leaf is somewhat longer than the laurel, and a little broader at the point. The nut is of the size and form of a pigeon's egg, and of a light brown colour; the substance of the shell about that of an egg. The kernel, when new, is nearly all butter. The shell is crushed from the kernel, which is also crushed and boiled with a little water in a pot for half an hour. It is then strained through a mat, when it is placed in a grass bag and pressed. A good sized tree will yield a bushel of nuts.

Shea Butter appears to be the same as that which is called Galam butter, and is derived from a species of *Bassia*, but the species has not yet been made out, as no specimens of the flower and fruit have reached botanists.

The oil upon which the following experiments were made, was obtained through the kindness of Dr. Carson of Liverpool, from Mr. Jameson, formerly of this city, and now of Liverpool, whose benevolent exertions for the improvement of Africa are so well known. The colour of the oil is white, with a shade of green. It is solid at the usual temperature in this country. At 95° it assumes the consistence of soft butter, and at 110° is a clear and liquid oil. When boiled in alcohol, the greater part is dissolved, and crystallizes on cooling, in needles. It dissolves in cold ether, and separates in needles by evaporation. The oil was saponified by means of caustic potash in a silver basin, the soap separated from its solution by common salt, and decomposed by tartaric acid. After being crystallized out from alcohol five or six times, and freed by pressure from adhering oleic acid, the acid was obtained in fine pearly scales, fusing at 142°. It was united with soda, and yielded a salt in fine pearly scales. Its atomic weight was estimated by means of the silver salt. In the first, second, and third experiments, the silver salt was formed by precipitating an aqueous solution of nitrate of silver, by an aqueous solution of the fatty acid united to soda. In the fourth and fifth experiments, an alcoholic solution of the acid was precipitated by a solution of nitrate of silver in alcohol, and hence the excess of acid.

I. 3·73 grains of silver salt gave 1·05 metallic silver = 1·126 oxide of silver = 30·19 per cent. AgO.

II. 10·65 grains of silver salt gave 3·01 silver = 3·221 oxide of silver = 30·23 per cent. AgO.

III. 2·85 grains gave ·861 AgO = 30·21 per cent.

IV. 4·71 grains gave 1·30 silver = 1·394 AgO = 29·53 per cent.

V. 2·72 grains gave ·743 silver = ·797 AgO = 29·30 per cent.

The following table will express the per centage composition of the silver salt by these five experiments:—

	I.	II.	III.	IV.	V.
Acid,	69·81	69·77	69·79	70·41	70·70
Oxide of silver,	30·19	30·23	30·21	29·59	29·30

Taking the mean of all these experiments, the constitution of the silver salt will be—

Acid,	70·10
Oxide of silver,	29·90

And the atomic weight of the anhydrous salt is—

Acid,	33·97
Oxide of silver,	14·50

Or leaving out the two last determinations, we shall have as a mean for the three higher results, the atomic weight of the acid equal to 33·82.

To determine the composition of the anhydrous acid, the three following analyses were made by means of oxide of copper, and chlorate of potash:—

I. 2·85 grs. of silver salt gave HO = 2·30 grs. and CO_2 = 5·73 grs.
II. 3·91 " " " = 3·39 " " = 7·87 "
III. 3·667 " " " = 3·058 " " = 7·334 "

The following table gives the composition of the above salt in 100 parts:—

	I.	II.	III.	Mean.	Anhydrous Acid.
C,......	54·73	54·88	54·54	54·71	77·83
H,......	8·94	8·78	9·22	8.98	12·77
O,......	6·12	6·75	6·94	6·60	9·40
AgO,...	30·21	29·59	29·30	29·71	—

From the facts, which have been stated in reference to the acid contained in the Shea butter, it is obvious that it is *Margaric acid*, the same substance which is found in human fat and butter. There is little doubt that, on examination, this acid will be found extensively distributed in the vegetable kingdom. Its presence in the Shea butter may assist in explaining the statement of Park, that this substance, when fresh, is equal in taste to butter.

Chinese Vegetable Tallow.—This is a solid oil long known to those who are acquainted with China, where it is extensively used for making candles. It is derived from the seeds of the Stillingia *sebifera*, which, according to Fortune, (Wanderings in China, p. 65,) are pulled in November and December. They are placed in a wooden cylinder with a perforated bottom, over an iron vessel filled with water, which is boiled, and the seeds well steamed, to soften the tallow. In ten minutes they are thrown into a large stone mortar, and beat with stone mallets to separate the tallow from the other parts of the seed. The tallow is thrown on a sieve, heated over the fire, and sifted, and is then squeezed out by a peculiar press. As imported, it is a hard white solid oil, with a green shade. It fuses at about 80°. The oil was saponified, and the acid separated and purified according to the method already noticed. A soda salt was formed, and from this a silver salt was precipitated.

14·38 grains of this salt, when burned, left 4·03 grains of metallic silver, which gives the following for the composition of the salt:—

		Atomic Weight.	Per cent.
Oxide of silver,.......	4·328	14·50	30·03
Acid,....................	10·052	33·67	69·97

The acid was not quite pure, for when heated it softened at 143°, became very soft at 149°, of the consistence of cream at 150°, and quite fluid at 154°. It obviously, therefore, retained some stearic acid, but must have consisted principally of *margaric acid*, as stearic acid fuses at 167°. There is no doubt that both of these oils might be advantageously employed in soap-making, the supply apparently, from the statements of the traders, being unlimited.

The following paper was communicated by Dr. R. D. Thomson:—

XLII.—*Examination of the Yellow Prussiate of Potash Cake.* By Mr. Hugh Brown Tennent, *Laboratory Assistant, Glasgow College.*

Yellow prussiate of potash or ferrocyanide of potassium was discovered by Macquer, and used as a test for persalts of iron. It was introduced into calico printing by Charles Macintosh, Esq., of Campsie, and was first manufactured upon the large scale at Campsie.* The process consists in igniting substances rich in nitrogen, such as, hoofs, horns, dried blood, woollen rags, &c., with carbonate of potash, in iron pots. The fused mass is then digested in water, and the yellow salt crystallized out. As much difference of opinion has existed respecting the composition of the black cake, when it is removed from the iron pots, previous to its digestion in water, the following experiments were made for the purpose of throwing some light on the nature of its constituents, and as the analyses are somewhat complicated, every step has been carefully described.

50 grains were digested in cold water, and filtered, the filter being previously dried at 212° and weighed, it was then washed, until the washings gave no reaction with nitrate of silver. The filter was again dried and weighed, when it gave 40·50 of insoluble matter, showing the presence of 59·5 per cent. of soluble salts and water.

I. Analysis of the Soluble Salts.

1. *Estimation of the Carbonate of Potash.*—To the solution which passed through the filter, as previously described, chloride of barium was added, which gave a bulky white precipitate, consisting of carbonate and sulphate of barytes, and caustic barytes. To determine the true quantity of carbonate of potash, the precipitate, after being rapidly washed under cover and ignited, was introduced into a flask containing a tube filled with hydrochloric acid, the bottle was then closed with a cork, through which a tube filled with chloride of calcium passed. The whole was then weighed and the weight carefully noted; the bottle was then shaken so as to overturn

* The following is an interesting note from Mr. Clarke regarding the commercial history of the prussiates:—

"Campsie Alum Works, 2*d October*, 1848.

"My Dear Sir,—The period when prussiate of potash and prussian blue were first begun to be manufactured here, was in 1807-8. The works were erected in 1806-7; and, when I came here in 1809, the manufacture of both these articles was in operation, and had been so for fully a year before. The prussiate was for some time, at that period, sent to the calico printers and dyers in a liquid state, with printed directions for the proper mode of applying it; but there was also a crystallization of it made when I came here, and in this form it came very soon to be preferred, and the liquid was abandoned.

"I am, my Dear Sir, yours truly,

"ROBT. CLARKE.

"Dr. R. D. Thomson."

the tube containing the acid. After the action had completely ceased, the cork was removed from the flask for a short time, so that the carbonic acid remaining in the tube might mingle with the air, and thus be expelled from the flask. It was then weighed. The loss in weight was 4·61 grains = 9·22 grains per cent. from the expulsion of carbonic acid, equivalent to 29.3 carbonate of potash in 100 parts of the cake.

2. *Estimation of the Caustic Potash.*—50 grains were treated in the same manner as the first, and through the solution a current of carbonic acid was passed, so as to convert the caustic potash into carbonate, and the solution heated to expel the excess of carbonic acid. Chloride of barium was added, which gave a bulky precipitate, consisting of carbonate and sulphate of barytes, which were treated in the same manner as in the former experiment. The excess of carbonic acid over the former experiment gave the quantity of carbonic acid taken up by the free potash, and from this the quantity of caustic potash was calculated. The total loss of carbonic acid amounted to 6·72 grains = 13·44 grains per cent. from which, if we deduct 9·22 grains, we obtain 4·22 grains of carbonic acid as saturating the free potash. The hydrate of potash required to saturate this amount of CO_2, is 10·93 grains per cent.

3. *Estimation of the Sulphate of Lime and Potash.*—After digesting the carbonate of barytes in hydrochloric acid, and filtering, the sulphate remained upon the filter equal to $BaO\,SO_3$ 11·96 = 4·12 SO_3. Oxalate of ammonia was added to a fresh portion, and boiled for some time, so as to decompose the sulphate of lime, which, after being burned, left 1·04 carbonate of lime = 1·90 sulphate of lime. 1·11 grains of SO_3 being required to unite with the lime, there remain 3·01 grains SO_3 to combine with potash. Hence the amount of sulphate of potash is 6·62 grains per cent.

4. *Estimation of the Chloride of Potassium.*—The solution from 100 grains was treated with nitrate of silver, and boiled with nitric acid, so as to decompose any cyanide of silver that might have been formed. The precipitate was then washed, dried, burned, and weighed, when it gave 3 grains chloride of silver = 1·58 chloride of potassium.

5. *Estimation of the Cyanide of Potassium.*—100 grains of the black cake were washed in a covered filter with cold water until all soluble salts were removed. To the solution, which was carefully protected from the air, nitrate of silver was added as long as a precipitate, consisting of chloride, cyanide, carbonate, and oxide of silver, fell. The whole was then thrown upon a filter and washed. It was boiled with nitric acid, and the silver dissolved was precipitated, as chloride of silver, by hydrochloric acid; this precipitate was then ignited and weighed. After deducting the quantity of chloride of silver equivalent to the carbonate, caustic potash, and also the chloride of potassium, from the excess of chloride of silver, the cyanide of potassium was calculated, thus:—

Total quantity of Ag Cl, ... 115·66

$$
\begin{array}{lcl}
29·30\ KO\,CO_2 & = & 60·27\ Ag\,Cl. \\
10·93\ KO\,HO & = & 27·48\ Ag\,Cl. \\
1·58\ K\,Cl & = & 3·00\ Ag\,Cl. \\
\hline
 & & 90·75
\end{array}
$$

Leaving 24·91 Ag Cl = 11·42 K Cy.

A second experiment gave............... 11·72 K Cy.

A third experiment gave .... 10·95 K Cy.

To determine whether the precipitate of cyanide of silver contained any ferrocyanide, after being ignited and weighed, it was digested in nitric acid, and tested by the following reagents:—yellow prussiate, hydrosulphuret of ammonia, caustic ammonia, and caustic soda, which gave none of the reactions characteristic of iron; thus proving the absence of all trace of iron. If there had been any ferrocyanide present, those tests could not have failed in detecting the iron. This is in accordance with Liebig's views, who states that the fused mass does not contain a trace of ferrocyanide, but it contains a large quantity of metallic iron, as well as sulphuret of iron, by the action of the sulphuret of potassium (which is derived from the sulphate in the potash,) on the oxide of iron of the blood, when dried blood is used, or that formed from the vessels. If the mass be treated with cold water, and the filtered solution evaporated, no ferrocyanide is obtained; but if, while covered with water, it is gently heated for some hours, iron is dissolved, and a yellow solution is obtained, which is rich in ferrocyanide of potassium. These results are opposed to those of Runge, who affirms (Poggendorff's Annalen, LXVI. 95,) that if the black cake is washed with spirit (he does not state the strength,) till nothing more is taken up, the black residue, when treated with cold water, gives yellow prussiate.

II. Analysis of Insoluble Matter.

1. *Estimation of Volatile Matter.*—The black mass, from 50 grs., after being ignited, lost 9 = 18 per cent. of volatile matter.

2. *Estimation of Sulphate of Lime.*—The residue was then washed with water, until the liquid passing through ceased to give a precipitate of Ba Cl, when it lost in weight 4·76 = 9·52, to which add 1·9 obtained in former experiment, and we have 11·42 Ca SO_3.

The insoluble portion was fused with NaO CO_2, the fused mass was then treated with HCl, and evaporated to dryness; HCl was again added to the dry silica, and after standing for some time, water was added; it was then filtered, washed, dried, ignited, and weighed, when it gave 1·65, or 3·3 per cent.

3. *Estimation of Iron.*—The solution filtered from the silica was treated with caustic ammonia, which gave a bulky brown precipitate con-

sisting of peroxide of iron, weighing 6·12 = 12·24, which, when reduced to the metallic state, gives 8·56 per cent.

4. *Estimation of Carbonate of Lime.*—The solution filtered from iron, was treated with oxalate of ammonia, which precipitated the lime as oxalate, which, after being burned, gave of CaO CO_2 ·36 = ·72 per cent.

The following are the results of the analyses of the entire prussiate cake:—

Soluble,	Carbonic acid,	9·21
	Chlorine,	0·75
	Cyanogen,	4·32
	Sulphuric acid,	9·83
	Potassium,	7·46
	Potash,	32·91
	Lime,	4·78
Insoluble,	Volatile matter,	18·00
	Silica,	3·30
	Carbonic acid,	·30
	Iron and Sulphur,	8·56
	Lime,	·42
		99·84

These may be arranged in the following manner:—

Soluble,	Carbonate of potash,	29·30	29·22		
	Hydrate of potash,	10·93	11·81		
	Chloride of potassium,	1·58			
	Cyanide of potassium,	10 95		11·72	11·42
	Sulphate of potash,	6·62			
	Sulphate of lime,	11·42			
Insoluble,	Volatile matter,	18·00			
	Iron, / Sulphuret of iron,	8·56			
	Carbonate of lime,	·72			
	Silica,	3·30			
		101·38			

There is an excess, probably, in consequence of the irregular distribution of the organic matter through the different portions used in the analyses.

Analysis of the Prussiate Cake Refuse.

After the yellow prussiate has been dissolved out from the black cake, there remains a quantity of carbonaceous matter, iron, &c. known under the name of prussiate refuse. From its great bulk and weight, the accumulation of this matter becomes a serious incumbrance to the prussiate manufacturer. It possesses considerable decolorizing power, and was at one time tried by the sugar refiners; but the result did not prove satisfactory. The following analysis would lead to the belief that it might be of benefit as a manure, although the experiments hitherto made have not confirmed this idea. Probably the active ingredients might be extracted by treatment with sulphuric acid and washing with water. The black matter, when treated with an acid, effervesces, and at the same time the smell of sulphohydric acid is evolved.

1. *Estimation of Volatile Matter.*—60 grains being dried at 212°, lost 11·4 grains, = 19 per cent. of water. The dry mass was then ignited, and lost 21·73 grains = 36·22 of carbon.

2. *Estimation of Soluble Sulphates.*—The residue was then washed with water, and gave of soluble salts 7·44, or 12·40 per cent., which consisted of sulphate of potash and lime. This solution was divided into two portions: to the first, chloride of barium was added, which gave of $BaO\ SO_3$ 19·43 grains per cent. = 6·70 SO_3. The second portion was then treated with oxalate of ammonia. The precipitate of oxalate of lime, after being burned, gave of carbonate of lime per cent. 5·35, = 6·75 $CaO\ SO_3$. The solution filtered from the oxalate of lime, was evaporated to dryness, and heated to redness, when there remained of sulphate of potash 3·025 grains, = 5·04 per cent.

3. *Estimation of the Silica.*—The insoluble portion in water was fused with carbonate of soda. The fused mass was then dissolved in hydrochloric acid, and evaporated to dryness. Hydrochloric acid was again added, the solution heated, and after standing for some time, water was added; it was then filtered, washed, dried, and ignited, and gave of silica 6·45 grains, = 10·75 per cent.

4. *Estimation of Iron and Alumina.*—Ammonia was added to the solution filtered from the silica, which precipitated the iron and alumina. This precipitate, after being washed, was dissolved in hydrochloric acid, and then boiled with caustic soda, which precipitated the iron as peroxide, and dissolved the alumina. On filtration, the peroxide of iron remained on the filter, and when ignited, weighed 8·35 grains, = 13·91 per cent. The solution containing the alumina was then neutralised by hydrochloric acid, and the alumina precipitated by carbonate of ammonia. It weighed 1·40 grains, = 2·33 per cent.

5. *Estimation of Phosphoric Acid.*—50 grains of the refuse were calcined and fused with carbonate of soda. The silica being separated in the usual manner, to the solution ammonia was added, which precipitated the alumina, peroxide, and phosphate of iron. This precipitate was well washed, and digested in hydrochloric acid. To the solution, tartaric acid was added to retain the iron in solution. An excess of ammonia was then poured in, until the white precipitate which was formed had completely redissolved. Sulphate of magnesia was then added, and the solution allowed to stand for 24 hours, when a crystalline precipitate deposited, which was thrown upon a filter, and washed with water containing

ammonia. It was then dried, ignited, and weighed, and gave of phosphate of magnesia ·80 grains, = 1·60 per cent. = 1·03 grains per cent. phosphoric acid. In a second experiment, 100 grains of the refuse gave 1·56 grains phosphate of magnesia, = 1·002 grains phosphoric acid.

6. *Estimation of the Carbonate of Lime.*—To the solution filtered from the iron and alumina of the analysis of 60 grains, oxalate of ammonia was added, which gave a precipitate consisting of oxalate of lime, affording of carbonate 2· = 3·33 $CaO\ CO_2$ per cent.

7. *Estimation of the Magnesia.*—To the solution filtered from the lime, phosphate of soda was added, and from the phosphate of magnesia obtained, the quantity of magnesia was calculated. The amount of phosphate of magnesia per cent. was 2·75 grains = 1·63 magnesia. The constituents of the refuse of the black cake are therefore as follows, with the addition of other trials:—

Carbon,	36·23	34·80	34·50
Water,	19·00	19·80	18·35
Sulphate of potash,	5·04	5·65	5 92
Sulphate of lime,	6·75	6·13	
Silica,	10·75	10·30	
Oxides of iron, Sulphuret of iron,	13·91		
Carbonate of lime,	3·33	4·96	
Phosphoric acid,	1·03	1·002	
Alumina,	2·33	2·65	
Magnesia,	1·63		
	100·00		

In some of the analyses, a quantity of titanic acid was obtained along with the silica, obviously derived from titanium contained in the iron pots.

Mr. Keddie gave in the following

Report from the Botanical Section.

January 11, 1848.—The Treasurer acknowledged a gift of £5 from the Philosophical Society for the Herbarium.

Dr. Walker Arnott exhibited specimens of plants illustrative of the genera of Chrysobalaneæ, and made some observations upon them, showing that the genus Prinsepia should be rejected from that order, as being more allied to *Prunus*, belonging to the order Amygdaleæ.

February 8.—Dr. Walker Arnott explained the general principles of the Carpellary theory, in order to illustrate the structure of the fruit of the Cucurbitaceæ. He stated the views entertained on the subject by Seringe and De Candolle, according to whom the middle of the back of the carpellary leaf is in the axis, whilst the upper surface and margins are towards the outside. He also noticed the explanation given by himself

(Dr. Walker Arnott,) in the article Botany in the Encyclopædia Britannica, by which it would be a mere modification of a common axile placentation. Dr. Lindley was the first to indicate that the placentation was parietal: but that view was weakened by Dr. Wight, (in his Illustrations of Indian Botany, and in the Madras Journal,) who reverted to the axile placentation, but apparently differing from Seringe, by supposing that it was the upper surface of the carpellary leaf that was next the axis. He then referred to the opinion stated by Dr. Lindley in the "Vegetable Kingdom," that the true structure of the Cucurbitaceæ had been misapprehended, "the illusion having arisen from three parietal placentæ, with revolute (*convolute* is obviously meant) seed-bearing edges projecting forward in the cavity where they adhere." Dr. Walker Arnott mentioned that he had come to a different conclusion from all these by observations made during last autumn, at a time when he had no opportunity of consulting any works on the subject. He agreed with Lindley that the placentation is truly parietal, but differed with him widely as to what were the carpellary leaves, the true ones being revolute, not convolute, and alternating with those considered as such by Lindley; in fact they are represented by the dark places in Lindley's figure. (p. 313.) This theory agrees most with Dr. Wight's, and chiefly differs in this, that the carpellary leaves are at first distinct from each other, and not united till the ovary is advanced, which latter hypothesis is necessary to the axile placentation.

March 14, 1848.—Mr. Gourlie exhibited specimens of Gutta Percha, and read an account of that substance by Dr. Oxley of Singapore, published in the Journal of the Indian Archipelago. He also exhibited a specimen of Strychnos toxifera (Sir R. Schomburgh).

April 18, 1848.—The following paper was read:—

XLIII.—*On the Introduction of Anomalous Genera into Natural Orders.* By G. A. Walker Arnott, LL.D., *Regius Professor of Botany.*

In defining natural orders, or in referring plants to them, it appears to me, that of late years botanists have been frequently pursuing a method which must soon lead to inextricable confusion. When one reads the character of an order, it is to be expected that every plant referred to it must not positively disagree with that character. The character of a species ought to be such, that any of its varieties will arrange themselves under it:—in the same way in a genus we have a right to expect that no species will be referred to it that militates against the generic character. The character may be altered according as we know new species, or if we see occasion to break up the old genus into several; but there must be no incongruity between the generic character and the plants referred to the genus. And, indeed, it is rare we find this to be the case, unless when through laziness one has taken the generic character without sufficient examination from some book, and admits into the genus a species which the composer of that character had not contemplated.

The same law applies to natural orders, which are merely natural groups of genera, or large natural genera; but here, unfortunately, practice and theory are often widely in opposition. Numerous instances might be quoted. Thus Ranunculaceæ, as defined in some of our British Floras, is said to be polyandrous, whereas *Myosurus* has never more than five stamens. If *Myosurus* had not been a native of Britain, I would not object to this, because if we can abridge the character of a genus or order, by omitting all that has no reference to the species described in the book, it is a great boon to the student, or to one who is not engaged in general botany; but such abridgment must not be at the expense of accuracy. In the same way I do not object to European, or North American, or even medical floras stating the Violaceæ to have irregular corollas, because every species found in Europe, in North America, or used in medicine, has such; but if we published the flora of Guiana or East India, we cannot restrict the order in this way, because plants do occur there with quite regular flowers, and differing in no other respect from that order. In a general work, we must therefore have a general or universal character, but it is there that we find numerous failures.

In nature every thing is continuous, and thus there may be said to be but one great natural order, perhaps only one genus: every attempt to break it up, and form smaller orders, must be, in a certain degree, artificial: and there can be but one object in breaking it up, that of conveying information more easily to others, about the plants that are already described. Now, in order that the affinities of such plants may be exhibited by their relative position, it is of importance that such divisions be as natural as possible: but in order that such divisions be also useful, each must be rigorously defined. There are, therefore, two elements inseparable from each other, and it is the judicious combination of these that must limit a natural order.

On a former occasion I made some remarks to this Society on the Chrysobalaneæ. So long as this was retained in the great group of Rosaceæ, there was necessarily a very great latitude in the ordinal character; but the almost impossibility of framing one applicable to all the genera, and, at the same time, sufficiently definite so as to exclude other orders, induced botanists to divide it into several, the more as there were three or four tolerably well marked groups. Perhaps no living botanist has studied that order with more attention than Dr. Lindley; and yet, whether from the desire not to split it up into too many orders, or from trusting too much to natural appearances, we find that some parts of the characters are in the above position; I allude particularly to his Sanguisorbeæ and Rosaceæ (proper). The former (I refer to the Vegetable Kingdom, as containing the latest views on the subject), he defines as *apetalous*, with a solitary carpel inclosed in the hardened calyx tube and forming a false pericarp, and with the ovule solitary On account of the constantly apetalous nature of the flowers, he places this order in his School Botany among the Monochlamydeæ. Now among the twelve genera here referred are *Alchemilla*, *Poterium*, *Adenostoma*, and *Leucosidea;* but *Alchemilla* has sometimes two, three, or four carpels or ovaries; *Poterium* and *Leucosidea* have from two to three ovaries; there are two ovules in *Adenostoma;* and in that same genus and in *Leucosidea* there are five petals. Yet Lindley says, "This order, usually combined with Rosaceæ, appears to demand a distinct station, on account of its constantly apetalous flowers, its hardened calyx, and the reduction of carpels to one only; it is not, however, distinguishable by any other characters; and therefore *Agrimonia*, sometimes stationed here, must be preserved among Rosaceæ, because of its petals." The above observations show that there is no character to be depended on except the hardened tube of the calyx, and that is found also in *Agrimonia*, the very genus referred to Rosaceæ.

If we now look to the character of Rosaceæ in the same excellent work, it is said to have polypetalous flowers, carpels free from the calyx, and quite, or nearly so, from each other; these may be solitary, but there must be two or more ovules in each ovary. Here, however, the characters of some genera adduced do not all respond; the genus *Rosa* itself giving the name to the order, has a solitary ovule in each carpel as in Sanguisorbeæ, so also has some *Rubi*, and the genera *Aremonia* and *Agrimonia*, which last, in fact, differs in no respect from Sanguisorbeæ, except by having petals. Far be it from me to say that Sanguisorbeæ ought to be re-united to Rosaceæ, for so many genera have no petals, and under no circumstances ever produce any, while the calyx itself is frequently more or less coloured as in Monochlamydeæ, that the presence or absence of petals in this tribe is probably of sufficient importance without any other distinctive characters, the introduction of which has only served to produce a *false character*.

What also tends at the present day to embroil the orders, is the removing a genus from one order with which it is found not to agree, and the placing it in another with which it agrees *better*, but the former precision of which this new adjunct overturns, even although, what is often not done, the character of the recipient order has been really changed to admit of the insertion of this new ally. Let me take a familiar instance. The place of the genus *Parnassia* in the Natural arrangement has been long a debateable point. De Candolle placed it at the end of Droseraceæ, although he properly defines Droseraceæ to have copious albumen and a circinnate vernation, while *Parnassia* has no albumen whatever and the common kind of vernation. Herein he is followed by Babington in his manual, seemingly without being aware of the exalbuminose nature of the seeds of *Parnassia*, as this is not alluded to. Sir James Smith referred it to Saxifrageæ, and for some time was followed by Lindley, but as the stamens are not perigynous, (although perhaps as much so as in some Saxifrages themselves,) and the true Saxifrageæ have albumen and a slender embryo, and a placentation, which is either axile or sutural, never parietal as in *Parnassia*, it was afterwards removed. Don proposed to place it in Hypericaceæ, and so now has Hooker in the British Flora, and Lindley in the Vegetable Kingdom; yet Hypericaceæ is essentially distinguished by its opposite leaves, long styles, oblique petals, which are spirally twisted in estivation, and axile or sutural placentæ, while *Parnassia* differs in *every one* of these particulars.* If, then, *Parnassia* is to be referred to Hypericaceæ, we have a right to expect that the character of that order shall be remodelled for its reception. But the question arises, Is such a step judicious? Are we to break down the limits of any order which is otherwise as natural in habit as the definition in words is precise; and this for the reception of some genus, merely because we do not well know how to dispose of it?

Lower down in the scale of arrangement we do not hesitate to constitute an aberrant species into a new genus, rather than destroy the unity and harmony of the other; and why this rule is not applied to genera when put into an order, I have never been able to discover. It is certainly of great benefit to science for an able botanist to indicate his views of the affinity of such a genus to some other, and to a third and to a fourth genus; but if the writer ends by placing the genus where no one else would look for it, and in an order which he has not carefully recharacterised for its reception, he creates new confusion.

Two methods for avoiding this are obvious: the one is to remodel the character of the order so that the entrant genus may form a legitimate part of it, provided this can be done without impairing the ordinal distinctive characters. The second is to retain only in an order those genera about which there can be no dispute, and which together yield a good and precise character to the order, and reject all the anomalous genera. That this last is to be preferred there seems little doubt; and the only question that can arise is as to what is to become of these *rejectamenta;*—are they to be erected into independent natural orders?

To this I see little objection: genera are but collections of species, natural orders are mere collections of genera; but, as we often find it absolutely necessary to constitute a single species into a genus, there can be no impropriety in extending the analogy and constituting a single genus into a distinct natural order. The only inconvenience is, that when other allied genera are discovered, we may have to alter considerably the ordinal character, that being only applicable to the first known genus; but we have the same to do in species and genera, and then we do not talk of it as at all inconvenient. It may be urged, that when a genus is isolated, and the ordinal character can contain no more information than that of the genus, it is sufficient to keep the genus in its proper

* In fact, *Parnassia* does not agree with the character of Lindley's Guttiferales, to which Hypericaceæ belongs, but with Violales, even after the character of that alliance is amended to admit of *Viola* itself, which it scarcely does at present.

place in the system without calling it a distinct order. This, however, is a mere dispute about words; it is of no consequence whether it be called a genus or an order, provided it be kept distinct from every other order whatever; and if the place of such genera alongside of other orders be not very clear, it may be prudent to collect them all together at the end of the system, and arrange them according to some artificial key. The objection to the last plan is, that if one's herbarium is arranged according to some book, there will be a great number of genera placed at the end, and thus widely removed from orders with which there is some generally acknowledged affinity, though not a very intimate one. By the former method, we have, in Endlicher's Genera Plantarum, genera introduced at the close of those orders to which they are most allied, with asterisks, to denote that these are only allied, but do not actually belong to the order or agree with its character. But from the names and characters of these genera not being printed in the same type as the names of the orders, a person consulting the book will readily pass them over, and not compare the plant in his hand with them. It appears to me that both methods might advantageously be followed: the isolated genera might be placed in the general system wherever the writer conceives it to be best, with remarks upon them; but all such ought again to be arranged at the end according to some simple but accurate method, to serve as a key to those which may be said to be

Rari nantes in gurgite vasto.

I have been led into these observations by having occasion lately to consider the limits of the Order Polygalaceæ.

* * * * * * * * *

I might illustrate these principles by a reference to many other orders, but the above will suffice to show the necessity of as accurate and precise definitions being given to natural orders, if we wish others to understand our writings, or obtemperate to our views of affinity, as they are to genera; and that it is necessary to reject a genus, if it breaks in upon a group of genera already united by several prominent characters. It does not matter much what becomes of the intruder: it must seek some other house of refuge, or occupy one by itself, if it cannot procure entrance into another, or get some friend to associate with it, without a quarrel.

Letters were read from Dr. Thomas Thomson, jun., dated Iskardo, the most northerly part of the Indus, from which it appeared that the first division of the Thibet expedition under his charge would be detained at this station during the winter, in consequence of the depth of snow in the mountain passes into Cashmere, which is the next destination of the expedition. The appearance of the country at this season was described as rather desolate. The valley of the river is filled with alluvial deposits, sometimes containing shells (planorbis and lymnaca were found). The height above the sea of Iskardo is 7000 feet. The mountains are tipped with snow, with a few junipers on their sides; but beyond the precincts of the village, there is no true vegetation. A species of rose and a Hippophae are the most abundant plants; a Barberry is frequent and new; several Gentians, an Iris, Prunella vulgaris, Veronica anagallis and beccabunga are found, and also a species of Parnassia. The stems and stray leaves of these plants were only, however, observed, as the winter was far advanced.

LIST OF MEMBERS

OF

THE PHILOSOPHICAL SOCIETY OF GLASGOW,

AT COMMENCEMENT OF SESSION 1848-49.

ORIGINAL MEMBERS.

Aitken, Peter, 96 Argyle-Street.
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Hart, Robert, 158 Hope-Street.
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Graham, C. M., Lish & Co.'s, Wilson-Street.
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Graham, Robert, 124 St. Vincent-Street.
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Hutcheson, William, M.D. Royal Lunatic Asylum.

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Murray, William, Monkland Iron and Steel Company.

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Tennant, John, *of* Charles Tennant & Co.'s.
Tennent, John, Bonnington Chemical Works, Edinburgh.
Thomson, Francis H., M.D. 100 Hope-Street.
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Thomson, James, Manufacturer, 2 South Exchange Court, Queen-Street.
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Thomson, Professor William, University.
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Thomson, Thomas, M.D. 8 Brandon Place.
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Watson, Charles, 9 Buchanan-Street.
Watson, Thomas, M.D. 54 West Nile-Street.
Watson, Thomas, Merchant, John-Street.
Watt, John, Civil Engineer, 109 Hope-Street.
Watt, William, Manufacturing Chemist, Dunchattan, Duke-Street.
White, John, 31 Union-Street.
Wilson, Alexander, 187 Stirling Road.
Wilson, George, Dalmarnock, 100 St. Vincent-Street.
Wilson, John, 100 St. Vincent-Street.
Wilson, William, 100 St. Vincent-Street.
Wingate, Alexander, National Bank Buildings.
Wylie, Robert, 28 Argyle-Street.

Young, A. K., M.D., 43 Bath-Street.
Young, J., Jeweller, 90 Buchanan-Street.

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GLASGOW:
PRINTED BY BELL AND BAIN, ST. ENOCH SQUARE.

CONSTITUTION

OF

THE PHILOSOPHICAL SOCIETY

OF GLASGOW.

INSTITUTED—1802.

Non fingendum aut excogitandum, sed inveniendum, quid Natura faciat aut ferat.—BACON.

GLASGOW:

PRINTED BY BELL & BAIN, ST. ENOCH SQUARE.

MDCCCXLV.

CONSTITUTION

OF THE

PHILOSOPHICAL SOCIETY

OF GLASGOW.

I.

Office-Bearers.

The business of the Society shall be conducted by the following Office-Bearers, namely, a President, Vice-President, Treasurer, Secretary, Assistant-Secretary, and Twelve Councillors, elected annually, as hereinafter prescribed. The Council shall hold their Meetings on the days of the Ordinary Meetings of the Society, at seven o'clock in the evening, without summons. They shall record their proceedings in a Minute-Book. Five a quorum.

II.

President.

The President shall take the chair on all occasions, when present, and shall convene Meetings of the Council, or Extraordinary Meetings of the Society, when deemed necessary by himself, or when he is requested in writing to do so by Three Members.

III.

Vice-President.

In absence of the President, the Vice-President shall take the chair; when both are absent, any Member may be voted into the chair.

IV.

Treasurer.

The Treasurer shall have in charge the Property of the Society, and shall receive all Payments due to the Society. Whenever the sum in his hands amounts to twenty pounds, he shall deposit it in one of the Glasgow banks, in name of the President and himself conjointly. He shall pay such sums as may be ordered by the Council, and shall keep an account of all his intromissions in the Society's General Cash-Book, which account shall be balanced annually, on the third Wednesday in November, and be examined, with the Vouchers, by two Auditors, appointed by the Society, at the first meeting in November, and who shall not be Members of the Council. There shall be appended yearly to this Financial Statement an Inventory of all the Property possessed by the Society.

The Treasurer shall also keep a Register of the Names of the Members of the Society, which shall be presented at the General Annual Meeting in November, and be so arranged as to distinguish such Members as have not paid up their Subscriptions to that date.

V.

Secretary.

The Secretary shall record in the Minute-Book the transactions of the Society, and give an abstract of the papers that are read at the Ordinary Meetings. He shall also conduct the Society's correspondence.

VI.

Assistant-Secretary.

In the absence of the Secretary, the Assistant-Secretary shall perform his duties. The Assistant-Secretary shall also act as Secretary to the Council, and keep the Minute-Book of their proceedings.

VII.

Librarian.

The Librarian shall have charge of the Books belonging to the Society, and shall keep a Catalogue of them and an account of their circulation among the Members. He shall levy the fines incurred by breach of the Library regulations, and pay over the same to the Treasurer, a week before the annual accounts are made up in November.

The Library Regulations are founded on the following Agreement, entered into between Anderson's University and the Philosophical Society of Glasgow, December 24th, 1840:—

1.—The Books contained at present in the Andersonian Library shall remain the property of the Andersonian University.

2.—The Books purchased by the Philosophical Society, from and after the month of January, 1840, shall be the property of the Philosophical Society.

3.—The connection between the Society and the University shall cease whenever either party shall desire it. In the event of a separation, the Books in the Library shall be divided agreeably to the right of property declared in sections 1 and 2.

4.—The Society shall continue to hold its meetings as hitherto, in the Andersonian Library, and shall have the privilege of depositing its Books and property in the same room; the use of which is granted for that purpose by the Managers of the University. The Society shall have the use of the Books in the Andersonian Library, and free admission to the Andersonian Museum. In consideration of these advantages, the Society shall pay to the University a yearly rent of Five Pounds, payable annually at Whitsunday, and shall also be at the expense of lighting and warming the Library, when required for their use, and shall pay for presses to contain their own Books.

5—The Books belonging to the Andersonian Library shall be under the care of a Librarian appointed by the University. But it is agreed that this Officer, or the Janitor of the University, shall also exchange the Books for readers in the Library of the Philosophical Society, and keep the Library Account-Book of the Society. The Regulations for the Management of the Library shall be jointly agreed to by the Society and the University, and shall apply equally to the Books belonging to both parties.

6.—This agreement shall not be held to affect the liferent right to the Andersonian Library, now possessed by life-subscribers, or granted to the original Members of the Philosophical Society, by the agreement between the University and the Society, of date 27th February, 1832.

Regulations for the Management of the Library.

1.—The Books may be exchanged daily between the hours of ten and four, or between six and eight in the evening, by the Librarian, or his substitute.

2.—No reader can be allowed more than one volume at a time, of Books that have been less than three months in the Library, or three volumes at a time, of Books that have been more than three months in the Library.

3.—The day of entry of every Book into the Library shall be marked in the Library Catalogue, and on the Book itself.

4.—The time allowed for reading the Books, and the fines for keeping them too long, shall be as follows:—

AFTER ENTRY.	TIME ALLOWED.	FINES IF KEPT LONGER.
First Month,	Three Days,	One Penny per Day.
Second & Third Months,	Seven Days,	Threepence per Week.
After the Third Month,	Two Weeks,	Twopence per Week.

☞ *If a reader, who has incurred fines, refuses to pay them, his right to read Books from the Library shall be suspended. The fines shall be paid to the Librarian, or his substitute.*

5.—When a Book is returned, it may be borrowed again, provided no other reader has bespoken it.

6.—If any reader retains a volume three months at one time, the Librarian shall write him to return it immediately; and if he does not comply, the Society may replace it, charging the reader in default, not only with the price, but also with the three months' fines due for not returning it. If the volume belongs to a set of Books, the whole must be so replaced, if the volume wanting cannot be got apart.

If any Book is damaged when returned, a fine equivalent to the injury, as the Society shall determine, must be paid; and if injured so as to be unfit for use, it must be replaced by a complete copy.

7.—None but Members of the Philosophical Society shall be entitled to read the Books belonging to the Society's Library.

8.—Members engaged in drawing up papers to be laid before the Society, may have an extra number of volumes, and be allowed a longer time to read them, upon producing an order to that effect from the convener of a Sectional Committee. Such orders are to be preserved and delivered to the Society's Librarian.

9.—Any circumstance occurring, not provided for in these Regulations, shall be submitted to an Ordinary Meeting of the Society, and their decision shall be final and binding on all concerned.

VIII.

The Funds.

The Funds shall be employed, under direction of the Council, to defray the necessary charges of the Society; to purchase books, models, and instruments; to print the Society's Transactions; or for any other purpose that the Council may judge to be conducive to the advancement, convenience, and prosperity of the Society.

IX.

Sections.

The Society shall be divided into the following Sections:—

Section A.—Agriculture, Statistics, and Domestic Economy.
— B.—Chemistry, Mineralogy, and Geology.
— C.—Physics, including Mechanics and Engineering.
— D.—Physiology and Natural History.
— E.—Botany.

Each Section may meet separately, and read and discuss papers, its Secretary furnishing an abstract of the proceedings to the next Ordinary Meeting of the Society. The Members of the Society may attach themselves to one or more of these Sections, according to the direction of their pursuits. Every Member shall communicate his intentions in this respect to the Secretaries of the Sections that he wishes to attend. The Members of each Section shall be convened by its Secretary, at least four days before the last Ordinary Meeting of each Session, for the purpose of electing a Chairman and Secretary, and such other Office-Bearers as may be required.

X.

Members.

There shall be three classes of Members, Resident, Corresponding, and Honorary. Upon admission, each Member shall sign his name to the following Declaration, in a book kept for the purpose, and shall receive a printed copy of the Laws of the Society, and a Diploma, sealed with the Society's seal, and attested by the signatures of the President, Vice-President, Treasurer, and Secretary.

The Corresponding and Honorary Members shall enjoy all the privileges of Resident Members, except that of Voting.

Declaration.

I hereby bind myself to observe and obey the Laws of the Philosophical Society of Glasgow, faithfully and conscientiously, and to use my utmost endeavours to promote the interests of the Society. I further bind myself to be careful of its Library, and all its other Property.

XI.

Resident Members.

Resident Members shall be proposed at one of the Ordinary Meetings, by three Members, who, from their own personal knowledge, shall certify the fitness of the individual recommended, who shall be balloted for at the next Ordinary Meeting. The Secretary shall inform Members of their election by letter. Upon his admission, every Member shall make payment of one guinea in name of Entry-money, and pay his first year's Annual Subscription. Failing to comply with the terms of this Article, within two months after his election, he ceases to be a Member of the Society.

The Annual Subscription to the Society shall be 15s., which shall be paid on the third Wednesday in November. Members whose Subscriptions are in arrear shall not have the power to vote on any question, nor to use the Library, nor be entitled to receive the printed Proceedings of the Society.

Members neglecting to pay their Annual Subscriptions for two years, shall be held to have resigned.

Members about to become Non-Resident, shall, on payment of their Subscriptions to the date, and giving notice in writing to the Secretary, become entitled to resume their position as Resident Members, whenever they return to Glasgow, upon payment of the current year's Subscription.

The Property of the Society shall be vested solely in the Resident Members, and be under the management of the Council.

Those resident Members of the Society who are referred to in paragraph 6 of the Agreement, recorded in Article VII., are exempted from payment of the Annual Subscription of 15s. But, by a formal Resolution of the Society, and by this Regulation, they are declared to be liable to the payment of 5s. on the third Wednesday in November annually.

XII.

Corresponding Members.

Men of Science, not resident in Glasgow, from whom early and valuable intelligence on Philosophical subjects may be expected, are eligible as Corresponding Members. They shall be proposed and ballotted for in the same manner as Resident Members, but they shall pay neither Entry-Money nor Annual Contributions.

XIII.

Honorary Members.

Individuals who have contributed in an eminent degree to the Advancement of the Arts and Sciences, may be elected Honorary Members, by Ballot, upon the recommendation of six Members presented at a previous Ordinary Meeting. Honorary Members are liable to no payments.

XIV.

Meetings of the Society.

The Ordinary Meetings shall be held in the Society's Rooms, every alternate Wednesday evening, from the first

Wednesday in November till the last Wednesday in April, inclusive. The Secretary shall announce these Meetings by circular, addressed to every Member who shall intimate his desire to receive such notice. Seven Members shall constitute a quorum. The chair to be taken at eight o'clock, when the ordinary business of the Society shall proceed as follows:—

1. The Minutes of the previous Meeting to be read and confirmed.
2. New Members to be balloted for.
3. New Members to be proposed.
4. Business respecting the Society to be disposed of.
5. Essays to be read.
6. Experiments to be performed.
7. Models, Drawings, Specimens, &c., to be exhibited.
8. Such subjects connected with the Arts or Sciences to be discussed as may be suggested by any of the Members.

There shall be a General Meeting of the Society held Annually, on the third Wednesday in November, or as near that day as may be, due intimation of which shall be communicated to all the Members of the Society by the Secretary, in writing. At this General Meeting the Council of the preceding year shall resign office, the Treasurer first exhibiting a clear statement of the Funds and other property of the Society, and the Secretary presenting a Report on such occurrences during the past year as the Council may think worthy of record. These documents shall be transcribed into the Minute-Book. Thereafter, the Society shall elect Office-Bearers for the ensuing year. Any of the former Office-Bearers may be re-elected. None shall vote at this Meeting but Resident Members, whose Subscriptions are paid up to the date.

XV.

Transactions of the Society.

All scientific papers shall be approved of by the Council previously to being read before the Society. The author of every Memoir read before the Society shall deposit a copy, with permission to publish it. The Council shall determine which of these papers shall be published, and also the manner of publication. Every Member of the Society shall be entitled to receive one copy of the printed Proceedings *gratis*. The Proceedings shall also be sold to Members and to the Public, at a price to be fixed on by the Council.

XVI.

Of Voting.

Votes for the election of Office-Bearers, and the admission of Members, to be given by ballot; all other votes *viva voce*.

Any motion may be carried by a simple majority of votes, excepting for the admission of Members, when one-fifth of the votes tendered shall exclude. When the votes are equal, whoever is in the chair has a casting vote, in addition to his deliberative vote.

A motion for either of the following purposes, *viz.*—1st, For disbursing more than One Guinea; 2d, For altering, annulling, or enacting Regulations—shall not receive final sanction until it has been approved of at two Ordinary Meetings of the Society; at either of which Meetings, should the motion be negatived, it is lost for that Session. But no vote shall be taken on any such motion, unless it has been previously considered and agreed to by the Council.

BELL AND BAIN, PRINTERS.