NEW SERIES, Vol. III. (1879-82).

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OF THE

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NATURALISTS' SOCIETY.

"*Rerum cognoscere causas.*"—VIRGIL.

BRISTOL:

JAMES FAWN & SON.

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NEW SERIES, VOL. III., PART I.

Some New Optical Illusions.[1]

By SYLVANUS P. THOMPSON, B.A., D.Sc., F.R.A.S.,

(Professor of Experimental Physics, University College, Bristol.)

IN the Transactions of various learned bodies—the Royal Society, the British Association, &c.—papers have appeared from time to time describing various Optical Illusions. Some of these illusions have depended upon the duration of retinal impressions, some upon the formation of accidental subjective images, some upon the dispersion or irradiation of the eye, and some upon the phenomena of binocular vision. The illusions to be described in the present paper do not fall exclusively under any one of the heads enumerated, though they depend upon the duration of visual impressions, and upon a further and less perfectly understood property of the retina. They are all dependent upon *motion*, either of the object or of the observer, or of both. In each case that will be here brought forward there is a movement of the object across the field of view, and consequently of the image across some portion of the retina.

The most frequent illusions which arise thus are those in which one form of motion apparently takes some other form. As a most familiar instance of this kind of illusion we may take the case of the apparent motion of trees, hedgerows, and houses, as seen from a rapidly-running railway-train, the deception of the senses being most complete when the personal sense of motion is least.

[1] The greater part of this article was read before the British Association, at Plymouth, in September, 1877, an abstract only having as yet been published. A few additional facts were recently communicated to the Bristol Naturalists' Society, and are embodied herewith.—S.P.T.

When the train in which you are seated is drawn up beside another train, and then moves slowly forward, smoothly and without jolting, it is extremely difficult to tell whether your own train or the other one is in motion.

So when light clouds are drifted across the moon, one can frequently hardly resist the notion that it is the moon that is sailing along amongst fixed clouds; and if the drifting of the clouds be due to an upper current, while the lower air is still, the impression that the moon is sailing along past the clouds asserts itself with remarkable force.

I have observed an illusion closely akin to this at Clifton. Underneath the famous Suspension Bridge, a zigzag path winds up to the top of the cliff, shaded overhead by trees. Walking up this path you see the bridge at intervals between the boughs, and, as the body rises and falls with the motion of each step, the bridge appears to be swaying violently up and down, as if it were blown about in the wind.

Many illusions akin to these very simple phenomena have been recorded from time to time. Three times—in 1845, 1848, and 1861—the late Sir David Brewster drew the attention of the British Association to some phenomena seen in railway travelling. If from the window of the carriage you look out at the pebbles and stones lying beside the line, you catch merely vague strips, due to the rapid motion of their images across the retina; but on suddenly shutting the eyes "a motion is perceived in a direction transverse to the real impressions on the retina; and there is the appearance of lines complementary in the same transverse direction."[1] This Sir David subsequently referred to a subjective opposite motion going on simultaneously, and so causing a compensation of the impressions moving on the retina. In 1861 he returned to the observation, and compared the phenomenon with that obtained by watching the motion of a rotating disk with

[1] Brit. Asso. Report, 1845.

radial markings, directing the eye first to a point near the circumference, and then afterwards to a point near the centre, where the motion was slower. He concluded that there was a neutral line across the retina at which the compensation of the subjective impression was complete.

In the "Philosophical Magazine" for 1834 (p. 373) R. Addams described a peculiar optical phenomenon. After looking for some time at a waterfall, and then at "the sombre water-worn rocks immediately contiguous," he "saw the rocky surface as if in motion upwards with an apparent velocity equal to that of the descending water." This he ascribed to an unconscious recurrent movement of the muscles of the eye-ball, continuing after the gaze had been directed to the rocks, and thus occasioning a displacement of the images on the retina.[1]

This illusion becomes more remarkable in the slightly varying case now to be mentioned. Watch the water of a rapid river, such as the Rhine immediately above Schaffhausen. The middle stream is running forward very rapidly. After watching it fixedly for some time, transfer your gaze to the slower stream near either bank. It actually seems to be running back.

I have also noticed, after watching a procession, that stationary objects appeared for a moment to be moving in a contrary direction.

In the "Journal of the Royal Institution, (vol. i., p. 609) an anonymous writer records a curious observation, that from a slowly-moving railway-train, while the stones and sleepers beside the line appear to fly back past the train, the neighbouring set of rails seems to be flying forward and keeping pace with the train. This he refers, and doubtless rightly, to the fact that the rails are

[1] An account of a very similar observation was communicated by Mr. J. Aitkin to the Royal Society of Edinburgh, in November, 1878, apparently without any knowledge of the observations of Addams, Brewster, or of the author of this article.

of nearly uniform tint, and destitute of markings that would produce upon the retina impressions like those of the adjacent objects.

The railway affords many other instances of optical deception, and of these I will mention a few of which I am not aware that any specific notice has hitherto been taken.

When a landscape is observed from a moving railway-train, all distant objects from the near hedgerows to the distant hills appear to be moving past in the opposite direction, the nearer objects having the greater apparent velocity. Consequently, if the attention be fixed upon any object at some distance from the line, all objects beyond will relatively appear to be moving forward with the train, while objects nearer appear to be moving backwards. The combined effect is to make the entire landscape appear to be *revolving centrally* round whatever point we fix out attention upon.

Falling rain seen from a moving train always seems to fall obliquely (except in a *very* strong gale in the direction of the train's motion) in a direction opposite to that of the motion of the train. But if another train happen to pass in an opposite direction, and we look out at this and follow it with our eyes, rain-drops falling between the two trains will seem to be flying forward with ourselves.

If we stand on the platform of a station and watch a train approach, the end of the engine appears to enlarge or swell up as it approaches and occupies a larger area of the field of vision. Conversely the end of the last carriage of a retreating train appears to shrink down and contract as it diminishes in apparent magnitude. Stationary objects by the side of the line similarly appear to swell up as we approach them in a train, and to shrink together as we retreat from them. Curiously enough, this motion is also one which calls forth a certain "compensation" in the action of the retina. For, suppose we have been watching objects enlarging as we approached them, and then suddenly transfer our gaze to the side of the carriage opposite to us, we shall observe that it is apparently shrinking together and retreating from us. The opposite effect—that of apparent enlargement and approach—is produced as a subjective compensative action after watching objects from which we are retreating. The effect is more amusing if, after observing either of these cases of motion, we transfer our gaze to the face of a fellow passenger sitting opposite.

An observer at some slight elevation above a railway, seeing two trains pass along the lines simultaneously in opposite directions, will receive the impression as of one long train moving round a circle. For when you look at a revolving wheel nearly edgewise, the nearer edge is seen moving past the farther edge, and in an opposite direction. The apparent motion of the two trains is the converse of this impression.

If from a similar situation two trains are observed, one moving rapidly, the other slowly in the same direction, the slower train may appear indeed to be moving in an opposite direction—a phenomenon similar to that of the Rhine above Schaffhausen already noticed.

Dr. F. Guthrie has noted the following illusion :—Looking at the arms of a windmill in motion, in the twilight, or at such a distance that their attachment to the mill is obscure, we can, when the aspect is very oblique, easily imagine the arms to be turning in the opposite direction. We then fancy we are looking at the other side of the mill : so that if the sails are actually towards us in their descent, we fancy them away from us in their descent, which gives the notion of rotation in the opposite direction. This hallucination can, after a little practice, be as readily controlled by the will as can the introversion of a linear drawing representing a solid."[1]

An analogous illusion is produced by illuminating certain vacuum-tubes with the sparks of induced electricity discharged

[1] GUTHRIE, Magnetism and Electricity, p. 243.

alternately in opposite directions,[1] when the tube appears to be rotating about an axis perpendicular to its length and to the line of vision.

A crow flying along at dusk, seen against the sky at a low altitude, shows, when passing the observer, his wing above and beneath his body alternately. The effect of this alternation is as if he had but one wing, which seems to revolve round like the blade of a screw-propeller about its axis.

I have frequently stood upon the lofty suspension-bridge over the Avon, at Clifton, when large ships have been passing beneath. Under these conditions a curious illusion may be observed. If you look perpendicularly down on to a ship, as it emerges from beneath, it appears to be heeling forward on to its bows; for as the masts emerge from under the bridge, and you see them growing longer as the fore-shortening effect passes off, the mind cannot resist the notion that—like the windmill-sails—they are revolving round a centre. I have pointed out this effect to several persons, who have expressed much surprise at the completeness of the illusion.

The last set of illusions which will be described took their origin in an observation made by the writer early in 1876. He had been drawing a series of concentric circles in black and white, for the purpose of testing the astigmatic conditions of the eye. Happening to shake the paper upon which the diagram was drawn, he observed a peculiar motion of apparent rotation of the circles. This illusion is extremely curious, and very easily reproduced. Let concentric circles in black and white be described upon a piece of card *(Pl. I., fig. 1)*. If this be held firmly between the thumb and finger of the hand, and then a slight but rapid circular shaking motion be imparted by the wrist and elbow, the circles will appear to rotate upon the card. The hallucination succeeds

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[1] See S. P. THOMPSON in Phil. Mag., 1876.

Fig. 1.

Fig. 2.

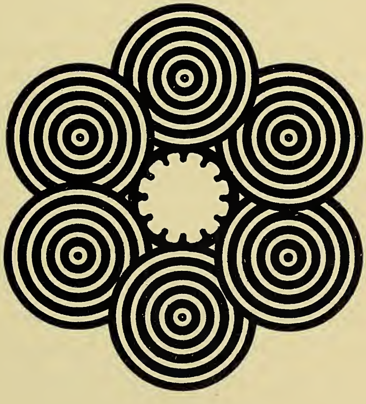


Fig. 3.

best if the circles be clear and sharp at their edges, and the successive rings of black and white of equal widths. Their number and width is immaterial, but there seems to be a particular distance from the eye for each width of successive rings, at which the illusion succeeds best. Finely-drawn narrow rings must be held near, to produce a maximum effect; while to enable a number of persons to see the illusion at once the rings may be half or three-quarters of an inch in width, and to the number of fifteen or twenty. The radius of the circle of imparted motion should equal the width of a black or of a white ring, and the rapidity found most successful is that when each rotation occupies from one-sixth to one-fourth of a second. The rings appear to rotate once for every complete motion of the hand and card in the circular path, and in the same direction as the imparted motion. In this experiment each ring is displaced to a distance equal to its own breadth in every direction successively around its centre; and as the impression remains a short time on the retina, the optical effect is equivalent to that of a ring eccentric to an equal amount and actually rotating. Hence the illusion.

I have constructed a large number of patterns of curvilinear, circular, elliptical, eccentric, and concentric lines, many of which exhibit, in whole or in part, the same phenomena of apparent rotation. One of these *(Pl. I., fig. 2)* is a single black circle, having a number of internal cog-teeth, upon a white ground. This circle, when shaken circularly in the manner described, appears to move round in the opposite direction to the imparted motion, and to move round through a distance of but one tooth for each successive complete motion. For circles possessing this property I have suggested the name of "Strobic Circles." Their motions are best seen when the eye is directed not exactly at the circles, but at some point near them. I have therefore found it more effective to have two strobic circles, drawn side by side upon one card. That circle rotates most obviously on which the gaze is *not* fixed.

Further, I have noticed that if a strobic circle be "rotated," while a number of other circles are lying stationary within the field of view, when the eye was directed to the moving circle the others also began to "rotate" *(Plate I., fig. 3).*

This last observation cannot, I think, be explained on any supposition of unconscious muscular movement. In fact I entirely doubt the validity of this hypothesis in the case of Addams's observation upon the waterfall before cited.

I am inclined rather to attribute these effects, and those of "compensation" in general, to waves of nervous disturbance moving over the retina; these waves, being of two orders,—one primary, and in the same direction as the objective motion of the images upon the retina; the other secondary and later in time,—giving rise to the subjective motions of compensation. I do not see how on any other supposition the phenomena noted in an earlier paragraph relative to compensative shrinking or expanding of objects can be explained. Such a hypothesis, will, I believe, also embrace all the other phenomena of apparent motion, except those which are the result of mental associations alone—such illusions, in fact, as those of the windmill and the flying crow. Such waves of nervous disturbance have, it would seem, a definite rate of propagation, probably not independent of the nature of the moving image with respect to colour, relative luminosity, and apparent magnitude. But whether these waves of sensible impression are due to a physical motion of any structures of the retina I am not yet prepared to offer an opinion.

Underground Temperature.

BY E. WETHERED, F.C.S., F.G.S.

GEOLOGY and Chemistry have revealed to us a mass of information concerning the nature and composition of the crust of our earth, but how far that crust extends, and what it encloses, is even at the present day a matter of considerable doubt.

The inconsistency between the known specific gravity of the rocks which compose the crust of the earth, and what would be the specific gravity of a similar solid globe, renders it clear, that the earth is not a solid, or, that there must be a nucleus, composed of a substance, or substances, of a much less density than those which compose the crust.

With a view of gaining information on this matter, we naturally turn to volcanoes, hot springs and geysers; these phenomena all indicate the presence of heat. But if we agree thus far, we may not concur as to the direct cause or source of this heat: are we to consider that the water of springs and geysers derives its heat from chemical action within the crust of the earth, or from the substances contained in the water, or is that heat derived from a lower region?

With regard to the first,—chemical action within the crust of the earth, Professor John A. Church, of Ohio, North America, recently contributed a paper at the Chetauooga Meeting of the American Institute of Mining Engineers on the "Heat of the Comstock Mines;" he states that the rocks in the lowest levels of the mines appear to have a pretty uniform temperature of 130° F.

The source of this heat is attributed to chemical action now maintained in the eruptive rocks. But it is remarkable that the heated rocks occur only in belts with cold masses between them.

Professor John A. Church[1] supposes the existence of a cold, and what may be termed a burnt-out layer of rocks, extending for 1000 feet below the surface, and a zone of hot rock still in active decomposition, which has been found to exist for a depth of about 1500 feet more, and no doubt, he thinks, extends thousands of feet further, and finally, a mass of cold rock at a great depth, which has not yet begun to decompose. The author also refers to one of the hottest belts, being a quartz seam, which appears to be entirely in the dorite; and though he attributes the heat to chemical action in the eruptive rocks, he states that it is not a combustion, for the oxidizable constituents are little altered. Now it is difficult to imagine chemical decomposition going on in any rocks without the oxidizable minerals being affected, especially at a temperature of 130° F.

It would be rash to express any decided opinion on the source of the great heat in the Comstock mines, from simply reading the paper referred to, but the fact of the oxidizable minerals not being affected seems to me to be a strong argument against Prof. A. Church's theory.

The fact of a quartz vein in the dorite being one of the hottest parts suggests another supposition, namely, may not the hot belts be fissures, through which hot water was, at one time, ejected, but which, in course of time, have been closed up, chiefly with silica deposited by the water, but through which heat may still be transmitted from below. As an instance of this, I may mention the "Great Geyser," which has deposited silica several feet thick in a crevice.

With regard to thermal springs and geysers, it is difficult to understand the temperature being maintained by chemical action

[1] Monthly Journal of Science, March, 1879, p. 224.

generated, either by the constituents contained in the water, or transmitted by the chemical decomposition of the environing strata, because of the high temperature to which the water sometimes attains, and its continuance for such long periods as are known. Salt and mineral waters have a slightly higher temperature than fresh, but from the experiments of Dr. Gustav Bischof[1] it would appear that the addition of such salts as these waters contain, causes a very slight increase in temperature. He says: "The Heilbronn, a mineral spring in a small valley of the Brohl, four miles distant from the Lake of Laach, is next to Bilui, near Bohemia, the richest in carbonate of soda known to me. It contains 0·0053 of fixed substances. Suppose that this spring were formed from anhydrous carbonate of soda, by the addition of concentrated sulphuric and muriatic acids and water, then according to my analysis 77·4 parts anhydrous carbonate of soda, 5 parts of concentrated sulphuric acid, 92 of smoking muriatic acid, and 22·687 parts of water would be required to compose a water containing the same proportions of carbonate and sulphate of soda and of chloride of sodium as that spring. In accordance with this, therefore, I put 77·4 grains of calcined carbonate of soda to 22·687 grains of water. The temperature of the water was—

Before the experiment - - -	42°·8
After - - - - -	43°·7
Increase of Temp.	0·9

To this solution of soda I added a mixture of 5 grains of concentrated sulphuric acid, and 92 grains of smoking muriatic acid. The temperature of the two liquids was—

Before the mixture - - -	50°·00
After - - - - -	50°·45
Increase of Temp. -	0·45

[1] Physical, Chemical, and Geological Researches on the Internal Heat of the Globe, p. 16.

"Now, although such a chemical process as this, which is very improbable to take place in the interior of the earth, is the most favourable for the production of heat, still it only caused an increase of temperature of 1°·35." We can, therefore, only attribute the temperature of thermal springs aud geysers to the superior temperature of the interior of the earth. Volcanic action is a strong argument in support of this view. The enormous quantity of molten matter thrown out from their craters tells of a heat below, such as would fuse any substance known. But as some substances are less fusible than others, it seems reasonable to suppose, that there is no hard and fast line between the solid and the fused, but that the former merges into the latter.

To solve the problem of underground temperature, resort has been made to mines, bore-holes, and wells; and from results obtained, the datum adopted by the Royal Coal Commission was, 1° increase for every 60 feet in descent, but I cannot but think, after reviewing many observations made, that there is not sufficient evidence to warrant the assertion as a fixed datum for calculation.

In 1867 the British Association appointed a committee to investigate this subject, and Prof. Everitt, the able secretary, has annually produced valuable reports. When this committee first entered upon the field, they had not only to find places for observations, but to devise a method, which could only be arrived at by experience. To the ordinary reader it may appear a very simple thing, but I can assure you there is scarcely any scientific work which requires greater care and thought.

The sinking of shafts has been looked upon as giving exceptional facilities for observation. The usual method has been to bore a hole in the strata two or three feet deep, at regular distances, say 50 feet. The hole is bored with an ordinary borer, then filled with water, and the thermometer inserted. The time which the instrument has been allowed to remain in has ranged from half-an-hour to several hours. Observations thus made, would appear at first sight, to give the most reliable results, and possibly some good ones may have been so obtained. But it frequently happens that a considerable amount of water flows down the sides of the shaft from springs cut through during the sinking, and varying in temperature: this water then, must have some effect on the strata at the bottom of the shaft; and to obtain accurate observations under such conditions is difficult, and may perhaps account for the discrepancy in results so obtained.

Then again, old shafts, partly filled with water, have been utilized for observations, it being assumed that the column of water would attain the temperature of the earth, but these, I consider, to be open to great objection, owing to the inflow of water of various temperatures (termed convection), which, in some instances, would vary with the seasons. A good illustration of this is shown in the observations made by Mr. David Burns, H.M. Geol. Survey, in a shaft at Allandale, near Carlisle. The shaft was over 50 fathoms deep, and was about half-full of water. The result was as follows:

i. *After a period of drought.*

Depth,	160 feet.	Temperature,	47°·5
„	200 „	„	47°·0
„	250 „	„	47°·7
„	300 „	„	47°·7

ii. *Shortly after heavy rain.*

Depth,	160 feet.	Temperature,	47°
„	200 „	„	47°·5
„	250 „	„	47°·3
„	300 „	„	47°·3

Another discrepancy, which I think may be ascribed to the same cause, was in the case of a well at Kentish Town where, for the depth of 210 feet, a second series of observations gave an excess above the first of from 2° to 5°.

Observations have also been made in deep bore-holes, but these offer two objections, viz.: convection, and the time it takes to raise the thermometer. The latter difficulty, however, has, to a great extent, been overcome by the construction of slow-acting thermometers, but the former has not as yet been satisfactorily dealt with.

In the Quarterly Journal of Science, for January, 1868, Mr. Hull, F.G.S., points out the necessity of observations at low depths, and suggests the idea of starting a bore-hole within the workings of a mine. I need hardly say, that if such could be accomplished, most reliable results could be obtained, but such opportunities do not often present themselves. A few observations have been made within the workings of mines, but objection has been taken on the ground, that the results would be affected by the air-currents, by the heat of the lamps, by the bodies of the colliers and horses. Doubtless where the thermometers cannot be isolated from these influences, little reliance could be placed in the results. In mines where explosive gas is generated, it might be impossible to isolate the thermometer from a brisk air-current, but, as in the case of our own coalfields, where the majority of coal-seams do not yield explosive gas, this difficulty may often be got over.

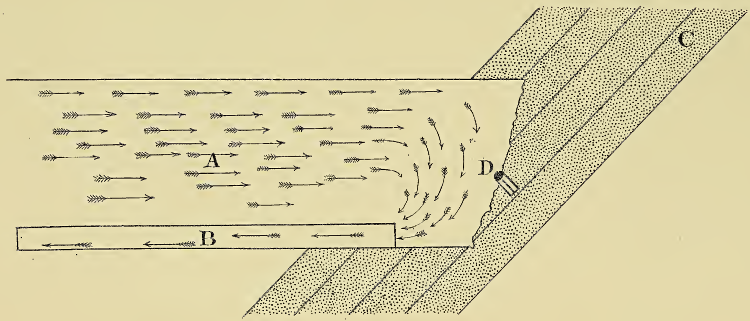
Last year (1878) Prof. Everitt sent me one of Negretti & Zambra's patent mining thermometers, for observations in the workings of the Kingswood Collieries, near this city. The way in which I proceeded was as follows:—observations were made only in new ground, and the thermometer was inserted on the day on which the strata were exposed: for this reason, cross measure branches and advanced levels were selected as the places for operation. The thermometer was placed in a hole 2 feet deep, and the mouth was tightly closed with clay rolled in the form of a plug.

The following is the method of which I was able to avail myself:

The branch A is driven in the solid rock; the air enters as indicated by the arrows, and returns through the trunks B. If, therefore, the mouth of the trunks is removed a few feet back

SECTION

of a Cross Measure Branch, Showing Temporary Ventilation, and Thermometer inserted.



from the face of the strata, of course the bulk of the air will not reach it, and it is therefore possible to protect the hole D, in which the thermometer is placed, from its effect, and when we remember that the top of the hole is tightly plugged with clay, there is not much chance of the instrument being affected. Some very satisfactory readings were taken in a branch of this description, at a depth of 1439 feet in the Speedwell Pit workings, the details are as follows :—

On Saturday, August 17th, 1878, the thermometer was placed in hard arenaceous rock, for the usual time (Saturday, 2 p.m. till Monday morning early), when 69°·7 F. was read : the reading was confirmed on the following Saturday till Monday. In the October following, a seam of coal was cut, known as the "Two feet," and an observation in this, and one in the strata upon which the coal rests, gave the same : so that I think there can be no doubt as to 69° 7 F. being the correct temperature for that depth. The next point was to ascertain the temperature at the surface, so as to get at the rate of increase. Various measures have been suggested, such as observations in wells, at stated periods, extending over, at least, twelve months, or selecting depths near the surface, so as to determine where the constant temperature begins. I think the former process is very liable to error, for two reasons—1st. Wells are very apt to contain organic matter, derived from the decay of dead leaves, and too often from various other organic contaminations, and by this decomposition, heat must be generated. 2nd. In deep wells, which alone would be serviceable, water, of different temperatures, might flow in, especially after a wet period.

Observations have been made in various places to determine the difference between the temperature of the earth a few feet down, and the mean temperature of the air on the surface. The result at 3ft. below the surface, at three stations established in Edinburgh by Prof. Forbes, gave, after five years' observations, an excess of 0.55 above the mean temperature of the air. In Paris, in the year 1825, observations were made by sinking a thermometer in the earth, and it was found that the influence of external heat did not extend below 25 feet. Prof. Everitt in some of his calculations, assumes that the surface of the earth has a temperature of 1° F. higher than that of the atmosphere. D'Aubuisson has put the depth, not affected by solar heat, at between 46 and 61 ft., and Kupuff at 77.

For my own observations, I preferred to take the mean annual temperature (48·7 F.) of the atmosphere as given by Dr. Burder, of Clifton, the results of 16 years' observations. They were taken in latitude 51°·27′ 49″ N. Longtitude, 2° 36′ 30″, and 192ft. above the sea level. The point on the surface, which is about the centre of the Kingswood workings, is just 3¼ miles distant in a straight line.

Adopting then 48°·7 as the surface of datum, the following will be the tabulated result of my observations, arranged in order of depth, and carried out after the method above described:—[1]

Depth in feet.	Temperature, Fathrenheit.
402	48 7
1232	54·7
1367	66·7
1439	68·5
1769	74·7

Comparing each depth with the next, we have the following results:—

First, 402 feet	1° for 67 feet.
Next, 830 „	1° „ 69 „
Next, 135 „	1° „ 75 „
Next, 72 „	1° „ 75 „
Next, 330 „	1° „ 66 „

The average, from the surface down to depth 1769 feet, is 1°F.

[1] For details of the observations see report of the Underground Temperatures Committee.—*Report of the British Association*, 1879.

in every 68 feet, or comparing the depth, 402 feet, with the lowest 1° in 68·35 feet.

All the observations made on behalf of the British Association Committee show an increase downwards, but the rate varies considerably, as the following tables[1] will show. In their construction, I have extracted the chief results, taking the lowest depths as the most reliable. I do not wish to under-rate their value, in any way, but I have little faith in the majority of observations made in shafts, wells, or bore-holes, unless special precaution has been adopted to protect the thermometer against the influences before referred to. Indeed I question whether sufficient precaution is practicable.

OBSERVATIONS IN MINES.

	Surface Temp. F.	Greatest Depth.	Temp. Registered.	Feet per ° F., 1°.
Baldon Colliery, between Newcastle and Sunderland ...	48°	1514	79°	49
Fowler's Colliery, Pontypridd, South Wales	51°·5	846	62°·7	76
Kingswood Colliery, near Bristol	48°·7	1769	74°·7	68

OBSERVATIONS IN SINKING SHAFTS.

NAME OF SHAFT.	Surface Temp. F.	Greatest Depth.	Temp. Registered.	Feet per 1° F.
Rosebridge	49°	2445	94°	54·3
Dunkingfield, Cheshire ...	49°	1401	$66\frac{1}{2}$°	80

[1] The result given in the Tables by no means represents the whole of the work done by the British Association Underground Temperature Committee.

OBSERVATIONS IN SHAFTS OR WELLS.

Name of Shaft or Well.	Surface Temp.	Greatest Depth in feet.	Temp. Read F.	Feet per 1° F.
Kentish Town Well, 1st series...	49°	1100	70°	52·4
,, ,, ,, 2nd ,,	49°	1100	69°·7	55·6
W.B. Lead Mines, Northumberland—1st, Gin Hill Shaft ...	45°·3	400	51°·3	66·6
2nd, High Underground Engine Shaft	44°·3	807	65°·4	40
3rd, Slitty Mine...	44°·3	660	64°·9	33·5

OBSERVATIONS IN BORE-HOLES.

Name of Bore.	Surface Temp.	Greatest Depth.	Temp. Registered.	Feet per 1° F.
Blythswood		354	53°·6	
South Balgray, west from Glasgow		525	59°·3	41
Crawriggs, Kirkintilloch, near Glasgow	34°	350	51°·	75
Bore at bottom of South Hutton Colliery, Derby		1924	96°	
Winderley, near Lincoln, ...	50°	2000	79°	69
Booth Waterworks, Liverpool		750	56°	131
La Chapelle, Paris	53°·1	1950	75·4°	84

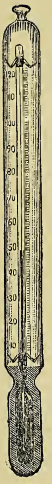


Fig. 3.

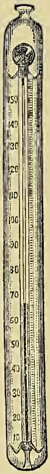


Fig. 4.

There are two thermometers now constructed especially for the committee by the firm of Negretti and Zambra. Fig. 3 is the slow action thermometer for taking direct earth temperatures. The bulb of this instrument is shown in its glass sheath surrounded by a good non-conducting substance, as suggested by Professor Everett. The thermometer is lowered down to the desired depth, in a copper case, and allowed to remain for a stated time (in the case of my observations for 48 hours.) It is then drawn up and the reading taken, but should the time occupied in raising the instrument exceed $4\frac{1}{2}$, or at the most, 5 minutes, the reading would not, I think, be reliable.

Fig. 4 represents the maximum thermometer. The mercury bulb is at the top, and on the temperature rising, the mercury of course expands, and leaks out into the glass tube; on gently tapping or shaking the thermometer, it falls down to the column in the bottom of the tube: the height of the whole represents the temperature.[1] This thermometer is available for any maximum temperatures, and will not fail to give satisfaction; the same may be said of the slow acting minimum thermometer.

[1] I am indebted to Messrs. Negretti & Zambra, of Holborn Viaduct, for the use of the stereo of the thermometers.

C 2

The Structure and Life-history of a Sponge.

By Professor W. J. SOLLAS, M.A., F.R.S.E., F.G.S., &c.

The presentation of a tolerably complete account of any single species of sponge is a matter of considerable difficulty, since, notwithstanding the existence of many hundreds of species of sponge, which have been made known to us by excellent figures and descriptions, there is not one of which the complete life-history is known. That of which the history makes the nearest approach to completeness is the calcareous sponge, now known to naturalists under the name of *Sycandra raphanus*.

General Form.—This little sponge, not more than 3 or 4 mms. (*i.e.* $\frac{1}{5}$ of an inch) in height, presents us with a variety of forms, being sometimes spindle-shaped, sometimes ovate, at others, turnip-shaped, and occasionally almost spherical. Sometimes it is supported on a short stalk, and sometimes it has no stalk, or is sessile. Internally it is hollow, like a sac, the walls, or sides of the sac, being 2 mms. thick, and the internal cavity about 2 mms. across. The sac is closed below, but opens above by a circular or elliptical mouth, which is surrounded by a graceful fringe of slender needle-shaped spicules, composed like the rest of the spicules of the sponge, of carbonate of lime, and an organic substance known as 'spiculin.'

The spicules of the fringe, or corona, are sometimes seen in movement, now diverging from each other till they give to the corona the form of an inverted cone, and again approaching one another to form a cylindrical tube. The surface of the sponge is covered all over by erectly projecting spicules, which render it hirsute.

General Movements.—With the exception of the movements of the spicules in the corona, the sponge gives very few signs of life, so that at first sight one might almost regard it, as indeed the older naturalists did regard it, as a plant. It is, however, in every respect, a true animal, lively enough in its way, and of wonderfully complex structure.

That it is not quite so inert as it seems may be easily shown by putting a little finely powdered indigo into the water in which a healthy specimen is confined. The particles of coloring matter will then be observed to make their way towards the general surface of the sponge, over which they spread themselves, and then disappear below it. After being lost to sight for a little while they re-appear, not over the surface where they went in, but streaming out of the central mouth in a powerful current. From this we may infer that minute currents are entering the sponge throughi ts general surface, passing through its walls into the central cavity, and then outwards by way of the mouth.

General Structure.—So far the sponge has been regarded simply as a hollow sac, but the walls of the sac possess a somewhat complicated structure, which we must now describe. Commencing from the inner face we find first a membranous lining, perforated by a great number of small holes, which are called mouths, or ostia, and because they open into the stomach, stomachal mouths or gastral ostia. Each is the open end of a thin-walled tube, which is closed and conical at the other end, and except that it is hexagonal in section, somewhat similar in form to a chemist's test-tube. These tubes radiate from the gastral ostia to the exterior of the sponge, and constitute, lying side by side, joined close together, the greate part of the sponge wall. By holding together a number of test-tubes, and supposing them to be joined along their lines of contact, we shall gain a fair idea of this arrangement. Further, it will be seen that however close the test-tubes lie to one another, narrow three-sided canals will remain between them, one such canal between every three mutually adjacent tubes. Precisely similar canals are left between the tubes of the sponge, and are known as inter-canals, whilst the tubes themselves are termed radial tubes. The radial tubes have not continuous walls like those of a test-tube, but are perforated all over by a number of minute apertures, or pores. Those pores which occur over the projecting conical ends of the tubes open immediately to the surrounding water; those which occur along the sides of the tubes, where they are not in contact, open into inter-canals, and so indirectly into the outer water, while those finally, which occur along the line of union of the radial tubes serve as a means of communication between these tubes, and do not open into the outer water at all, except, of course, by way of the stomach through the mouth.

Histology.—The proper wall of the stomach, and alike of the radial tubes, consists of three layers of tissue, an outer, or ectoderm; an inner, or entoderm; and a middle, or mesoderm.

The *ectoderm*, which covers the stomach and the exterior of the radial tube lining the inter-canals, consists of a single layer of plate-like polygonal cells, 0·015 to 0·025 mm. in diameter. Each contains a circular cake-like nucleus, bounded by a nuclear membrane, and full of watery fluid, in which are suspended two or three very refractile granules, or nucleoli; the protoplasm in the centre of the cell, surrounding the nucleus, is more or less granular, but towards the margin perfectly clear.

The *mesoderm*, which succeeds, is of a very different nature, the great mass of it consists of a clear transparent jelly-like material, which does not stain with carmine or other colouring re-agents: dispersed through this jelly-like matrix are numerous cells of branching form. Each contains in the middle a long oval nucleus, with spherical nucleolus, and is surrounded by finely granular protoplasm, from which are produced a number of fine irregularly branched filaments, which anastomose with similar filaments from similar adjacent cells. In general terms, therefore, this tissue may be said to consist of a network of protoplasmic cells immersed in a quantity of clear indifferent jelly : the jelly, in all probability, being derived from the contained cells by metamorphosis. Altogether the tissue most closely resembles the jelly-like tissue of the disc of the medusa, or jelly fish, and is also related to the embryonic connective tissue of the higher animals.

The matrix of the mesoderm serves as a medium for two other forms of cells, in addition to the stellate, or branched ones; in some parts of it, particularly in the neighbourhood of the gastral ostia, the stellate cells pass into others of a simpler form, by losing their branching processes, and becoming fusiform. The fusiform cells, so produced, are of considerable length, and lie in parallel bundles concentrically round the edges of the gastral ostia; and since they have the property of shortening in the long direction, and broadening in the transverse direction, under the influence of a stimulus, they serve as muscular sphincters to the ostia, closing them when irritated and opening them again on relapsing into their normal state. The third kind of cell found in this tissue is probably the least differentiated, and is possibly the parent form of the others, it is a little mass of protoplasm, containing a nucleus and nucleolus, and closely resembles an ordinary amœba, or nucleated blood corpuscle, thrusting out pseudopodia in various directions during life, and moving freely by their means through the surrounding medium.

The innermost layer, or *endoderm* forms a continuous lining to the inner wall of the radial tubes, meeting at the edges of the pores and gastral ostia, the outer layer of plate-like epithelium or ectoderm.[1] It consists of more or less flask-shaped cells, each

[1] I have followed Hackel in referring the lining membrane of the stomach

having a nearly spherical body, flattened below where it is seated on the inner face of the mesoderm, and rounded above and prolonged into a long neck or *collum*. Near its end the collum is surrounded by a delicate collar of transparent sarcode, which gives it the form of a wine glass. From the end of the collum is produced a long filament of hyaline protoplasm, known as the flagellum, because it flagellates the surrounding water.

The cell, in general, consists of a more fluid granular central protoplasm, or endosarc, surrounded by an outer firmer transparent contractile layer, or ectosarc. It is the ectosarc which is extended to form the collar and flagellum, which we may regard as highly specialised derivatives of pseudopodia. In the endosarc is a conical nucleus, surrounded by numerous granules, and some little blebs of watery fluid, known as vacuoles. Altogether the cell closely resembles some forms of infusoria, and it is of such cells, arranged close together, side by side, that the endoderm is wholly composed.

Before describing the remaining tissues of the sponge, it will be convenient to introduce here a short account of its physiology, so far as the knowledge we have now attained of its structure makes possible.

The flagella of the endodermic cells, which, as we have already noticed, form a continuous lining to the inner wall of the radial tubes, are almost always in motion, bending downwards with a rapid movement in one direction and then returning to their position of rest, and doing this so rapidly that the eye cannot follow them in the active state, so that usually they are quite invisible. Each movement of the flagellum 'flicks' the water, as it were, in one direction, and the rapid successive movements of the almost infinitely numerous flagella drive the water out of the radial tubes into the stomach of the sponge, from which it emerges,

to the ectoderm, though it appears to me that it might more naturally be regarded as endoderm.

as we have already stated, in a powerful stream through the mouth. But as water is driven out of the radial tubes the pressure within them is diminished, and to restore equilibrium,—to supply the place of the water which has been expelled,—fresh water flows in from the interior through the pores at the ends of the tubes, and also, after passing down the inter-canals, through the pores at the sides of the tubes.

The circulation thus established from the pores through the radial tubes into the stomach, and so out through the mouth, is the means through which, as we shall now see, the nourishment and respiration of the sponge are carried on.

The water in which the sponge lives is inhabited by a large number of infusoria and other minute forms of life, and contains besides many small particles derived from decaying organisms; these enter the sponge, borne along with the inflowing currents of water, and are seized upon by the flagellate cells of the endoderm, as they pass through the radial tubes.

The manner in which the flagellated cells extract their food from the water is worth noticing; it is precisely similar to that in which the flagellated monads, which so closely resemble these cells, feed. No sooner does a little particle of food touch the edge of the delicate collar which surrounds the collum, than it adheres to it and is carried down by currents, that circulate up one side of the collar and down the other, to the end of the collum, in which, along with an accompanying drop of water, it becomes at once engulped. If the particle should come directly in contact with the collum itself, it is engulped in the same way. The included drop of water, enclosing its particle of food, travels down the collum into the base of the cell, where it forms a little 'bleb,' which we have already noticed as a 'vacuole.' The food of the vacuole undergoes digestion, and when all the 'goodness' has been got out of it, the indigestible residue is extruded from the cell, through an extemporised aperture, to be forthwith swept away in the torrent of the circulation, through the stomach, and then out by the mouth. In this way each flagellated cell eats and drinks, living to itself. It also breathes, the water which conveys its food containing dissolved oxygen, which passes into the cell by osmosis. Thus with food for fuel, and oxygen to burn it, the cell is provided with energy, which it expends in maintaining the water circulation, from which it obtains food and oxygen again. Though each cell lives its own life, yet the different cells all work more or less in unison; thus when they have taken enough food to satisfy their wants for the time, they frequently rest together to digest it; more or fewer of them cease to lash the water, the ostia and pores are closed by the contractile sphincters, which also seem to be in sympathy, and the circulation goes on feebly, or, for a time, altogether stops, to begin afresh when digestion is completed, and hunger urges the cells to renewed activity. Though the flagellated cells live each, as has been stated, their own life, yet it is no less true that each lives for the rest of the organism, as indeed must happen in all organised communities. The nutrition received is, under favourable circumstances, more than enough to make good the loss of substance involved in work, and the surplus leads to that increase in size, which is termed growth.

But to increase in size, there is in every individual a limit, which overpassed usually leads to division, and thus soon after the flagellated cell has passed its full size, a constriction makes its appearance transversely round the basal part, and extends inwards till the lower part of the base is completely severed from the rest; in this way the single cell becomes two, one of which retains its original character, while the other resembles an amœba, and making its way into the mesoderm lives a wandering life, possibly like a colourless blood corpuscle, serving as a food carrier to the rest of the organism. This is the origin of the third kind of cells which we mentioned as forming a part of the mesoderm. The splitting or fission of the flagellate cell is not always transverse;

sometimes it is longitudinal, and then produces two similar flagellated cells, instead of a flagellated and an amœbiform cell. It is by longitudinal fission that the endoderm grows in extent, correspondingly with the growth of the surface it covers.

We will now resume our description of the structure of the sponge.

The *Skeleton.*—The soft tissues of the sponge require some kind of support, and this is afforded to them by the hard parts, or skeleton. This consists of needle-shaped, tri-radiate, and quadri-radiate spicules, disposed in a definite manner. The proper wall of the stomach is furnished with three and four-rayed spicules, three of the rays of the quadri-radiate, and all those of the tri-radiate spicules, lying in the substance of the wall, parallel to its surface, while the fourth ray of the quadri-radiate spicules projects with a gentle upward curve into the gastric cavity, carrying the gastral membrane with it.

The radial tubes are furnished with tri-radiate spicules, arranged in successive, concentric, or transverse rows. The form of each spicule is such that two of its rays, those including the largest angle, may be taken to form a pair, the third ray being therefore 'odd;' and they are so arranged that the paired rays lie concentrically, while the odd ray lies longitudinally, in the wall of the tube. The paired rays, which form the basal or proximal row of each radial tube, lie back to back, as it were, with the spicules of the stomach wall, which is thus doubly strengthened.

The outer ends of the radial tubes are furnished, in addition, with colossal fusiform spicules, each often 3 mm. long; these are embedded at one end in the tissue of the tube, and at the other project freely beyond it; about the base of each colossal spicule there is usually a pencil of similar, but much smaller spicules, and a few large grapnel-like spicules are also present. The spicules, large and small, thus projecting from the end of the tube in the form of a brush or pencil, give to the surface of the sponge the hairy appearance, to which attention has already been directed.

The spicules of the corona, are partly colossal spicules similar to the foregoing, partly tri-radiate and quadri-radiate spicules, with three rays of the latter and two of the former embedded around the mouth, the remaining ray in each case projecting vertically upwards.

This nearly completes our account of the structure of the sponge; that which remains, the nature of the reproductive organs, will form a natural introduction to the account of its life-history.

Certain amœboid cells have already been described as inhabitants of the mesoderm, and the origin, or probable origin, of these cells has also been pointed out. What the subsequent history of them all may be we do not yet surely know, but some of them, at all events, continue for some time wandering through the mesoderm, and instead of contributing food to the rest of the sponge, obtain their nutriment from it, like parasites; thus they grow big, at the same time they become lazy, and at length cease to move about at all; then they assume a spherical form, and remain stationary in a cavity of the mesoderm. If they now retain their simple cell-form, simply increasing in size, they are known as *ova*. Some of them, however, undergo a structural change (at least, so we infer, for this is one of the stages in the history of the sponge which has not yet been directly observed), and as a result of this change, the nucleus of the cell disappears, and the cell itself becomes fibrillated, the fibres all radiating from the centre of the cell to the exterior. It is now called a *sperm-ball*. When it becomes mature, the fibres within are set free; each consists of a little highly-refractile conical head, with a long tail, which vibrating rapidly, propels the *spermatazoon*, as the structure is called, head foremost through the water.

The *spermatazoon* is the male element, the *ovum* the female element of the sponge. Both occur in the mesoderm. It is a singular thing that the male elements have not yet been discovered in *Sycandra raphanus*, but they have been seen in various other sponges; in some species occurring in the same individuals as contain the ova, in others in different individuals, so that some sponges are hermaphrodite, and others bisexual.

If the ova and spermatazoa be kept separate from each other, nothing remarkable will happen, each will lead its own life, and die a natural death. But they do not as a rule remain apart; the spermatazoa when set free on the disruption of the sperm balls, are carried away in the out-flowing water from the radial tubes of one individual, to enter along with the incurrent water the radial tubes of another. Should this latter contain ova, the spermatazoa on approaching an ovum swim towards it like so many tadpoles, and striking it head foremost, with their tails streaming outwards, remain for a while radiately disposed about its circumference. Finally they enter the substance of the ovum, are absorbed and disappear. The ovum is then said to be impregnated. Unfortunately this process, though it has been witnessed in many other sponges, has not been observed in *Sycandra raphanus*. As a consequence of the fusion of the spermatazoa with an ovum, the latter undergoes a remarkable series of changes, which end in producing a fresh sponge like the parent. First of all the nucleus disappears, and after awhile two fresh nuclei appear in its place; a constriction then occurs round the exterior of the ovum, as a shallow furrow, which deepens, extending inwards between the two nuclei till it actually divides the ovum into two parts, each of which has the value of a true cell. The direction in which this division takes place is constantly from the top of the ovum (that side facing the endodermal layer), to the bottom, or as we may briefly formulate it—perpendicular. The cells resulting from the division are flattened below and also against each other, but rounded off towards the top, so that they may be said to diminish in size from the base upwards. They soon undergo the same kind of change as the parent ovum, the nucleus of each disappears, and is replaced by two fresh nuclei, each is then furrowed by a constriction, and eventually divided into two cells. The plane of division is still perpendicular, but at right angles to the previous one. The four cells thus resulting resemble the parent cells in being broad and flat below, and narrower towards the top; they are likewise flattened against each other, but rounded off along their inner perpendicular edges, so as to leave a small cavity or canal in the axis of the group. This canal is the beginning of what we shall know hereafter as the cleavage cavity. Division again takes place, and still in a perpendicular direction; each of the four cells is divided into two from top to bottom, and thus eight cells arise, which form a ring, surrounding the cleavage cavity, and narrowing from the base upwards. After these three perpendicular divisions, which have given us first two, then four, and finally eight, cells, a fourth one occurs, which is horizontal, and so at right angles to all the preceding ones. As the tops of the cells, previous to this division, were, as stated before, smaller than the bottoms, so it follows that the eight upper cells above the median plane of division are smaller than the eight lower cells beneath it. The embryo consists now of 16 cells in two rows, an upper or apical row, and a lower or basal row, of eight cells each, surrounding the cleavage cavity, which opens by a wide lumen below, and a much narrower aperture above. The embryo exchanges now its plano-convex or cake-like for a cushion-like, or biconvex, form. Two more divisions, also in a horizontal direction, now succeed, severing each ring into two, and thus producing a four ringed form; one ring is apical, one basal, and the two between may be called equatorial. The cells of the equatorial rings are again divided, and this time vertically, in a meridional direction, we might say; in this way each equatorial row comes to contain sixteen cells. The embryo now is a cushion-like sac, the wall being composed of a single layer of similar cells, forty-eight in number, sixteen in each equatorial ring, and eight in each polar ring. The number of cells is further increased by division, the sac becomes more spherical in form, and the apical end of the cleavage cavity closes up. The next stage in the development is a differentiation of the cells, the eight which surrounded the basal opening of the cleavage cavity, and which are larger than the rest, acquire a dark appearance, owing to the development of a great number of dark granules within them. The remaining cells are much clearer, and multiplying in number, are converted into elongated small prism-like cells, radially arranged. The basal end of the cleavage cavity now closes up, and the dark granular cells increase in number. The next stage is either abnormal, inconstant, or in any case subsequently reversed; in it the layer of granular cells becomes flattened, depressed, and then pushed into the cleavage cavity, which is thereby diminished, or even almost obliterated, the granular cells applying themselves to the inner face of the prismatic layer. The form so produced is similar to the gastrula of other animals, but it is not permanent, the granular cells withdrawing themselves, and subsequently resuming their former position.

We may, therefore, return to the larva, where we left it in the normal course of development. The embryo is now more or less egg-shaped; the smaller end consists of the numerous small clear prismatic cells, which are now furnished with flagella, projecting from their outer ends; the larger end consists of the fewer (32) larger, rounded, dark, granular cells, sixteen of which are arranged to form a girdle round the equator, next to the prismatic half. The cleavage cavity still exists as a more or less spherical space in the middle, bounded half by the pigmented ends of the prismatic cells, half by the granular cells. By the movements of its flagella the larva now is liberated from its encapsuled cavity in the mesoderm, passes through the endodermal layer, into the radial tube, and so, borne along by the out-flowing currents of the circulation, out of the sponge into the surrounding water, where it spins about in a lively whirling kind of dance. As it grows, the little 'blastula,' as it may now be called, becomes less ovate and more spherical, and then commences to pass through one of the most important stages of its existence; the flagellated layer begins to lose its spherical contour, becomes flattened, depressed, and is at length drawn quite within the hemisphere of granular cells; it then applies itself to the inner face of this layer, entirely obliterates the cleavage cavity, and thus gives rise to the true *gastrula* form. It will be seen that the embryo is now somewhat bee-hive shaped, its wall is double, consisting of an outer ectodermic layer of granular cells, and an inner endodermic layer of prismatic cells, the cleavage cavity has disappeared, and a new cavity with a widely-open aperture below has arisen by invagination. This aperture is bounded by the row of sixteen granular cells, which previously formed the equatorial girdle of the embryo, they now grow radially inwards towards the centre of the aperture, and thus diminish its area, till it becomes reduced to a comparatively small opening; it is the larval mouth, as the cavity produced by invagination is the larval stomach. So far the larva has led an active, if not an industrious, existence, with the continual promise of better things; it now proceeds to a step, which, in the history of animal development, has generally proved fatal to further progress of importance, and has indeed often led to change in a backward direction. Settling down on some fixed object, such as a bit of stone, or the stem of a seaweed, it exchanges a free for a fixed and stationary existence. The granular cells surrounding the mouth grow inwards towards its centre, and completely obliterate it, at the same time they grow outwards over the surface of attachment in transparent, irregular, jagged, pseudopodia-like processes, which solder the young sponge securely to its seat.

By the absorption of a part of their granules, the granular cells lose, to a great extent, their opacity, so that one can see the layer of prismatic, or cylindrical cells, through them. They have, evidently, at this stage, lost their flagella. By excretion, or alteration, of the granular cells, a thin layer of jelly-like material is formed between the two layers of the embryo, this is the beginning of the future mesoderm, and in it the spicules as delicate needle-shaped forms first make their appearance. As they grow they soon enter the outer, or ectodermic, layer.

The larva grows in the direction of its axis, and so elongates into a cylindrical or conical body, the distal end flattens, and becomes perforated by a hole which puts the stomach cavity into communication with the surrounding water. This hole is the adult mouth, the endodermal cells retreat from it, leaving the ectodermal layer alone around it, as a clear thin membrane terminating the gastral cavity. Little round spaces open in the side-walls of the sponge and form the pores, the endodermal cells acquire their characteristic collar and re-acquire their flagella. Simultaneously with these changes additional spicules appear. The double-pointed needle-like spicules projecting obliquely upwards and outwards, form a sort of tube, extending from the base to the summit; immediately round the basal edge and the summital edge, they project outwards at right angles, forming a kind of collar. Mingled with the basal spicules are those with toothed ends before alluded to as grapnel-like spicules. Between the needle-like spicules are tri-radiate ones, all similarly arranged, two rays being directed, more or less concentrically, and the third longitudinally and downwards. Quadriradiates also make their appearance, and first round the terminal edge, two of their rays lying in the edge, one being directed longitudinally downwards, the other radiately towards the mouth, and serving as a support for the oral, or terminal, membrane. They are usually 4, 6, or 8 in number at first, and are always symmetrically arranged.

The description of the young sponge is so far complete; it consists of a sac, with a mouth at one end and pores at the sides, spicules to support it, and with three layers of tissue composing the wall, the ectodermal covering of plate-like cells, the jelly-like mesoderm in the middle and the flagellated endodermal cells within. But, as yet, there is no trace of the radial tubes. Some sponges *(Olynthus)* which have the same developmental history as Sycandra, up to this point, remain persistently in the stage now reached by it; in the young Sycandra, however, budding now begins to take place from the stomach wall, little hollow processes jut out from it, as if pushed out by a finger, these grow outwards, till they acquire exactly the same characters as the sac from which they proceed; the open gastral ends correspond to the mouth of the stomach, and the outer ends of the tubes to the base of the stomach. These are the radial tubes, and at first they are separate from each other, not united; this stage in the history of the sponge remains permanently throughout life in a related species (S. coronata); in our sponge, however, they soon become united by transverse bars of tissue, which cross from one tube to another. The ends of the tubes, however, always remain free as little conical protuberances, but in another sponge (S. capillosa) development proceeds the one step further, and the tubes become joined right up to their extremities. The fact here illustrated, that a stage which is transitory in the history of one animal is persistent in another, is one of the strongest arguments 'for Darwin.'

After so much pure description one may fairly be allowed to indulge in a little speculation; at one time people who thought at all about the matter were accustomed to believe that the young animal was produced from the adult all at once, at a single stroke; it commenced as a minute germ, a more or less exact likeness of the parent in miniature, which had nothing to do except to grow big; such, however, is as we can see, the very opposite of being the case, a vast number of phases of development intervene between the fertilized ovum and the young sponge. What then is the meaning of these phases, why all this complicated process, instead of the simple impress of the parental image on a young germ? The explanation which has the merit of being at once the simplest and the most rational, is that the various stages in the development of the individual mark the various stages in the history of the species; they present us, in the course of a few days, with a summary very much abridged of the successive steps by which the organism, as it at present exists, was evolved in the course of ages from some simpler form of life. Thus to confine ourselves to the history of the sponge which we have now made our own, we may assume that its earliest ancestor was a simple cell, closely resembling an ordinary amœba, this amœba, after leading a wandering life, feeding and growing big, became stationary, folded its arms, to speak symbolically, withdrew them into itself, and formed a spherical ovum; this either with or without fusing with another individual previously, split into two, as amœbas in such circumstances do at the present day, but the resulting twins, instead of separating from one another, as ordinary young amœbas do, remained in contact, for no obvious reason that one can see unless to keep each other warm; they grew up till the time came for them to split as their parent did, and thus four cells were produced, and so the process continued, all the young cells sticking together on the principle of co-operation. But co-operation by itself will not produce very great results; it frequently, however, leads to something much more important, and that is the specialisation of function and the differentiation of parts; here, in the cluster of young amœbas, such a specialisation took place, some became set apart as food providers and agents in locomotion, their pseudopodia becoming converted into flagella (one wishes one knew how), the others served some other purpose, perhaps of secretion, perhaps as storers of nutriment, and perhaps as reproductive agents. So far the corals, sea-anemonies, and such like creatures (cœlenterata) appear to have travelled along very much the same road as the sponges, but now they part company, the cœlenterata originated in the growth of the ciliated cells over the cilialess cells, so that the latter formed the digestive lining inside the resulting *gastrula*, as we have agreed to call the sac formed by the invagination of the preceding form or blastula; in the sponges, on the contrary, as we have seen, the ciliated cells withdraw into the cilialess layer, which thus becomes a protecting, instead of a digestive, layer. But now it is worth while recollecting that though this is the normal process with the sponge, yet that the opposite one is frequently passed through as a transitory stage, preliminary to it, and thus we may conjecture that the larva which becomes a sponge now, by invagination of the ciliated layer, is a descendent of a form which used to become a coral by the invagination of the other layer, that is, that a form on the way to become a cœlenterate, took the wrong turn for once, and so ended in a cul-de-sac, and became a sponge. Thus the abnormal kind of invagination in Sycandra may be an instance of what is termed 'reversion to the ancestral type'; on the other hand it may simply indicate the balancing play of forces on the young organism, so that it looks as if it could not make up its mind, and was undecided as to whether to turn the flagellated layer inside and become a sponge, or outside, and become a cœlenterate. Between these alternative possibilities we cannot decide, the day has not yet come when the development of an animal may be represented by a mathematical formula, and that wonderful man, the mathematical physicist, has not yet taken the matter in hand,

To resume our history. The young gastrula, which we believe to have led an independent life, a free swimmer in the sea, whose parent lived and died a gastrula, took another step in development, by becoming sessile, and here again its contrary disposition was displayed, for instead of settling base downwards, as the cœlenterate gastrula did, when it similarly resigned a free existence, it,

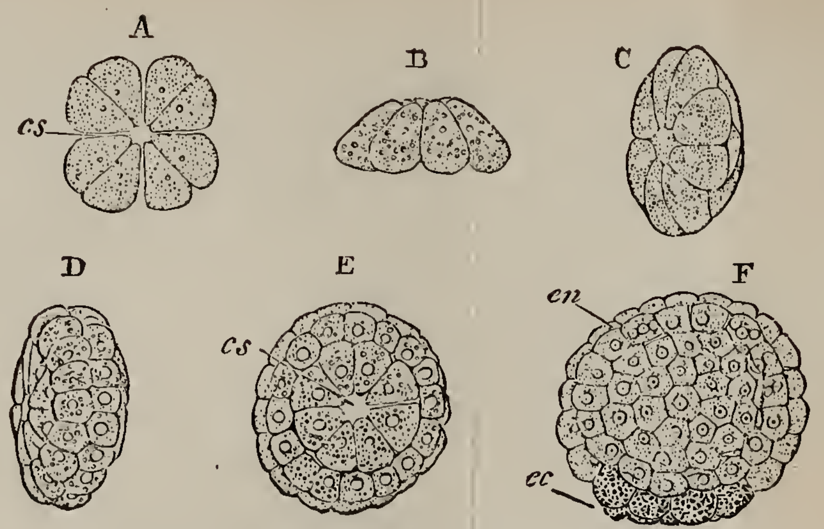


FIG. 1.—Successive stages in the segmentation of Sycandra raphanus. *(Copied from F. E. Schulze).*

A. Stage with eight segments still arranged in pairs, seen from above.
B. Side view of stage with eight segments.
C. Side view of stage with sixteen segments.
D. Side view of stage with forty-eight segments.
E. View from above of stage with forty-eight segments.
F. Side view of embryo in the blastosphere stage, eight of the granular cells which give rise to the ectoderm of the adult are present at the lower pole.
cs. Segmentation cavity; *ec.* granular cells, which form the ectoderm; *en.* clear cells which form the endoderm.

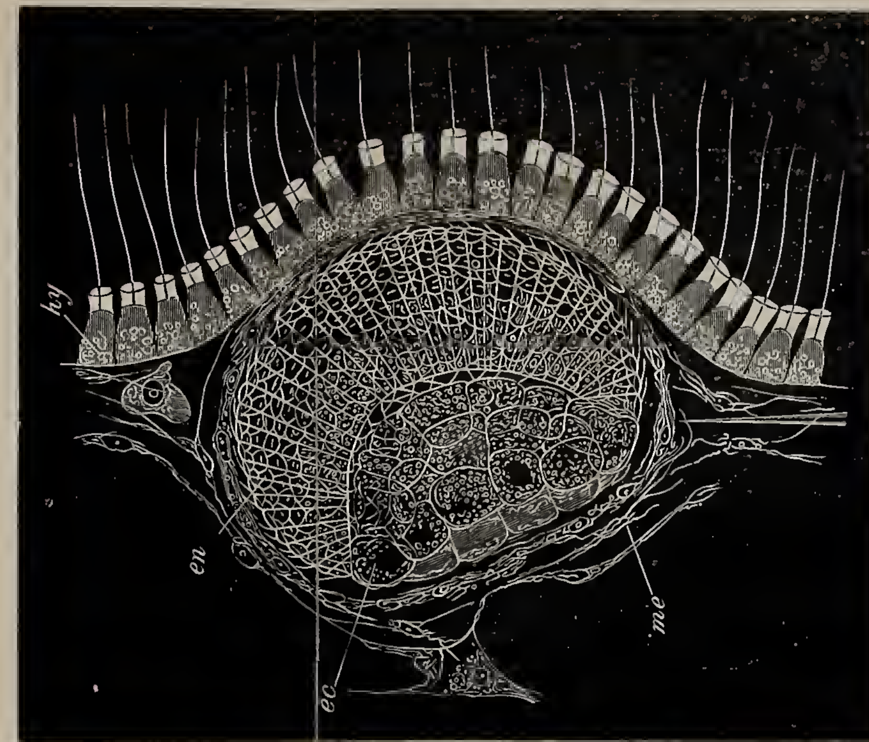


FIG. 2.—Larva of Sycandra raphanus at pseudogastrula stage, in situ in the maternal tissues. *(Copied from F. E. Schulze).*

me. Mesoderm of adult; *hy.* collared cells, or endoderm, of adult; *en.* clear cells of larva, which eventually become involuted to form the endoderm; *ec.* granular cells of larva, which give rise to the ectoderm; at this stage they are partially involuted.

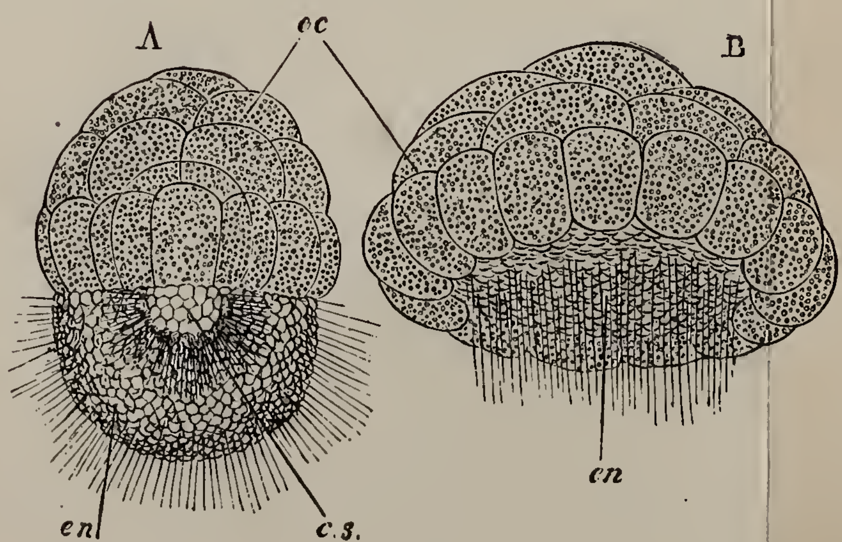


FIG. 3.—Two free stages in the development of Sycandra raphanus. *(Copied from F. E. Schulze).*

A. Amplisblastula stage.
B. A later stage, after the ciliated cells have commenced to become invaginated.
cs. Segmetation cavity; *ec.* granular cells which form the ectoderm; *en.* ciliated cells, which become invaginated to form the endoderm.

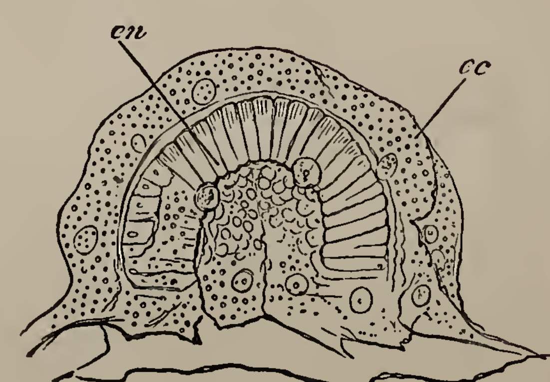


FIG. 4—Fixed gastrula stage of Sycandra raphanus *(Copied from Schulze).*

The figure shews the amœboid ectoderm cells (*ec*) derived from the granular cells of the earlier stage, and the columnar endoderm cells, lining the gastrula cavity, derived from the ciliated cells of the earlier stage; the larva is fixed by the amœboid cells on the side on which the original mouth opening is situated.

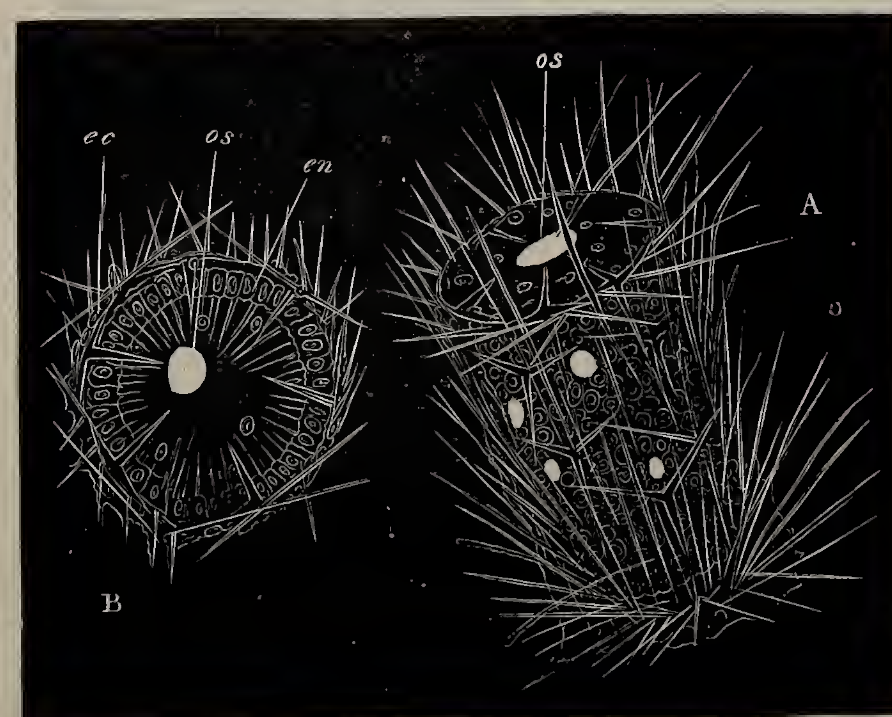
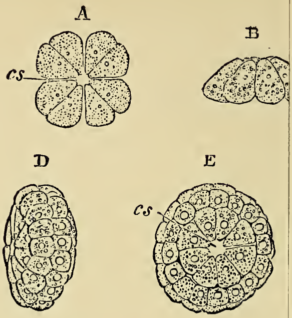


FIG. 5. The young of Sycandra raphanus, shortly after the development of the spicules *(Copied from Schulze).*

A. View from the side.
B. View from the free extremity.
os. Osculum; *ec.* ectoderm; *en.* endoderm, composed of ciliated cells. The terminal osculum and lateral pores are represented as oval white spaces.

The author is indebted to the kindness of F. M. Balfour, Esq., F.R.S., for the loan of the Plates, from which the Figures are produced.



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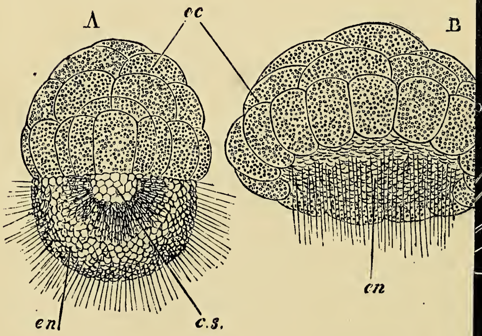

on the contrary, attached itself by the mouth, which, by subsequent growth, became obliterated. Hence the origin of pores, and the vent which we conventionally call the mouth. We have already stated that some sponges remain their whole life through in the simple stage now reached, giving rise to other sponges, which no more pass beyond it than their parents did; yet in the history of the sponges, there must have been a time when one of these simple Olynthi progressed a step further and produced the additional complication of radial-tubes. These are simply so many repetitions of the young Olynthus budded out from its sides, and thus again we have co-operation, a number of young Olynthi, remaining attached together to form the wall of the Sycandra. But they all perform the same functions; the succeeding and more important step, the acquirement, by some of the tubes, of one set of functions, and by others, of another, has not yet taken place; some day, perhaps it may; the future is infinite with possibility, and Sycandra may even yet, be destined to a brilliant and successful career.

On some Cases of Prolification in
"*CYCLAMEN PERSICUM*,"

By ADOLPH LEIPNER, F.Z.A.

HAVING, during the last two years, met with several cases of Prolification, or of formation of adventitious buds in Cyclamens, the author thought it right to draw the attention of the members of the society to this interesting phenomenon. The two cases illustrated here explain themselves: in one specimen (*plate* V. *fig.* 2) the *flower*-stalk, instead of normally terminating in one solitary flower, has produced a small leaf immediately below the calyx of that flower, and another leaf, with a small axillary flower-bud, about one half-inch below;—in the other case (*plate* IV. *fig.* 1) the *leaf*-stalk has produced, at a distance of about two inches from its origin, another plant with one leaf and three flowers. In a third case, which the author exhibited, the leaf-stalk branched, and formed four fully developed leaves, with one diminutive flower-bud in the axil of each leaf. Prolification occurs, therefore, in these plants, both upon the inflorescence and upon the leaves.

The two plants of cyclamen, which produced these abnormal growths, had been obtained from Messrs. Garaway; and on examining their stock, a short time ago, several more instances of it were discovered. It would be interesting to observe whether this prolification has a hereditary tendency;—as yet the author has not been able to get seed from proliferous flowers, but is desirous to do so, in order to experiment with it.

It would appear that the first of these three cases, thus briefly described, may be similar to the two referred to by Dr. Masters in his "Vegetable Teratology," p. 104.

LAVARS, LITH. BRISTOL.

The Ethnology of the Paropamisus or Hindoo Koosh.

BY JOHN BEDDOE, M.D., F.R.S.

THIS subject was treated under the following heads :— The geography of the countries, their history as regards ethnology, and the various races inhabiting them. As to the geographical characteristics of this region, it was highland as compared with most of the surrounding countries, consisting mainly of ranges of hills enclosing narrow valleys and small elevated plains, and radiating from two principal ranges, the Hindoo Koosh, running nearly east and west, and the Suliman mountains, nearly north and south. The former is not really a prolongation westward of the Himalayah, which does not cross the Indus, and is represented, if at all, by the Safed Koh (White Mount) range, south of the Kabul river: this range terminates to the west in knots of mountains, among which lies the Shutargardan Pass, of which we have heard so much of late. As we proceed southwards and westwards the elevation of the country decreases, and we find considerable diversity of climate. The north-western portion is of a more open character, the central and eastern parts are well wooded and watered, while in the west, pasture is the chief feature and wood is scarce. The streams flowing southwards never reach the sea, but converge towards the small lake of Seistan, from which there is no outlet.

The various tribes which inhabit this region present great varieties of character; the Ghilzais (the second in population and importance of the Afghan clans), and Kaffirs being the most warlike and indomitable, while others, though nominally under the sway of a sovereign, are very much in the position of the Scottish clans in olden times. Most of these are regarded as branches of the great Aryan race, and this opinion obtains support from the references in the Zendavesta to the regions beyond the river Oxus, whence the Aryans issued. Alexander the Great during his conquests found Aryans only, it would seem, in these regions, but Grecian historians considered the more Eastern of them to be Indians rather than Persians, and doubtless they judged by their language and physical aspect. The fact, of small statuettes of classical form having been found in some of these parts, indicates the people to have been advanced to some extent in civilization under the Græco-Bactrian kingdom. Dr. Leitner, of Lahore, has made some interesting discoveries of this nature. The inhabitants of Afghanistan are, ethnologically, classed under two great divisions, viz., Iranians, or Aryans, and Turanians, each of which is again sub-divided into numerous tribes. The former comprise the Kaffirs, Jats, Hindkis, Badakshis, Sarts, Tajiks, Biluchis, and the Afghans, or Patans; while the latter include the Uzbeks, Kizilbashis, Huzarehs, and Eimauks. The physiognomy presents different types; we have some of a Jewish cast, others showing more or less of a Tartar cross, while the Persian type, as shown in the Persepolitan sculptures, is exemplified in the Tajiks, who are scattered over the west and north-west. The Kaffirs are said to be distinguished by light hair and eyes. The Huzarehs, who speak the Persian language, and profess the same religion with the Persians, are allied to the Mongols in blood, and their physical characteristics, such as short stature, narrow oblique eyes and broad cheek-bones, still attest their descent, which is supposed to be from the armies of Jenghiz Khan. As to the origin of the Afghans proper, some few, among whom is Dr. Bellew, lean to the opinion that they are of Jewish descent, and base their theory on several peculiarities, which seem at first sight to favour their views, such as the form of features, especially the nose; the practice of certain customs once thought peculiar to the Jews, *e.g.*, the ceremony of the scapegoat, punishment by stoning, &c. Saul, the son of Kish, is regarded by the Afghans themselves as their ancestor, though much weight cannot attach to this tradition, which is probably of comparatively modern date, and borrowed from the Arabs. Mountstuart Elphinstone, on the other hand, basing his opinion chiefly on the language, regards them as of Perso-Aryan origin, and his authority carries the greatest weight; in fact all, or nearly all, ethnologists subscribe to this view. It is curious that the Povindahs, the most mercantile clans among the Afghans, seem to be among those who approach most distinctly to the Jewish type of features, while in the portraits of Duranis, Ghilzais, Momunds, and other military and pastoral tribes, there does not appear to be anything Semitic.

Catalogue of the Lepidoptera of the Bristol District.

PART 3.

BY ALFRED E. HUDD, M.E.S.

Noctuæ.

Thyatira derasa. L. Generally distributed throughout the district, but not common.

„ batis. L. Generally distributed and sometimes common.

Cymatophora duplaris. L. Glos. Almondsbury, Rudgewood, Cook's Folly Wood, Wotton-under-Edge, Woodchester.

Somerset Bedmiminster. R.F. Leigh Woods, Portishead, Weston-super-Mare. Not very common.

„ diluta. W.V. Glos. Clifton, Wotton-under-Edge.

Somerset. Leigh Woods, Portishead, Weston-super-Mare. Not uncommon.

CYMATOPHORA OR. W.V. GLOS. "Bristol and Cotswolds."—"*Stainton's Manual*," *I., p. 175.*
SOMERSET. Portishead Woods. J.M.D. "Common at sugar."

„ [OCULARIS. L. Not recorded from my district, but reported from the neighbourhood of Taunton, Somerset, by Mr. F. Stansell, in 1874.—See *Entomologist* VIII., p. 159.]

„ FLAVICORNIS. L. GLOS. Clifton.
SOMERSET. Leigh. Scarce in Birch-woods.

„ RIDENS. F. GLOS. Clifton and Durdham Downs.
SOMERSET. Brislington, by Mr. Sircom; Brockley and Leigh Woods. Scarce.

BRYOPHILA GLANDIFERA, W.V. Generally distributed and often common on old walls..

„ PERLA. W.V. Common everywhere.

ACRONYCTA TRIDENS. W.V. GLOS. "Bristol:" *Stainton's Manual.* Redland. P.H.V.
SOMERSET. Wells and Weston-super-Mare. Scarce.

„ PSI. L. Common everywhere.

„ LEPORINA. L. GLOS. Stapleton. G.H. Wotton-under-Edge.
Somerset. Bath, Bedminster, Leigh Woods, Wells. Not common.

„ ACERIS L. SOMERSET. Recorded only by Mr. Crotch. "Near Weston-super-Mare."

„ MEGACEPHALA. W.V. Generally distributed, the larvæ being sometimes common.

„ ALNI. L. GLOS. A specimen was bred in May, (1855 ?) from a larva found the previous autumn on hawthorn, at Almondsbury, by Mr. Allen Hill. A larva taken by Mr. Harding at Stoke

Gifford, on apple, produced an imago the following spring. A fine male was bred by the Rev. Jos. Greene, on April 29th, 1878, from a larva found the previous year in the Gully, on hazel. Mr. Greene also found, some time previously, a dead larva at the foot of an elm tree at Stapleton. An imago found at rest on a stone-wall at Woodchester, in July, 1879, is recorded by the Rev. H. S. Gates, O.P.; also a larva in the same locality in 1880.

SOMERSET. Reported only from Leigh Woods and Portishead. This species seems to be widely distributed throughout the country, but is everywhere scarce, probably in consequence of the larvæ being so susceptible to attack from *hymenopterous* and *dipterous* parasites. The moth is very rare on the Continent, and is therefore not in every British collection.

ACRONYCTA LIGUSTRI. W.V. Generally distributed throughout the district, but scarce.

„ RUMICIS. Generally distributed and common

LEUCANIA CONIGERA. W.V. Generally distributed and not scarce.

„ LITHARGYRIA. E. GLOS. Durdham Down, Stapleton, Wotton-under-Edge, Woodchester.

SOMERSET. Brislington, Wells, Weston, &c.

„ LITTORALIS. C. GLOS. One specimen at sugar at Stapleton, by Mr. Harding.

SOMERSET. Weston-super-Mare. G.R.C.

„ COMMA. L. Generally distributed and common.

„ STRAMINEA. T. SOMERSET. Dr. Livett reports this species from marshes near Wells, and it is also marked on Mr. Crotch's list from Weston-super-Mare.

LENCINEA IMPURA. H. Generally distributed.

„ PALLENS. L. Generally distributed.

NONAGRIA DESPECTA. T. GLOS. One specimen only, taken by Mr. W. H. Grigg, on a gas-lamp near Cotham.

„ FULVA. H. Glos. Baptist's Mills and Clifton. SOMERSET. Leigh Down, Weston-super-Mare, etc. Scarce.

„ GEMINIPUNCTA. H. SOMERSET. Taken rather freely in the larval state, by the late Mr. Crotch, near Weston-super-Mare.

„ TYPHÆ. E. GLOS. Wotton-under-Edge. V.R.P. SOMERSET. Brislington and Weston-super-Mare. Scarce.

„ LUTOSA. H. GLOS. Almondsbury, Baptist's Mills, Cotham, Stapleton, Wotton-under-Edge. SOMERSET. Leigh, Weston-super-Mare.

GORTYNA FLAVAGO W.V. Generally distributed throughout the district; the larvæ sometimes abundant in thistle stems.

HYDRÆCIA NICTITANS. L. GLOS. Ashley Hill, Almondsbury, Stapleton, Wotton-under-Edge. SOMERSET. Bath, Keynsham, Weston-super-Mare. Not common.

„ MICACEA. E. Generally distributed.

AXYLIA PUTRIS. L. Generally distributed, but not often common.

XYLOPHASIA RUREA. F. Throughout the district, sometimes abundant. The variety *Combusta* sometimes comes to sugar at Almondsbury, Stapleton, &c., but is scarce.

„ LITHOXYLEA. W.V. Generally distributed, but not very common.

„ SUBLUSTRIS. E. GLOS. Stapleton, "*Bristol*," Woodchester, SOMERSET. Brislington. Scarce.

XYLOPHASIA POLYODON. L. Common everywhere.

" HEPATICA. C. GLOS. Durdham Down, Horfield, Stapleton; "Larvæ and pupæ common under moss at Woodchester."—Rev. H. S. Gates.

SOMERSET. Bath, Portishead, Wells, Weston-super-Mare. Sometimes common at Sugar.

" SCOLOPACINA. E. SOMERSET. One specimen taken 1875, at Wells, by Dr. Livett. Weston-super-Mare. G.R.C.

DIPTERYGIA PINASTRI. L. GLOS. Mr. Perkins writes: "Common at sugar on elms, at Wotton-under-Edge."

SOMERSET. Weston-super-Mare.

[XYLOMIGES CONSPICILLARIS. L. Not recorded from my district, but specimens have been found in both counties: near Gloucester, by Mr. Merrin (*E. An.*, 1869), and Taunton, by the late Mr. Crotch.]

NEURIA SAPONARIAE. B. GLOS. Stapleton, Westbury, Woodchester.

SOMERSET. Bath, Brislington. Scarce.

HELIOSPHOBUS POPULARIS. F. Generally distributed, but not common.

" HISPIDA H. GLOS. One specimen flying over grass at Clifton, in September, 1866, recorded in "*The Entomologist's Annual*" for 1867, on my authority.

CHARÆAS GRAMINIS. L. GLOS. "Bristol," Almondsbury.

SOMERSET. Bath, Brockley, Leigh Down, Weston-super-Mare. Not common.

CERIGO CYTHEREA. F. GLOS. Durdham Down, Woodchester.

SOMERSET. Leigh Down. Not common.

LUPERINA TESTACEA. W.V. Generally common.

LUPERINA CESPITIS. W.V. GLOS. One specimen taken at Redland by Mr. P. H. Vaughan. [Cotswolds].
SOMERSET. One specimen on Leigh Down, Oct. 1879. W.H.G.

MAMESTRA ABJECTA H. SOMERSET. This species is marked on Mr. Crotch's list from Weston-super-Mare, which is the only record I have of its occurrence in the district.

,, ANCEPS. H. GLOS. "Bristol," Stapleton, Woodchester, Cotswolds.
SOMERSET. Bath, Brislington, Leigh, &c. Not common.

,, ALBICOLON. H. SOMERSET. Weston-super-Mare. By Mr. Crotch only.

,, FURVA. W.V. GLOS. Durdham Down, Redland.
SOMERSET. Weston-super-Mare. Scarce, at flowers of guelder-rose, &c.

,, BRASSICÆ. L. Abundant everywhere.

,, PERSICARIÆ. L. SOMERSET. Near Bath and Weston-super-Mare. Not common. No records in my district from Gloucestershire.

APAMEA BASILINEA. W.V. Generally distributed, and sometimes common at sugar.

,, GEMINA. H. Generally distributed, but not common.

,, UNANIMIS. T. GLOS. Stapleton, Baptist's Mills, Woodchester.
SOMERSET. Bath, Brislington, Weston. Sometimes common at sugar.

,, FIBROSA. H. GLOS. Wotton-under-Edge. A few specimens only, taken by Mr. Perkins in his garden.

,, OCULEA. F. Abundant everywhere, and greatly varies in colour.

MIANA STRIGILIS. L. Generally distributed and abundant.
MIANA FASCIUNCULA. H. Generally distributed.
„ LITEROSA. H. GLOS. Clifton Down, Wotton-under-Edge.
SOMERSET. Leigh Woods, Weston-super-Mare.
„ FURUNCULA. W.V. GLOS. "Bristol and Cotswolds," Wotton-under-Edge.
SOMERSET. Bath, Brislington, Leigh, Weston-super-Mare. Not common.
„ ARCUOSA. H. GLOS. Almondsbury, Durdham Down, Stapleton, Woodchester.
SOMERSET. Brislington, Bath, Keynsham, Wells, Weston. Not common.
GRAMMESIA TRILINEA. W.V. Generally distributed, and common.
CARADRINA MORPHEUS. H. GLOS. Stapleton, Wotton-under-Edge.
SOMERSET. Bath, Brislington, Weston. Scarce.
„ ALSINES. B. GLOS. Stapleton, Woodchester, Wotton-under-Edge.
SOMERSET. Bath, Brislington, Weston, &c.
„ BLANDA. W.V. GLOS. Almondsbury, Stapleton, Woodchester, Wotton-under-Edge.
SOMERSET. Bath, Brislington, Leigh, Weston.
„ CUBICULARIS. W.V. Common everywhere.
RUSINA TENEBROSA. H. GLOS. Durdham Down, Stapleton, Woodchester, Wotton-under-Edge.
SOMERSET. Bath, Leigh, Weston. Scarce.
AGROTIS VALLIGERA. W.V. GLOS. Wotton under-Edge.
SOMERSET. Weston-super-Mare. Scarce.
„ PUTA. H. GLOS. Durdham Down, Stapleton, Frome Glen, &c.
SOMERSET. Bath, Brislington, Wells, Weston. Sometimes abundant at sugar.

AGROTIS SUFFUSA. W.V. Common everywhere.

„ SAUCIA. H. Generally distributed, and common.

„ SEGETUM. W.V. Abundant everywhere.

„ EXCLAMATIONIS. L. Abundant everywhere.

„ CORTICEA. W.V. GLOS. Durdham Down, Redland, Stapleton.
SOMERSET. Bath, Brislington, Clevedon, Glastonbury, Weston-super-Mare.

„ CINEREA. W.V. GLOS. Two specimens only, taken by Mr. George Harding on Durdham Down. Woodchester, by Rev. H. S. Gates.

„ RIPAE. H. SOMERSET. Taken by Mr. Crotch, near Weston-super-Mare.

„ NIGRICANS. L. GLOS. Taken on leek-flowers, at Stapleton, by Mr. George Harding.
SOMERSET. Bath, Brislington, Weston, &c.

„ TRITICI. L. GLOS. Stapleton.
SOMERSET. Bath, Brislington, Weston, &c.

„ AQUILINA. W.V. GLOS. Scarce at Stapleton; by Mr. George Harding.
SOMERSET. Weston-super-Mare.

„ [OBELISCA. W.V. Taken on the Cotswolds by the Rev. E. H. Todd.]—*See E. M. M., 1867, p. 210.*

„ PORPHYREA. W.V. Not scarce on heaths, Durdham Down, Redland, Leigh, &c.

„ RAVIDA. W.V. GLOS. One specimen taken by Mr. Harding at Stapleton. [Cotswolds, by Mr. Todd.]

„ [PYRPOHILA. W.V. Cotswolds, by Mr. Todd.]

„ LUCERNEA. L. GLOS. One specimen taken on Durdham Down by Mr. Vaughan.

TRIPHÆNA JANTHINA. W.V. Generally distributed, and not uncommon.

TRIPHÆNA FIMBRIA. L. GLOS. Stapleton, Woodchester, Wotton-under-Edge.
SOMERSET. Brislington, Wells, Weston. Not very common.

" INTERJECTA. H. GLOS. Almondsbury, Stapleton,
SOMERSET. Bath, Bedminster, Portishead, Weston-super-Mare. Not Common.

" ORBONA. H. Abundant everywhere.

" PRONUBA. L. Abundant everywhere.

NOCTUA GLAREOSA. E. GLOS. Not recorded.
SOMERSET. Leigh Woods and Apperton.

" AUGUR. F. GLOS. Horfield, Patchway, Stapleton, Wotton-under-Edge.
SOMERSET Leigh Woods. Not common.

" PLECTA. L. Common everywhere.

" C-NIGRUM. L. Generally common.

" TRIANGULUM. H. GLOS. "Bristol," Stapleton, Wotton-under-Edge.
SOMERSET. Bath, Brislington, Leigh, Portishead, Weston-super-Mare. Not common.

" [RHOMBOIDEA. E. GLOS. ? Recorded in "*Stainton's Manual*," from Bristol. I know of no captures in the district.]

" BRUNNEA. W.V. GLOS. "Bristol," Stapleton, Wotton-under-Edge, Woodchester.
SOMERSET. Bath, Portishead, Weston-super-Mare. At sugar, not common.

" FESTIVA. W.V. Generally common.

" [DAHLII. H. "Bristol"—"*Stainton's Manual*" only: locality unknown to me.]

" RUBI. V. Generally distributed, and abundant at sugar.

" UMBROSA. H. Generally distributed, but not common.

" BAJA. W.V. Generally distributed, but not common.

NOCTUA NEGLECTA. H. SOMERSET. Recorded from near Weston-super-Mare by Mr. Crotch only.

" XANTHOGRAPHA. W.V. Abundant everywhere.

TRACHEA PINIPERDA. P. GLOS. Wotton-under-Edge.
SOMERSET. Brockley, Leigh, Portishead, Weston-super-Mare, &c. Larvæ sometimes common in pine-woods.

TÆNIOCAMPA GOTHICA. L. Common everywhere.

" LEUCOGRAPHA. W.V. SOMERSET. Recorded from Weston-super-Mare by Mr. Crotch.

" RUBRICOSA. W.V. Generally distributed, and sometimes rather common at sallow-bloom.

" INSTABILIS. W.V. Common everywhere.

" OPIMA. H. GLOS. "Bristol," Almondsbury.
SOMERSET. Leigh Woods. Scarce.

" POPULETI. F. GLOS. "Bristol," Frome Glen, Almondsbury.
SOMERSET. Weston-super-Mare. Scarce.

" STABILIS. W.V. Abundant everywhere.

" GRACILIS. W.V. Generally distributed.

" MINIOSA. W.V. GLOS. One by Mr. Grigg at Stapleton.
SOMERSET. Leigh, Weston-super-Mare. Scarce.

" MUNDA. W.V. GLOS. Stapleton, Wotton.
SOMERSET. Bath, Leigh, Weston-super-Mare. Sometimes abundant at sallows.

" CRUDA. W.V. Common everywhere.

ORTHOSIA SUSPECTA. H. GLOS. A few at Downend, by Messrs. Hill & Mayes; Woodchester. H.S.G.

" UPSILON. W.V. GLOS. "Bristol," Cotham, Stapleton. Abundant at Wotton-under-Edge.
SOMERSET. Brislington.

ORTHOSIA LOTA. L. Generally distributed; larvæ sometimes abundant on willows.

" MACILENTA. H. Generally distributed, and sometimes abundant at ivy-bloom.

ANCHOCELIS RUFINA. L. GLOS. Almondsbury, Durdham Down. SOMERSET. Leigh, Weston-super-Mare. Scarce.

" PISTACINA. W.V. Abundant everywhere, and extremely variable.

" LUNOSA. H. Generally distributed, and common.

" LITURA. L. Generally distributed, and common.

CERASTIS VACCINII. L. Abundant everywhere.

" SPADICEA. G. Abundant everywhere.

" ERYTHROCEPHALA. W.V. GLOS. No record.
SOMERSET. Very rare. One specimen taken at sugar at Wells, by Dr. Livett, Oct. 4th, 1874, and one or two near Weston, by Mr. Crotch.—*See "Intelligencer," Vol.* III. *p.* 53.

SCOPELOSOMA SATELLITIA. L. Common everywhere.

DASYCAMPA RUBIGINEA. W.V. GLOS. Almondsbury, Clifton, Henbury, Stapleton.
SOMERSET. Brislington, Leigh, Wells, Weston-super-Mare. Scarce.

HOPORINA CROCEAGO. W.V. GLOS. No record.
SOMERSET. One specimen beaten from ivy-bloom at Leigh, in November, 1866, by Mr. Hutchins; Weston-super-Mare, by Mr. Crotch.

XANTHIA CITRAGO. L. Generally distributed, the larvæ being sometimes common.

" CERAGO. W.V. Generally distributed, but not common.

" SILAGO. H. Throughout the district, the larvæ sometimes common in sallow-catkins.

" AURAGO. W.V. GLOS. Clifton and Durdham Downs.

SOMERSET. Bath, Brislington, Leigh Woods, Portishead. Not common.

XANTHIA FERRUGINEA. W.V. Common everywhere.

CIRRHŒDIA XERAMPELINA. H. GLOS. The Rev. Jos. Greene writes: "Pupæ abundant some years at roots of ash on Durdham Downs. From one of these I bred the variety commonly supposed to exist only in the Isle of Man." A few specimens of the imago have also been found at Almondsbury, Ashley Hill, Bristol, Stapleton, and near Gloucester.

SOMERSET. Brislington, Leigh, &c.

TETHEA SUBTUSA W.V. GLOS. "Bristol," Stapleton, Wotton-under-Edge. [Gloucester.]

SOMERSET. Weston-super-Mare. Scarce.

" RETUSA. L. GLOS. Almondsbury, Wotton-under-Edge.

SOMERSET. Brislington. P.H.V. Scarce.

EUPERIA FULVAGO. W.V. GLOS. One specimen taken at Redland by Mr. Vaughan; one at Fishponds, in 1875, by Mr. Preston.

SOMERSET. Keynsham. Scarce. R.F.

COSMIA TRAPEZINA. L. Abundant everywhere.

" PYRALINA. W.V. GLOS. Montpelier, by Mr. Vaughan, [Dean Forest]. Scarce.

" DIFFINIS. L. GLOS. Almondsbury, Clifton, Durdham Down, Wotton-under-Edge.

SOMERSET. Bath, Brislington, Wells, Weston-super-Mare. Not common.

, AFFINIS. L. GLOS. "Common in many places round Bristol." P.H.V. Woodchester, Wotton, &c.

SOMERSET. Bath, Brislington, Wells, Weston.

EREMOBIA OCHROLEUCA. W.V. GLOS. "Bristol," Horfield.

SOMERSET. Brislington, Weston-super-Mare.

DIANTHÆCIA CARPOPHAGA. B. Common, & generally distributed.

„ CAPSOPHILA. D. SOMERSET. One specimen reported from Wells by Dr. Livett: named for him by the late Edward Newman.

„ CAPSINCOLA. W.V. GLOS. "Bristol," Stapleton, Wotton-under-Edge.

SOMERSET. Brislington, Leigh, Weston-super-Mare. Larvae sometimes abundant.

„ CUCUBALI. W.V. GLOS. "Bristol," Redland. P.H.V.

SOMERSET. Weston-super-Mare. Scarce.

„ CONSPERSA. W.V. GLOS. Woodchester, 1879, by Rev. H. S. Gates.

SOMERSET. Leigh Woods, by the Rev. Jos. Greene; scarce.

HECATERA DYSODEA. W.V. SOMERSET. Weston-super-Mare.

„ SERENA. W.V. GLOS. Fishponds, Stapleton, Wotton-under-Edge.

SOMERSET. Bath, Brislington, Weston.

POLIA FLAVICINCTA. W.V. Common, and generally distributed.

DASYPOLIA TEMPLI. T. GLOS. Almondsbury, Clifton, Redland.

SOMERSET. Weston-super-Mare, and near Taunton. Scarce at light.

EPUNDA LUTULENTA. W.V. SOMERSET. Weston-super-Mare, by Mr. Crotch.

„ NIGRA. H. GLOS. Clifton, Durdham Down, Stoke Bishop.

SOMERSET. Bath, Leigh, Nailsea, Weston-super-Mare. Not common.

„ VIMINALIS. F. GLOS. "Bristol." [Cotswolds].

SOMERSET. Bath, Brislington, Leigh. Scarce.

„ LICHENEA. H. GLOS. Clifton and Durdham Downs, Westbury, Wotton-under-Edge.

SOMERSET. Wells. Scarce.

MISELIA BIMACULOSA. L. GLOS. "Once near Bristol in 1815," *Stainton's Manual, Vol.* I., *p.* 268. The late J. F. Stephens, in his "*Illustrations Haustellata,*" *Vol.* III., *p.* 24, states; "The only indigeneous example (of *M. bimaculosa*) I have seen, is contained in the collection at the British Museum, to which it was presented by Dr. Leach; it was captured near Bristol, I believe in 1815." This specimen is still in the British Museum collection, with Dr. Leach's ticket attached.

„ OXYACANTHAE. L. Common everywhere.

AGRIOPIS APRILINA. Generally distributed, but not very common.

PHLOGOPHORA METICULOSA. L. Abundant everywhere.

EUPLEXIA LUCIPARA, L. GLOS. "Bristol," Stapleton, Wotton-under-Edge.

SOMERSET. Leigh, Wells, Weston-super-Mare,

APLECTA HERBIDA. W.V. GLOS. Durdham Down [Cotswolds].

SOMERSET. Brockley, Weston-super-Mare.

„ NEBULOSA. H. GLOS. Redland, Stapleton.

SOMERSET. Bath, Leigh, Weston-super-Mare.

„ ADVENA. W.V. Generally distributed, but not common.

HADENA ADUSTA. E. GLOS. Bristol, Stapleton, Woodchester.

SOMERSET. Leigh, Portishead. Scarce.

„ PROTEA. W.V. Common, and generally distributed.

„ DENTINA. W.V. GLOS. Clifton, Stoke, Stapleton.

SOMERSET. Leigh Woods, Weston-super-Mare.

„ CHENOPODII. W.V. GLOS. Stapleton, Wotton-under-Edge.

SOMERSET. Weston-super-Mare. Scarce.

„ SUASA. W.V. GLOS. "Bristol."

SOMERSET. Leigh, Portishead, Weston. At sugar, &c. Not common.

HADENA OLERACEA. L. Abundant everywhere.

„ PISI. L. GLOS. Stapleton, Wotton, Woodchester. SOMERSET. Weston-super-Mare.

„ THALASSINA. B. GLOS. Bristol, Stapleton, Woodchester. SOMERSET. Bath, Leigh, Portishead, Weston-super-Mare. Sometimes common at sugar.

„ CONTIGUA. W.V. GLOS. Recorded only from Durdham Down, by Mr. Vaughan.

„ GENISTAE. B. GLOS. Durdham Down, Hortham Wood, Stapleton.

SOMERSET. Brislington, Leigh, Portishead. Not common.

XYLOCAMPA LITHORIZA. B. Generally distributed.

CALOCAMPA VETUSTA. H. GLOS. Almondsbury, Stoke Druid, Horfield.

SOMERSET. Weston-super-Mare. Scarce.

„ EXOLETA. L. Generally distributed, but scarce.

XYLINA RHIZOLITHA. W.V. Generally distributed.

„ SEMIBRUNNEA. H. Generally distributed, but not common.

„ PETRIFICATA. W.V. GLOS. Durdham Down, Westbury, &c.

SOMERSET. Bath, Brislington, Leigh, Wells, Weston-super-Mare. Not common.

CUCULLIA VERBASCI. L. Common, and generally distributed.

„ SCROPHULARIAE. W.V. GLOS. Mr. Perkins writes: "I found several larvae of this moth in June, 1868, feeding on *Scrophularia nodosa*, along the banks of my pond at Wotton-under-Edge, and though I have constantly searched for them, have not seen another since." Mr. Hill met with some larvae in his garden at Almondsbury.

„ LYCHNITIS. R. GLOS. I have lately, through the kindness of the Rev. H. Gates, been shown a specimen of this local species, captured by him near Woodchester, in August, 1879.

CULCULLIA CHAMOMILLAE. W.V. GLOS. Reported from Westbury, by Mr. P. H. Vaughan.

„ UMBRATICA. L. Generally distributed, but not common.

HELIOTHIS MARGINATA. F. GLOS. No records.

SOMERSET. Brislington, Weston-super-Mare. Not common.

„ PELTIGERA. GLOS. At Clifton, by Mr. Mayes.

„ ARMIGERA. H. GLOS. Clifton, Stapleton (?), Fishponds; Wotton-under-Edge, Aug. 29th, 1878.

SOMERSET. Brislington, Weston, Nr. Taunton, &c.

„ [DIPSACEA. L. GLOS. No records from my district, but taken by the Rev. E. H. Todd, on Cotswolds.]

„ SCUTOSA. W.V. SOMERSET. A fine specimen taken on the coast, near Weston-super-Mare, by Mr. Jones, of Redland, in August, 1876, is now in the rich collection of Mr. W. H. Grigg.

HELIODES ARBUTI. F. Generally distributed, and sometimes common.

ACONTIA LUCTUOSA. W.V. GLOS. Wotton-under-Edge "three specimens in July, 1870." V.R.P.; also near Tetbury Road, Oakley Woods, and on the Cotswolds.

SOMERSET. Weston-super-Mare.

ERASTRIA FUSCULA. W.V. GLOS. "Bristol" (?), Wotton-under-Edge, among coarse herbage in woods. V.R.P.

SOMERSET. Weston-super-Mare. Scarce.

Directions for finding the larvae of this species, on grass *(Molinia cærulea)*, will be found in "*The Entomologist*," VII., *p.* 185.

HYDRELIA UNCA. W.V. SOMERSET. Weston, by Mr. Crotch.

MICRA PARVA. H. SOMERSET. A specimen was captured on Brean Down some years ago, by the late Mr. Crotch.

BREPHOS PARTHENIAS. L. GLOS. No records.
SOMERSET. Birch Woods, at Leigh, and near Wells. Not common.

ABROSTOLA URTICAE. H. Generally distributed, but not common.

„ TRIPLASIA. L. Generally distributed.

PLUSIA ORICHALCEA. F. GLOS. A few specimens only, near Dursley, Woodchester, and Wotton-under-Edge, by Messrs. Phillips, Gates, and Perkins.—*See The Entomologist Vol.* XII, *pp.* 221-227. Mr. Perkins writes: "Nine specimens were found in 1868, but not one would come to sugar."

„ CHRYSITIS. L. Generally distributed.

„ FESTUCÆ. L. SOMERSET. One specimen taken at Brislington, by Mr. Grigg. Weston-super-Mare, by Mr. Crotch.

„ IOTA. L. GLOS. Almondsbury, Horfield, Redland, Westbury, Woodchester, Wotton-under-Edge.
SOMERSET. Bath, Brislington, Wells, Weston-super-Mare. Not generally common.

„ V-AUREM. G. Generally distributed, & sometimes abundant.

„ GAMMA. Abundant everywhere.

GONOPTERA LIBATRIX. L. Generally distributed.

AMPHIPYRA PYRAMIDEA. L. Common, and generally distributed.

„ TRAGOPOGONIS. L. „ „ „

MANIA TYPICA. L. „ „ „

„ MAURA. L. „ „ „

TOXOCAMPA PASTINUM. T. GLOS. No records.
SOMERSET. Weston-super-Mare. Not common.

[STILBIA ANOMALA. L. Not recorded from the Bristol District, but is not uncommon in North Devon.]

CATOCALA FRAXINA L. SOMERSET. A specimen of this very rare and beautiful moth, in rather worn condition, was taken at sugar in Leigh Woods, on Sept. 1st, 1880, by Mr. G. C. Griffiths, and was exhibited by him at the October meeting of the Entomological Section of our Society.—*See "The Entomologist," p.* 241.

„ NUPTA. L. Generally distributed, and sometimes common at sugar.

„ PROMISSA. W.V. GLOS. Used to be found round oak-trees in Over Park, Compton Greenfleld. P.H.V.

„ SPONSA. L. GLOS. Over Park P.H.V.

EUCLIDIA MI. L. Generally distributed, but local.

„ GLYPHICA. L. Generally distributed, but not common.

PHYTOMETRA AENEA. W.V. GLOS. Durdham Down, Woodchester, Wotton-under-Edge.
SOMERSET. Leigh, Clevedon, Weston-super-Mare. Common on heaths and downs.

The Fungi of the Bristol District.
PART 3.

BY CEDRIC BUCKNALL, Mus. Bac.

AMANITA.		
502. Agaricus strangulatus, *Fr.*	Leigh Wood,	Sept. 1879.
TRICHOLOMA.		
503. Agaricus murinaceus, *Bull.*	Stapleton Park,	Oct. ,,
504. ,, saponaceus, *Fr.*	Leigh Wood,	,, ,,
CLITOCYBE.		
505. Agaricus cerussatus, *Fr.*	Coombe Dingle	,, 1878.
506. ,, metachrous, *Fr.* ?	Glen Froome,	Nov. 1879.
PLEUROTUS.		
507. Agaricus tremulus, *Schaeff.*	Leigh Wood,	Oct. ,,
COLLYBIA.		
508. Agaricus confluens, *Pers.*	Tyntesfield,	July, ,,
509. ,, cirrhatus, *Schum.*	Leigh Down,	Oct. ,,
510. ,, xanthopus, *Fr.*	Brintry,	May ,,
MYCENA.		
511. Agaricus vulgaris, *Pers.*	Leigh Down,	Oct. ,,
512. ,, roridus, *Fr.*	Clifton,	May ,,

This species grew on dead bramble which had been kept in the water during the winter.

513. Agaricus sacchariferus, *B.&Br.?*	Leigh Down,	Oct. ,,

On dead furse, bracken, &c.—This is smaller and more delicate, and has fewer gills than an original specimen given me by Mr. Broome.—Entirely white. Pileus hemispherical, at length sulcate, clothed, as well as the stem and gills, with sparkling, glandular pubescence ; stem filiform, slightly dilated and hairy at the base ; gills adnate, broad, triangular--four to nine.

OMPHALIA.

514.	Agaricus atropunctus, *Pers.*	Haw Wood,	Oct. 1879.
*	Agaricus fibula, var. Swartzii, *Fr.*	Leigh Wood,	July ,,

This is evidently the plant described by Fries, but is so much like his figure of Ag. setipes as to make it doubtful whether they are not the same species, especially as he remarks that the latter is "too near" to Ag. fibula.

PLUTEUS.

515.	Agaricus nanus, *Pers.*	Stapleton Park,	July, 1879.
	,, var. lutescens.	,, ,,	Sept. ,,

ENTOLOMA.

516.	Agaricus sericellus, *Fr.*	Leigh Down,	Sept. ,,

CLAUDOPUS.

517.	Agaricus euosmus, *Berk.*	Glen Froome,	May ,,

LEPTONIA.

518.	Agaricus euchrous, *Pers.*	Haw Wood,	Oct. ,,

NOLANEA.

519.	Agaricus pascuus, *Pers.*	Leigh Down,	May ,,

INOCYBE.

520.	Agaricus fastigiatus, *Schaeff.*	Stapleton Park,	July ,,
521.	,, geophyllus, *var.* lateritius.	Leigh Wood,	,, ,,
522.	,, scabellus, *Fr.*	Durdham Down,	Sept. ,,

HEBELOMA.

523.	Agaricus longicaudus, *Pers.*	Leigh Down,	,, ,,

CREPIDOTUS.

524.	Agaricus mollis, *Schaeff.*	Leigh Wood,	July, 1878.
525.	,, rubi, *Berk.*	Brockley Coombe	,, 1879.

HYPHOLOMA.

526.	Agaricus sublateritius, *Schaeff.*	Stapleton Park,	Nov. ,,

The plant referred to this species in Part I. is Ag. epixanthus, *Fr.*

527.	Agaricus capnoides, *Fr.*	Tyntesfield,	Nov. ,,
*	,, epixanthus, *Fr.*	Sandy Lane,	Aug. 1877.

PSILOCYBE

528.	Agaricus cernuus, *Müll.*	Stapleton Park,	Sep., 1879.

529. Cortinarius (Phlegmacium) largus, *Fr.*	Leigh Down,	Oct.	1879,

This fine species was exhibited at the Hereford Fungus Meeting as new to Britain, about a fortnight before I found my specimens.

530. Cortinarius (Myxacium) Riederi, *Fr.*	Leigh Down,	Sep.	1879.

New to Britain. My specimens were named by Dr. Quelet at the Hereford Fungus Meeting.

531. Cortinarius (Telamonia) torvus, *Fr.*	Leigh Do.	Oct.	,,
* ,, ,, paleaceus, *Fr.*	,, ,,	,,	,,

This plant has been known for several years, but has only just been identified as the above species. It appears in Part II. as *Cort. diabolicus*, which is, therefore, incorrect.

532. Cortinarius (Hydrocybe) acutus, *Fr.*	Glen Froome,	Nov.	1879.
533. Hygrophorus eburneus, *Fr.*	Stapleton Park,	Oct.	,,
534. ,, russocoriaceus, *B. & Br.*	Leigh Down,	Nov.	,,
535. Hygrophorus puniceus, *Fr.*	Clifton Down,	Oct.	,,
536. Lactarius blennius, *Fr.*	Stapleton Park,	Sep.	,,
537. Russula furcata, *Fr.*	,, ,,	,,	,,
* ,, Queletii, *Fr.*	Near Failand,	Nov.	1877,

The plant referred to. *R. rubra* in Part I. proves to be this species.

538. Russula emetica, *Fr.*	Stapleton Park,	Sep.	1879.
539. Cantharellus cupulatus, *Pers.*	Tyntesfield,	Nov.	,,
540. Marasmius foetidus, *Fr.*	Haw Wood,	Oct.	,,
541. ,, androsaceus, *Fr.*	Leigh Wood,	July	,,
542. Boletus elegans, *Schum.*	Tyntesfield,	,,	,,
543. Polyporus squamosus, *Fr.*	Shirehampton Park,	June,	1879.
544. ,, chioneus, *Fr.*	Leigh Wood,	Nov.	,,
545. ,, fraxineus, *Fr.*	Shirehampton Park,	June,	1879.

546.	Trametes suaveolens, *Fr.*	Henbury,	Oct. 1879.
547.	„ serpens, *Fr.* (On pine bark.)	Ashton,	Sep. „
548.	„ Stephensii, *B. & Br.*	Leigh Wood,	Oct. „
549.	Daedalea unicolor, *Fr.*	Henbury,	„ „
550.	Hydnum ferruginosum, *Fr.*	Stapleton Park,	July „
551.	„ udum, *Fr.*	„ „	„ „
552.	„ farinaceum, *Pers.*	Leigh Wood,	Dec. 1877.
553.	„ niveum, *Pers.*	„ „	Nov. 1879.
*	Thelephora laciniata, *Pers.*	Leigh Down,	Oct. „

A small specimen was referred to *T. mollissima* in Part II., which, on comparison, proves to be the present species.

554.	Phlebia vaga, *Fr.*	Haw Wood,	Oct. 1879.
555.	Corticium incarnatum, *Fr.*	Leigh Wood,	May, 1880.
556.	Clavaria abietina, *Pers.*	Tyntesfield,	Nov. 1879.
557.	„ juncea, *Fr.*	Leigh Down,	Oct. „
558.	Typhula erythropus, *Desm.*	Leigh Wood,	„ „
559.	Tremella epigaea, *B. & Br.*	„ „	„ „
560.	Octaviana compacta, *Tul.*	„ (C.E.Broome, Esq.)	„
561.	Hymenogaster vulgaris, *Tul.*	„ „	„ „
562.	„ tener, *Berk.*	„ „	„ „

The following is a list of all the species of *Myxomycetes* which I have met with in this district, arranged according to the method of Rostafinski. It is impossible to determine these plants correctly without attending to the microscopical characters which he gives; *Didymium nigripes, Fr. D. hemisphaericum, Fr. D. farinaceum, Fr. Stemonitis typhoides, D.C. Trichia turbinata, With. T. chrysosperma, D.C.* and *Licea cylindrica, Fr.* must therefore be erased from the former lists.

*	Badhamia hyalina, *Pers.*	Leigh Wood,	Apr. 1877.
*	„ utricularis, *Bull.*	Stapleton Park,	Nov. 1878.
*	Physarum cinereum, *Batsch.*	Ashley Hill,	Apr. 1879.
563.	„ leucophaeum, *Fr.*	Clifton,	May, 1878.
564.	Fuligo varians, *Sommf.* var *a.* ecorticata, var. B. strata floccosa.	Stapleton Park,	Autumn, 1879.

565.	Craterium minutum, *Leers.*	Clifton Down,	Oct. 1876.
566.	Leocarpus fragilis, *Dicks.*	Leigh Wood	,, ,,
*	Tilmadoche nutans, *Pers.*	,, ,,	Apr. 1878.
567.	,, mutabilis, *Rtfki.*	Tyntesfield,	July, 1879.
*	Didymium squamulosum, *A.&S.*	Westbury,	Mar. 1877
*	Spumaria alba, *Bull.*	Leigh Woods,	Oct. 1878.
*	Comatricha Friesiana, *D. By.*		
	var. *a.* obovata.	,, ,,	Jan. ,,
	var. B oblonga.	Brockley Coombe,	1878.
*	Stemonitis fusca, *Roth.*	Leigh Wood,	May, 1878.
*	Brefeldia maxima, *Fr.*	Shirehampton Park,	Nov. ,,
*	Enerthenema papillata, *Pers.*	Leigh Wood,	Spring, ,,
*	Clathroptychium rugulosum, *Wall.*	,, ,,	Dec. 1877.
568	Dictydium cernuum, *Pers.*	Stapleton Park,	July, 1879.
*	Cribaria intricata, *Schrad?*	Leigh Wood,	,, 1877.
*	Reticularia lycoperdon, *Bull.*	,, ,,	April ,,
*	Cornuvia metallica, *B. & Br.*	,, ,,	,, ,,
*	Arcyria punicea, *Pers.*	Stapleton Park,	Dec. 1878.
569.	,, pomiformis, *Roth.*	Leigh Wood	June, 1879.
570.	,, cinerea, *Bull.*	,, ,,	,, ,,
571.	,, incarnata, *Pers.*	,, ,,	,, ,,
*	,, nutans, *Bull.*	,, ,,	July, 1878.
*	Lycogala epidendrum, *Bux.*	,, ,,	Dec. 1877.
*	Trichia fallax, *Pers.*	Leigh Wood,	Nov. 1878.
*	,, varia, *Pers.* var. genuina,	Stapleton Park,	Dec. ,,
572.	,, scabra, *Rost.*	,, ,,	,, ,,

The *Trichia* from Leigh Wood, referred to *T. chrysosperma* in Part II., is certainly not that species, nor does it agree well with T. scabra ; the elaters are narrower and not echinulate, and the warted spores are slightly larger.

573.	Hemiarcyria rubiformis, *Pers.*	Stapleton Park,	Sep. 1879.

574.	Crucibulum vulgare, *Tul.*	Abbot's Leigh,	Apr. 1880.
575.	Phoma concentricum, *Desm.*	Cotham (A. Leipner, Esq.)	Apr. 1880.
576.	Dothiora sphaeroides, *Fr.*	Leigh Wood	„ 1879.
577.	Diplodia vulgaris, *Lev.*	Glen Froome,	May, 1878.
578.	„ herbarum, *Lev.*	The Avon,	Mar. 1880.
579.	Hendersonia corni, *Fckl.*	The Gully,	Feb. „
580.	Discosea alnea, *Lib.*	Leigh Down,	Oct. 1879.
581.	Discella microsperma, *B. & Br.*	The Gully,	Feb. 1880.
582.	Coryneum microstictum, *B& Br.*	„	„ „
583.	Dictyosporium elegans, *Corda.*	Leigh Wood,	Apr. 1879.
584.	Puccinia arundinacea, *Hedw.*	The Avon,	„ 1880.
585.	„ polygonorum, *Link.*	Ashton,	Sep. 1879.
586.	Coleosporium rhinanthacearum, *Lev.*	Durdham Down,	July, 1878.
587.	Melampsora betulina *Desm.* (winter spores).	Leigh Wood,	Nov. 1879.
588	Aecidium rubellum, *Pers.*	The Avon,	May, 1880.
589.	Pachnocybe subulata, *Berk.*	Leigh Wood,	July, 1879.
590.	Helminthosporium subulatum, *Nees.*	„ „	Dec. 1877.
591.	„ velutinum, *Link.*	Abbot's Leigh,	Apr. 1880.
592.	„ delicatulum *Berk.*	West Town,	May, 1879.
593.	Macrosporium concinnum, *Berk,*	The Gully,	Feb. 1880.
594.	Gonatosporium puccinioides, *Corda.*	The Avon,	Mar. „
595.	Aspergillus virens, *Link.*	Leigh Wood,	1878.
596.	Fusidium flavovirens, *Fr.*	„ „	Oct. 1879.
597.	Sepedonium chrysospermum, *Link.*	Leigh Down,	„ „
598.	Pilacre Petersii, *B. & Curt.*	Tyntesfield,	Nov. „

599.	Sphaerotheca pannosa, *Lev.*	Clifton Down,	Summer, 1878.
600.	Cephalotheca sulphurea, *Fckl.*	Henbury, (C. H. Sp. Perceval, Esq.)	Oct. 1879.
601.	Morchella crassipes, *Pers.*	Brockley Coombe,	May, 1879.
602.	Vibrissea turbinata, *Ph. in MS.*	Abbot's Leigh,	Apr. 1880.
603.	Geoglossum glabrum, *P.*	Tyntesfield,	Nov., 1879.
604.	„ hirsutum, *P.*	„	„ „
605.	Peziza macropus, *Pers.*	„	July, „
606.	„ reticulata, *Grev.*	Brockley Coombe,	May, „
607.	„ succosa, *Berk.*	Leigh Woods, Haw Wood,	Sep., „ Oct., „
608.	„ vesiculosa, *Bull.*	Leigh Down,	May, „
609.	„ cupularis, *L.*	Brockley Coombe,	„
610.	„ granulata, *Bull.*	Shirehampton Park,	June, „
611.	„ (Humaria) misturae, *Phillips.* n.s.	Cotham (A. Leipner, Esq.)	Apr., 1880.

Crowded or scattered, sessile, concave when dry, applanate when moist, submarginate, chestnut-brown, glabrous; asci cylindraceo-clavate; sporidia 8, subglobose, smooth, with one large nucleus, ·014 – ·016 × ·011 – ·012 m.m.; paraphyses from one to six times branched, summits proliferously pyriform, or moniliform, or only slightly enlarged.

On a mixture of lime and cow-dung spread on apple trees.

The cups are ½ to 3 m.m. across; the paraphyses are remarkable for their proliferous growth. The cells of the exterior of the cup are small, and oblong rather than globose.

This will be published by Mr. Phillips in his next fasciculus of *Elvellacei Britannici.*

612.	Peziza umbrata, *Fr.*	Leigh Wood,	July, 1879.
613.	„ bicolor, *Bull.*	Brockley Coombe,	May, „
614.	„ cerina, *P.*	Stapleton Park,	June, „

615. „ Schumacheri, *var.* plumbea, *Fr.* Near Brockley Coombe, May, 1879.

616. „ brunneola, *Desm.* Brockley Coombe, May, „

On beech mast and leaves. Mr. Phillips, to whom I am indebted for much valuable assistance, tells me that this *Peziza* has hitherto been met with only on oak leaves. I also found it on beech mast, near Rouen, last year.

617. Peziza trichodea, *Phillips*, Clifton Down, Oct., 1879.

618. „ solfatera, *C. & E.* „ „ July, „

New Jersey Fungi, Grevillea, vii., p. 7. On pine leaves. New to Britain.

619. Peziza pellita, *Pers.* Brockley Coombe, May, „

On beech mast. New to Britain.

620. Peziza aspidiicola, *B. & Br.* Leigh Down, June, „

On dead stems of *Pteris aquilina.*

621. Peziza (Dasy. Sess.) araneo-cincta *Phillips*, N.S. „ „ Autumn, 1879.

Scattered, minute, sessile, concave, thin, pale yellow, margin fringed with long, slender, flexuous, pointed, white hairs; asci broadly clavate; sporidia 8, biseriate, narrowly fusiform, acutely pointed, ·01 – ·013 × ·001 – ·0015 m.m.

On decayed birch leaves.

Cups ·2 – ·3 m.m. across. The hairs are without septa, and so delicate that they are diffluent in water, with only slight pressure.

This will be published by Mr. Phillips in his next fasciculus of Elvellacei Britannici.

622. Peziza domestica, *Sow.* Clifton, Feb., 1880.

On wall paper in a house in which a cistern had overflowed about a fortnight previously.

623. Peziza vinosa, *A. & S.* Leigh Wood, Aug., 1879.

624. „ erumpens, *Grev.* „ „ May, „

625. „ atrata. *Pers.* „ „ June, „

626. „ inflatula, *Karst.* { Leigh Wood, 1878. Stapleton Park, June, 1879.

New to Britain.

627. Peziza punctoidea, *Karst* Portbury, June, „

628. Peziza pulla, *Ph. & K.*, *Belonidium pullum*, *Grevillea*, vi., p. 75.	The Avon,	May, 1880.
629. Helotium aeruginosum, *Fr.*	Leigh Wood,	May, ,,
630. ,, citrinum, *Fr.*	Haw Wood,	Oct., 1879.
631. ,, pruinosum, *Jerd.*	Leigh Wood,	Feb., 1880.
632. ,, epiphyllum, *Fr.*	Leigh Down,	Oct., 1879.
633. Patellaria atrata, *Fr.*	Nailsea,	July, ,,
634. ,, proxima, *B. & Br.*	Near the Avon,	Nov., ,,
635. ,, olivacea, *Batsch.*	Stapleton Park,	June, ,,
636. ,, lignyota, *Fr.*	Leigh Wood,	Apr., 1877.
637. Tympanis fraxini, *Schm.*	,, ,,	Feb., 1880.
638. Dermatea dryina, *C.*	,, ,,	Dec., 1878.
639. Ascobolus furfuraceus, *Pers.*	Stapleton Park,	Apr, 1880.
640. ,, granuliformis, *Crouan*,	,, ,,	,, ,,
641. ,, (Thecotheus) Pelletièri, *Crouan.*	Clifton,	Mar., ,,

This species appeared under a bell-glass on soil containing a small *Coprinus*, which had been brought from Glen Froome, in the autumn of last year.

642. Ascobolus (Ascophanus) lacteus, *C. & Ph.*	Stapleton Park,	Apr. 1879.
643. Stictis versicolor, *Fr.*	Leigh Wood,	May, 1880.
644. Hydnobolites cerebriformis, *Tul.*	,, ,,	Oct. 1879.
645. Hysterium angustatum, *A. & S.*	Durdham Down,	Mar. ,,
646. Nectria episphaeria, *Fr.*	Leigh Wood,	Apr. ,,
647. Xylaria digitata, *Grev.*	Stapleton Park,	June, ,,
648. Eutypa Acharii, *Tul. ?*	Beggars' Bush Lane,	Feb. 1878
649. ,, scabrosa, *Fckl.*	Leigh Wood,	Apr. 1879.
650. Diaporthe spiculosa, *Pers.*	Portbury,	June, ,,
651. ,, scobina, *Nke.*	Near Brockley Coombe,	May, 1879.

652.	Diaporthe pantherina, *Berk.*	Leigh Wood,	Apr. 1879.
653.	Diatrype aspera, *Fr.*	Shirehampton Park,	Jan. 1878.
654.	„ verrucaeformis, *Fr.*	Leigh Wood,	Feb. 1877.
655.	„ angulata, *Fr.*	Stapleton Park,	Mar. 1880.
656.	„ ferruginea, *Fr.*	Leigh Wood,	Jan. „
657.	Melanconis chrysostoma, *Tul.*	„ „	Mar. „
658.	Valsa controversa, *Fr.*	„ „	Jan. „
659.	„ ceratophora, *Tul.*	„ „	„ „
660.	„ ambiens, *Fr.*	The Gully,	Feb. „
661.	„ quaternata, *Fr.*	Stapleton Park,	Mar. „
662.	„ leiphemia, *Fr.*	Leigh Wood,	Jan. „
663.	„ circumscripta, *Mont.*	Near the Avon,	Mar. „
664.	Massaria siparia, *Tul.*	Leigh Wood,	Feb. 1877.
665.	Ceratostoma ampullasca, *Cooke.*	„ „	„
666.	Byssosphaeria aquila, *Fr.*	Shirehampton,	June, 1879.
667.	Psilosphaeria pulveracea, *Ehr.*	Stapleton Park,	July, „
668.	Lasiosphaeria ovina, *Pers.*	Leigh Wood,	Apr. „
669.	Sordaria coprophila, *Fr.*	Stapleton Park,	„ „
670.	„ platyspora, *Ph. & P.*	Leigh Down,	May „
671.	Sporormia intermedia, *Awd.*	„ „	Apr. „
672.	Conisphaeria pertusa, *Pers.*	Sandy Lane,	May, 1878.
673.	Xylosphaeria melanotes, *B & Br.* On a willow stick.	Leigh Wood,	Mar. 1880.
674.	Sphaeria fraxinicola, *Curr.*	Brockley Coombe,	May, 1879.
675.	„ millepunctata, *Grev.*	Leigh Wood,	Apr. 1878.
676.	„ salicella, *Fr.*	Near Brockley Coombe,	May, 1878.
677.	„ appendiculosa, *B. & Br.*	Leigh Road,	Apr. 1880.
678.	„ palustris, *B. & Br.*	The Avon,	May, 1880.
679.	„ ulnaspora, *Cooke.*	West Town,	„ 1879.
680.	„ agnita, *Desm.*	The Avon,	„ 1880.

681. Sphaeria complanata, *Tode.*	Shirehampton Park,	June,	1879.
682. ,, nigrans, *Desm.*	Portbury,	,,	,,
683. ,, tosta, *B. & Br.*	Coombe Dingle,	May,	,,
684. ,, infectoria, *Fckl.*	The Avon,	Mar.	1880.
685. Sphaerella oblivia, *Cooke.*	Brockley Coombe,	May,	1879.
686. ,, latebrosa, *Cooke.*	Leigh Wood,	,,	,,
687. ,, carpinea, *Fr.*	,, ,,	,,	,,
688. ,, errabunda, *Gonn & Rabh.*	Brintry,	,,	,,

On beech leaves. New to Britain.

689. Gnomonia setacea, *Pers. var.* petiolae.	Leigh Wood,	May,	,,

The Pomarine Skua.

By H. CHARBONNIER.

Six specimens of Lestris Pomatorhinus (Tem.)—The Pomarine, or Pomatorine, Skua, obtained in November, 1879, were exhibited.

No. 1,	shot at the New Passage.		
2 & 3,	,,	Clevedon.	
4 ,, 5,	,,	Filey.	
6	,,	Scarborough.	

Several other specimens were obtained in the neighbourhood, one at Chew Magna and two more at Clevedon. The plumage was singularly varied, no two being alike. Nos. 5 and 6 were birds of the year, in the barred stage, and with the centre tail feathers projecting half-an-inch beyond the others; Nos. 2, 3, and 4 were old birds, with more, or less, of white on the breast and pale yellow on the sides of the head. The centre tail feathers were unfortunately broken off short in these three specimens. No. 1 was in the intermediate stage, upper parts brown, throat, breast, and tail coverts, white barred with brown, a faint tinge of yellow on the sides of the head, and the centre tail feathers *two and-a-half inches* longer than the others.

L. Pomatorhinus closely resembles L. Richardsonii in some of its stages, but can always be distinguished on accurate measurement by its superior size. Like the rest of the Skuas these birds are predaceous in habit, living by plundering the Gulls and other birds of their prey. They are rare in England; and I have never heard of their occurrence within our district before. They are possessed of great powers of flight, and range over a vast area, their utmost northern range is 82° N. lat., from thence they extend as far south as Cape York, in Australia, Alaska and Pennsylvania, in America, they also occur in Africa and in Japan. Middendorf found them breeding in Siberia, and they are also believed to breed in Greenland.

It is very singular that a large proportion of the specimens obtained had the centre tail feathers broken, and broken *shorter*, in some cases, by an inch or more than the other tail feathers, which latter were quite perfect. The only way I can account for this is by supposing that these feathers are broken by the tail being violently rubbed on the ground *when fully expanded.* The outline of the tail would then be a semi-circle, and the central radii of the arc could then be rubbed or broken off *shorter* than the rest, without these latter being injured. I may add that I have seen feathers so broken in poultry.

Rainfall at Clifton in 1879.

BY GEORGE F. BURDER, M.D., F.M.S.

TABLE OF RAINFALL.

	1879.	Average of 25 years.	Departure from Average.	Greatest Fall in 24 hours.		Number of days on which ·01 in. or more fell.
				Depth.	Date.	
	Inches.	Inches.	Inches.	Inches.		
January	4·307	3·462	+0·845	1·571	1st	11
February... ...	3·921	2·120	+1·801	0·540	20th	22
March	1·102	2·247	−1·145	0·242	30th	13
April	2·863	2·057	+0 806	0·555	23rd	14
May	3·218	2·284	+0·934	1·055	28th	18
June	5·145	2·441	+2·704	0·616	30th	24
July...	3·669	2·783	+0·886	0·603	19th	20
August	7·319	3·404	+3·915	1·243	16th	21
September ...	3.906	3·414	+0·492	0·661	8th	19
October	1·276	3·646	−2·370	0·305	19th	11
November ...	0·586	2·749	−2·163	0·180	11th	8
December ...	1·345	2·711	−1·366	0·541	30th	8
Year	38·657	33·319	+5·338	1·571	Jan. 1st.	189

REMARKS.—The year 1879 was characterised by a total rainfall considerably in excess of the average, notwithstanding that the three last months of the year were remarkably dry. The extraordinary succession of rainy years with which we have been visited since 1872, will be seen by a reference to the following table:

RAINFALL OF EIGHT YEARS.

Year.	Rainfall.	Departure from Average of 25 years.
	Inches.	Inches.
1872...	42·366	+ 9·047
1873...	32·069	− 1·250
1874...	35·248	+ 1·929
1875...	44·047	+ 10·728
1876...	42·415	+ 9·096
1877...	38·230	+ 4·911
1878...	38·019	+ 4·700
1879...	38·657	+ 5·338
Mean of 8 years.	38·881	+ 5·562

It will be noticed that of the last eight years one only has shown a deficiency, all the rest an excess. The deficiency in 1873 was trifling, the excess in most of the other years was large. The largest excess was in 1875, which was the wettest year ever observed at this station the total downfall being over 44 inches. In 1872 and 1876 the fall, was also exceedingly large, each of those years yielding upwards of 42 inches of rain. For the whole period of eight years the annual mean has been nearly 39 inches, and the mean annual excess, more than five and a half inches.

The rainiest month in 1879 was August, with 7·319 inches—a monthly total which has only twice been exceeded within the period of observation. The driest month was November, with 0·586 inch. October, November, and December, were all very dry, the aggregate of the three months being no more than 3·207 inches—a quantity much less than has ever before been recorded in the same three months.

The heaviest diurnal fall in 1879 was on the 1st of January, when the rain and melted snow measured together 1.571 inches.

The principal snow-storm of the year occurred on the 7th of January, when the average depth of snow was 5 inches, and drifts were formed in exposed situations to a depth of 3 or 4 feet.

REPORT.

THE Council of the Bristol Naturalists' Society, in presenting their Annual Report, cannot but refer, in the first place, to the heavy loss the Society has sustained by the recent death of its president, Dr. Henry Edward Fripp. Dr. Fripp had been connected with the Society from its commencement, and had been president since the year 1876, when he was elected to that office in succession to the late Mr. William Sanders. He died from an attack of apoplexy on the 23rd of March, after a few hours' illness. Dr. Fripp was born in 1816, and passed through his curriculum of medical education at the Bristol Medical School, being a pupil of the late Dr. Symonds, at the General Hospital. Becoming a member of the Royal College of Surgeons in 1838, he began practice in Wales as medical officer to the iron works at Yniscedwyn, near Swansea. Shortly afterwards he went to Germany as medical officer to the iron works at Nisterthal, in the Duchy of Nassau. By nature a mechanical genius, Dr. Fripp took so great an interest in these works, that, in addition to his professional responsibilities, at the request of the directors, he accepted the office of chief engineer, and held his post till 1848, when the works were closed owing to disturbances consequent upon the unsettled state of the political atmosphere. After this, Dr. Fripp spent some years on the Continent, in medical and scientific study and research, and in 1855 took the degree of M.D. at Würtzburg. Returning to England, he obtained, in 1856, the diploma of membership of the Royal College of Physicians of London, and settled in Clifton as a physician. In 1859 he was elected physician to the Bristol General Hospital, and in 1873, on retiring from the more active duties, he was appointed consulting physician to that institution.

He occupied the chair of physiology in the Bristol Medical School from 1857 to 1869. Dr. Fripp was an industrious worker in science, both medical and general. The published proceedings of our own Society contain many valuable contributions from his pen, several of them relating to microscopy, and others to insect anatomy. The Bristol Microscopical Society also benefited by his labours, his knowledge of the microscope, both in regard to its theory and its practical use, being most intimate and complete. During the year 1878-79, he was president of the Bristol Medico-Chirurgical Society, and his inaugural address, which was published by request, was a learned dissertation on "The Doctrine of Contagium Vivum in its relation to Parasitic Disease." Dr. Fripp was an ardent lover of music, and was himself an accomplished musician. As illustrating both his musical and mechanical skill, it may be mentioned he possessed an organ which he had himself built. As a physician, Dr. Fripp was held in the highest regard both by the members of his own profession and by his patients. Of sound judgment, fertile in resources, and full of tender sympathy, he won both confidence and love. Passing from this brief record of the life and work of our lamented president, the Council regret to have to report the removal from the neighbourhood of some valued members. Professor Letts, F.R.S.E., has been appointed to the chair of chemistry at Queen's College, Belfast, and Dr. Tildon (whom the council congratulate on his newly-acquired distinction of F.R.S.) has accepted a similar appointment at Birmingham. Mr. J. Norman Collie, who had also given promise of good service to the Society, has followed Prof. Letts to Belfast. Altogether the losses to the society by resignation, removal, or death have numbered, during the year, sixteen; but as seventeen new members have joined, our numerical strength has been somewhat more than maintained. The total number of members is at present 169. During the past session, the General and Sectional Meetings of the Society have been held as usual.

The attendance at the General Meetings has been less numerous than could be wished, averaging nineteen members and nine visitors. In consequence of the unsettled state of the weather, it was not thought expedient to organise any general excursion last summer. The Botanical Section, however, pursued their work with little interruption, taking weekly rambles during the greater part of the season, and working up the botany of the district with a view to the publication of a local "Flora" The Council are pleased to report that, by an arrangement with the Council of the Museum and Library, a number of additional shelves have been secured for the Society's Library, the books of which will now, it is hoped, be more accessible to members than they have hitherto been. The Financial Statement, which the Council presents herewith, shows the finances of the Society to be in a satisfactory condition. Owing to the exertions of the honorary treasurer in collecting arrears of subscriptions, the balance in hand is considerably larger than at the corresponding period of last year.

Balance Sheet, from 1st May, 1879, to 30th April, 1880.

CAPITAL ACCOUNT.

1878. May 22.	By Cash Invested in Hand and Hand Building Society	£10 0 0

GENERAL ACCOUNT.

		£	s.	d.
1879.	To Balance brought forward	17	0	8
	,, Subscriptions to 1st May, 1880	64	10	0
	,, Arrears paid	25	15	0
	,, Interest on Investment	0	10	0
		£107	15	8

	£	s.	d.
Arrears for 1879	14	5	0
Previous Arrears	1	10	0
	£15	15	0

		£	s.	d.
1879. June 26.	By Museum Custodian	1	1	0
,, ,,	,, Donation to Museum	10	10	0
Aug. 20.	,, Hemmons, Proceedings	40	0	0
1880. Jan.	,, Morgan, Stationery	1	0	6
	,, Hemmons, Notices	5	11	0
April	,, Postage, Hon. Treas	0	10	0
Expenses of Hon. Sec.	,, Notices—General and Council Meetings	3	5	2
	,, Postage of Proceedings	2	15	3
	,, Post Cards and Stamps	1	10	4
	,, Stationery	0	6	4
	,, Printing	0	8	6
	,, Carriage for Book Parcel	0	7	8
	,, Assistant Secretary	8	0	0
	,, Balance	32	9	11
		£107	15	8

LIBRARY ACCOUNT.

		£	s.	d.
	To Balance brought forward	12	5	4
	,, Donation to 1st May, 1880	2	0	6
	,, Entrance Fees	2	15	0
		£17	0	10

		£	s.	d.
1879. Nov. 22.	By Zoological Record	1	0	0
	,, New Doors to Library	2	5	6
	,, Kerslake, Binding	2	9	0
	,, Balance	11	6	4
		£17	0	10

DONATIONS TO THE LIBRARY.

	£	s.	d.
Braikenridge, Rev. J. W.	1	0	0
Derham, James	0	2	6
Derham, Samuel	0	2	6
Derham, Walter	0	2	6
Stuckey, Samuel	0	2	6
Thomas, Herbert	0	10	6
	£2	0	6

Examined the above Account, and found the same correct.

F. V. JACQUES,
ALFRED E. HUDD.

6th May, 1880.

REPORTS OF MEETINGS.

Geological Section.

Last year, owing to the very wet season, nearly all the excursions fell through. Only one was actually taken, which was to Dundry, on July 9th, but, unfortunately, the day proved very boisterous and rainy, so that but little work was done.

Report of Entomological Section, 1879.

During the summer, owing to the long continued wet weather, only one excursion was taken, to Brockley, in June.

At the November Meeting of the Section Mr. HUDD exhibited a box of *Lepidoptera* taken near Stroud, by the REV. R. S. GATES, which contained, among other things, three species not recorded as having occurred in the Bristol District—*viz. Lithosia Aureola, Cleora Glabraria, and Cucullia Lychnitis.*

At the December Meeting Mr. ROSS exhibited fine varieties of *Polyomatus Corydon*, and a very singular hermaphrodite specimen of *P. Ægon*, the wings being distinctly of the male and female forms on opposite sides.

Mr. FICKLIN also exhibited a number of specimens of a new species of the *Genus Eupithesia* bred from *Larva* captured by himself in North Devon.

At the January Meeting of the Section Mr. GRIGG exhibited a box containing a fine set of *Drepana sicula*, with living *pupa*, and drawings of the *larva*, and read a short paper showing that the life history of this interesting species had been now worked out. He also exhibited a specimen of *Heliothis Scutosa*, interesting, not only on account of its excessive rarity in England, but also from having been captured in the borders of the Bristol District.

Many interesting exhibitions of foreign and exotic *Lepidoptera and Coleoptera* were also shown at the different meetings of the Sections.

GEORGE HARDING, *Hon. Sec.*

Annual Report of the Botanical Section of the Bristol Naturalists' Society, 1879.

The prevalence of wet weather during the spring and summer caused the failure of much of the out-door work undertaken by the Section, and some of the weekly excursions were abandoned on this account. Good progress has been made however in preparing the MSS. of the *Flora* of the Bristol Coal-Fields.

In response to circular invitations issued by the Hon. Sec., a great deal of valuable material in notes and records has been furnished by the members of the Section, and much, also, by naturalists in the outlying portions of the district. This is now in process of examination and arrangement.

The Sectional Meetings during the winter months have chiefly been devoted to the study of Structural Botany, under the able direction of the President.

Physical and Chemical Section.

The following communications have been made to the Section during the year :—

Oct. 28th, 1879.

Dr. G. S. Thomson.—" On Hughes' Induction Balance."

W. L. Carpenter, Esq., B.A., B.Sc.—" Some Observations on the Teaching of Physics and Chemistry in Canada and the United States."

Dec. 2nd, 1879.

Dr. G S. Thomson—" On Crossley's Carbon Transmitter."

Francis J. Fry, Esq.—"On Mr. Crooke's Recent Researches on Radiant Matter."

Jan. 29th.

Mr. A. M. Worthington, M.A.—" The Splash of a Drop."

April 27th.

Professor W. Ramsay, Ph.D., F.R.S.E.—" On the Cohesion of Liquids."

Dr. G S. Thomson.—" On Balmain's Luminous Paint."

Professor P. S. Thompson, D.Sc.—" On the Audiphone."

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NEW SERIES, VOL. III., PART II.

On the Breathing Apparatus of Aquatic Larvæ.

By W. J. FULLER, F.C.S.

THE object of the following Paper is to lay before the Society one or two peculiarities which I have noticed in the breathing apparatus of some aquatic larvæ. The first to be considered are the *Libellulidæ*, and then a short sketch of *Corethra* and *Chironomus* will follow.

The larvæ of the *Libellulidæ* are very interesting creatures, though they are sluggish in their movements; some (*e. g. Æschna* and *Agrion*) perch all day on aquatic plants; others (*e. g. Libellula*) bury themselves in the mud up to their eyes and stay perfectly motionless till some unsuspecting water shrimp or *Daphne* comes swimming near them, when the *labium* (which is formed to work like a man's arm, the shoulder being attached to the chin, and the hand extending over the lower part of the face when at rest) is suddenly extended, and the unfortunate shrimp is caught in the hand-like extremity and conveyed to the mouth.

The larvæ can, however, move moderately fast if frightened, and they do this by drawing water into a sac, which is situated in the caudal extremity of the abdomen, and expelling it by contraction of the abdominal rings, thereby propelling themselves an inch or two forward, and repeating this, they progress with a jerky movement. That this is really the mode of progression may be seen by placing them in a glass of water with a little sand at the bottom, when the effect of the jet from the tail is easily observed, the sand being spirted up at every movement of the animal.

It is within this sac that the breathing organs of *Æschna*, *Libellula*, and *Calopteryx* are situated, but to study the disposal of them it is necessary that the larva should be dissected. To do this it is best to fix the animal on its back, and open the abdomen all round the lateral seam with curved scissors, taking great care not to injure any of the internal organs in so doing; then turn back the skin and cut it off close to the thorax; having done this, the disposition of the intestines, trachea, and respiratory sac may be observed with the greatest facility.

First, close to the thorax is the stomach, leading into the small intestines, to which are attached the peculiar filamentous bodies which are generally called "Biliary canals"; further on the large intestine, and then the *sphincter ani;* this opens into the breathing sac at its anterior extremity, and all fœcal matter on passing into this sac is instantly discharged at the posterior valve by a rapid contraction of the abdomen, similar to that by which the animal propels itself through the water.

Thus it will be noticed that this sac is not identical with the large intestine, as stated by Dr. Duncan and others, but is supplementary; the real *sphincter ani* being situated at its anterior extremity.

In the case of *Agrion*, however, this sac is altogether wanting, so far as I have been able to observe, and the quick movement which it makes when escaping an enemy, is managed by means of three broad leaf-like appendages situated on the end of the tail; these are spread out, somewhat like a chestnut leaf, and suddenly are brought together backwards, thus acting as paddles in sending the insect through the water; these appendages are strongly keeled, to give them more power of resistance.

If these plates be examined, it will be found that they are filled with *trachea* ramifying over the whole surface, and it is by means of these *trachea* that the animal breathes, by taking the oxygen from the surrounding water and giving off the carbonic acid gas which has been produced by circulation.

These plates are connected with the tracheal system of the body as follows. As in most other larvæ there is one leading tracheal canal running down either side of the body; this, on arriving at the last segment of the abdomen, splits in two, the lower half passing into the leaf-like plate on that side, and the upper half, together with the upper half of the other side, passing into the upper plate; the third plate being supplied from the lower branch of that side.

Thus there is no real circulation of the air in the trachea; diffusion probably being sufficient to renew the air as fast as it becomes vitiated.

So here we have *Agrion* with three external breathing plates situated on the eleventh segment of the abdomen, and on the ninth there are five small pointed plates, three on the belly and one on either side, which, according to Burmeister, are the seat of the male organs of generation in the perfect insect. I shall call attention to these after speaking of some of the other allied larvæ.

In the case of *Calopteryx* the sac which I mentioned above also occurs; and, on dissecting it, there will be found three plates, similar to those of *Agrion*, within it, affixed to the innermost extremity and surrounding the anal orifice.

The water for aeration is admitted through the valve in the extremity of the abdomen, and is expelled by the flattening of the rings containing the sac.

Thus we have *Calopteryx* with three plates situated internally, but in all other respects similar to those of *Agrion;* that is, they are fixed on the circle surrounding the anus, but the anus is internal.

Libellula has the breathing apparatus still more developed;

like *Calopteryx,* the Branchial plates are enclosed in an internal sac, but the three large plates are replaced by about three hundred much smaller ones, which are arranged most symmetrically in six rows; each row having the appearance of being double, owing to the plates laying first on one side and next on the other, giving to each row very much the appearance of an acacia leaf with its leaflets.

These rows are connected with the general trachea by quite an extensive system of small branches. First, there are two tubes which supply the intestines, &c.; these are connected with the two lower rows of *branchiæ,* each tube running the whole length of a row, and throwing off branches *en route,* but upon the outside of the sac. Then there are the two large trachea running the whole length of the body, and supplying head, legs, and embryo wings; these are connected with the four upper rows of plates, each tube passing down outside two rows of plates and sending out branches to the individual *branchiæ.* These branches, on entering the plates, sub-divide into the minutest threads which entirely fill the space between the thin walls, and thus offer a comparatively enormous surface for aeration.

In *Æschna* the same apparatus is present in all its details, the only difference being in the shape of the plates. This sac is closed by three semicircular plates, closing partly over each other, and situated in the extremity of the abdomen, being protected by five pointed plates which open and close at will, and assist in making the propulsive jet more effectual by concentrating it.

These five pointed plates are situated on the ninth segment of the abdomen, and, on finding this was the case, I wondered considerably what had become of the other two segments, which are present in *Agrion.*

Now, if we return to the above remarks on *Agrion,* it will be noticed that there are five small, apparently useless points on the ninth segment, and the natural inference will be that the two succeeding segments have been invaginated in *Calopteryx*, carrying the terminal plates with them, thus forming the enclosed sac with the breathing-plates contained in it.

In the case of *Libellula*, the plates have gradually increased in number until they have attained their present profusion, the five points of *Agrion* having become modified into a guard for the valves, and a concentrater for the jet of water used in propulsion.

It may, perhaps, be interesting to state here that, in casting its skin, the larva throws off the external skin of this sac intact, all the numerous plates being distinctly recognizable in the cast-off skin, and still occupying the same position at the lower end of the abdomen.

This fact appears to corroborate the foregoing opinion that the sac with its *branchiæ* in *Æschna*, &c., represents the two terminal segments of *Agrion*.

The Larva of the *Ephemeridæ* are in many respects similar to those of the *Libellulidæ ;* their breathing *branchiæ* are arranged down the sides of the abdomen, two or four gills being present on each segment; these are connected from the two main tracheæ which run down either side of the body, by short tubes running directly into them, and then subdividing into the usual capillary tubes. These gills are constantly waving about in the water, absorbing oxygen, and giving out carbonic acid formed in the body.

In these beautiful creatures the tracheal system may be followed into the most remote points of the body, owing to their transparency, especially when young. Sir John Lubbock states, that *Cloeon* has not these gills when young, and that it breathes by osinosis through the skin itself until the fourth moult, when the gills appear; but still there are no tracheæ till the next moult. A similarly progressive change may be noticed in the larva of *Corethra plumicornis*, the well-known glass larva. In the larval condition there is no special breathing apparatus, unless the beautiful plumose tail, or the bundles of setæ, are in some way used for that purpose.

It seems, however, far more probable that aeration takes place through the skin itself, or the joints, as in the foregoing instance of *Cloeon*. There are four kidney-shaped air bladders, arranged two at the tail and two near the head of the larva, which are of a tracheal nature, being lined with the ordinary spirally arranged hair; but there is no tracheal tube connecting either of these four with each other, each appearing to be independent of the other, and being probably for the purpose of preserving a balance, and enabling the animal, which has no legs, to maintain a horizontal position when suspended in the water.

When, however, the larva has changed its skin for the last time, before changing to the pupa state, a definite tracheal system may be seen running the whole length of the body, and in front and above the two thoracic air sacs, are two spindle-shaped bodies; but as yet none of these newly developed organs contain air.

After the next moult has taken place the tracheæ are found full of air, and the kidney-shaped air sacs have disappeared, whilst the two spindle-shaped bodies, above mentioned, having been liberated from their confined position, are filled with air, and stand out straight above the pupa, which now assumes an upright position. These floats are not filled by rising to the surface and drawing in the external free air, as is the case with gnat pupæ, but from the trachea, the air absorbed from the water first passing through the body.

I can speak with certainty on this point, as I have seen the larva change to a pupa, and the floats gradually filled, without its once rising to the surface.

It is highly probable that these assist in the breathing, as the large surface exposed to the surrounding fluid would naturally cause a good deal of oxygen to be absorbed through the walls, but I think it is materially assisted by the broad fan-shaped tail, which has a large tracheal tube ramifying through it.

The manner in which these larvæ and pupæ maintain themselves suspended in water is of great consequence to their preservation, for their near relation, the *Chironomus*, which is always either on the surface or at the bottom of the water, is constantly falling a prey to the *Planarians*, which are roving about in search of what they may devour; being unable to swim freely through the water they fail to catch the *Corethra* larvæ or pupæ, which may be kept in the same glass with *Planarians* without chance of injury, whereas the *Chironomus*, as I have frequently found to my discomfiture, immediately falls a prey to them; this is owing to its habit of falling to the bottom of the water, or resting at the top against some weed or the sides of the vessel, according to whether he has his tubes full of air, or empty. In either of these positions it falls an easy prey, and I have no doubt that most other aquatic larvæ are troubled with the same pest, unless they have some means of protecting themselves, such as the case of Caddis worms, a burrow like the *Ephemera*, a means of floating as in *Corethra*, &c., or continually swimming about like *Daphne*.

Thus it will be seen that the breathing apparatus in *Agrion*, *Libellula*, *Ephemera*, and *Corethra*, are used not only as such, but also as the means of locomotion and of protection from their enemies. This beautiful adaptation of means to an end cannot fail to strike the most careless observer, and appears to me a good illustration of the variations which circumstances may produce in any given organ.

On Hearing with Two Ears.

By SILVANUS P. THOMPSON, D.Sc., B.A., F.R.A.S.
(Professor of Experimental Physics in University College, Bristol.)

1.—MAN is provided with two ears, as well as two eyes. If he had not two eyes, it would be almost impossible for him to distinguish the distances and solid forms of objects; for, as Wheatstone showed, the perceptions of solidity and of distance acquired through the eye are due to the fact of our having two eyes; the former of these perceptions having for its starting point the slight differences between the two retinal pictures in the two eyes, the latter being based upon the muscular sensations of the greater or less convergence of the optical axes when viewing near or distant objects, or, as it is sometimes termed, upon binocular parallax. The theory of Binocular Vision was practically complete when the invention of the stereoscope, and of its *reductio-ad-absurdum*, the Pseudoscope, proved the correctness of Wheatstone's theoretical views.

Man has two ears; and whatever view we take of the process of creation, theological or evolutionist, we must admit that the two ears, like the two eyes, serve a purpose which one ear could not serve alone. It has therefore been my endeavour, in a research carried on at intervals during several years, to investigate the functions of the two ears, in the hope of throwing light upon some of the unexplained facts in the perception of sound. These researches in Binaural Audition are therefore analogous in aim to those of Wheatstone in Binocular Vision.

2.—One of the facts in the perception of sound which has never been satisfactorily explained is that of the acoustical perception of *direction*. A blind-folded man in a perfectly dark room is able to say, with very considerable accuracy, in what direction the source of any sound that may be made in the room is situated. In the open air he has a similar perception of the direction of a sound, but is liable to be deceived by sounds of a certain class. It has been my aim more particularly to bear this matter in mind during my investigations, which have a direct bearing upon it.

The facts which I have brought to light are of the highest importance both for the physicist and the physiologist. I cannot claim, however, to rank either as a physiologist or an anatomist; and the methods of research employed have been purely physical. I will give the results of my investigations as briefly as possible.

3.—*It is possible to produce an "interference" in the perception of sounds.* I prove the existence of this interference by the following simple experiment:—Let two tuning-forks, in unison with one another, be taken, and let one be loaded with a pellet of wax so as to vibrate a little more slowly than the other. When these two tuning-forks are excited by striking or bowing, and placed near one another so that their vibrations are communicated to adjacent masses of air, we have the phenomenon of interference commonly known as "beats." If, now, the sounds of these forks are separately led to the two ears by means of india-rubber tubes the beats are still heard; and they appear to be taking place in the interior of the head. They can be distinguished even when each of the sounds is too feeble to be heard separately, and when every precaution is taken to guard against the actual commingling of the sound waves. They are even heard when the Eustachian tubes of the ears are closed during a catarrh.

4.—*If two simple sounds in unison with one another reach the ears in opposite phases, the resulting sensation instead of being localized in the ears appears to proceed from the back of the head.*

There are several ways of observing this singular subjective phenomenon. (1) The sound of a tuning-fork may be led to the two ears by two tubes whose lengths differ by half the wave-length of the sound employed, so that the vibrations reach the ear in opposite phases. (2) Two tubes, of equal length, leading separately to the ears may have their other ends placed opposite to two adjacent quadrants of the space surrounding a vibrating tuning-fork, in which case also there will be complete opposition of phase in the sounds that reach the ears. (3) While two tubes of equal length lead to the ears, two tuning-forks, tuned to perfect unison, are made to vibrate opposite the respective ends of these tubes, one of the forks being fixed while the other is slowly rotated around its axis. Here the sounds will arrive alternately in complete agreement and complete opposition of phase. (4) Lastly, we may transmit a sound electrically by any telephonic transmitter and receive it by the aid of a pair of Bell Telephones applied to the ears. If these telephones are joined up in the circuit, so that the current can be made to traverse the coils round their magnets, either in the same direction, or in opposite directions (the magnets being set similarly in each) the vibrations of the diaphragms will be either in agreement, or in opposition of phase. When they agree in phase the sounds appear to be localised in the ears, when they are opposed in phase they appear to be localised at the back of the head. In the case of some observers the sensation of any definite localisation fades rapidly away, to be revived again when the difference of phase of the two sounds is altered. These phenomena of "localisation" have been observed many times by persons experimenting with the telephone, and they were independently announced (after the present writer had published them to the British Association) by Sir William Thomson and by Professor Graham Bell. With a microphone and a pair of receiving telephones the effect of localisation is remarkable.

5.—*This localisation of the subjective acoustic "image" is independent of the pitch of the sound.* This is proved for sounds of all degrees of pitch and of every possible complexity of "timbre" by the employment of telephones. If the sounds are transmitted by tubes of india-rubber the localisation is manifested only for *simple* sounds: for complex sounds the difference of length which produces complete opposition of phase for the fundamental sound does not give the same effect for all the upper partial tones.

6.—*This last observation suggests a method for analysing complex sounds without the employment of Resonators.* In fact, by binaural audition, it is possible to recognise a difference between two complex sounds, the separate partial tones of which are present in equal numbers, and of the same pitch and intensity, and which present only differences of *phase.* This proposition, it will be remarked, contradicts the assertion of Helmholtz that the ear cannot distinguish differences of phase. This conclusion, which was drawn from the joint sensations of the ears, is negatived by the phenomena which are observed when the sounds that differ *in phase only* are led *separately* to the two ears.

7.—*When the difference of phase of the two tones thus led to the ears is less than half an undulation, the sensation is only partially localised in the back of the head,* and partly in the ears. The sensation is not simple nor capable of exact description.

8.—*If the difference of phase is complete, but the two sounds of unequal intensity, the "acoustic image," instead of being at the middle of the back of the skull, is nearer to the side of that ear which is receiving the louder sound.* This can be shown by taking tubes of unequal diameters, or with two telephones in which the magnets are not equally strong.

9.—*To binaural audition the consonant intervals appear rough, and the dissonant intervals extremely harsh.* If different simple tones are led to the ear, as c' and e', or c' and g', the effect is disagreeable. The seventh c' b' unendurably grating.

10.—*When two sounds constituting a simple interval are led separately to the ears*, there is no differential resultant-tone ("Tartini's tone"); at least I have never been able to hear one. I am disposed to attribute the unexpected harshness of the ordinary intervals to the absence of this differential tone, which would harmonise the two. It must, however, be added, that if the two tuning-forks used have only a narrow interval, and are capable of producing a clearly distinguishable differential tone, and if they are placed together near a Hughes' Microphone to which two telephones are connected so as to give opposed phases of vibration, then not only will the two primary sounds be heard, but also their differential tone; and they will all be apparently localised at the back of the head.

11.—When a sound reaches an observer from a point right in front of, or behind, or above him, the length of path travelled by the sounds to the two ears is the same for all sounds. But if the source of sound be to right or left of the observer, the sound will reach the one ear a little later than the other, and with a difference of phase depending both on the wave-length of the sound and on the cosine of the angle between the line of the sound and the median plane of the head. Hence it is *possible* that a difference of phase in the ears may suggest to the mind that the sound is coming obliquely.

12.—Since these results were worked out, Prof. Steinhauser has published a theory of Binaural hearing, in which he has worked out on geometrical principles the laws which determine the relative *intensity* with which a sound will reach the two ears when starting from different points. The intensities are equal in the two ears when the source of sound is in the median plane, and is a maximum when in front, a minimum when behind the head; since the ears are set angularly, so as to catch sounds from in front of the head, in planes, which determine, according to Steinhauser, the conditions of best hearing. The operation, therefore, of finding the direction for the sound—say a lark singing high up in the air—will, according to Steinhauser, be as follows:—first the head is turned horizontally until the sound is equally loud in both ears, then the head is moved up and down until maximum loudness is attained; when the lark will be found in the line of sight. Steinhauser's theory, it will be noted, takes into account no differences of phase, pitch, or timbre, but of intensity only: and it fails to account for the fact that we have, *without moving the head at all*, a very fair sense of the direction of sounds.

13.—To test Steinhauser's theory I have devised a little instrument called the *Pseudophone*, which is, for the ears, what Wheatstone's Pendoscope was for the eyes—an instrument for verifying the laws of perception by means of the illusions which it produces. The *Pseudophone* consists merely of a pair of adjustable reflectors, or flaps, which can be fitted into the ears, and capable of turning round to any required position. By altering the position of the flaps we alter the relative intensities of two sounds as received in the ears; and this can be done without the blindfolded experimenter knowing how the flaps are set. If, for example, the flaps are set to catch sounds from behind, the experimenter will think that he is looking in the direction of sound, when he is looking in precisely the reverse direction. But I find that the instrument fails to give satisfactory illusions with *simple tones*, such as those of tuning-forks, especially when the experiments are made out of doors. I cannot therefore accept Steinhauser's theory without some considerable modifications.

14.—Lord Rayleigh[1] has pointed out that the diffraction of complex sounds round the head will produce the result that tones of different pitch arrive the opposite side of the head to

[1] Transactions of Musical Association, 1876.

that nearest the source of sound with very different intensities. He is disposed, from some careful experiments made on an open lawn with different kinds of sounds, to attribute the perception of the direction of sounds to this inequality produced by diffraction, the brain drawing from the slight differences of the tones received in the two ears an unconscious judgment based on empirical observation. It is undoubtedly a remarkable fact that while the ears can distinguish perfectly well whether the simple tone of a small tuning-fork comes from the right or from the left, they often cannot tell one whether such a sound is immediately in front or immediately behind. Now it is for simple tones that Steinhauser's theory ought to be true if for any; and it is precisely for these that it fails when put into practice in the *Pseudophone.* When the effects of diffraction are such as to be relatively negligible, as for shrill sounds, whose wave length is very small, then Steinhauser's theory of the *relative intensities* appears to hold good. It may possibly hold good in the case of very low tones, where the differences of phase could be (since the waves are so long) only very slight. Any one may easily convince himself, however, that it is possible for diffraction to produce a very marked difference in the relative intensities with which the partial tones of a compound sound reach the ears. For this, the simple experiment suffices of comparing the *note* of a musically-ticking clock, placed in front of the head, with its note when placed an equal distance behind. The sound will seem almost as loud, but there is a very decided difference in the *timbre* of the note.

In conclusion, it appears, in the present state of our knowledge, impossible, as yet, to decide whether difference in phase, or in intensity, or in quality, of the sounds that reach our two ears is to be regarded as the criterion by which we judge of the direction of a sound.

Remarks on the Preparation of a Local Flora.

By J. WALTER WHITE.

THE study of Geographical Botany has of late years attracted much attention, and in this country the investigation of the history and distribution of our plants, has been pursued with ardour, by men of the highest attainments in botanical science.

Their efforts have been very greatly assisted, indeed we may almost say, have been rendered possible, by the labours of local Botanists, who have recorded accumulations of small facts concerning the species inhabiting their special districts, and have examined with more or less accuracy the floral peculiarities of the soil on which they dwell. The rapidly increasing number of reliable local records extends and supplements the knowledge acquired by personal investigation, and enables the Phytogeographer to trace out the diversities and similarities of the Floras of various parts of the kingdom, helping him in his endeavour to ascertain the circumstances or influences, which have determined the existing conditions of plant distribution.

By means of these records also one can compare the botanical geography of our own country with that of any other; or one part of itself with another. The relative distribution of different species may also be studied. It is perhaps from these considerations that we may derive the truest idea of the value of Local Floras, although their utility may be demonstrated on many other grounds.

The desirability of possessing carefully worked records of local Botany being admitted, I will pass on to consider the manner in which a work of this kind should be produced, in order to possess true scientific value; throwing out a few crude thoughts upon various portions of the subject as they are reviewed.

In the first place, respecting the man who may endeavour to construct a Local Flora.

He will be of course an experienced Botanist, fairly acquainted with our critical genera, otherwise his labour in going over the same ground repeatedly will be vastly increased.

Further, it is most desirable that he should not have confined his studies to the Botany of this country, but should have a comprehensive knowledge of European plants. He will then know what to look for, and will the more readily recognize continental species: stragglers, introductions, or otherwise, which may exist in his area. For like reasons, he should be acquainted with the Flora of the country adjoining his particular district. Other desirable qualifications are, a good development of the sense of colour, and a quick and trained eye to differentiate. Granted that he is an enthusiastic worker, able to devote entire leisure to this pursuit, let him be also a man of little faith, wary and circumspect in adopting the views of others, patiently and cautiously investigating all things for himself. Lastly, by all means, let physical vigour be added to mental capacity, so shall our author be enabled to brave exposure, and withstand fatigue during his lengthy rambles.

As the first preliminary to actual work, the district to be examined must be mapped out, and a natural or arbitrary limit assigned to it.

For an inland Flora, it seems to me that an area having a radius of seven miles would afford ample scope for the exertions of any Botanist, however energetic, who works single-handed and hopes to publish his work in a state approaching completeness.

Our own case is exceptional; although, looking at the extent of country, it may be considered with some reason that in determining to work up the Flora of the Bristol Coal Fields, we have attempted a task beyond our powers. This, however, is the joint work of the members of the Botanical Section of this Society, some of whom have studied the Bristol Flora for many years. Also, our confreres, the geologists and entomologists, had already adopted the same area. For the sake of uniformity, therefore, we felt constrained to follow their lead.

I believe I speak within the mark in saying, that the Flora of an average-sized county cannot be satisfactorily compiled by one man, unless nearly his whole life be given to the labour, and even then it would be impossible for him to claim that the district had been exhaustively searched. Doubtless there are extant, well-worked county Floras; but it will usually be found that portions of the area had previously been examined, and the records used by the more ambitious Botanographer, whose work was thereby greatly facilitated. It seems right to lay stress on this point, as, without doubt, a Flora should not go forth until it has been made as complete as possible, and of course the more extended the area, the greater the difficulty in complying with this proviso.

For be it remembered, that unless every yard of land be carefully examined, and every ditch and pool peered into, there can be no comfortable sense of having thoroughly done the work. Many species will have been overlooked. In proof, take the existence of *Menyanthes trifoliata* in Leigh Wood, the single spot for many miles around Bristol, where this plant can be found. Or the equally remarkable presence of *Scutellaria minor* on the margin of another pool, where it remained unheeded and unknown to the Bristol Flora, until a few years ago; though scores of botanists must have passed yearly within a stone's throw of the place. Perhaps more singular still, was the discovery of *Alchemilla vulgaris* in a frequented part of Leigh Wood, near the Suspension Bridge, where its presence had never been dreamt of, until Mr. Bucknall happily noticed it.

The well-known lines from Gray's Elegy are most appropriately remembered, as one dwells upon these examples, of which one more may be given. *Bidens tripartita* had not been included in the Flora of Weymouth until the other day, when a friend of mine found a ditchful of it on the Lodmoor, a marsh contiguous to the town. Now, my friend and I have botanized upon the Lodmoor perhaps a hundred times, and many others also, yet apparently, because we all followed an inviting track, this out of the way ditch was never visited. The lesson to be here learnt is, that paths and beaten tracks are to be avoided, and that it is in the most unfrequented, unattractive, and unlikely situations, that discoveries are chiefly to be made.

A maritime district being necessarily bounded by the coast-line, at some point on which its centre will be placed, approaches more or less to a semicircle in outline, and might, on account of the reduction in area, have an increased radius, say of twelve miles. This limit was adopted by Mr. Archer Briggs in his most admirable Flora of Plymouth.

If the geographical features of the country permit, it may be deemed advisable for convenience of record, that the area within the limit be divided into subordinate districts. These should be clearly defined on the map to be published with the Flora.

As a second preliminary, there arises the very important and practical question of classification and nomenclature—the arrangement and naming of the plants. On what lines shall the new Flora be constructed, in order that it may fulfil the highest requirements? Shall it reflect the views of Bentham, Babington, Boswell Syme, or those of the compiler of the London Catalogue? These very influential authorities differ greatly, *inter alia,* upon a point of the most vital moment to works like the one now treated of. They have diverse methods of separating or grouping, of segregating or aggregating plants. Now it is unnecessary for our author to enter upon the study of natural affinities, or to entangle himself in an attempt to define what is a species, and what something else. Luckily he is relieved from all speculation on this vexed question. He will probably have views of his own, but their expression would be out of place in the pages of his work His task is a purely practical one: in the first place, that of discovering the plants which grow in a particular tract of country; and, secondly, of recording their names and habitats, in language perfectly intelligible to other botanists.

To do this latter, he must follow one of the systems of nomenclature given to us by leading botanical writers. Some of these have chosen to keep alive the old aggregate species named by Linnæus, Hudson, and Smith; whilst others, less conservative, and more discriminating, have recognized and described the large number of subordinate segregates, which those aggregates include, and which, as time moves on, become more and more clearly understood by, and familiar to, students of field botany. Perhaps the book most representative of the views of the older botanists, is Bentham's "Handbook of the British Flora." It has met with much commendation, and is doubtless an almost perfect guide to beginners in the science. In it the aggregation or "lumping" of species is carried to an extreme, which, however convenient it may be in relieving a learner from perplexity at the beginning of his study, detracts largely from the usefulness of the book, in making records of localities and other like purposes. As a matter of fact, in my own experience, I find that six out of every seven amateur botanists, put their trust in the "Handbook," and from their point of view very properly so indeed. But when these botanists are appealed to for assistance in compiling a local Flora, of what value is the bulk of their notes and records? When our author is informed that *Ranunculus aquatilis* has been gathered in such a situation, what significance can he possibly attach to the circumstance? None whatever. He is supposed to be well acquainted with three or four distinct species, which come under this particular aggregate, and whatever he may think of the other segregates, which are frequently separated from it, he wishes to record them all, if found in his locality, by names which will tell precisely what is meant.

In this way only can the special distribution of the segregates be ascertained; and to exclude these from the Flora, would rob it of much value, if not render it entirely useless.

The requirements of science therefore will make it necessary to arrange the Flora on a broad basis, and the writer probably cannot do better than follow the London Catalogue, or Babington's "Manual"; being careful to state explicitly which edition is adopted.

The work of compilation will commence with the search for, and examination of, old records relating to the locality. Some of the more noteworthy plants will probably have attracted attention a century or two ago, when, in the early dawn of the day of science, the first field botanists went forth through the land. And these early notes, mingled though they may be with much, that now proves to be erroneous and absurd, are often of great interest, and afford, in some cases, valuable evidence on the nativity of rare plants still surviving in their ancient habitats.

Towards the end of last century, Mr. Sowerby gathered *Tragopogon porrifolius* in a field by the Avon, below Cook's Folly; and the specimen is figured in Smith's "English Botany." The plant seems to have disappeared from that locality shortly after it was seen by Mr. Sowerby, and for very many years his record was the sole ground for its inclusion in the Bristol Flora. However, after the construction of the Port and Pier Railway, when the ground at that spot was much disturbed, the *Tragopogon* again appeared, and was to be seen during several seasons, though I fear it will not be permitted a permanent residence. Undoubtedly this reappearance proves the accuracy of the old recorder, and the old record returns the compliment by affording strong evidence of the nativity of the plants recently gathered; these might, in its absence, have been considered casual introductions, deserving no place in the Local Flora.

It will be found that the geography of some old botanists was very greatly at fault. For instance, the Isle of Portland, off the coast of Dorset, has been said to belong to Cornwall; and the town of Plymouth, in Devonshire, was also allotted to the adjoining county. A minor error of the same sort, was the assumption, that our St. Vincent's Rocks were located on both sides of the Avon, and, in consequence, that both the counties of Somerset and Gloucester might lay claim to the rarities growing thereon.

Another, but less frequent, source of difficulty in this relation is, that a single station by being variously noted in different works, and by being copied by one author after another, may at last come to be considered as three or four. Anything more misleading than this multiplication of records, can hardly be conceived.

The old recorders naturally noted the aggregates, the books of past generations therefore do not give assistance in working up the critical genera.

The attempt to eliminate errors from old literature is scarcely more necessary than the cautious avoidance of those of more recent date. Records of localities in Guide Books, and other like sources of information, are to be viewed with great suspicion. Such records are unfortunately sometimes inserted on little or no authority, and their acceptance might give permanence to many errors.

With respect to the form in which each station is to be noted in the Flora, the author will exercise his discretion as to whether the exact habitat of a plant shall be indicated or not. When the plant is rare, or grows sparingly, it will be wise to give it protection by describing rather loosely the place where it is to be found. In such a case, it seems to me that the mention of the parish, or nearest village, would be quite sufficient for the purpose. This view, however, will not find universal acceptance, for it was lately suggested, in the pages of a popular periodical, that the chief object of a Local Flora should be to point out the exact spots where the more uncommon plants of a district are to be found! It was calmly remarked, that minute descriptions of the localities, specifying even the roads and paths to be taken, "would be a very great advantage." Doubtless, but to whom? Certainly the rapacious plant collector, eager to make up his bundle for the Exchange Club, will eye with dismal scorn the "mere Catalogue with its vague remarks," which does not spread at his feet the treasures enumerated therein, and humbly entreat him to root them up. But it is not for such as this that the local botanist toils, season after season, at his difficult and pains-requiring task. A keen delight possesses the true naturalist, when he discovers a rare plant, or one not suspected to grow within his reach. Will he not guard his fortunate discovery with jealous care, instead of straightway inviting all and sundry to its extirpation; and look askance upon the "battue-shooters," who go forth with reams of paper, and coffins of japan wherein to inter every green thing, which may be a desideratum to their correspondents or themselves? The gathering and distribution of specimens by wholesale can at best bear the very smallest relation to botanical science, and if *any* public benefit be reaped thereby, it cannot for a moment be considered compensation for the abhorrent and ruthless destruction of native rarities. It seems also that care for his own reputation should restrain the writer of a Flora from publishing exact stations for scarce plants. It has very curiously happened to a well-known botanist, that his accuracy has been impugned, because some habitats very precisely indicated in his County Flora no longer yield the plants with which they once abounded ; and disappointed searchers, not recognizing the mischievous result of proceedings like unto their own, were impolite enough to say that the records were erroneous.

In field work some difficulties are to be encountered in the present day, arising from extended cultivation. The plough is rapidly altering the surface features of the country. Heaths and commons are being enclosed, bogs and marshes reclaimed and drained. The extent of aboriginal wood and virgin sod is gradually diminishing. Thus it happens here and there, that a species has become extinct, through the removal of conditions necessary for its existence ; whilst many others increase in rarity, as man's interference with the soil makes their position on it less tenable. Improved systems of farming, too, tend to destroy weeds of cultivation, and help to guard against plethora in the botanist's vasculum. A friend writes, that he has this season been conscious of an undue predominance of bulls of a ferocious type in the pasture lands of his district. This certainly ranks as a practical difficulty.

But there are advantages also by which the modern field botanist can largely profit. It is no longer necessary, as in the old days, to expend a fortune in becoming master of a science. Precise information in books can be had at very moderate expenditure, or may with ease be referred to in public institutions, where also good series of specimens are frequently to be found. Optical instruments are good and cheap. Railways have grown into a network of invaluable locomotive facilities, saving time and sparing leg-weariness. Improved postal communication permits consultation with friends, and valuable assistance in the identification of plants to be received from the best authorities. These are indeed great advantages, and, if used as they deserve to be, with energy and perseverance, will help on the naturalist to attain that great proficiency, and superior accuracy which should ever be his aim.

Darwinism.

By CHARLES JECKS.

WHAT is the meaning of the term "Darwinism"? or what are those opinions, which, in the aggregate, are called the "Darwinian Theory"? I believe these. Given the occasional variation in structure of a plant or animal, that, if this variation tend towards its welfare, but not otherwise, such plant or animal will thus be given certain advantages over others less favoured, which advantages will, by the law of heredity, tend to increase, and in this way, supposing that any form of life give rise to a variety in the structure of its progeny, advantageous to its existence, and sufficiently marked (its surroundings, as regards other organisms, being favourable), the form of life in which this variation appears, being thus able to survive in circumstances injurious or fatal to other forms, hands down to its progeny these advantages in an ever increasing ratio, the ultimate results being what we call a species.

It will thus be seen that there can be no direct connection between the parent-form and its remote descendant, for these are separated by many other forms, each of which is noted for a more or less marked variation from the original stock, one form sometimes diverging into two or more branches, as represented in the diagram in Mr. Darwin's "Origin of Species," so that the original form would be almost lost. We cannot, therefore, thus reasonably expect to find any two forms of life connected together by any unbroken line of descent, but must, on the other hand, be prepared to meet with several apparently broken links. Indeed, there would naturally be such an amazing amount of modification between the parent-form and its remote descendant, and this would be expressed in so many and such divergent ways, that the apparent absence of any connecting links, so far from being an objection, is a necessary result of the theory, and really rather an argument in its favour than otherwise, because it is just what we might reasonably have expected. This, then, so far as I understand it, is the meaning of the "Darwinian Theory," which, I need scarcely say, has been more misunderstood, and, as a natural consequence, more misrepresented, than any other of our day, but which is, after all, generally and increasingly acknowledged to be the best if not the only workable theory extant. As regards the opposite one—that of Special Creation—I think that any one who has read attentively and thoughtfully the works of Messrs. Darwin and Wallace—especially the curious and interesting facts related by the former in his chapter on "Geographical Distribution" ("Origin of Species")—will surely be convinced that, judging from all that we know upon the subject, it has no reasonable basis. The Development Theory, as it is called, has also the advantage of being capable of legitimate application to vegetable and animal life in a wider sense than any other. It would seem, indeed, as if by it we had touched the very warp and woof of organic life, and were, at length, in a fair way to get some faint glimpses of the great central ruling principle, intertwined as it is in the labyrinth of being, and branching out in many different ways.

As one instance of this capacity for broad application, I think that of what are called "Insectivorous Plants" presents itself. It is well known that these have generally but slight and insignificant roots, depending, as they do, chiefly upon insects for subsistence, though in a different and perhaps more literal way to that which we have been used to observe in the fertilization of plants. Now, as regards the origin of these curious forms of life, let us suppose that a plant be placed in certain abnormal conditions, so as not to be able to derive nutriment from the usual source—the roots; is it not possible that the organs of absorption would be increased in power in the effort to adapt the plant to the circumstances in which it is placed, and to supply the needed nutriment in another way? till at length by reason of a favourable variation, sufficiently marked to be taken hold of by natural selection, and increased by the law of heredity, these organs are not only increased in power, but perhaps altered in function, and united with appropriate glands, the whole structure being correlated as to the possession of hairy appendages, &c., suitable to the requirements of the plant. With regard to the retention of insects, we know that the leaves of many plants exude a gummy matter, which serves to attach them (insects) to the surface of the leaf, and have only to suppose it to be an advantage to the plant to have this exudation increased, with the object of supplying a source of nutriment; this being probably effected, first, by the decomposition of the animal matter and its absorption as a kind of manure, when the plant may be said to be partly insectivorous—in a transition state; and then, the appearance through a favourable variation, of the direct digestive power, which, giving the plant a more decided advantage over others, would, if sufficiently marked, be laid hold of by natural selection and the law of heredity, and at length become confirmed. We know at present little or nothing regarding these curious forms of life; but it may perhaps be suggested as probable that they differ much as to the power of digesting insects; and if this be so, the plant which has most power of this kind will have an advantage over others, and will therefore tend to increase.

If, however, the plant be thus benefited, it seems but reasonable to believe that though the individual insect derives no advantage, the species may do so, for it is quite possible (and all analogy tends to strengthen the idea) that the rationale of the insect falling a prey to the plant, is the possession by it of some organic imperfection not found in others.

That which we call beauty in plants and animals, and protective resemblance, seems also to come under the action of development by natural selection. What do we mean by the expression "Utility of Beauty"? and is the possession of beauty or adornment of any service to the form of life in which it is found as a means of giving it any advantage over other forms? The answer which Mr. Darwin and others, including, I believe, Messrs. Wallace and Bates, would give to these questions is—That beauty in all its forms seems to be of real and essential service, and that its possession does really give a certain tangible advantage over other forms of life. Thus, according to the views of Mr. Darwin and others, the possession of what we call beauty, in plant or animal, is not so much an end in itself as a means towards an end, which, in so far as the plant or animal is concerned, is higher and more important than mere beauty, because it contributes towards its welfare and preservation in the great battle of life, and this is surely of more real importance than that the sole or even the chief end of beauty should be to call forth the idea in ourselves. We also find that both beauty and protective resemblance exist in places and under circumstances in which they are hidden from human eyes, and it would seem from this that they are rather a natural result of a variation in colour, &c., which tends towards the advantage of the form of life possessing it, than expressly developed to please our sense of beauty. Moreover, though it frequently happens, it is not always the case, that these variations in colour or resemblance to other forms of life are in themselves what we should call beautiful, though they may be of equal advantage, for in those cases which strike us most prominently it may perhaps be suggested that it is often because we are naturally more impressed by what is beautiful or pleasing to the eye, and so more readily bear it in mind. The instances in which the possession of beauty or of a resemblance to another form of life are known to be of advantage to animals and plants are too numerous to need mention. Many of both kinds will, I doubt not, occur to you. In that, however, of plants we cannot help noting that while many parts of a plant are remarkable for their beauty, still the idea of beauty as an end seems to be kept in subordination to that of utility. Now, what can be more natural or appropriate than the application of the "Development Theory" as a means of explaining these phenomena? We know that variety in colour and adornment are often advantageous to the plant or animal possessing them, and have, therefore, only to suppose that these originally arose from a slight variation which, being advantageous, was seized upon by natural selection and increased by the law of heredity, till at length the desired end was effected. We have thus, I think, a far higher and more satisfactory reason for the existence of beauty in so many and such varied forms, and also a more rational explanation of that singular phenomenon—protective resemblance—than any other theory can give us.

Mr. Darwin's theory has also thrown an altogether new light upon the succession of life upon the globe, for instead of a certain form of life always making its appearance exactly at a given period, when everything seems to be prepared for it (if I may be allowed the comparison) like the transformation scene of a pantomime, we find that fitting conditions seem to have occurred without the presence of this form, whence, together with the fact of the lower forms of life generally preceding the higher in a gradually ascending scale, we are led to the conclusion that in all probability the continued succession of life on our globe is governed more by the immediate precession of lower forms than by suitability of outward surroundings. A great difficulty connected with the Development Theory is its application to those forms of life in which development seems to be of no service—at least for the course of several generations—until it is perfected, as, for instance, in the case of the electrical eel. Here, however, the law of correlation of structure may perhaps help us, for if, as I am inclined to believe, all variations are attended by a correlation of structure, then a variation in a given direction and possibly commencing from within, and attended by a corresponding correlation—both being advantageous to the fish—at length finds expression in what we call development in the formation of the electric organ.

As to the future of Mr. Darwin's theory, I am, I confess, very hopeful, and cannot help believing that it will ultimately cover a much wider field than now, embracing man himself, with all his moral and intellectual faculties, as well as his mere physical form. Towards this, I think, all our scientific progress leads the way; every newly-discovered fact in biology brings us nearer to the advent of a general recognition of the imminent presence throughout all life of a gradual evolution from lowest to highest, finding its expression in a thousand varied ways, yet manifesting through all the great key-note of unity in diversity.

Why, of any two forms of life, both exposed to the same outward conditions, and both, perhaps, belonging to what we call the same species, should the one flourish and the other gradually become extinct? All that we can say is that we do not know. But if we do not know the causes of extinction, if we cannot tell what those mysterious influences are, by reason of which a plant or animal becomes more and more rare, and finally disappears altogether, we surely have no right to be surprised at its extinction; for, as Mr. Darwin has well remarked, "This is as if one should not be at all surprised at a man's falling ill, or at his getting gradually worse, but should be amazed beyond measure at his ceasing to exist."

We all know that however startling the effect may be, the causes of extinction are continually going on around us, and are common to all forms and all conditions of life ; and we know, too, that while some forms become extinct, others flourish. These things are more and more impressed upon our minds every day, and though we cannot tell all the causes of the phenomena, it may surely be affirmed that the " Origin of Species by Natural Selection " is, if not the principal, at least one of considerable weight and importance.

A New Phonautograph.

By Professor SILVANUS P. THOMPSON, D.Sc., B.A.

THE Phonautograph, invented in 1859 by Léon Scott de Martinville, of Paris, and perfected by Dr. Rudolph König, is an instrument for recording graphically traces corresponding to the vibrations of sounds. It consisted, in the original (and usual) form of instrument, of three essential parts :

(*a*) A receiver, in the shape of a hollow paraboloid closed at the lower end by a thin membrane of skin to take up the vibrations.

(*b*) A light style made of a hog's bristle attached to the membrane, and working with guiding levers or joints.

(*c*) A recording apparatus consisting of a cylinder covered with smoked paper to receive the traces of the style, and rotating upon a screw axis which at the same time carried it longitudinally forward.

With this instrument Scott and König made a number of researches about the years 1859-64, and examined the traces of a good many sounds.

Simple musical tones gave simple harmonic curves as their traces.

Simple combinations of consonant tones gave more complex harmonic curves.

Mere noises produced totally irregular traces.

The vowel sounds gave complex harmonic curves, thus affording confirmation of their structure from certain partial tones.

Consonants were scarcely recorded at all.

This instrument had a more grave defect. The membrane of skin stretched over a brass ring possessed a tone of its own, and vibrated more strongly in resonance with this note than with others.

Since the invention of the Phonautograph several other acoustical instruments of the highest importance have been invented.

(1) *Barlow's Logograph*, described before the Royal Society, in 1874, is an instrument for measuring the varying pressures of air in the cavity between the lips during speech. It consists of a trumpet-shaped mouthpiece, fitting almost tightly to the lips, which narrows, then widens, and is closed by a piece of elastic indiarubber, which bulges out more or less according to the pressure exerted by the air upon it. Against this elastic membrane rests a light lever of aluminium, hinged at one end to the supports of the instrument, the longer end of which carries a small pointed camel's hair brush, which is charged with ink, and the lip of which touches a strip of paper carried beneath it by clockwork, like the paper strip of the Morse telegraph instrument.

The traces obtained by the Logograph do not correspond, strictly speaking, to sounds at all, and do not represent sonorous vibrations; they give the mechanical displacements of the air due to the change of wind-pressure in the cavities of the mouth during articulation. Vowels and musical sounds made no trace at all in the Logograph.

(2) The Speaking Telephone of Graham Bell, invented in 1876, first proved that metallic plates can accurately take up and reproduce the vibrations both of consonants and of vowels.

(3) The Phonograph of Edison carried this discovery one

stage further; for in this instrument the metallic disc not only took up the vibrations both of vowels and of consonants, but recorded them by indenting their form into tinfoil, and reproduced them again when forced mechanically to follow the ups and downs of the recorded tracing.

Our knowledge of the exact nature of the *vowel*-sounds, and of the characteristic form of their vibrations, is now very complete, thanks to the independent researches of Helmholtz, Donders, and König, and to the study of their traces with the Phonautograph and Phonograph.

Our knowledge, on the other hand, of the exact nature of the vibrations of the consonants is extremely imperfect. The Phonautograph did not record consonantal tracings; the Logograph merely recorded mechanical displacements due to varying air pressures.

I therefore have proposod a new Phonautograph for the purpose of investigating the quality of the consonantal sounds. Its receiver is precisely like the receiver of my Phonograph—a disc of ferrotype iron, behind a mouthpiece like that of the Telephone. A small system of levers, working on spring joints, carries the motions of the disc to a needle-point which rests lightly above a horizontal bed, along which smoked pieces of ordinary window-glass are drawn by a clockwork arrangement.

I believe it will be of great advantage thus to substitute tracings on a flat surface for tracings on a cylindrical one, as they can more easily be taken away from the instrument for purposes of observation, and for observation in the microscope. I also invite attention to the clockwork arrangement, and the means by which a perfect maintaining motion is obtained with a weight hanging upon an endless chain which passes over a winding pulley armed with a ratchet-click, as well as over the driving pulley.

No connected experiments have yet been made with the instrument, which will probably require some further modifications. I hope at a future day to have the honour of laying before the Society, or before its Physical and Chemical Section, an account of the investigations which I purpose to make with the new instrument.

The Boulders of the Bromsgrove District.

By OLIVER GILES.

THERE are in and around the town of Bromsgrove a large number of erratic blocks, or boulders. Having spent the earlier years of my life in their immediate vicinity, I became familiar with these remarkable stones. At that time, however, I regarded them simply as *stones*, and nothing more; much as Peter Bell looked upon the primroses on the river's brim; but, with a little geological knowledge these blocks assumed quite a different aspect. My curiosity was aroused; I looked around to see if I could find the rocks, from which they came, but could find nothing approaching to them in structure, or appearance. The local rocks being of Triasic age, and composed of Bunter Sandstone, Bunter Conglomerate, and Keuper Marls, I became anxious to know whence they had come, how they had travelled, and how they had been deposited in their present position. Upon asking some of the older inhabitants, I was told that in days gone by, when there were giants in the land, they were in the habit of quarrelling, and throwing stones at each other; and that they used stones as weapons of warfare, pitched battles being sometimes fought by different tribes, one party being stationed on Malvern Hill, and another on the Lickey; the Malvern party having flung these stones at their enemies on the Lickey, a distance of about twenty miles in direct line. Most of these blocks lie round about the foot of the Lickey Hill. This legend is still believed by many of the old people in the locality, while others will tell you, that "them stooans wun left were they bin now by the flud," meaning by the flood, the Noahic Deluge.

But, apart from legend, these travelled blocks have assumed an important position in geological science during the last few years; so much so, that a committee was appointed by the British Association to examine, map, and, as far as possible, adopt means to preserve, for the study of scientific men, these remnants of the great ice age, for such they are proved to be. Large numbers of these stones have been utilized in various ways; some in foundations of houses, walls, &c., others as parish boundaries and the like, while several are used as curb-stones and as seats for wayfarers, &c. Besides those which the British Association Committee examined, and described, I have discovered several, since their visit to the locality, many of which are partly buried.

The whole, or nearly so, of these remarkable boulders have been traced to the Arenig Mountains in North Wales, and were doubtless dropped from floating ice. As the ice floes travelled southward, they would become melted by the warmer atmosphere, and these, with other rock *débris* of much smaller dimensions, such as sand and gravel, which is sometimes called "Northern Drift," would be dropped upon the then sea bottom. And as the land rose again, and the ocean bed became dry land, such blocks became exposed to view. It is a little remarkable that so many of these boulders should remain *in situ* during the many ages that the land has been under cultivation. Some, we know, have been removed from their original positions; one at the Woodrow, a few years ago, having been a hindrance to the cultivation of a certain field, the farmer hitched the whole of his horse power to it, and removed it from the field to an adjacent lane, where it now remains. This is one of the largest in the district. I do not know of more than one block, which shows ice markings: it is a large block, and lies in a lane near Finstal Park. They are all, more or less, sub-angular; some of the more compact blocks having suffered less by atmospheric erosion than the softer ones. There are three varieties of felspathic rock among them; one with small porphyritic crystals, one very compact, and one a decided ash. They vary in colour, from light grey to dark grey —frequently with a bluish tinge. The following is a list of the principal boulders in this locality:—

	Dimensions.	Height above the sea in ft.
Corner of road near Station, compact felstone (C. F. below) ...	2′ 0″ × 2′ 0″ × 3′ 0″ ...	275
Close to Railway Bridge, three fragments felstone with quartz.		
Near Finstal House, three boulders with fragments, C. F.	2′ 0″ × 2′ 0″ × 2′ 0″ ...	276
Another, 100 yards up East Road, felspathic ash (F. A. below) ...	5′ 0″ × 3′ 6″ × 3′ 0″ ...	280
With four smaller, near Webb's Farm.		
Near Stoke Elm and Canal Bridge, almost hornstone	2′ 0″ × 1′ 6″ × 1′ 0″	
Near Meadow Farm, felstone.		
On Hanbury Road, near Stoke, greenish F. A....	21″ × 14″ × 12″	
Opposite Stoke Church, with smaller ones, F. A.	18″ × 15″ × 12″	
At Fringe Green, horny F. A. ...	5′ 6″ × 4′ 0″ × 2′ 4″ ...	273
Several on new road to Bromsgrove, felstone...	...	270
Near Police Station, several ...	...	292
Others, similar in structure, corner of Old Station Street, Hobbis's Yard, Chapel Street, Mill Lane, Alcester Road, &c., at heights varying from		282 to 296

	Dimensions.	Height above the sea in ft.
Dog Lane, Cat's Hill, felspar porphyrite (F. P. below)	4′ 8″ × 2′ 6″ × 1′ 9″ ...	410
Near Canister, with another almost as large, F. A....	3′ 0″ × 2′ 0″ × 1′ 8″ ...	415
Near Woodrow, at corner of road to Lydyate Ash, F. P.	6′ 9″ × 2′ 9″ × 1′ 6″ ...	858
Near Whetty, angular, F. P. ...	8′ 5″ × 4′ 0″ × 2′ 0″ ...	700
At Burcott, F. A.	3′ 0″ × 2′ 0″ × 1′ 6″ ...	380
Corner of Perry Hall, opposite church, dolorite	2′ 0″ × 1′ 6″ × 1′ 0″ ...	280
Near Halfway House, F. A. with quartz	4′ 0″ × 2′ 0″ × 1′ 3″	
Ditto, with several others near, F. A. with quartz	3′ 0″ × 1′ 0″ × 1′ 3″	
At Woodcote Farm, with eight others near, F. A.	4′ 0″ × 2′ 0″ × 4′ 0″	

In addition to the above, two large groups are reported at King's Norton, some of which have been worked into the foundation of the church tower.[1]

[1] I am indebted to the British Association Reports for the lithological character and measurements of the boulders.

Catalogue of the Lepidoptera of the Bristol District.

PART IV.

BY ALFRED E. HUDD, M.E.S.

DELTOIDES.

HYPENA PROBOSCIDALIS. L. Abundant everywhere.

,, ROSTRALIS. L. GLOS. Scarce at Almondsbury, Woodchester, and Wotton-under-Edge.

SOMERSET. Wells and Weston-super-Mare.

HYPENODES ALBISTRIGALIS. H. GLOS. Frome Glen, Durdham Down, and Wotton-under-Edge.

SOMERSET. Leigh Woods, Portishead, &c. Sometimes common at sugar.

,, COSTÆSTRIGALIS. S. GLOS. "Bristol:" *Stainton's Manual*, Vol. II.

SOMERSET. Woods at Leigh and Portishead.

RIVULA SERICEALIS. S. GLOS. Durdham Down, Almondsbury, Wotton-under-Edge, &c.

SOMERSET. Leigh Woods, Portishead, Weston-super-Mare. Not very common.

HERMINIA BARBALIS. L. SOMERSET. The only record in the district is by Mr. Crotch, from Weston-super-Mare.

,, TARSIPENNALIS. T. GLOS. Durdham Down, Ashley Hill, Almondsbury, Wotton-under-Edge, &c.

SOMERSET. Leigh, Brislington, Portishead.

HERMINIA GRISEALIS. W.V. Abundant everywhere.

,, CRIBRALIS. H. SOMERSET. Several specimens were taken some years ago on the moors near Glastonbury, by Dr. Livett, of Wells.

AVENTIÆ.

AVENTIA FLEXULA. F. GLOS. Woods near Cook's Folly, Almondsbury, and Wotton-under-Edge. Scarce.

SOMERSET. A few specimens only have been recorded; from Portishead, by Mr. I. W. Clarke; from Nailsea, by Mr. Collison; from Weston-super-Mare, by Mr. W. H. Grigg; and from near Bath, by Mr. Ross.

PYRALIDES.

PYRALIS FIMBRIALIS. L. GLOS. Mr. Perkins reports several specimens from Wotton-under-Edge.

,, FARINALIS. L. Common everywhere, in stables and granaries.

,, GLAUCINALIS. L. GLOS. A few specimens have been taken at Stapleton, by Mr. Harding and Mr. H. Bolt, and one at Clifton by myself.

SOMERSET. A few at Brislington, by Mr. Ficklin.

AGLOSSA PINGUINALIS. Common everywhere, in farmyards and out-houses.

,, [CUPREALIS. H. GLOS. I took a specimen at Stapleton, in the summer of 1869, which I believed to be this species; but as it was in very poor condition, I do not feel sufficiently sure of its identity to include this local species in my list.]

[CLEODEOBIA ANGUSTALIS. L. SOMERSET. This species is not uncommon on the hills near Minehead, but I have no records from my district.]

PYRAUSTA PUNICEALIS. W.V. GLOS. Durdham Down, Wotton-under-Edge.

SOMERSET. Leigh Woods, Brockley Coombe, Portishead, Weston-super-Mare, &c.

„ PURPURALIS. L. GLOS. Durdham Down, Wotton-under-Edge.

SOMERSET. Brockley Coombe and Weston-super-Mare. This species is much less common in this neighbourhood than *P. ostrinalis,* from which, I believe, it is distinct. They are, I think, seldom found flying together.

„ OSTRINALIS. H. Common everywhere, on heaths and downs.

HERBULA CESPITALIS. W.V. On heaths and downs; not so common as the last-named species.

ENNYCHIA CINGULALIS. L. GLOS. Durdham Down.

SOMERSET. Leigh Down, Portishead, Clevedon, &c. Not common.

„ ANGUINALIS. H. GLOS. Durdham Down, Worcombe, Almondsbury, Wotton-under-Edge.

SOMERSET. Leigh Woods, Clevedon, Weston-super-Mare.

ENDOTRICHA FLAMMEALIS. W.V. GLOS. I used to take this commonly on Clifton Down.

SOMERSET. Brislington, by Mr. Vaughan.

DIASEMIA LITERALIS. S. GLOS. Mr. Harding took two specimens of this very local species on a gas lamp at Baptist's Mills, near Bristol, some years ago. It has also been met with in the Dean Forest District. See *Intelligencer*, Vol. III.

STENIA PUNCTALIS. W.V. SOMERSET. Reported from Weston-super-Mare, by the late Mr. G. R. Crotch.

CATACLYSTA LEMNALIS. L. Abundant everywhere, over duck-ponds and stagnant pools.

PARAPONYX STRATIOTALIS. L. GLOS. Among reeds on the banks of the river Frome, at Stapleton, and at Wotton-under-Edge; not common.

SOMERSET. Near Weston-super-Mare.

HYDROCAMPA NYMPHÆALIS. L. Tolerably common on the banks of streams and rivers throughout the district.

„ STAGNALIS. D. In most of the localities of the last named, and more abundant.

BOTYS PANDALIS. H. GLOS. "Woodland Copse," near Almondsbury, by Mr. Hill; Dursley, *Stainton's Manual;* Wotton-under-Edge, by Mr. Perkins.

SOMERSET. Weston-super-Mare. Scarce.

„ HYALINALIS. H. GLOS. Scarce, among nettles, &c., on Durdham Down, and near Wotton-under-Edge.

SOMERSET. Leigh Woods. Scarcer than formerly.

„ VERTICALIS. W.V. Abundant everywhere among nettles.

„ LANCEALIS. W.V. GLOS. Dursley, *Stainton's Manual,* Vol. II.; Wotton-under-Edge.

SOMERSET. My brother and I met with several specimens near Rownham Ferry some years ago, but I have heard of no recent captures.

„ FUSCALIS. W.V. GLOS. "Hedges and wood-sides near Almondsbury; not common." J. A. Hill; Wotton-under-Edge.

SOMERSET. "Rare in Portishead Wood." J. N. Duck; Brislington, P. H. Vaughan; Weston-super-Mare, by Mr. Crotch. *Stainton's Manual* says of this species, "Common everywhere"; but, like other species so described in that work, I have never seen a live specimen.

BOTYS ASINALIS. H. Common throughout the district wherever the food-plant of the larvæ—*Rubia peregrina*—grows. The presence of these larvæ can always be detected by the white blotches they make on the madder leaves.

BOTYS URTICALIS. L. Abundant everywhere among nettles.

EBULEA CROCEALIS. H. Common in marshy places throughout the district, amongst *Inula dysenterica*, on which the larvæ may be found in April.

,, SAMBUCALIS. W.V. Throughout the district, among elders, but not very common.

,, VERBASCALIS. GLOS. Wotton-under-Edge. V.R.P. The only record in the district.

PIONIA FORFICALIS. L. Abundant everywhere in kitchen-gardens.

,, [MARGARITALIS. W.V. GLOS. Three specimens from Redland were recorded by Mr. Vaughan in the *Zoologist*, but on further examination proved to be *S. cinctalis*.—See *Zoologist*, 1974.]

SPILODES STICTICALIS. L. GLOS. A few specimens have been taken on Durdham Down by Mr. Harding; and Mr. Hill writes:—"Rare on a dry, grassy bank in Hortham Wood, in August."

,, CINCTALIS. T. GLOS. Almondsbury, Redland, Stapleton, and Wotton-under-Edge.

SOMERSET. Leigh Woods, Portishead, Weston-super-Mare. Scarce.

SCOPULA LUTEALIS. H. GLOS. Clifton and Durdham Downs, Wotton-under-Edge, &c.

SOMERSET. Leigh Woods, Clevedon, Weston-super-Mare. Not common.

,, OLIVALIS. W.V. Common everywhere.

,, PRUNALIS. W.V. Abundant everywhere.

,, FERRUGALIS. H. Throughout the district, sometimes abundant in oak-woods.

STENOPTERYX HYBRIDALIS. H. Throughout the district; common on rough ground and dry hill sides.

SCOPARIA AMBIGUALIS. T. Throughout the district, abundant.

,, BASISTRIGALIS. K. GLOS. Sidcup, by Mr. H. Jenner Fust; see *Entomologists' Annual* for 1867, p. 157.

SOMERSET. One specimen at Portbury, by Mr. Harding. One in Leigh Woods, by myself, in 1880.

,, ZELLERI. W. Marshy places throughout the district; local, and not common.

,, CEMBRÆ. H. Generally distributed, and common.

,, DUBITALIS. H. Throughout the district, abundant everywhere.

,, LINEOLA. C. "Bristol," *Stainton's Manual.*

,, MERCURELLA. L. Common throughout the district.

,, CRATÆGELLA. H. GLOS. "Bristol"; Stapleton.

SOMERSET. Brockley, Weston super-Mare.

,, RESINALIS. H. GLOS. "Bristol"; Almondsbury, "on trunks of trees in the orchard, common, but very local." J. A. Hill.

,, TRUNCICOLELLA. S. GLOS. "Common at Bristol," *Stainton's Manual.* Wotton-under-Edge.

,, COARCTALIS. Z. (=ANGUSTEA. C.) Throughout the district, on old walls, &c., but not common.

,, PALLIDA. S. GLOS. Abundant on marshy grounds near Ashley Hill and Stapleton, but very local.

SOMERSET. Bank of the Avon, opposite the Sea-Walls, Durdham Down.

CRAMBITES.

CRAMBUS FALSELLUS. W.V. GLOS. One specimen near Stapleton, by Mr. Harding.

,, PRATELLUS. C. Abundant everywhere.

CRAMBUS DUMETELLUS. H. GLOS. Common on the banks of the Avon near Sea Mills. G.H. Wotton-under-Edge.

" PASCUELLUS. L. Abundant everywhere, on marshy ground and by streams.

" ULIGINOSELLUS. Z. GLOS. Recorded from "the Boiling Wells," near Bristol, by Mr. Harding.

" PINETELLUS. L. Throughout the district, on heaths and downs; not scarce.

" PERLELLUS. S. Common on marsh-lands throughout the district.

" WARRINGTONELLUS. Z. (? *var. præc.*) GLOS. With the preceding species at Boiling Wells; not scarce. I think this is not specifically distinct from *perlellus, Scop.*

" SELASELLUS. H. GLOS. A few specimens have been taken on the bank of the Avon, under Cook's Folly, and near Wotton-under-Edge.

" TRISTELLUS. W.V. Abundant throughout the district, and variable in colour and markings.

" INQUINATELLUS. W.V. Generally distributed and common.

" CONTAMINELLUS. H. GLOS. "Bristol," *Stainton's Manual.* I have never met with more than one specimen in the district, which I took near Sea Mills, many years since.

" GENICULELLUS. H. Common and generally distributed throughout the district.

" CULMELLUS. L. Abundant everywhere.

" CHRYSONUCHELLUS. S. GLOS. Gully, Durdham Down; Henbury, &c.

SOMERSET. Leigh Down, Portishead, Clevedon, &c. Probably common amongst *Helianthemum* throughout the district.

Crambus hortuellus. H. Abundant everywhere.

Schœnobius forficellus. T. Glos. Redland, Stapleton. Somerset. Brockley, Nailsea, &c. Not common.

Myelophila cribrella. H. Glos. Durdham Down, Stapleton, Ashley Hill, New Passage, &c. Somerset. Cadbury Hill, Yatton, &c. Larvæ sometimes abundant in thistle-stems.

Homœosoma [nimbella. Z. Glos. "Bristol," *Stainton's Manual.* This is probably a mistake.]

,, senecionis. V. Glos. Not scarce among *Compositæ* on Durdham Down, and at Stapleton.

,, saxicola. V. Glos. I have taken a few specimens on the railway bank near the Black-rock Quarry, Durdham Down, which have been compared with specimens received from Mr. Barrett.

,, nebulella. W.V. Glos. "Bristol," *Stainton's Manual.*

,, binævella. H. (=eluviella. G.) Glos. "Bristol," *Stainton's Manual.*

Ephestia elutella. H. Generally distributed throughout the district, but not very common.

,, semirufa. H. Glos. Taken at Redland by Mr. P. H. Vaughan; "Bristol," *Stainton's Manual.*

,, pinguis. H. On ash trees throughout the district, but not common.

,, cinerosella. Z. Glos. Mr. Harding used to take this local species at Stapleton, but has not met with it lately.

Cryptoblabes bistrigella. H. Glos. "Bristol." (?) Somerset. Very rare. Leigh Woods, by Mr. Vaughan; and Portbury, by Mr. Harding.

Plodia interpunctella. H. Glos. One specimen taken flying in my garden at Clifton, in 1875.

Nephopteryx angustella. H. Glos. Redland. p.h.v. Scarce.

Phycis betulella. G. Glos. Durdham Down.
Somerset. Sometimes abundant amongst birch-trees at Leigh.

,, subornatella. Z. Glos. Durdham Down, Henbury, Westbury, Almondsbury, &c.
Somerset. Leigh Down. Not common.

,, abietella. W.V. Somerset. Scarce at Brockley Coombe, among spruce-firs.

,, roborella. W.V. Throughout the district, the larvæ being sometimes common on oaks.

Pempelia palumbella. W.V. Throughout the district on heaths and downs.

Rhodophæa consociella. H. Glos. Gully, Durdham Down, Almondsbury, Stapleton, and Wotton-under-Edge.
Somerset. Leigh Woods. Not common.

,, advenella. Z. Glos. Durdham Down and Purdown.

,, marmorella. H. Glos. Gully, Durdham Down.

,, suavella. Z. Glos. Durdham Down; not common.

,, tumidella. Z. Glos. Durdham Down.
Somerset. Leigh and Portishead Woods.

Oncocera ahenella. W.V. Glos. Durdham Down and Almondsbury; local and not common.
Somerset. Leigh Down. Scarce.

Melia sociella. L. Generally distributed throughout the district, but not very common.

Meliphora alveariella. G. Common amongst beehives.

The Fungi of the Bristol District.

PART IV.

BY CEDRIC BUCKNALL, Mus. Bac.

AMANITA.

690.	Agaricus ovoideus, *Bull.*, t. 364.	Abbots' Leigh,	Oct. 1880.

New to Britain. This fine species occurred on bare ground under trees in a field near Sandy Lane. One young specimen only was found, the top of the pileus just appearing above the surface of the earth. It agrees well with Bulliard's figure, except that fragments of the volva remained attached to the pileus, forming large, flat, white warts. Unexpanded pileus 3½ inches across; stem 5½ inches high, 2 inches thick.

691.	Agaricus pantherinus, *Fr.*	Leigh Wood, Shirehampton Park	Oct. 1880.
692.	„ asper, *Fr.*	Leigh Wood,	Aug. „

LEPIOTA.

693.	Agaricus procerus, *Scop.*	Leigh Wood,	Sept. „
694.	„ granulosus, *var.* rufescens, *B. & Br.*, Ann. Nat. Hist., No. 1834.	Leigh Wood,	Sept. „

A curious form, quite pure white at first, then partially turning red, and in drying acquiring everywhere a rufous tint. *B. & Br.* (Plate II., fig. 1.)

695.	Agaricus seminudus, *Lasch.*	Leigh Wood,	Sept. 1880.
696.	„ Bucknalli, *B. & Br.* Ann. Nat. Hist., No. 1836	Leigh Wood,	Sept. „

Olidus, pileo e campanulato convexo, albo, stipiteque deorsum pulvere lilacino conspersis, lamellis albis marginem vix attingentibus.

Pileus nearly 1 inch across; stem 3 inches high, dilated at the base. A doubt has been suggested whether this may not be Quelet's var. *lilacinus* of *Ag. seminudus;* but as he does not mention the strong gas-tar smell, they cannot be the same. The spores in this species are much longer, ·00027×·0001 in.; in *Ag. seminudus*, ·00015×·00007 in. *B. & Br.* (Plate I., fig. 2.)

TRICHOLOMA.

*	Agaricus terreus, v. argyraceus, *Bull.*	Leigh Wood,	Nov. 1877.

The plant referred to *Ag. scalpturatus*, at p. 208, Vol. II., is pronounced by the Rev. M. J. Berkeley to be this species. The pileus and gills become stained with lemon-yellow as the plant decays.

CLITOCYBE.

697.	Agaricus candicans, *Fr.*	Wick,	Sept. 1880.

PLEUROTUS.

698.	Agaricus subpalmatus, *Fr.*	Portishead,	July, 1880.

COLLYBIA.

699.	Agaricus platyphyllus, *Fr.*	Blaize Castle Wood,	Oct. 1880.
700.	,, butyraceus, *Bull.*	Abbots' Leigh,	,, ,,
701.	,, rancidus, *Fr.*	Leigh Wood,	,, ,,
702.	,, atratus, *Fr.*	,,	,, ,,

MYCENA.

703.	Agaricus rugosus, *Fr.*	Westridge Wood, Wotton-under-Edge	Sept. 1880.
704.	,, sudorus, *Fr.*	Stapleton Park,	,, ,,
*	,, electicus, n. sp.	Leigh Wood, Abbots' Leigh,	Oct. 1879. Mar. 1881.

On dead furze, bracken, &c. Entirely white. Pileus hemispherical, at length sulcate, clothed, as well as the stem and gills, with sparkling, glandular pubescence; stem filiform, slightly dilated and hairy at the base; gills adnate, broad—four to nine.

This is No. 513, Part 3, Vol. III., where it was referred doubtfully to *Ag. sacchariferus, B. & Br.* The Rev. M. J. Berkeley, however, decides that it is new, and suggests the above name. (Plate II., fig. 2.)

Volvaria.

705. Agaricus Taylori, *B.* Brockley Coombe, July, 1880.

Entoloma.

706. Agaricus prunuloides, *Fr.* Abbots' Leigh, Oct. 1880.
707. ,, Bloxami, *B. & Br.* ,, ,, ,,

Clitopilus.

708. Agaricus cancrinus, *Fr.* Weston-in-Gordano, July, ,,

Leptonia.

709. Agaricus solstitialis, *Fr.* Weston-in-Gordano, July, ,,
710. ,, asprellus, *Fr.* Leigh Down, Aug. ,,

Pholiota.

711. Agaricus pudicus, *Bull.* { Sandford, July, ,, / Portbury, ,, ,, }
712. ,, muricatus, *var.* gracilis. Shirehampton Park, Oct. ,,

Quelet, Champignons du Jura et des Vosges, p. 231. Champ. Normandie, &c., (Rouen, 1880,) t. 1, fig. 3. (Plate III., fig. 1.)

713. Agaricus marginatus, *Batsch.* Haw Wood, Oct. 1879.

Hebeloma.

714. Agaricus mesophæus, *Pers.* Leigh Road, Sept. 1880.

Flammula.

715. Agaricus carbonarius, *Fr.* Leigh Wood, Oct. ,,

Naucoria.

716. Agaricus melinoides, *Fr.* Clifton Down, May, 1879.

Galera.

717. Agaricus vestitus, *Fr.* *Quel. t. 23, fig. 3.* Stoke, Oct. 1880.

New to Britain. (Plate III., fig. 2.)

	PSALLIOTA.		
718.	Agaricus echinatus, *Roth.*	Clifton,	Aug. 1880.
	STROPHARIA.		
719.	Agaricus inunctus, *Fr.*	Beggars' Bush Lane,	Oct. 1880.
	PSILOCYBE.		
720.	Agaricus sarcocephalus, *Fr. Icon.*, *t.* 135, *fig.* 1	Shirehampton Park,	Nov. 1878.
		Leigh Wood,	Autumn, 1880.
	New to Britain. (Plate III., fig. 3.)		
721.	Coprinus radiatus, *Fr.*	Clifton,	Mar. 1881.
722.	,, ephemerus, *Fr.*	Portishead,	July, 1880.
723.	Cortinarius (Phlegmacium) claricolor, *Fr.*	Abbots' Leigh,	Oct. 1877.
724.	Cortinarius (Phlegmacium) multiformis, *Fr.*	Westridge Wood,	Nov. 1880.
725.	Cortinarius (Phlegmacium) cærulescens, *Fr.*	Blaize Castle Wood,	Sept. ,,
726.	Cortinarius (Myxacium) elatior, *Fr.*	Leigh Wood,	Oct. ,,
727.	Cortinarius (Inoloma) Bulliardi, *Fr.*	Westridge Wood,	Nov. ,,
728.	Cortinarius (Telamonia) licinipes, *Fr.*	Abbots' Leigh,	Oct. 1877.
729.	Cortinarius (Hydrocybe) firmus, *Fr.*	Westridge Wood,	Sept. 1880.
	New to Britain. (Plate I., fig. I.)		
730.	Paxillus panuoides, *Fr.*	Mangotsfield,	Oct. 1880.
731.	Hygrophorus chrysodon, *Fr.*	Westridge Wood,	Nov. ,,
732.	,, limacinus, *Fr.*	Blaize Castle Wood,	Oct. ,,
733.	,, ceraceus, *Fr.*	Abbots' Leigh,	Oct. ,,
734.	,, unguinosus, *Fr.*	Haw Wood,	Aug. ,,
735.	Lactarius hysginus, *Fr.*	Leigh Wood,	Aug. ,,

736.	Lactarius chrysorrhæus, *Fr.*	Leigh Wood,	July, 1880.
737.	„ volemum, *Fr.*	Haw Wood,	Aug. „
738.	„ mitissimus, *Fr.*	Leigh Wood,	Oct. „
739.	Russula chamæleontina, *Fr.*	Kingswood, Somerset,	July, „
740.	Cantharellus infundibuliformis, *Fr.*	Westridge Wood,	Nov. „
741.	Marasmius urens, *Fr.*	„	Sept. „
742.	Lentinus lepideus, *Fr.*	Mangotsfield,	Sept. „
743.	Schizophyllum commune, *Fr.* On a fallen ash.	Leigh Wood,	Oct. „
744.	Boletus piperatus, *Bull.*	Abbots' Leigh,	Oct. „
745.	„ subtomentosus, *Linn.*	Leigh Wood,	Aug. „
746.	„ variecolor, *B. & Br.*	Abbots' Leigh,	Oct. „
747.	„ candicans, *Fr.* *Saund. & Smith, t.* 17.	Leigh Wood,	Oct. „
748.	Boletus edulis, *Bull.*	„	Autumn, „
749.	Polyporus melanopus, *Fr.*	Stapleton Park,	Sept. „
750.	„ varius, *Fr.*	Near Ashton,	May, „
751.	„ sulphureus, *Fr.*	Westridge Wood,	Sept. „
752.	„ borealis, *Fr.*	„	Sept. „
753.	„ connatus, *Fr.*	Abbots' Leigh,	Mar. 1881.
*	„ molluscus, *Fr.*	Westridge Wood,	Oct. 1880.
754.	„ vaporarius, *Fr.*	Leigh Wood,	Jan. 1877.
755.	Hydnum variecolor, *Fr.*	„	Dec. 1878.
756.	Cyphella pallida, *B. & Br.*	„	Oct. 1879.
757.	Clavaria aurea, *Schaeff.*	Westridge Wood,	Sept. 1880.
758.	„ vermiculata, *Scop.*	Weston-in-Gordano,	July, „
759.	„ pistillaris, *L.*	Westridge Wood,	Sept. „
760.	„ uncialis, *Grev.*	Filton,	June, „
761.	Næmatelia virescens, *Corda.*	Leigh Wood,	Feb. 1881.
762.	Bovista plumbea, *P.*	Durdham Down,	July, 1880.

763.	Lamproderma physarioides, *A. & S.*	Clifton,	June, 1880.
764.	Trichia varia, *var.* nigripes	Westridge Wood,	Oct. ,,
765.	,, chrysosperma, *Bull.*	Leigh Wood,	Sept. ,,
766.	Cyathus striatus, *Hoffm.*	Glen Frome,	Dec. ,,
767.	Sphærobolus stellatus, *Tode.*	Stapleton Park,	Oct. ,,
768.	Sphæronema vitreum, *Corda.*	Leigh Wood,	Sept. ,,
769.	Diplodia fibricola, *Berk.*	The Gully,	April, 1878.
770.	Dinemasporium graminum, *var.* herbarum, *Cke.*	Glen Frome,	Dec. 1880.
771.	Nemaspora crocea, *P.*	Bridge Yate,	Sept. ,,
772.	Puccinia graminis, *Pers.*	Cotham,	Mar. 1881.
773.	,, primulæ, *Grev.*	Goblin Combe,	July, 1880.
774.	Ustilago carbo, *Tul.*	Sandford,	July, ,,
775.	,, longissima, *Tul.*	Cheddar,	July, ,,
776.	Trichobasis Ulmariæ, *Cooke.*	Portbury,	July, ,,
777.	Æcidium valerianacearum, *Duby.*	Near Ashton,	May, ,,
778.	Æcidium primulæ, *D. C.*	Westridge Wood,	May, ,,
779.	Epicoccum neglectum, *Desm.*	Clifton,	June, ,,
780.	Cladosporium herbarum, *Lk.*	Cotham,	Mar. 1881.
781.	Coccotrichum brevius, *B.&Br.* *Ann. Nat. Hist., No.* 1918	Leigh Wood,	Dec. 1879.
782.	Dactylium roseum, *Berk.*	Clifton,	Sept. 1880.
783.	Fusidium album, *Desm.*	Leigh Wood,	Nov. ,,
784.	Botryosporium pulchrum, *Corda.*	Clifton,	Feb. 1881.
785.	Acrostalagmus cinnabarinus, *Corda.*	,,	Aug. 1880.
786.	Erysiphe lamprocarpa, *Lev.*	Portbury,	July, ,,
787.	,, tortilis, *Lk.*	Portishead,	July, ,,
788.	,, communis, *Schl.*	Stapleton Park,	Sept. ,,
789.	Chætomium elatum, *Kze.*	Clifton,	Aug. ,,

790.	Peziza leporina, *Batsch.*	Abbots' Leigh,	Sept. 1880.
791.	„ aurantia, *Fr.*	Blaize Castle Wood,	Oct. „
792.	„ humosa, *Fr.*	Leigh Wood,	Oct. „
793.	„ omphalodes, *Bull.*	Stapleton Park,	Sept. „
794.	„ macrocystis, *Cooke.*	Leigh Wood,	Oct. „
795.	„ apala, *B. & Br.*	Mangotsfield,	Sept. „
796.	„ echinulata, *Awd.*	Leigh Wood,	Aug. „

This has frequently been found in this country, but has not hitherto been recorded. (Plate IV., fig. 1.)

797.	Peziza palearum, *Desm.*	Mangotsfield,	Sept. 1880.
798.	„ straminum, *B. & Br.*	Clifton Rocks,	May, „
799.	„ micacea, *Pers.*	Leigh Wood,	July, 1879.

New to Britain.

800.	Peziza (Dasyscypha) fugiens, n. sp.	Mangotsfield, Abbots' Leigh,	June, 1880. Mar. 1881.

Very minute, scattered, sessile, globose, then expanded, thin, tomentose, white; asci oblong or clavate ·001 in. × ·0003 in.; sporidia eight, linear, straight or slightly curved ·0003 in. – ·0004 in. × ·00008 in., obliquely biseriate, so that only four are visible in the ascus. (Plate IV., fig. 2.)

On dead rushes in bogs; probably common, but, as Mr. Phillips believes it to be undescribed, it is named provisionally. The cups seldom exceed ·008 in.

801.	Peziza Curreiana, *Tul.*	Abbots' Leigh,	Mar. 1881.
802.	Helotium flavum, *Klotsch.*	Glen Frome,	1880.

New to Britain. (Plate IV., fig. 3.)

803.	Helotium pallescens, *Fr.*	Leigh Wood,	Nov. „
804.	„ fagineum, *Fr.*	Henbury.	
805.	„ albopunctum, *Desm.*	Leigh Down,	Nov. 1879.

New to Britain.

806.	Ascobolus vinosus, *B.*	Abbots' Leigh,	Mar. 1881.
807.	„ glaber, *Pers.*	Leigh Down,	Jan. „
808.	„ immersus, *Pers.*	Stapleton Park,	Feb. „

809.	Ascobolus (Saccobolus) neglectus, *Boud.*	Leigh Down,	Jan. 1881.
810.	Ascobolus (Ascophanus) argenteus, *Curr.*	Stapleton Park,	Mar. ,,
811.	Ascobolus sexdecemsporus, *Crouan.*	Abbots' Leigh,	Mar. ,,
812.	Ascobolus (Ryparobius) argenteus, *B. & Br.*	Leigh Down,	Jan. ,,
813.	Heterosphæria patella, *Grev.*	Dundry,	May, 1880.
814.	Hypomyces luteovirens, *Tul.*	Leigh Wood,	Aug. ,,
815.	,, Broomeianus, *Tul.*	{ Abbots' Leigh, { Stapleton Park,	Oct. ,, Dec. ,,
816.	Acrospermum compressum, *Tode.*	Abbots' Leigh,	Mar. 1881.
817.	Nectria erubescens, *Desm.*	Clifton Down,	Oct. 1879.
	On holly leaves. New to Britain. (Plate IV., fig. 4.)		
818.	Dothidea filicina, *Fr.*	Leigh Wood,	Nov. 1878.
819.	Diaporthe ilicina, *Cke.*	Durdham Down,	May, ,,
820.	Melanconis lanciformis, *Tul.*	Leigh Wood,	April, 1877.
821.	Valsa dissepta, *Fr.*	,,	Winter ,,
822.	Sordaria merdaria, *Fr.*	Leigh Down,	Mar. 1881.
823.	,, minuta, *W. var.* tetraspora. (Plate IV., fig. 5.)	,,	Jan. ,,
824.	Sordaria curvula, *D. By.*	Stapleton Park,	Feb. ,,
825.	,, pleiospora, *W.* (Plate IV., fig. 6.)	Leigh Down,	Jan. ,,
826.	,, Winteri, *Ph. & P.*	,,	Feb. ,,
827.	,, bisporula, *Hans.*	,,	Mar. ,,
828.	Xylosphæria hemitapha, *B. & Br.*	Leigh Wood,	Mar. 1880.
829.	Sphæria decedens, *Fr.*	,,	Jan. ,,
830.	,, quadrinucleata, *Curr.*	The Gully,	Feb. ,,

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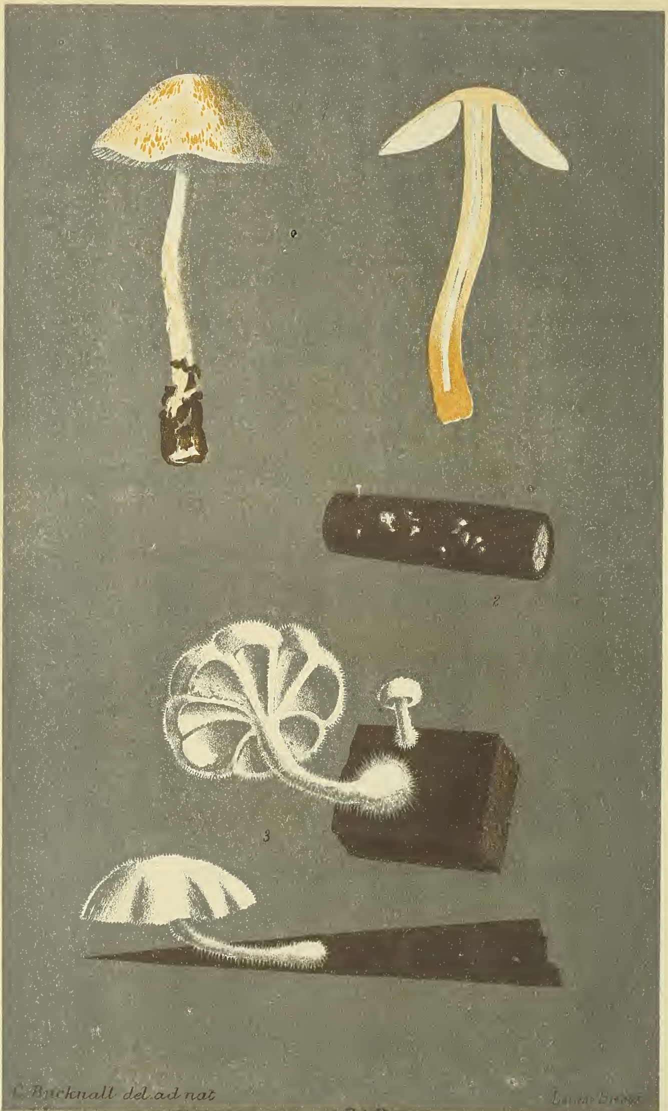
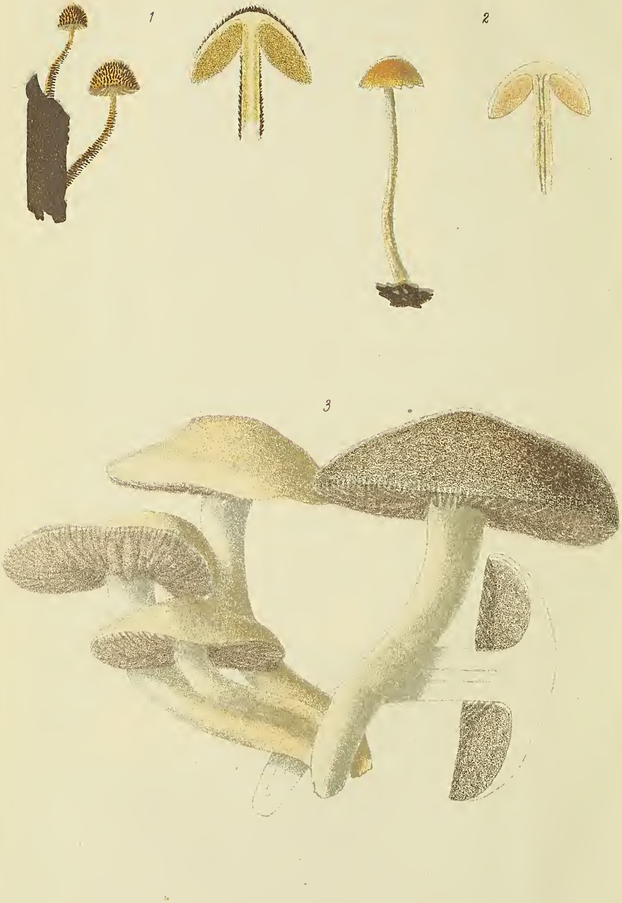
C. Bucknall del. ad. nat.

Lavars, Bristol.

1. Cortinarius firmus, Fr. ⅔ nat. size.
2. Agaricus Bucknalli B. & Br.



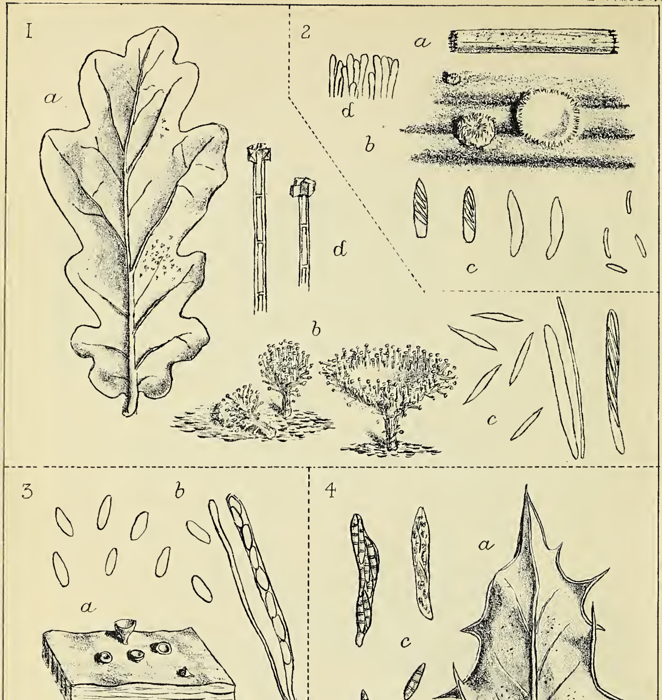
1. Agaricus granulosus var. rufescens, B. & Br.
2. " electicus n. sp. nat. size.
3. " " magnified.



C. Bucknall del. ad nat.

Lavars Bristol

1. Agaricus muricatus var gracilis Quel
2. " vestitus, Fr.
3. " sarcocephalus Fr.



1. *Peziza echinulata*, 3 *Helotium flavum*, 5. *Sordaria pleiospora*.

2. *Peziza fugiens*, 4. *Nectria erubescens*, 6. *Sordaria minuta*,

831. Sphæria scirpicola, *D. C.*	Cheddar,	July, 1880.
832. „ clypeata, *Nees.*	The Gully,	Feb. „
833. „ vectis, *B. & Br.*	Portbury,	June, „
834. „ Michotii, *West.*	Filton,	June, „
835. „ nardi, *Fr.*	Leigh Down,	Mar. „
836. „ infectoria, *Fckl.*	Leigh Wood,	Mar. „

DESCRIPTION OF PLATES.

Plate I.

Fig. 1. Cortinarius firmus, *Fr.*
Fig. 2. Agaricus Bucknalli, *B. & Br.*

Plate II.

Fig. 1. Agaricus granulosus, var. rufescens, *B. & Br.*
Fig. 2. „ electicus, *B.*

Plate III.

Fig. 1. Agaricus muricatus, var. gracilis, *Quel.*
Fig. 2. „ vestitus, *Fr.*
Fig. 3. „ sarcocephalus, *Fr.*

Plate IV.

Fig. 1. *a.* Peziza echinulata, *Awd.*
b. Plant × 30.
c. Asci and sporidia × 330.
d. Hairs of cup × 330.
Fig. 2. *a.* Peziza fugiens.
b. Plant × 50.
c. Asci and sporidia × 330.
d. Hairs of cup × 330.
Fig. 3. *a.* Helotium flavum, *Klotsch.*
b. Asci and sporidia × 330.
Fig. 4. *a.* Nectria erubescens, *Desm.*
b. Perithecium × 50.
c. Asci and sporidia × 330.
Fig. 5. *a.* Sordaria pleiospora, *W.*; perithecium × 40.
b. Asci and sporidia × 200.
Fig. 6. *a.* Sordaria minuta, *W.*; perithecium × 40.
b. Asci and sporidia × 200.

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Recent Investigations on the Course of Storms.

By G. F. BURDER, M.D., F.M.S.

EVERY one is familiar with the phenomena of a storm, as they appear to an isolated observer at any one spot, where he and the storm may happen to be. A fall of the barometer, a gale of wind, and generally a downpour of rain—these are the chief incidents observed. But the meteorologist, who would contribute anything to the advance of the science, or who would even keep abreast of the advance already made, must look at a storm from quite another point of view. He must take his stand-point (so to speak) outside the storm. He must collect and collate observations of the same storm taken at many different places, with a view to discover the mode in which it originates, to trace its path over the earth's surface, and, by a comparison of the direction of the wind at the same instant in different parts of the area covered by it, to determine the laws which govern the movements of the air within it.

This has been the great work of modern meteorology. It is not yet nearly completed, but it is making very satisfactory progress.

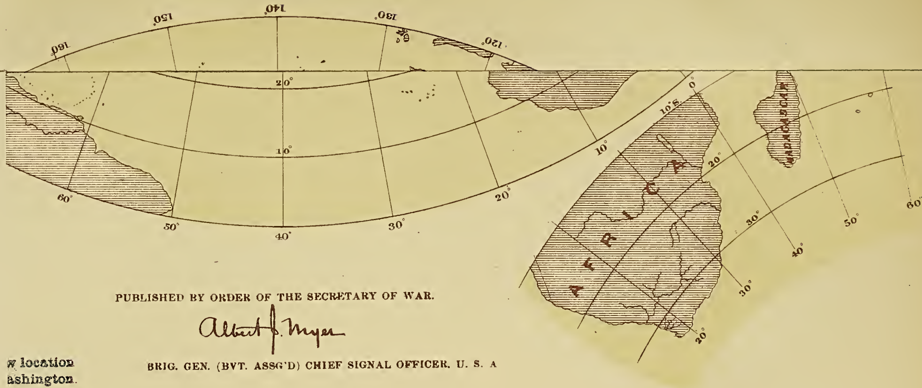
It is not without interest to look back upon the history of this department of meteorology. It has a history of about fifty years.

In the year 1831, Mr. Redfield, of New York, published the results of his investigations regarding the phenomena of West Indian hurricanes. These destructive visitations (to which we

INTERNATIONAL CHART.

Showing Tracks of Centres of Low Barometer for April, 1878.

No. VI.



PUBLISHED BY ORDER OF THE SECRETARY OF WAR.

Albert J. Myer

BRIG. GEN. (BVT. ASSG'D) CHIEF SIGNAL OFFICER. U. S. A

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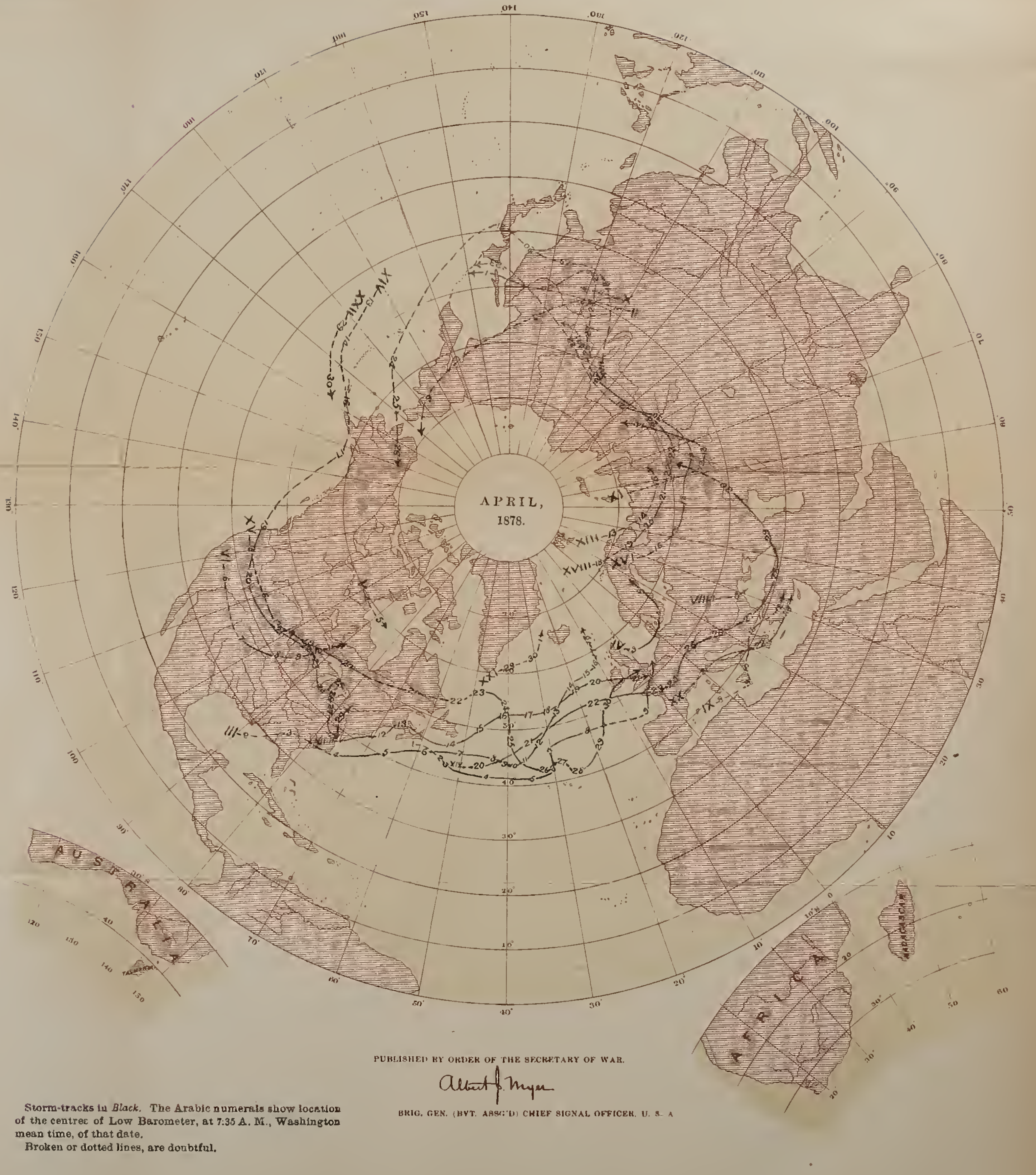

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Storm-tracks in *Black*. The Arabic numerals show location of the centres of Low Barometer, at 7:35 A. M., Washington mean time, of that date.

Broken or dotted lines, are doubtful.

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have no parallel in our own latitudes) offered an inviting field for inquiry, and it is likely enough that before Redfield's time, many had suspected what it was reserved for him to demonstrate. The very peculiar and striking phenomena observed in places over which the centre of the storm passed—first a hurricane of wind from a certain quarter, then a period of dead calm, and then a hurricane of wind from precisely the opposite quarter to that from which it first blew—these successive incidents must often have suggested the idea of a gigantic whirlwind passing over the spot. Indeed, we have it in evidence, that so long ago as the year 1801, this idea had presented itself to one Colonel Capper, whose observations were made upon similar storms occurring on the coast of Coromandel. Nevertheless the credit belongs to Redfield of having proved by a comparison of actual observations at many different places, that the hurricanes of the West Indies are circular or rotatory storms. He did more than this. He showed that not only was there a gyratory movement of the air within the storm, but that the storm itself—say, the centre of it—moved over the earth's surface in a very definite and determinate manner.

The work commenced by Redfield was taken up by Lieut.-Col. Reid in this country. In the year 1838 Reid published a book on the "Law of Storms." In this he not only confirmed abundantly the conclusions of Redfield with regard to the West Indian hurricanes, but showed also that the typhoons of the China Sea, and those of the Indian Ocean were governed by the same general laws. He also pointed out the remarkable fact, that whereas in the hurricanes of the northern hemisphere the wind circulates in a direction contrary to the hands of a watch, in those of the southern hemisphere the rotation is invariably in an opposite direction. North of the equator the rotation is retrograde; south of that line it is direct. Reid also expresses his belief (as Col. Capper had done before him) that many of the storms of the temperate latitudes partake of the same nature essentially as the tropical hurricanes.

Since the date of Reid's work, and especially within the last twenty years, a great impulse has been given to the study of this branch of meteorology. Several causes have contributed to this—the establishment of Meteorological Societies in various countries, the multiplication of observers (without whose aid nothing can be done), and, perhaps most of all, the introduction and application of the electric telegraph. The advantage of the telegraph to meteorology has been mainly indirect. For purposes of study the storms of last year are as valuable as those of yesterday, and more so, inasmuch as they admit of the observations being more complete. But what the telegraph has done for meteorology is this. It has created a kind of living interest in the study, and, by holding out the prospect of immediate practical application, it has stimulated the Governments of various countries to organise systems of observation to an extent, which could hardly have been compassed, either by individuals or by societies.

The great meteorological achievement of the last twenty years has undoubtedly been the establishment of the principle, that all great atmospheric commotions, in whatever part of the world they occur, are essentially cyclonic in character—that is, that they partake of the same nature as the so-called cyclones, or circular storms of the tropics. We may even go further than this, and apply the same law to those minor atmospheric movements, which are concerned in the ordinary weather changes with which we are familiar. This becomes obvious enough when we examine an isobaric chart of any considerable tract of the earth's surface. An isobaric chart is a chart, upon which the lines of equal barometric pressure are marked—the isobaric lines, as they are called, or sometimes, for shortness' sake, isobars. One of the most valuable series of charts of this kind that have yet been published, is that constructed by Captain Hoffmeyer, of Copenhagen, embracing the whole of Europe, and the North Atlantic Ocean, with parts of Asia, Africa, and America, and representing the chief meteorological elements at a given hour on every day of the year.

Having once mastered the general laws of the wind, the observer of the weather is no longer confined to a knowledge of what is going on at his own post of observation. He sees in his mind's eye the whole system, of which the weather at his own station forms a part. Like the comparative anatomist with his bone, he constructs an entire storm from a mere local fragment. If, for example, he notes a strong S.E. wind, he knows with as much certainty, as if he had telegraphic information of the fact, that a centre of barometric depression lies in the S.W. He has no positive means of ascertaining the distance of this centre, but if he sees his barometer falling fast, he knows that the centre is moving rapidly towards him. Should he observe the wind slowly veer from S.E. to S. and S.W., he will conclude that the centre of the storm is no longer coming towards him, but is passing at a considerable distance in the N.W. If the changes of wind, instead of being slow, are very rapid, he knows that the centre is passing at no great distance from him. If the wind, instead of veering in the ordinary direction, backs from S.E. to E. and N.E. (supposing him to observe in this locality), he infers that the centre is passing up the English Channel or across France. If, as sometimes happens, a dead calm prevails with a low barometer, he judges that he is in the centre of a cyclonic system. In the case of persistent gales such as we have lately experienced,[1] oscillating between S.W. and W., he rightly pictures to himself a succession of deep depressions passing in the far North. In this way, so much additional interest is given to the observation of weather changes, as goes

[1] This paper was read March 4, 1880.

far to compensate the observer for the physical discomfort which these changes often bring.

I have spoken of the movements of a storm-centre with reference to the observer, and this leads me to what is really the nucleus of my subject. Centres of barometric depression (which are also centres of circulating winds) have certain movements of their own, more or less regular and determinate. And this is equally true, whether the centre of depression be the focus of a tropical hurricane, or whether it be the centre of an ordinary Atlantic gale, or whether it be merely the centre of a comparatively languid circulation of air.

The paths of storms over the earth's surface—this is what I propose now to say a few words about. And here we must be careful not to lose sight of the distinction between the path of the storm, and the path of the wind. By the path of the storm we mean the path of the whole storm system, or perhaps we had better say the path of the centre of the storm; for though the whole storm moves bodily, it is clear that the centre is the only part, the movement of which can be accurately traced. The direction of the wind within the area of the storm will of course vary with every point of the circle. Now, the path of the centre of a storm is laid down on a chart, by marking the position on successive days (or at shorter intervals if observations are available) of the point of lowest barometric pressure. A line joining all these points gives the true path of the centre of the storm, or (as we may say) the path of the storm.

It is upon this principle that a chart has been constructed, lately issued from the Signal Office of the United States of America, the salient features of which have now to be explained.[1]

[1] For copies of the chart to accompany this paper, the author is indebted to the courtesy of Major-General Hazen, Chief Signal Officer of the United States.

The irregular and somewhat interlacing lines observed upon the chart, represent the paths of all the centres of barometric depression, which admitted of being traced in the month of April, 1878. I say the paths of the centres of barometric depression, because there is no reason to suppose that all of these centres were centres of actual storms. If a choice existed, one would have preferred a chart of all the great storms of a year to one of all the barometric depressions of a month, for although, as I have already said, there is an essential identity of nature between all depression-centres as regards the circulation of winds around them, it by no means follows that the minor depressions can be taken as types of the major, with reference either to rapidity of movement or to direction of movement. However, we must make the best of the material to hand. Possibly, at some future time, when other charts have been issued, we may have a further opportunity of pursuing the subject.

Let us see, then, what the chart teaches with regard to the paths of storms or of depression-centres.

Notice first the *number* of these lines. There are altogether twenty-two, representing that number of separate depression-centres. There might probably be more in a winter month.

Notice next the *point of origin*. That is very various. Some make their first appearance on the Pacific coast of America, others on the Atlantic coast. Some commence their career at sea, others on land. Several appear to take their origin in the Arctic regions.

The *direction* in which the centres move is a point of special interest. As a rule, and speaking generally, they all move from West to East, but the deviations from a straight course are numerous and large. A common tendency is to take a South-East course at first, and afterwards a North-East course, the result being a curved line with its concavity towards the North.

The *length of course* varies greatly. Some have a very short life. Others retain their identity through a course of many thousands of miles. One originating on the Pacific coast of America traverses the entire American continent, and the Atlantic Ocean.

Lastly, the *rate* at which these centres move is by no means uniform. In the chart we find eight to twelve days occupied in crossing the Atlantic. From other sources there is reason to believe, that the time occupied may range from three to sixteen or even twenty days.

A number of interesting questions are suggested by a chart of this kind.

What determines, in the first instance, the formation of a centre of depression with winds circulating round it?

What is the causal relation between the depression and the wind? Does the wind cause the barometer to fall, or does the fall of the barometer produce the wind?

Why should storms once formed move from West to East, rather than from East to West?

Why in particular instances should they change their direction or become stationary?

Why should some fly across the ocean with the speed of an express train, while others, not less energetic as regards their internal movements, creep and loiter in their course?

Lastly, what light does the chart throw upon the vexed question of the possibility of predicting European storms from the American side of the Atlantic?

I pass over all these inquiries but the last. On that I have a word to say.

It is well known that some few years ago, the enterprising proprietor of the *New York Herald* instituted a system of storm-warnings, despatched by telegraph from New York to London, and published in the daily newspapers throughout this country.

Opinions are, I believe, still divided as to the success or non-success, on the whole, of these forecasts. There have no doubt been some striking verifications (or coincidences), but I believe there have been a much larger number of conspicuous failures.

At the end of January last, I took the trouble to search the file of *The Times* newspaper for that month, with a view to see how many storms had been predicted from America, and with what success. Now, the month of January last was a month of exceptionally high barometer and settled weather. Excluding a few days at the beginning and end of the month, I found that from the 4th to the 27th inclusive, the daily charts gave no indication of any atmospheric disturbance of any moment in any part of Western Europe. Yet during this same interval no fewer than nine storms were telegraphed from New York as threatening " the British, Norwegian, and French coasts." The contrast between prediction and fact could hardly be more complete. Yet I have no reason to doubt, that the forecasts were the best that could be made. Each of them, we may assume, was based on the occurrence of an actual storm on the American coast, and we know that during a great part of the month, the Atlantic was tossed by tempests of unusual violence. But the inference that these storms would reach Europe was not justified by the event.

Consulting the chart on the practical feasibility of these predictions, we get no conclusive answer, but what answer we get is discouraging.

Of the five depression-centres, which appear on the chart to be crossing the Atlantic, one, turning northward, passed near Iceland, three became exhausted in the neighbourhood of the British Isles; while the only one, which from the length of its European course would seem to admit of prediction, will be found to have had its origin in the Atlantic Ocean.

Professor Loomis, an eminent American meteorologist, has examined this question with care. He finds, that of the storm-centres which leave the American coast, one in nine passes over some part of England, while one in six comes sufficiently near to occasion a gale.

A very instructive chart, as showing the erratic behaviour which some storms exhibit in their passage across the Atlantic, is published by Professor Loomis in a recent number of the *American Journal of Science.* In this case, the storm-centre, starting from a spot a little distance south of Greenland, and proceeding for some days in a regular easterly course, suddenly turns upon itself, and, after wandering in an aimless manner about the middle of the Atlantic, is found after the lapse of a fortnight at a place not many hundred miles from that, whence it started. Then, as if reminded of its duty, it takes a fresh start, and finally reaches the coast of Norway. A storm such as that must defy accurate prediction.

For the solution of some of the questions which I indicated just now, we may have to wait until observations have been collected and discussed from a wider area than at present. We need observations from southern, as well as northern latitudes, from the Pacific, as well as from the Atlantic. In the meteorological millennium, when we shall have the barometric pressure over the whole world charted for every day in the year, a flood of light will no doubt be thrown upon points which are now obscure, and if the forecasting of the weather should never arrive at the perfection which some anticipate, we shall at least have the satisfaction of knowing the reason why.

A Naturalist's Ramble in Guernsey.

By ADOLPH LEIPNER, F.Z.S.

THIS island, the second of the Channel Islands in point of size, is in the form of an isosceles triangle, its eastern and southern sides being each about seven miles in length; the western, the most indented side, is nearly ten miles long; its area is twenty-three square miles.

The southern portion, which resembles in many respects the south coast of Cornwall, is mountainous, attaining in some parts an elevation of nearly 400 feet above the sea, and forms a plateau, gradually declining to the north about half way across the island; the northern part is flat, diversified by irregular hills of no great elevation. The geological formation of the northern part is Syenite, of the south Gneiss, which is traversed by large seams of hornblende, called in the locality "Trap Dykes." The Syenite, or Guernsey granite, is largely quarried, and forms the principal article of export, not less than 238,345 tons having been shipped in 1879, and a similar quantity the previous year. It is preferred on account of its extreme hardness, and is exported in rough pieces to be broken in England—in spalls ready for Macadamizing, in blocks for pitching, and prepared for kerbs. Valuing it at 6s. per ton, the annual return from this source alone is £70,000.

The export trade of the island is almost entirely confined to England, and includes, beside the granite, vegetables (potatoes, broccoli, &c.) and fruits (grapes, tomatoes, pears, &c.). Owing to the early spring—vegetation being usually a month in advance of that of England—these products fetch a high price in the English market. Glass is extensively used in raising this produce and in horticulture, and it is no exaggeration to say there are acres of greenhouses. The quantity of grapes exported, all grown under glass, in 1880, is estimated at 200 tons; they fetch in Covent Garden Market from 15s. to 8d. per lb., according to season and quality—estimated value, £20,000. The soil is not naturally of exceptional fertility, yet, owing to the mildness of the winter, two crops are frequently obtained in a year. Seaweed, here called "Wrack," a corruption of "Vraic," is the principal manure. This is cut at low water of spring tides, and collected from the beach after storms; and is also used in the manufacture of iodine, &c. The article is so important, that its collection is regulated by local ordinances; each parish can only cut at its appointed bays, and no one must cut but at the authorized times. The collection of the vraic-harvest is a most animated scene; all the country carts, horses, and labourers are in request, the beach is alive; there are men up to their waists in the sea, cutting the weed from the rock, others collecting it with large wooden rakes, others carrying or carting it to a place of safety above the flood-tide; then at greater leisure it is carted away to the farm, or spread out in odorous patches on the shingle or turf by the roadside along the bays to dry. (I remember the smell arising from it along Vazon Bay, and the blue-eyed children running after the carriage, crying "Des doubles," "Des pennies").

With all its productiveness the islanders cannot raise sufficient food to feed the inhabitants, nor is this to be wondered at when we remember that 30,000 people are here concentrated on twenty-three square miles. The deficiency is largely supplied from France, there being constant communication with St. Malo, St. Brieux, Cherbourg, and Binic. Manufactured goods come from England; coal from the North. Here we have the apparent anomaly of a place exporting and importing the same articles. But the potatoes exported are early produce, raised in greenhouses and the open fields, and exported before Midsummer, while those imported arrive in November and subsequent months, and are purchased at a quarter of the rate received for those exported. There is a great demand for the island cattle for dairy purposes, both in England and America; a herd was recently forwarded to the latter country by the Great Western Steamship Company—Guernsey cows being a branch of the famed Alderney breed, but excelling in size and equalling in yield of milk the Jersey stock. Alderney itself hardly exports a score in a year. Bullocks have to be imported from France and Spain, and mutton from England. Increasing attention is being given every year to market-gardening, the orchards producing the cider, for which the island was formerly noted, are being rooted up. Small vegetables become in their season important articles of export, *e.g.*, asparagus and radishes—more than 1000 packages of these latter were exported in the week ending March 19, 1881—even parcels of groundsel have paid well for carriage to London.

The country people live very frugally, cabbage soup, "soup à la graisse," is one of the common dishes. The farms are generally cultivated by the owners with very little hired help. The successful result of the island trade is shown in the wealth of the inhabitants. Besides the value of landed estate and house property, there are £240,000 in the Guernsey Savings Bank, about £230,000 invested with the States at 3 per cent., all local capital, large amounts are invested in shipping, and there is an unusually large proportion of English and foreign bondholders. The monetary system is most confusing: the silver currency is French, francs, half-francs, five-francs, &c.;

the only local coins in existence are bronze, doubles, two-doubles, four doubles. and eight-double pieces, called pence, and exactly on par with the French "dix centimes," so that ten eight-double pieces make a franc. The States and two local banks issue notes of £1. Prices are always quoted in shillings and pence, but shillings are non-existent, having to be made up by a franc and two eight-double pieces. English money commands a premium, varying with the exchange on Paris—a sovereign is at present worth a Guernsey pound note, a shilling, and a halfpenny. This complicated system is kept up apparently on account of the advantages it offers to the States and shareholders in local banks, who, being persons of influence, can control the action of the States in this matter. A prejudice against French gold is wisely stimulated, so that all who have to pay or receive large amounts are compelled to employ £1 notes, which therefore circulate to a large amount (£90,000). There are few strangers who get to comprehend this complicated system even in a year's residence.

The language is a French patois, but the rising generation evince great desire to acquire English, as their prospects in after life depend greatly on a knowledge of it. In the "Folk-Lore of Guernsey and Sark," by Louisa Lane-Clarke, the Guernsey-French is thus described :—"The language of the townspeople, from their constant intercourse with strangers, is very intelligible English, though spoken with a peculiar accent, and frequently interlarded with the mother tongue; but in the country, or if marketing on a Saturday, when the town is thronged with peasants, the stranger may be greatly puzzled to make out what language the people are talking. It is a good old dialect, which, during the last century at least, has proceeded in a steady course of gathering, like a rolling snowball, from everything it encountered, and increasing its vocabulary by various compounds of Latin, Welsh, Scotch, German, English, and Italian, added to the original stock, which was Norman-French, making altogether a very expressive and by no means an inharmonious patois. If it *seems* to be rude and harsh, it is because you do not hear it kindly spoken; because, perhaps, you listen to the contentions of the market-place, or the coarse voices on the pier—no language is euphonious in these places."

The inhabitants of the island are excessively exclusive and broken up into cliques; one result of which is, that societies for mutual improvement, such as a Naturalists' Society, are unknown there. This is much to be regretted, as there are few localities where natural history could be studied to greater advantage than here; the area being so small, it could be thoroughly worked, and yet there need be no fear that the materials at command would soon be exhausted.

The varieties of soil are very great, the cliffs, the low sandy sea-shore, and the marsh-land, each produces its peculiar plants: the number of flowering plants, exclusive of sedges and grasses, enumerated in Professor Ansted's work, is 505. The list, though the latest, is notoriously inexact, and requires an authoritative revision. Such a work would fall to a Naturalists' Society, if such existed, and, by putting himself into communication with working members of it, the author would no doubt have been able to enjoy his stay there to a far greater extent, and to produce a much longer list of objects seen and studied. Indeed, had it not been for the most kind attention and valuable assistance of Mr. George Derrick, of St. Peter's Port, even the sight of the most interesting plants in the island—*Cyperus longus, Orchis laxiflora, Spiranthes æstivalis*—would not have been obtained. *Spiranthis autumnalis* and *Scilla autumnalis* were too widely distributed and far too abundant to have escaped detection; they were to be met with everywhere along the coast in perfection in August; but *Pyrola rotundifolia*, though plentiful where it did grow, was too local, and made a guide almost indispensable, and even with a guide to the exact locality, *Isoetes Hystrix* might be passed over. The thinness of the soil causes the cliffs and higher sloping grounds to be burned up in summer. The botanist has to wait till October in order to find *Ophioglossum lusitanicum* and *Trichonema Columnæ (R.)* and to see the cliffs on the whole to perfection. It is somewhat tantalizing to see *Agave Americana*, tall *Dracænæ*, myrtles planted in the open ground, and fuchsias amongst heaps of stones, and nearly as secure from winter frosts as they are in our greenhouses in England. Skates are not likely to be of use once in five years in Guernsey. It is a rare thing to see snow lying on the ground, and in proof of the mildness of the winters it may be mentioned, that a friend of the author has for nearly twenty years without break never been without primroses in the house, picked from the open fields from December to June. During this last severe winter of 1880-1881 there has been only one heavy fall of snow.

One of the most remarkable acclimatized vegetable productions of Guernsey is *Gunnera scabra*, belonging to the *Araliaceæ*. It is mentioned by Darwin as occurring in Chili, and described by him as attaining there a great size, with stems as thick as a man's leg. But some of the Guernsey specimens are quite as large. In its mode of growth and shape of the leaves it much resembles rhubarb, and indeed the people of the island very generally call it "wild rhubarb." The author saw it in great perfection in Mr. Smith's nursery, and obtained through his kindness two fruiting spikes, which were exhibited at the meeting of the Society. These compound fruiting spikes were pyramidal in form, thirty inches in length and about six inches in diameter at their base; the small orange-red fruits, with which they were covered, gave them almost the appearance of hugh green fir-cones studded over with little red corals. The leaves of the *Gunnera* being from six to eight feet in diameter, with leaf-stalks as thick as a man's wrist, give the plant altogether a magnificent, almost tropical aspect.

Of all branches of natural history, botany is the one to which most attention has been given. Professor Babington visited the island, and so thoroughly examined it, that there are few districts which can produce so complete and trustworthy a list as Guernsey. Mr. Wolsey and others have worthily followed up his researches, and their success may be judged of by the addition of *Ophioglossum Lusitanicum;* of *Isoetes Hystrix,* by Mr. Wolsey; and *Gymnogramma Leptophylla*, by Mr. Derrick (1877). The island is one of those places which has been spoken of as a fern paradise, but rather on account of their extreme abundance than from the number of varieties. Walls and hedgerows are everywhere crowded with *Scolopendrium, Polypodium, Asplenium Adiantum-nigrum*, and *Asplenium lanceolatum.* There is ample scope for the lover of lichens, mosses, liverworts, &c., while an enthusiastic searcher for sea-weeds will be delighted with the beautiful and rare specimens to be found in the picturesque rock-pools.

Turning now to the animal productions of the sea, the author, who however only once indulged in the luxury of dredging, and for the rest had to content himself with shore-work, did not notice any great difference between the Devon and Cornwall coasts and the sea around Guernsey. Foraminifera, Sponges, Sertularians, Campanularians, Medusæ, Actinozoa, and similar organisms abounded, also—even in high rock pools on one part of the island—that lovely little coral, *Balanophyllea regia.* Of Echinodermata, the following were obtained and exhibited at the meeting:—*Comatula rosacea; Ophiura texturata* and *albida; Ophiocoma neglecta, granulata, bellis*, and *rosula; Uraster glacialis* and *rubens; Cribella oculata; Luidia fragilissima; Asterina gibbosa; Echinus sphæra* and *miliaris; Spatangus purpureus; Echinocyamus pusillus* (of Forbes' British Starfishes).

Amongst the Turbellaria found the most curious one was *Nemertes purpurea,* which was kept alive for several days in an improvised aquarium, and its peculiar mode of progression and habits observed. Not the least interesting marine production was a large broken mast washed ashore at Bordeaux Harbour, a little to the north of St. Sampson's, which was found riddled by shipworms, and its lower submerged half covered with Barnacles *(Lepas)* in such masses, as would have more than filled three carts, and the salmon-coloured peduncles of which, 12 to 18 inches long, were twisting and writhing in snake-like fashion as long as the poor creatures were alive.

On the shore, too, especially on the eastern part of the island, one often finds small heaps of Ormer-shells or Ear-shells *(Haliotis tuberculata),* of which the Channel Islands are our nearest station; but these have not been thrown up by the sea, but are the deposits of man, for these molluscs are collected at extreme low water, especially during the highest spring tides in March and April, and brought to market, or enjoyed by the collectors themselves. The few that were obtained among the rocks at low-water at the time to which this account refers (August) were small, but served on that account all the better for the preparation of their most beautiful Odontophores or tongues as microscopical objects.

The waters around Guernsey seem to be particularly rich in Polyzoa, a group of animals in which the author is specially interested. Of the following species collected in Guernsey (named according to Hincks' Monograph of British Polyzoa) not less than 62 were obtained in the one dredging operation between Guernsey and Herm, of about four hours' duration, referred to above, and were brought home dried, for the purpose of identification. The remaining nine species are only a few of those that were gathered along the shore, and mounted for the microscope with their tentacles extended—the rest, refusing to be charmed into a display of their beauty, were thrown away and remain unrecorded :—

1. *Aetea anguina*
2. ,, *recta*
3. *Alyonidium hirsutum*
4. *Amathia lendigera*
5. *Beania mirabilis*
6. *Bowerbankia imbricata*
7. *Bugula avicularia*
8. ,, *flabellata*
9. *Caberea Boryi*
10. *Cellaria fistulosa*
11. *Cellepora pumicosa*
12. ,, *ramulosa*
13. *Chorizopora Brongniartii*
14. *Cribrilina figularis*
15. ,, *Gattyæ*
16. ,, *punctata*
17. ,, *radiata*
18. *Crisia cornuta*
19. ,, *denticulata*
20. *Diastopora obelia*
21. ,, *patina*
22. ,, *Sarniensis*
23. *Flustra foliacea*
24. ,, *papyracea*
25. *Flustrella hispida*
26. *Hippothoa divericata*
27. ,, ,, var. *carinata*
28. *Lepralia foliacea*
29. ,, *Pallasiana*
30. ,, *pertusa*
31. *Lichenopora hispida*
32. *Membranipora Dumerilii*
33. ,, *flustroides*
34. ,, *pilosa*
35. ,, ,, var. *dentata*
36. ,, *solidula*
37. ,, *spinifera*
38. *Membraniporella nitida*
39. *Micropora coriacea*
40. *Microporella ciliata*
41. ,, ,, var. *personata*
42. ,, *Malusii*
43. ,, *violacea*
44. ,, ,, var. *a*.
45. *Mucronella coccinea*
46. ,, *Peachii*
47. ,, *variolosa*
48. *Pedicellina cernua*
49. *Phylactella collaris*
50. ,, *labrosa*
51. *Porella concinna*
52. ,, *minuta*
53. *Rhynchopora bispinosa*
54. *Schizoporella auriculata*
55. ,, *biaperta*
56. ,, ,, var. *divergens*
57. ,, *Cecilii*
58. ,, *discoidea*

59. *Schizoporella linearis*
60. ,, *spinifera*
61. ,, *unicornis*
62. *Schizotheca fissa*
63. *Scrupocellaria scrupea*
64. *Smittia cheilostoma*
65. ,, *Landsborovii*
66. *Smittia reticulata*
67. ,, *trispinosa*
68. *Stomatopora granulata*
69. ,, *Johnstoni*
70. *Tubulipora flabellaria*
71. *Vesicularia spinosa.*

What a rich harvest might not be gathered in by a Zoologist, who could afford the rather expensive luxury of dredging, aided by such local knowledge as a "Guernsey Naturalists' Society" might and would possess! May the time be not far distant when such an Association is formed not only in Guernsey, but in Jersey too! Besides giving such aid to visitors, as may be desirable and desired, how much would not the members of it enrich their own lives by the acquisition of knowledge and the cultivation of improved social relations!

Rainfall at Clifton in 1880.

By GEORGE F. BURDER, M.D., F.M.S.

TABLE OF RAINFALL.

	1880.	Average of 28 Years.	Departure from Average.	Greatest Fall in 24 Hours.		Number of days on which ·01 in. or more fell.
				Depth.	Date.	
	Inches.	Inches.	Inches.	Inches.		
January ...	0·658	3 325	−2·667	0·314	13th	7
February ...	4·519	2·260	+2·259	0·899	18th	21
March ...	2·639	2·223	+0·416	1·361	2nd	9
April ...	2·397	2·130	+0·267	0·485	13th	14
May ...	1·244	2·408	−1·164	0·317	27th	8
June ...	2·447	2·563	−0·116	0·370	20th	17
July ...	4 831	2·861	+1·970	0·816	22nd	18
August ...	0·409	3·466	−3·057	0·170	7th	5
September...	3·661	3·423	+0·238	0·810	12th	12
October ...	5·997	3·728	+2·269	1·722	4th	14
November...	3·095	2·698	+0·397	0·589	15th	14
December ...	5·476	2·737	+2·739	0·762	14th	18
Year ...	37·373	33·822	+3·551	1·722	Oct. 4th	157

Remarks.—The rainfall of 1880, although less than that of any year since 1874, was still considerably above the average. Speaking generally, and without regard to intermediate droughts, it may be said that a rainy period has prevailed now for nine years. During this long term there has been but one year (1873) in which the rainfall was not above the average of 28 years, and the aggregate excess in the whole period has been upwards of 44 inches. So marked and long-continued a deviation as this from the normal state of things can hardly be without some important consequences.

Notwithstanding the generally rainy character of the year 1880, two of its months, January and August, were distinguished by an exceptional degree of dryness. January, with 0·658 inch, was the driest January since 1855, and was the more remarkable as following three months of unprecedented dryness at the end of the previous year. August, with 0·409 inch, was by a long way the driest August that has been observed at this station. May was also a very dry and fine month; as March would have been too, but for a heavy downpour on its second day. Three weeks passed in March with scarcely a drop of rain, and 34 days in April and May with less than two-tenths of an inch.

The wettest months of the year were October and December, the former yielding close upon six inches, the latter nearly five and a half inches.

Three times in the course of the year the diurnal fall exceeded an inch, namely, once in March and twice in October. The heaviest fall in 24 hours was on the 4th of October, 1·722 inch.

Snow fell on the 13th of January to an average depth of four inches, and this was the only snowstorm of importance throughout the year.

Reports of Meetings.

GENERAL.

THE first meeting of the year was held on the evening of January 1st, when a paper was read by Professor Thompson on "Hearing with Two Ears." The conclusions arrived at by him were illustrated by various experiments with telephones. The subject attracted a considerable number of visitors as well as members, and the paper appears in full in the foregoing pages.

The next meeting occurred on the evening of February 5th, when Mr. Chas. Jecks contributed a paper, entitled "A Few Thoughts on Darwinism," which will also be found in the present Part.

Professor Sollas followed with his paper on "Evolution in Geology," in treating of which he commenced by stating the views held by the earliest sect of geologists, viz., the Catastrophists, who asserted that all changes in the crust of the globe were the result of convulsions of nature; the granite having been formed from the molten earth, and the strata, according to them, deposited in regular succession. As directly disproving this theory, Mr. Sollas referred to the interruption of the strata along the river Avon. Next come the Uniformitarians, who attribute geological changes to the action of water: the rain corroding the earth's surface, and sweeping the *débris* into the sea, while the waves gradually disintegrate the coast. Denudation and deposition are thus the two great processes at work in altering the earth's surface. The Uniformitarians were succeeded by the Evolutionists, who ascribe the changes to physical causes, the sun being, as it were, the mainspring, which sets the machinery in motion, causing rain, wind, and other meteorological phenomena, all which are factors in the forces at work. The heat lost by the earth may in great part account for the elevations and depressions on its surface, owing to the difference in the rate of contraction between the interior and exterior. Sir W. Thomson has calculated that it is between 100 and 200 millions of years since the earth began to consolidate; the geologists assign from 50 to 500 millions of years as the period. As we go back to the past, we must naturally expect that the forces at work were more powerful, owing to the increased temperature; and as a proof of this, we find that in layers of equal thickness in the Palæozoic and Tertiary rocks, we have the proportion of extinct species, as one in the former, to four in the latter, owing to difference in the rate of deposition; and the conclusion arrived at is, that the decreasing energy of the sun and earth, must have led to diminishing rapidity in the action of the main factors in geologic change, viz., denudation, reproduction, and elevation and depression of strata.

At the following meeting on the evening of March 4th, Mr. W. J. Fuller's paper on "The Breathing Apparatus of certain Aquatic Larvæ" was read by the Hon. Secretary in the author's absence. This communication appears in this year's Proceedings. Dr. Burder also gave the result of "Recent Investigations on the Course of Storms," which, illustrated by some excellent charts executed under the auspices of the United States Government, will be found in the preceding pages.

At the meeting on the 8th of April, Mr. Leipner read the following paragraphs from the *Natal Colonist* of March 2nd, 1880:—

ANTIDOTE FOR SNAKE BITES.

The *Beaufort Courier* has been favoured by a respected correspondent with an interesting paper on snakes, containing notes on the puff-adder, springslang, hornsman, and the night-adder. The author maintains that Ipecacuanha is an infallible antidote against the bites of all venomous reptiles, and relates the following incidents in support of his view :—" I soon discovered that a more reliable antidote was necessary for persons out of the reach of medical assistance ; and as my attention was drawn to the subject by something I read in an Indian newspaper, I resolved to give Ipecacuanha a fair trial, and soon discovered that I was in possession of the desired antidote. I will here relate a little of my experience in the use of this medicine. The first time I tried it was on a boy stung by a scorpion, and I found it cured him in about half an hour. The next case was a woman bitten in the back by a puff-adder. The wound was close to the spine, and received while sleeping at noon. She also recovered. Since then, I have cured people suffering from bites from many kinds of snakes and venomous reptiles, and have not known it to fail in a single instance. One of the most remarkable cures effected by the use of Ipecacuanha powder I will here relate. A reaper on a neighbouring farm was taking a nap at noon, under a shady tree, and a puff-adder came and lay alongside of him. As he woke he pressed against his unwelcome companion with his elbow, and in return received a severe bite in the fore-arm. The farmer not knowing what to use, dispatched a messenger on horseback for advice. Under the impression that it would be too late to apply the remedy in the shape of poultice, I mixed about two teaspoonsful of powder in a pint bottle of water, and told the bearer of it to let his master give it by table-spoonsful until he had used the whole of it. On his arrival with the medicine, it was discovered that the man was lock-jawed, and to all appearances in a dying state. The farmer, however, had the presence of mind to force his jaw open with an iron spoon, and give the medicine by spoonsful. During the evening it began to take effect, and by eight o'clock in the morning the man was able to walk abroad, and take his breakfast, and a speedy recovery followed. The following is the best mode of using this invaluable antidote:—Mix a tea-spoonful of Ipecacuanha with a little cold water; then scarify the part bitten (making two or three cuts through the skin), and apply the same as poultice. This should be followed by about thirty grains in a wine glass of cold water as an emetic; and, if necessary, both may be repeated in half-an-hour. But this is seldom required to complete the cure, as the pain generally ceases in less than this time, and appetite and health speedily follow." As this is a simple remedy, and is to be found in every farmer's "huis apotheek," I hope this notice will be of service to some unfortunate individuals who are beyond the reach of medical aid.

SINGULAR ENCOUNTER BETWEEN A RINGHALS AND A CROW.

An English farmer living near the border of Tembuland, and not more than three hours from Dordrecht, had occasion recently to take a ride into the veldt, some distance from his homestead, when his attention was drawn to a flock of some twenty or thirty crows who were assembled together near a large heap of stones, and who appeared, from the loud "caw-cawing" and flapping of wings made by them, to be greatly excited about something. On top of the pile of stones one of the crows was engaged in a deadly contest with a snake of the "ringhals" species, about three feet in length. The reptile appeared to be acting on the defensive, and the crow made occasional fierce onslaughts upon his adversary, his object appearing to be to get a good hold of him by the back of the neck; but although the snake showed innumerable marks upon his body, testifying to the sharpness of the bird's beak, he for some time guarded his neck so well that the other could not succeed in his manifest desire. The farmer stood watching the novel contest for the space of some twenty minutes, and the other crows appeared also to take a great interest in the affair, although they did not offer to interfere, no doubt considering that it would not be fair towards his snakeship for any more of their number to take part against him. The snake seemed by this time to be almost exhausted, and although he made some gallant efforts to get a chance of inserting his fangs in the body of the crow, the latter was too wily for him, and dodged about in such a manner as to avoid his every attempt. At last the reptile (who was standing upon his tail during the fight) suddenly fell down from sheer weakness, when the crow immediately made dart upon its opponent, seized him by the neck, bore him to a great height in the air, and then allowed him to drop upon the very heap of stones whereon the combat took place. The bird then quickly returned, and repeated the manœuvre over and over again, until the snake was quite dead. He then rejoined his companions, when they took their departure together, after having first set up a great "caw-caw," which the birds repeated three times, and which was evidently intended to answer the purpose of three cheers, given in token of victory. Our informant tells us he never saw a snake battered and bruised in such an unmerciful manner as this one was; it was beaten out of all shape, and the poor ringhals' own mother would not have recognised her son had she seen him in such a sad plight.—*Frontier Guardian*, February 6, 1880.

Mr. Leipner then proceeded to give the following paper on "Corals and Coral Reefs":—This substance is produced by vegetable and animal organisms. As an instance of the former, we find certain varieties of seaweed, such as corallines, which secrete carbonate of lime. These, though sometimes classed as corals, are properly, seaweeds. In the animal kingdom there are two sub-kingdoms, the Coelenterata and Molluscoida, which include the true coral-builders. The latter of these are cylindrical in form, and externally resemble Hydra; the tentacles are ciliated for the purpose of producing currents in the surrounding water, and thus assisting in respiration and feeding. They possess perfect muscular, digestive, and nervous systems. In the Coelenterata we have Hydrozoa and Actinozoa, the latter of which possess the greater interest. The body in them is divided into compartments by six membranes, and between these again others intervene, so that the interior cavity is subdivided into a series of cells or chambers, the total number of which is a multiple of six. It is a remarkable circumstance that among the corals which exist in the Palæozoic formations we find none with six divisions, four being the number. It is within the septa that the coral is deposited, the animal growing upwards as the formation proceeds. Reproduction takes place by budding, an instance of which Mr. Leipner described as having occurred under his eye in the case of a coral in an aquarium. Budding may take place in a four-fold manner—from the base, side, margin, or from the disc itself. The area in which reef-building corals occur is limited. They require for full development a temperature ranging between 70 and 85 degrees Fahr., and the extreme depth must not exceed 20 fathoms. The distribution is not uniform, but it is in the Central Pacific Ocean that we find reefs of the greatest extent; while in the Atlantic and other quarters of the globe they vary considerably in size, according to the nature of their surroundings; the formation of coral being checked by the cold Antarctic currents, fresh water, and the *débris* brought down by rivers. Branch coral grows more rapidly than the massive variety. In the case of a sunken vessel, over which the deposit had gradually formed, it was found to increase at the rate of 3 in. per year. Want of time prevented Mr. Leipner from entering upon several other points connected with the subject, and at the close a unanimous vote of thanks was accorded him for his very interesting and instructive communication.

On October 7th, the Society met, when Mr. Leipner gave, as the result of his holiday tour, "A Naturalist's Ramble in Guernsey," which appears in full in this part of the Proceedings.

On November 4th, Professor Thompson exhibited his new Phonautograph, which is fully described by him in the preceding pages. He was followed by Professor Sollas on "Siliceous Skeletons, and their Mineral Transformations." He commenced with the consideration of sponges, the skeletons of some of which are directly related to the subject he was about to discuss. In certain varieties of sponge we find the framework arranged in the form of lattice-work, filled up with cubical meshes. Of these we meet with several varieties, such as the Lithistid, the skeleton of which is made up of spicules composed of four rays, terminating in botryoidal expansions, which interlace with one another. In addition to them, there are Hexactinillid and Renierid sponges, the latter of which have skeletons composed of sheaths containing numerous fibres resembling fine needles. All these consist mainly of silica. Among fossil sponges are some, which we cannot find among those at present existing, and *vice versâ*. In the former we frequently find silica replaced by carbonate of lime, an instance of which was produced by Professor Sollas as occurring in a specimen sent to him from the green sand at Folkestone. The formation of flint is intimately connected with the existence of sponge, arising as it does from the deposition of sponge spicules, which we find in all flint. In order to account for such transformation, we must admit that, in some stage of the process, the silica becomes more or less soluble; and to explain this solubility, some writers have framed the hypothesis that it is due to humic acid, which certainly might produce the effect; but this acid has not as yet been proved to exist at the bottom of the sea. That ordinary flint is to a certain extent soluble, is shown in the case of flint walls, where we find the freshly-exposed black surface of the flint gradually disappearing, and leaving behind a white, chalky deposit. Professor Sollas was inclined to attribute the solubility to the great pressure existing at considerable depths, aided by the peculiar action of spiculin, an active principle contained in the spicules. But the subject is still involved in doubt.

The last meeting of the year took place on the evening of December 2nd, when Mr. J. W. White gave "Remarks on the

Formation of a Local Flora"; and Mr. Oliver Giles an account of "The Glacial Boulders of Bromsgrove, Worcestershire": both of which papers have been printed in the Society's Proceedings.

GEOLOGICAL SECTION.

THIS Section held the usual meetings, but of the papers read at them, the only one suitable for publication was that by Prof. Sollas, which has already appeared in another publication.

ENTOMOLOGICAL SECTION.

ALTHOUGH this Section met regularly, the communications contained nothing suitable for insertion in the Proceedings.

BOTANICAL SECTION.

IN contrast with the experience of the previous season, when the weather was unpropitious in the extreme, the Saturday excursions during this summer have been notably successful.

The attendances were large; and although the number of visitors usually present did not permit the members of the Section to apply themselves closely to botanical investigation on every occasion, yet many valuable observations were recorded. It is believed that the popularity of these excursions with the public is one evidence of that increasing interest in scientific matters which is one of the signs of the times, and which, it may be anticipated, will, as a minor result, afford much additional support to the Society.

Subjoined are jottings by the Hon. Secretary of a few of the most interesting of these excursions.

April 10th, 1880.—Present, six members of the Section and eight visitors. Took the private road from Beggar's Bush Lane which leads by a farmstead towards the Abbot's Pond; turned to the left before reaching the latter, and arrived at Failand Farm. In a pasture here Daffodils grow in great abundance, and were now seen in perfection. This is the only good habitat near Bristol, and the party halted to gather the flowers. At this spot the spring-flowering form of *Colchicum autumnale*, discovered by the Secretary in March, was pointed out, being still in blossom here and there among the Daffodils. It was observed that in the adjoining field, where Colchicum abounded, flowers were entirely absent, and that the plants had developed leaves to the extent usual at this period, whereas at the spot where flowers occurred but few leaves were to be seen, and those just peeping above the soil. Close by grew *Polygonum Bistorta* in plenty, and a little beyond the farm some fine plants of *Lathræa squamaria* were very welcome. Here also *Viola hirta, V. Reichenbachiana*, and *Chrysosplenium oppositifolium* were noted. The party now turned into the lane running south, and walked a short distance in that direction to visit a luxuriant colony of *Helleborus viridis*, located in a stony field, which at a remote date may possibly have been an orchard. Retracing our steps, a return was made around the Failand House Estate, where were one or two birch trees in a remarkable state of prolification. Home by the Tan Pits, Sandy Lane, and Abbot's Leigh.

April 17th.—Present, six members of the Section and eleven visitors. Arrived at St. George's Church about 3 p.m., and proceeded through the market gardens to the Avon. Found *Lamium amplexicaule* under a wall at Crew's Hole. This is almost the sole habitat for the plant in the Bristol district. Ferried across to St. Anne's Wood, and made a long but unsuccessful search for *Gagea lutea*, formerly to be found there, and to look for which was the chief purpose of this excursion. In a cultivated field bordering the wood were growing *Sisymbrium thalianum* (very luxuriantly), *Alchemilla arvensis*, and *Veronica Buxbaumii*, all in plenty. There were here several widely differing forms of *Stellaria media* and a great crop of young Lamb's Lettuce in excellent condition for salads. Returned by Brislington and the Bath Road.

May 1st.—On arrival of the train at Clevedon, the party was found to include eight members of the Section and twenty visitors. Among the latter were Mrs. Lainson and Miss Winter, who with Mr. Jecks were kind enough to direct the excursion during the earlier portion of the walk, and pointed out many objects of interest. *Bartramia pomiformis*, *Pogonatum urnigerum*, *Polytrichum juniperinum*, *Ptychomitrium polyphyllum*, and some other mosses were found. Later on, the profusion of wild flowers in Sir Arthur Elton's woods afforded great enjoyment to many of the party, who occupied themselves in gathering large bouquets of primroses, anemones, and woodrush. Pink and purplish varieties of *Anemone nemorosa* were frequent, and the great luxuriance and plenty of *Luzula sylvatica* and *L. pilosa* added a graceful feature to the scene. The walk was continued over the high ground to Cadbury Camp ; and the majority of those present ultimately found their way home by rail from Portbury

Station. A small group, however, walked on to Clifton by way of Failand and Beggars' Bush Lane, reaching home at 8 p.m.

May 8th.—Present, seven members and twelve visitors. Arrived at Cheddar Cliffs, 1.45 p.m. The first acquisition was *Ranunculus pseudofluitans*, gathered in the river below the mill, where it was abundant. Passing into the gorge the party separated. Messrs. Giles, Waterfall, and the Secretary ascended the cliffs to the right, while the rest proceeded, some up the the road, and the others to the slopes on the left. The botanists named spent several hours in exploring the upper ledges and rocks on their side of the cliffs. The plant most conspicuous at this early season was *Cochlearia officinalis*, flowering in profusion. *Dianthus cæsius*, now coming into bud, was noticed in its accustomed haunts; but a careful search for *Meconopsis cambrica* did not result in the discovery of a single specimen. *Potentilla verna, Myosotis collina, Hieracium cæsium, Hippocrepis comosa, Alchemilla vulgaris*, with the root leaves of *Campanula Trachelium*, and the Cheddar *Thalictra*, were successively recognized. *Carex præcox, C. glauca*, and *C. pulicaris* represented the sedges, and the beautiful spikes of *Orchis mascula*, large and abundant, bravely set forth the glories of Orchidaceæ. The Limestone Polypody, as usual, clothed many of the "screes," and *Asplenium Trichomanes*, with *Cystopteris fragilis*, were not unfrequent in more retired and sheltered situations. Descending at length through the fir plantations, Mr. Giles left his comrades and returned to the railway station. It remained for the two others to make the best discovery of the day, for, in a last hunt for *Meconopsis* on some grassy ledges under the high cliffs, Mr. Waterfall fortunately came upon *Saxifraga hypnoïdes*, festooned in mat-like masses on the moist declivity.

May 22nd.—Present, seven members and twenty-six visitors. This large party made its way to Dundry across the fields, passing through Ashton Park, and over the road at the Smythe

Arms. Many plants were gathered *en route*, viz.:—*Ranunculus tricophyllus*, *Galium uliginosum*, *Silaus pratensis*, *Carex riparia*, *C. pendula*, *C. distans*, *C. hirta*, *Ophioglossum vulgatum*, and *Alchemilla vulgaris*; the latter the most noteworthy find. The summit of Dundry Hill was attained before five o'clock, and whilst tea was being prepared at Hill House Farm, the old oolite quarries were revisited, and acquaintance renewed, in this habitat, with *Cystopteris fragilis*. After tea it was determined to push on to Bourton, and return thence to Bristol by the 7 p.m. train. Descending the hill to the far side of the Bristol Water Company's reservoirs, some marshy ground yielded *Pedicularis sylvatica*, *Lathyrus macrorrhizus*, *Valeriana dioica*, *Carduus pratensis*, *Carex præcox*, *C. pallescens*, *C. panicea*, and *C. vulgaris*. Little time could be afforded for botanizing, however, in the general anxiety to reach Bourton. Unluckily, the way thither proved to be longer than was anticipated, and the naturalists were unsuccessful in their endeavour to catch the train. Several remained at the station and came on later, but the main body, including most of the ladies, trudged home through dusty and dreary Long Ashton.

June 5th.—Present, eleven members of the Society and eight visitors. The party left Clifton Down at 1.5. The train not stopping at Charfield, it was necessary to change, and wait about an hour, at Mangotsfield. The time was utilized in examining the vicinity of the station. *Hieracium vulgatum* was very abundant on the cutting, where White Foxglove had been sown by the station-master. On the heath was *Lepigonum rubrum*, and in some marshy ground close by several good plants were discovered, viz., *Scirpus setaceus*, *Carex ovalis*, *C. stellulata*, *C. flava*, *Ranunculus Flammula*, *R. hederaceus*, *Montia fontana*, *Nardus stricta*, *Hydrocotyle vulgaris*, *Lychnis Flos-cuculi*, and *Pedicularis sylvatica*. Two or three of these were new to the district Flora. Proceeded at 2.15 to Charfield, and thence walked through Wotton-under-Edge up to the summit of the ridge, where *Hippocrepis comosa* and *Avena pubescens*, with other limestone plants, were particularly abundant. From this point the party proceeded leisurely through the wood towards Nibley, and many good finds resulted from the exploration. *Epipactis latifolia* was frequent, but not yet in flower. A grand specimen of *Neottia Nidus-avis* fell to the lot of one botanist, and another gentleman gathered *Habenaria chlorantha*. Several patches of *Polygonatum officinale*, flowering freely, and a great many plants of *Daphne Laureola* were met with; also Columbine, White Bugle, and great quantities of Sanicle. Emerging at length upon Nibley Knoll, the naturalists visited the monument erected to the memory of John Tyndale, and enjoyed the magnificent view presented from this spot. Descending the slope into the high road, a speedy return was made to Charfield, where "mine host" at the Railway Inn had prepared a substantial tea. To Bristol by train a few minutes after eight.

June 12th.—Present, eight members and thirteen visitors. Broke the journey at Mangotsfield as on the 5th, but found nothing more than was then gathered. On arrival at Yate the party dispersed over the Common. Many new plants were here, including *Ranunculus peltatus*, *Salix fusca*, *Sm.*, *Genista anglica*, *Aira præcox*, *Polygala depressa*, *Nardus stricta*, and good store of Carices. From Yate Common proceeded to Sodbury Common, finding on the way *Geranium pratense*, *Stellaria umbrosa*, *Pastinaca sativa*, and *Carex distans*. Sodbury Common yielded little excepting a titlark's nest containing a cuckoo's egg, so after a short halt the party returned through Chipping Sodbury by the high road to Yate. Tea at the Railway Inn, and home by the train reaching Bristol at 8.50.

The first part of the Flora of the Bristol Coal Fields, *i. e.*, the Thalamifloræ, is now in the press, and will shortly be ready for issue.

PHYSICAL AND CHEMICAL SECTION.

THE meetings of this Section held during the year, and the papers read at them, were as follows :—

January 29th, 1880.

Mr. A. M. Worthington, M.A.—"On the Splash of a Drop."

April 27th, 1880.

Prof. W. Ramsay, Ph.D.—"On the Cohesion of Liquids."

Dr. G. S. Thomson.—"On some Applications of Balmain's Luminous Paint."

November 3rd, 1880.

E. Wethered, Esq., F.G.S.—"On the Chemical Action of Carbonaceous Matter on Carboniferous Rocks."

Mr. M. W. Dunscombe.—Exhibition of some new forms of Kaleidoscope.

Prof. S. P. Thompson.—"Further Researches on the Illusions of Complementary Subjective Motion."

November 26th, 1880.

F. J. Fry, Esq. (The President).—Exhibition of Tubes shewing Phosphorescent Phenomena and Molecular Shadows.

Prof. S. P. Thompson.—"Some Experiments on Induction."

J. G. Grenfell, Esq., M.A.—"On the Supersaturation of Chlorate of Potash."

Prof. S. P. Thompson.—"On a System of Electric Clocks."

December 10th, 1880.

F. J. Fry, Esq.—"On Lord Rayleigh's Colour Combination Discs."

Prof. W. Ramsay.—"On the Determination of Specific Volumes."

Mr. D. Orme Masson, M.A., B.Sc.—"On the Specific Volume of Phosphorus in the Free and Combined States."

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NEW SERIES, VOL. III., PART III.

On the Gradual Diminution of the Human Head.

By F. F. TUCKETT and Dr. BEDDOE, F.R.S.

Mr. Tuckett's attention had first been directed to the subject of his communication by a remark made to him some time ago by Mr. Castle, hatter in St. Augustine's Parade, to the effect that during the last twenty-five years the size of hats, as regards the dimensions of the head, had been gradually diminishing, the difference of the circumferential measurement during that period amounting to as much as half an inch. Other hatters, both in Bristol and in different parts of England, were requested to communicate whatever information they might possess on the subject; and it appeared that this experience agreed with Mr. Castle's. Mr. Tuckett gave a tabulated form, drawn up by Mr. Castle from the hats supplied to him by Messrs. Lincoln & Bennet, the well-known London hatters, and shewing the progressive rate of diminution since 1855, from which it appeared that the average size of hats sold by them had fallen from No. $7\frac{1}{25}$ in 1855 to $6\frac{19}{21}$ in 1880, the average shrinking in size being $\frac{1}{7}$ in , or rather more than one size, which amounts to $\frac{1}{8}$ in., the scale of measurement used by hatters being derived from the sum of the length and width of the head, divided by two, and is expressed in inches, and eighths of an inch. One hat manufacturer wrote:—"Fifteen years ago the usual sizes of hats in England were from $6\frac{3}{4}$ to $7\frac{3}{8}$, and even $7\frac{1}{2}$ was not uncommon. But now, if a $7\frac{3}{8}$ hat was wanted, we should have to make a block purposely. The diminution in size has been attributed by some to the prevailing fashion of wearing the hair short; but as heads certainly average two sizes less than they did, and as the difference between long and short hair cannot amount to a quarter of an inch in length and the same in width, this solution of the matter is inadmissible." Dr. Beddoe produced evidence, collected for him by Mr. Garlich, hatter, of Castle Street, which very nearly agreed, as to the extent of the reduction, with that given by Mr. Tuckett. While in Scotland last summer, Dr. B. inquired of Mr. Kirsop, the principal hatter in Glasgow, what his experience was, and he fully corroborated what had been stated, so that the diminution appeared not to be confined to the southern portion of the islands. Several explanations had been brought forward, but none were entirely satisfactory. The most plausible of these rested on the different manner of wearing the hat, which was formerly drawn somewhat further down on the back of the head. Those which were based on supposed changes in the classes of people wearing hats did not appear to Dr. Beddoe to be of any value—the lower classes, who had the smallest heads, wore fewer stiff hats now than formerly. There was a good deal of evidence, much of it collected by himself, pointing to a certain degree of physical degeneration in the population of large towns; and he thought it possible that heads as well as bodies might have dwindled somewhat; but the fact, if it were one, was not capable of proof.

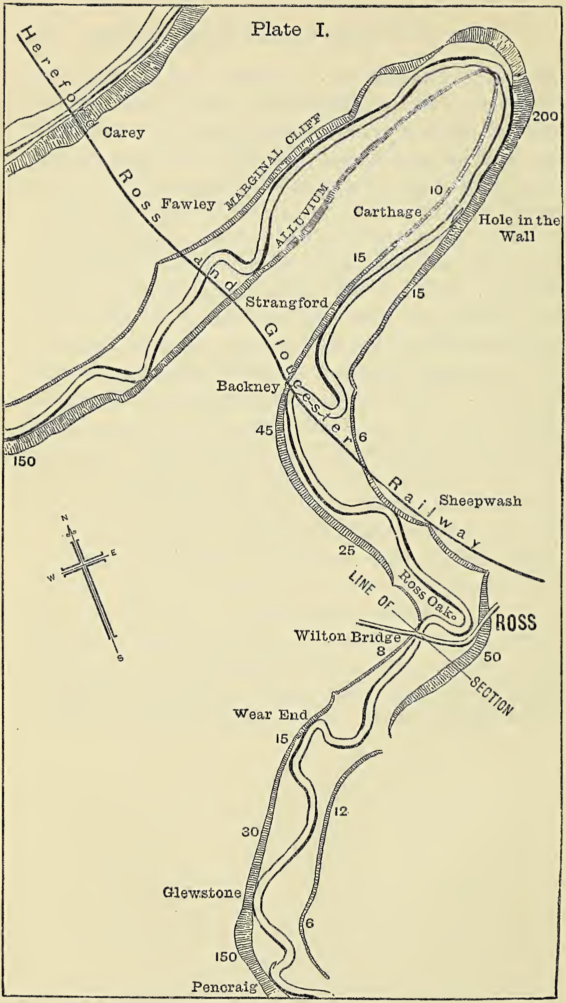

Plate I.
Hereford
Ross
and
Gloucester
Railway
Carey
MARGINAL CLIFF
ALLUVIUM
Fawley
Carthage
Hole in the Wall
Strangford
Backney
Sheepwash
Ross Oak
LINE OF SECTION
Wilton Bridge
ROSS
Wear End
Glewstone
Pencraig
200
10
15
15
45
6
150
25
8
50
15
12
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The Age of the Wye.

By CHARLES RICHARDSON.

THE original draft of this paper was written in 1856, and was printed in the *Edinburgh Philosophical Journal* of that year. Since that time, further consideration of the facts has induced me somewhat to modify my conclusions, and I have now, accordingly, entirely re-written the paper.

At the time when the original paper was written, I had been living in Ross eight or nine years, during the construction of the Hereford, Ross and Gloucester Railway, of which I was the Resident Engineer. In the construction of that line of railway, many deep cuttings were made through the old red sandstone, and four bridges were built across the River Wye. I had, therefore, unusual opportunities of becoming acquainted with the facts detailed below.

The part of the River Wye more immediately alluded to in this paper and from which I shall draw most of my conclusions, is the six miles nearest to Ross, and is shown on the map exhibited on the wall. The river runs down from the north towards the south. The river itself is about eighty yards wide, with a fall of two feet six inches in a mile down its "general course." In this term I include the river-formed alluvium as well as the stream itself; for the position in the alluvial land at present occupied by the stream, is a mere accident of the time: it has, over and over again, in the course of time, occupied all parts of the alluvium.

This alluvial land is shown on the map by a pale-green colour, and the present channel of the river by a blue tint. It may be observed that the banks of the stream are, in some places, marked by a strong and dark line, and in others by a fainter line: the dark line shows the parts where the stream is now fretting or wearing the bank away; the fainter line shows the part where the bank is either stationary or growing—for the river always preserves its average width.

The alluvial land, it may be observed, is all along bounded by banks or cliffs of the old red sandstone, which is the rock of this part of the country. These cliffs vary considerably in height in different situations; and, as this variation is a matter of some interest, the heights are accordingly shown on the map, approximatively by the breadth of the shading. Some figured heights are also added here and there. The alluvial land is here from 400 to 500 yards in width from cliff to cliff.

In order to follow clearly what is said below, it will be well to bear in mind that when the term "cliff" is used, in connection with the river, it is intended to refer to the cliffs, or marginal banks, bounding the alluvial land all along the course of the river; and that when the term "general course" of the river is used, the general direction of the river and the alluvium together, between these cliffs, is to be understood. The word "river-channel" or "stream" is used to denote the course of the river as contained between its alluvial banks.

The water level of the river, in its usual or low water state, is about ten feet below the alluvial level, but the water rises rapidly up to, or above, the alluvial level after heavy rain amongst the mountains near the source of the river.

The speed of the current, when the river is "bankfull," is about five and a half miles an hour, at which time the water is heavily laden with sediment.

The stream, it may be observed, winds backwards and forwards across the alluvial land from cliff to cliff, in "bends" of a peculiar form and curvature, wearing away its *outer* banks and the "cliffs" themselves wherever it reaches them, as shown by the dark marginal lines already alluded to, and leaving a deposit on the *inner* banks so as always to maintain its average width.

The curvature of these "bends" evidently depends upon the magnitude of the stream. If different streams of various sizes, large and small, be carefully inspected, either on the ground or on a correct map, it may be observed that they all wind backwards and forwards across their alluvial lands in a similar manner; and that the radius of the curvature of their "bends," though it does not, so far as I know, admit of exact measurement, yet clearly and evidently bears a definite ratio to the *size* of the stream.

Looking now at the "general course" of the river on the portion shown on the wall map, and starting from the Hole-in-the-Wall, it will be observed that, after having rounded the abrupt turn above the Hole-in-the-Wall, its "general course" is nearly straight till it arrives at Backney. The consequence has been that the "cliffs" on the two sides are of about the same height, which indicates that the wear has been about equal on both sides. But when it arrives at Backney the "general course" makes a bend to the east, and here we see, as might have been expected, that the force of the waters has been thrown against the west or salient cliff and has worn it largely, while the east or retreating cliff is comparatively little worn.

Again, proceeding down the river, we find that at Ross there is a westward bend in the "general course," and that this is attended by exactly the same results, namely, a high and greatly worn cliff on the east side, just below Ross, and a low and slightly worn cliff on the west side.

Lastly, there is an eastward bend at the Wear end, attended by just the same results.

It may here be remarked, that looking down the whole length of the river, on the ground or even as shown on the ordnance map, it will be noticed that the "bends" of the stream, as they wind about through the alluvium, frequently do not arrive at the cliff on the retreating side, but always impinge forcibly on the salient cliff, unless artificially hindered, and that, in those cases in which the stream does arrive at the *retreating* cliff, the length of the cliff exposed to the action of the water is usually less than in the opposite cases of the *salient* cliff.

These are, evidently, the main causes of the greater amount of wear from the salient cliff. But, nevertheless, the mechanical attrition of the gritty water may also have some small effect in addition.

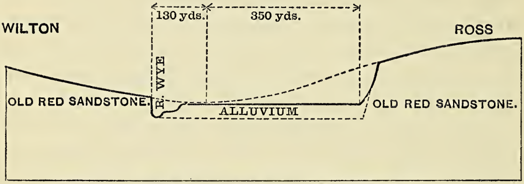
These remarks apply, of course, only to those parts of the stream where the banks are left to natural causes, and not artificially protected by walls or cribbs, &c.

The six miles of country near Ross, through which the river flows, have a gently undulating and rounded surface of no great elevation. The sections of the ground made for the railway fully bear out this character, excepting only in those places where they cross the marginal cliff of the river.

I had also three sections taken across the "general course" of the river in different, but characteristic, places. These sections were prolonged, at both ends, for a certain distance over the natural surface of the ground, and when the sections were plotted, it was sufficiently evident where the surface should have been in order to preserve the same rounded contour of the ground. One of these sections was made just below Wilton Bridge, and is

Plate II.

Section at Wilton Bridge.



Scale Horizontal 16 Chains.– Vertical 200 Feet.

Plate III.

——The "Great Bed" at——
Huntsham Hill.

25 ft. thick.

represented in Plate 2. The strong line shows the present surface, as taken over the river, the alluvium, the cliffs, and the original surface beyond on both sides. The dotted line represents the supposed restoration of the original surface as existing before the river had worn away either bank; and according to the universal curvature of the surface throughout the whole of this district, there is no doubt that this restoration must be very near the mark.

If we now suppose that the river originally ran down the lowest ground, its centre must have been about 350 yards from the salient cliff and 130 from the retreating cliff. And deducting 40 yards, or half the width of the river, from each, we have the amount of "wear" in each case, namely, 90 yards from the retreating cliff and 310 from the salient cliff, the whole breadth from cliff to cliff being 480 yards. The amount of wear from the salient cliff we shall want again, further on, when we will call it 300 yards as being fairly within the mark.

We see, therefore, that these cliffs have been worn away to a greater or less degree, exactly according to their position in regard to the "general course" of the river.

Now, the surface of all the country about here is, as has been said, of a gently undulating and rounded character. There is no instance of an abrupt fall, much less of a cliff, anywhere except along the course of the river, but *there* we have them all along and on both sides down the "general course" of the river; and, as this course bends one way or the other, we have seen that the cliffs show distinctly, by the greater or less evidences of wear, the effect of the impact of the current due to their greater or less opposition to its force by reason of these bends.

This evidence is so striking to an observer who carefully looks at the whole length of the river course, that I do not think it possible for him to doubt that these cliffs have been formed, during the process of time, by the action of the river itself. To this evidence it may also be added, on the other hand, that if sufficient time is allowed, the forces of the river are quite sufficient to account for the whole of the facts.

My purpose now is to deduce from these facts, so nearly as I can from such observations as I have been able to make, the length of time that would be required for the river to do what we see it has done, supposing the natural forces to have been the same as we now find them.

The old red sandstone of this district, though much used for building purposes, is not a good weather stone. A house built of it keeps its face pretty well for about 20 years; the surface of the stone then begins, very gradually, to peel off, the tooled surface having the appearance of, for a time, preserving the face of the stone, which then peels off in a flake. The exposed face, afterwards, slowly assumes a rounded and sandy appearance; as may be observed in all old buildings made of this material.

To judge from its appearance, I should fancy that the grains of sand forming the material of the stone were held together by a cement of iron, and that by exposure to the air, the iron became gradually oxidised and lost its hold, the particles of sand being then washed away by the rain. The process is, no doubt, a very slow one, but it is constant; for the older the building the greater is the evidence of wear, more particularly in projecting stones. In Hereford Cathedral, for example, all the salient ornaments have been washed off; and though the face of the work has since been restored, at great cost, it was with the same sort of stone, and this is again beginning to go in the same way. The old Market-house in Ross is another good example. It was built during the reign of Charles the Second, or 200 years ago, and the stones have acquired that rounded and sandy appearance already alluded to. From the best measurement I could make, I ascertained that the face of the work had worn back, on an average, about five-eighths of an inch in the 200 years. It is to be noticed, however, that there is a variety in this respect, for that some of the beds of stone are better than others and do not fall into decay so fast; but *all* the old red beds in this district are subject to it, with the notable exception of one great bed, presently to be alluded to, which occurs on the higher ground surrounding the Forest of Dean.

Another and most remarkable fact, connected with this subject, is that, in this neighbourhood, there is no good building stone to be got near the surface of the ground. In making the deeper railway cuttings, beds of capital building stone were found at a depth of twenty feet or more below the surface; but none nearer the top. A 3-feet bed of firm building stone, for instance, may be followed for many yards along the deeper part of the cutting, where it is hard and strong, but, as this same bed rises towards the surface, it gradually gets softer until, when only 8 or 10 feet under the soil, it becomes what is locally called "dunstone," a sort of indurated sand in the form of rock, but which can be broken easily between the fingers. Every bed of rock in the cutting may thus be followed to its outcrop, being hard rock when 20 feet or more below the surface, and dunstone when only 8 or 10 feet below. This "surface softening" of the beds of rock is no doubt due to the same weathering process, already alluded to, continued through a vast period of time. It is quite general and is characteristic of the material. All the rock is "dunstone" within 10 feet of the surface, and no "dunstone" is ever found at a depth of 20 or 30 feet below. There are, occasionally, beds of marl amongst the rock beds. Where these crop out the beds of rock beneath the marl are somewhat less softened than usual; as if the atmospheric influences could not get through marl so easily as through rock.

The disintegration of the rock, in the case of this surface softening, is a very much slower process than it is in the case of an exposed vertical wall or cliff, because there is no washing away of the loosened particles, and these must form a considerable protection against atmospheric influences, increasing rapidly with the depth. Taking, in fact, the rate of first wear from the old Market-house, and assuming that the "surface softening" has now penetrated to 20 feet, I find from calculation that the penetration varies as the square root of the cube of the time.

There is, however, *one* bed of the old red which is a perfect weather stone. This is a very strong bed 18 or 20 feet thick, which is to be found towards the upper parts of the higher hills around the northern and western borders of the Forest of Dean —it lies about 320 feet below the bottom of the mountain limestone—it is mostly in the form of a conglomerate, but there are places where it is a fine-grained sandstone, and in all cases a perfect weather stone. This great bed is seen cropping out on the north-western faces of most of the hills surrounding the Forest of Dean, such as Penyard, Howl, Bishop's Wood, Great and Little Doward, and at Staunton, where it forms the ridge or summit of the Buckstone Hill (one of the highest in the Forest of Dean), the old Buckstone, or rocking-stone, itself being a piece of it, about 80 tons in weight, which had fallen away from the cliff and bedded itself some 20 or 30 feet below, frowning over the hill side.

The rocking-stone is, no doubt, where it was placed by nature; but it has evidently been artificially undercut to a knife edge, and with wonderful skill, if we fully consider the difficulty and the delicacy of the operation, with the mechanical appliances then known. Think of the enormous weight of the stone, its great size and its awkward bulk. It is about 18 feet long, 14 feet wide, and 5 to 6 feet thick, besides the pyramid below, on which it rests, but very irregular in shape. It rests upon a slab of similar stone, which must have formed one block with the stone itself when it fell away from the cliff. This bottom slab slopes at an angle of about 1 in 4 towards the precipitous hill side, so that when looked at from above, one cannot help feeling surprised that it has not before now toppled over and fallen, crashing down the hill. It has, however, been left so firmly planted as to have resisted the united strength of a gang of "Foresters," who, it is said, vainly endeavoured, with pinch bars, to roll it over down the hill. Yet the base it rests upon is only about 3 feet long and 8 inches wide, the 3 feet length being, of course, up and down hill, and the 8 inches breadth being slightly rounded off so as to allow the stone to be rocked. The photograph shows the south and east faces of the stone, but the small, rocking base is hidden by the sloping stone on which it rests.

The extreme difficulty of undercutting the stone would arise when the last few inches of breadth had to be taken off, before the true point of equilibrium could be known, and when the slightest error in cutting in the least too far on either side would have immediately let the stone fall over and all would have been lost at once. The remarkable operation was, however, successfully performed, and the stone is so admirably poised that I have frequently rocked it myself sufficiently to cause great alarm to persons who had climbed upon it, and I have seen it rocked by a boy of 12. If this stone had not been entirely proof against the weather the narrow knife edge on which it rests would have long since crumbled away.

I may add that the prospect from this stone is very grand. The height of the hill is, I believe, about 900 feet.

The slopes of the higher hills in which this "great bed" is found are much steeper than the slopes of the ground in the lower country near the river at Ross, but yet the hills of the old red have always a perfectly rounded contour, excepting only where this bed crops out. The rounded contour of the hill side is then broken by a 20 feet cliff, as is shown on the section of Copped Wood Hill. It is there seen that the slope of the hill above the great bed does not run in a fair line with that below.

In fact, all the appearances here point to a period, antecedent to the establishment of the River Wye, when the whole of these hills were submerged under a sea, having a strong current from the north-west by north, during which this great bed resisted the action of the waters in a far greater degree than the weaker and softer beds lying above and below it. The consequence was, that these softer beds were mined away from above and below until great masses, many as big as a small cottage, fell away and rolled down the steep hill side. Some of those large blocks rolled to the bottom of the hill, and one now lies in the present river channel, while many others have stuck, in fantastic positions, part of the way down the steep slope, and appear now ready to fall over on the slightest provocation. The position of these last forms a clear proof that they fell through *water*, which let them down easy, for, if they had fallen from that height through *air*, they could not possibly have stopped where we now find them, but would have acquired such a velocity in their decent as would have carried them far on the level at the bottom. The water must, at that time, have been high enough to have covered the summit of the Buckstone Hill, already alluded to, for that hill shows to its very top the unmistakable signs of denudation.

The accumulation of these blocks of stone which have thus fallen away, and now lie exposed below, represents many feet of the bed, and point to a very lengthened period during which this part of the country was submerged, and the comparatively softer and less durable beds above and below the great bed were subjected to the very slow action of being worn away by a marine current, the water surface of which must have been several hundred feet above. For, from my observations, I have found that the "surface softening" before alluded to does not take place at anything like the same rate when the rock is always under water that it does when the rock is exposed to the air. In the places where the railway crosses the river, and where we founded the piers of the bridges on the rock bottom, as at Backney for example, the rock, though less than four feet below the ordinary surface of the water, was still hard and but little softened.

Returning again to the consideration of the course of the river. It may be noticed, by a glance at the ordnance map, that, all along its course for many miles, the river runs across its alluvial lands in "bends" of its own peculiar form, and of about the same average length. The average length of one of these bends, in the six miles under consideration, is about 1690 yards from the point where its waters fret the marginal cliff, to that where it next returns to the same cliff.

These bends are constantly *descending* the course of the river, as might be expected from the fact that the alluvial land is on an incline of $2\frac{1}{2}$ feet in a mile, and as may be proved by an inspection of any one of the bends on the wall map. Take, for instance, the "bend" between the Sheepwash and Ross. The banks marked with the dark lines are those which are being washed away, while those with the faint lines are advancing. Now, if we imagine that all the dark banks lose a yard, while the same breadth is gained on the faint line banks, the whole "bend" will, evidently, have descended a yard southwards through the alluvium. This process is always going on when the water is high, and, in an average of years, the river channel progresses downwards at a rate which I shall now endeavour to ascertain.

In the meadow opposite the town of Ross there grows a remarkable old tree, which has been dignified by the name of "the Ross Oak" for many years past. This tree, when I measured it, was 29 feet in circumference at 3 feet from the ground. The tree had originally been forked at a height of 8 or 9 feet from the ground, but the eastern limb had fallen many years before, and the trunk, when I knew it, had become hollow on that side. In the winter of 1849 some boys set it on fire, and the western limb then fell and came into my possession. When this fire occurred *The Times* and other London papers inserted paragraphs about this oak. In some its age was put down at 900 years, and in others at 1200 or more. Now the land on which it stands belongs to Guy's Hospital, and they still possess a capital plan of this estate, made by a surveyor named John Green in 1756, and on this plan the position of this tree, which was then called "the Ross Oak," is marked. It must then have been a noble tree and in its prime.

On Green's survey the edge of the river was 118 yards from the tree, but when I measured it in 1856 the river bank was 170 yards away. The river had, therefore, shifted its course 52 yards downwards in 100 years, and, supposing the river to have advanced at the same rate, the tree must have been a sapling on its bank 327 years before that time. Again, when I got the fallen limb home, I found that it was sound to the core at a height that must have been about 35 feet from the ground, and, by counting the concentric rings, I ascertained the age of the limb to have been 278 years. If to this we add 40 years for the time it would take an oak to grow to a height of 35 feet, and 7 years for the time since the limb fell, it will give us 325 years for the age of the tree; agreeing remarkably with the former calculation. A third calculation from the concentric rings in the shell of the trunk, which was still 6 inches thick, made into an average with that of a bit of the central part of the trunk which still remained, gave an age of 316 years, which is a tolerable approximation to the former. The age of the tree without doubt, therefore, did not exceed 330 years.

From Green's survey, I found that, at the Wear End "bend," the river appeared to have shifted its channel nearly 60 yards in the century; but, as we have the means of testing the rate of wear for more than 300 years at the Ross "bend," I have adopted the 52 yards in 100 years as the best average rate attainable.

As, therefore, the "bends" of the river are 1690 yards in length, and that the river wears it channel downwards, through the alluvium, at the rate of 52 yards in a hundred years, a "bend" would occupy the position of the bend below in 3250 years. That is to say, that the alluvium now being worn away at any point is 3000 years old, and was deposited there, by the "bend" which is now nearly a mile below, that number of years ago.

The process of wear from the outer side of the stream and of deposit on the inner, is very plain to the observer *now*, and is full of interest. It takes place only during freshes, and its amount at any place is in proportion to the curvature of the channel at that spot. In parts where the curvature is the sharpest the deposition on the inner side does not always keep pace with the wearing away of the outer bank, and, in such places, the alluvium has time only to be deposited to a lower level; from some cause the stream may then remain nearly stationary for a few years, and a peculiar ridge is formed near the water's edge, where the greatest amount of deposit takes place, while the part further inshore remains at a lower level. A good instance of this is shown upon the wall map at Pencraig, where the river had worn away its banks very rapidly, and the opposite bank had not had time to become silted up to its proper level. A wall, to prevent the loss of his land, was then built by the proprietor round the side which was being worn away, and the river, being checked in its advance through the alluvium, began at once to form the bank or spit of land shown on the map. But the ridge near the water's edge thus formed never joins on to the alluvium at the lower end, but leaves a gutter or opening through which the flood waters enter upon the lower ground within, by a slow back current or eddy, carrying on its surface many floating objects, such as branches of trees, and frequently, in the autumn, leaves in large quantities. These objects are deposited on this lower ground inside the ridge as the waters recede, and are afterwards buried by the subsequent deposit of the alluvial soil. At a place below the Wear End a deposit of this sort, which had formerly occurred, is being cut away by the stream, and now large trunks of oak trees are laid bare, with layers of leaves and hazelnuts, which must have been left there by the stream, in the manner just described, full 3000 years ago.

If the river now remains stationary for some years this ridge is raised rapidly by deposition up to the highest level attained by the alluvium, the reason being that the conditions needful for deposit are most favourable in such positions. These conditions are sufficiently simple:—In times of flood the water pours down the 80-yard wide channel at a great speed, and heavily laden with sediment. In those parts of the channel in which the water runs at or near to its full speed the tendency is to scour and not to deposit; but when the stream passes round a bend of the sort I have named the swiftest current is thrown towards the outer side of the stream, and as you look from thence towards the inner side you may observe that the speed of the current gradually diminishes until at the inner margin it has become slow enough for the great bulk of the suspended particles to be allowed to settle down. This occurs at the place where the ridge is formed. The water further inshore is, of course, still more quiet, but it is almost clear, having deposited already the great bulk of the sediment, and only carried over with it the very fine particles which are there deposited, but only amount to a very small quantity. The water there is also nearly stationary, so that few fresh particles are brought there from the adjacent stream. This is evidently why the ridges are formed in such places.

These ridges and hollows are to be seen in many places now, though the hollows have, of course, been considerably raised by a slow deposit from the greater floods which cover all the alluvium occasionally. The Ross Oak itself growing on one such ridge, as shown on the wall map, which shows distinctly the course of the river channel when the tree first grew there.

It should be noted here that in modern days the regular course of the wearing away of the river bank is in some places considerably interfered with by the erection of cribbs or walls for the purpose of stopping the encroachment of the stream. This is now the case at the Ross bend, where the stream has been kept from getting nearer the town, at which point it would otherwise have been hard up against its marginal cliff without that protection. But these cribbs are not numerous, for they are costly to build, having to be founded under water on the rock bottom.

To proceed now with the consideration of the process by which the river wears away its *marginal cliffs* :—

It has been shown that after the stream has struck the cliff on one side, say the west for example, it rebounds, as it were, across the alluvium to strike the east cliff, and again returns from that to the west cliff, forming thus one of the "bends" of the river. The length of one of these bends has been shown to average at present 1690 yards. In a bend of this description I find from many measurements that the actual length of cliff directly exposed to the action of the stream measures 110 yards on the salient cliff. On the retreating cliff the measurement would average much less, as has been before explained, but the retreating cliff does not claim our attention at present.

We will again take for our example, therefore, the salient cliff just below Ross, at the part where the section across the river course was made. 110 yards of this cliff will then be under direct exposure to the wearing of the stream, and along the remaining 1,580 yards the base of the cliff will be covered by 10 or 12 feet of alluvial soil. These are the comparative lengths in a "bend" at the present day, but it must be remembered that the "bends" were shorter when the width of alluvium was less.

Starting, in fact, from the beginning, the length of the "bends" would at first be zero; but, as the river began to wear away its cliffs, the formation of the alluvium would begin, and then would begin also the "bends." Let us now consider what the length of the bend would be when there was only a five yards' width of alluvium. The river would then have pressed against the cliff for 110 yards (which we must consider a constant quantity), have then left it, gone five yards away, and then returned to the same cliff. Now, judging from the present curvature of the stream, it could not have done that in less average distance than 180 yards, making the whole "bend" 180+110=290 yards. Again, looking at a part of the river where the breadth of alluvium is now about 150 yards, we find the length of the "bend" 1110 yards, or 1000 + 110. Putting these figures into a tabular form, we have:—

Breadth	0	Length	0
,, ...	5	,, ...	180
,, ...	150	,, ...	1000
,, ...	400	,, ...	1580

From these figures, which leave out the constant 110 yards, it may be perceived that the breadth very nearly varies directly as the square of the length. If the lengths, therefore, be taken along a horizontal line, and the corresponding breadths perpendicular to that line, the ends of the co-ordinates will be in a parabolic curve, of which the apex will be at the zero point; therefore, from a well-known property of this curve, the average "length" from the beginning until now will be just two-thirds of what it is at the present time, or 1053 yards.

A parabolic curve will not, however, truly represent the facts in an extreme case. The conditions will be more correctly represented by tangential circles of a radius equal to the average radius of curvature of the "bends"; but, as the co-ordinates due to these tangential circles do not depart materially from the parabolic curve in the small arcs required for our question, the difference it would make in our reckoning of the *average* length of the bends does not claim further notice. If we call the average radius of curvature R, the lengths L, and the corresponding breadths W, the formula for the co-ordinates due to the tangential circles is $16\,R\,W - 4\,W^2 = L^2$, which is the equation to an ellipse whose axes are 8 R and 4 R, and the average length, in our case, becomes *very slightly* more than two-thirds of the present length.

Let us consider next the process by which the sandstone rock is worn away. It has been shown that the cause of wear is mainly atmospheric; that, though mechanical attrition may do a little, the chief action of the stream is to wash away the particles of sand already loosened by the air. We may conclude, therefore, that the rate of wear will be greatly more rapid from the 110 yards of cliff fully exposed than from the 1580 yards covered by the alluvium, and thus in a great degree protected from the direct action of the air.

The comparative rate of the disintegration of the rock under these two conditions we have no positive means of determining with accuracy. At the present rate of the progression of the "bends" downwards already proved, of 52 yards in 100 years, the 110 yards would be exposed to the air for 212 years, and the 1580 yards would then be covered by alluvium for 3039 years.

After the foot of the cliff had been covered, the face of the cliff above would be subject to all atmospheric influences; but that below the alluvial level would only be subject to a modified "surface softening" process—modified because the rock would have been already fully exposed to the air for 212 years before it was covered, and afterwards because that covering of alluvium would probably be more pervious to those atmospheric influences than the more compact rock in situ, and because the rains, and with them some portion of air, might find their way down the face of the rock between it and the deposited alluvium, so that when the cliff was again exposed by the descent of the "bend" above its face it would be in some degree softened, and thus subject to more rapid wear than it otherwise would. In the figures I am about to give I have therefore assumed that the face of the cliff which has been covered by the alluvium would be worn away at *half* the rate at which the exposed cliff is actually worn away by the river. This is, of course, only an assumption; but if there is an error, the assumption will most probably be in excess, rather than in dimunition, of the proportional rate of wear from the protected cliff.

Coming now to the last element required for our calculation —namely, the rate at which the old red sandstone of this district is worn away by the river in the manner already described—I find that the Wilton Bridge, near Ross, was built in the year 1599, or 257 years before my measurements were made. The western abutment of this bridge was founded upon an exposed bed of the old red rock, the surface of which lay 15 or 16 feet below the ground and about 7 feet below the alluvial level, so that the foundation is exposed to the air when the water is at its ordinary level, but is subject to the action of the stream on the occurrence of any "fresh," a position the most favourable for wear that I can imagine. Now this bed is by no means composed of the best and firmest quality of stone in this district, for it is comparatively thin, and what is here called "shelly," or composed of laminæ of less than an inch in thickness, and it is not more than 16 feet below the original surface; but it is certainly a very hard bed considering these circumstances.

I found, by careful measurement, that the whole surface of this bed has, in the course of the 257 years since the bridge was founded upon it, been worn away 3¾ inches—that is, at the rate of an inch in 64½ years.

This rate of wear is very much faster than that shown by the old Market House; but it must be borne in mind that the stone selected for the old building was of a better quality than the bed at Wilton Bridge, that the stones were fresh and hard out of the quarry, and that it would take many years for the atmospheric action to get well into them, and also that the conditions of river wear must be more severe than that of the elements alone.

We have now got the elements of our calculation—let us sum them up. We have ascertained, firstly, that the cliff at Ross has been worn back at least 300 yards; secondly, that, taking the time from the origin of the river, 110 yards of the cliff are under full wear, while an average length of 1073 are under half wear; and, thirdly, that the rate of wear has been an inch in 64½ years. And these figures have been taken at a minimum.

Now if 110 yards of cliff are worn at the rate of an inch in $64\frac{1}{2}$ years, while 1073 are worn at the rate of an inch in 129 years, the rate of wear over the whole cliff of 1183 yards will be at the average rate of an inch in 118 years. Then, as 300 yards, or 10,800 inches, have been worn at the rate of an inch in 118 years, the time required will be 1,274,000 years; and, as all the figures have been taken at a minimum, this is, therefore, the smallest figure that can be calculated to represent the present "Age of the Wye."

In conclusion, I may say that this subject has naturally been present to my mind for many years past. I have always observed the evidences of wear in other streams, whether large or small, that came under my notice, and to my mind they all bear equal testimony to the vast length of time during which they must have been performing a similar operation. If we regard the comparatively sluggish Thames, which appears to wear its banks so very slowly, and has yet accumulated a wide margin of alluvium all along its course, or if we look at any other stream that I have ever seen, they all tell the same tale; but in no other case that I know of do the elements exist for making a definite, though approximate, calculation of the actual period of time required for the work that has been done.

The Wye happens to run through a district of the old red sandstone which is subject to a slow but equable and constant rate of wear just suited to our purpose. If the rate of wear had been slower it could hardly have been measured, and if it had been faster the river would have worn for itself such a breadth of alluvium that the stream would frequently have failed to reach its marginal cliffs, as its "bends" descended through the alluvium, and the chief requirements for a definite calculation would thus have been wanting. Thus it is that the conditions under which the Wye runs down its course through the Ross meadows, make it bear the evidences of its actual age upon its banks; and these evidences I have endeavoured to collect, so far as opportunities served me, and I have now placed the result before you in this paper.

Some Remarks on the Methods of Wind Measurement.

By H. S. HELE SHAW, Assoc. M. Inst. C.E.

THE various methods of Wind measurement, or Anemometry, cannot be profitably discussed without a clear understanding of the objects for which the science is either useful or necessary, and these may be at once divided into two classes:

1st.—The discovery of laws relating to the movement of the wind that may lead to reliable weather forecasts. This is a most important branch of Meteorology.

2nd.—The knowledge of the action of the wind in its dynamical aspect, that is, of its force and velocity, in order to determine its effect upon structures or for purposes of navigation, and this is a nearly equally important branch of Engineering.

With regard to the first of these objects, there is scarcely anyone who has not some knowledge of a subject to which so many eminent men have devoted their time, but though Sir John Herschel fifteen years ago bore testimony to the voluminous nature of the records and amount of work done, yet he held Meteorology, so far as weather predictions were concerned, to be a science still in its infancy. That the wind does obey laws as certainly as any other body in nature, no scientific man for a moment doubts, and no better proof of this could be given than the regularity of the trade winds in latitudes comparatively free from disturbing causes, the action of which is completely accounted for on theoretic grounds, as also that of monsoons, land and sea breezes, and many other well-ascertained phenomena. But what about weather predictions generally ? Since the time mentioned, the Meteorological Office at London has instituted a system of daily forecasts based upon information of wind, atmospheric pressure, etc., telegraphed from stations all over the country, and the authorities are enabled by generalizing upon this knowledge to form a supposition as to the direction and velocity of the wind for a limited period in advance—but more than this appears at present quite impossible. To take, for instance, the memorable storm of October 14th. *The Times* forecast for the day gave " veering winds and gales," and for one part of England " heavy gales," but as the *Daily News*, discussing the scientific aspect of the storm, puts it, the authorities of the Office were scarcely prepared for the spectacle which awaited them on Friday morning. And the loss of life to the fishermen on the Berwick coast may surely be quoted as showing that there is yet much that is unknown as to the precise action of the wind. American storm predictions are conjectured by one of the lecturers in a course delivered under the auspices of the Meteorological Society[1] to be merely a question, first, of collecting the facts as to the direction of a storm over there, and then, of course, the length of warning given is a matter of the difference in speed of the storm from that of an electric message. But though often proving correct, the prediction has on several occasions proved otherwise, and either the storm has been dispersed on the road, or been lost altogether. Take the storm which was, according to the *New York Herald*, " of dangerous energy, crossing north of latitude 40, arriving on British coast between 30th inst. and Nov. 1st." The wind rose, it is true, on the 31st, but it could not by any means be called a storm of dangerous energy.

[1] Lectures on Modern Meteorology, p. 95.

From the engineering point of view the state of knowledge is still most unsatisfactory, as shown by a perusal of the "Report of the Committee to consider the question of Wind Pressure on Railway Structures," formed in consequence of the Tay Bridge disaster. From this Report it would seem that a pressure of nearly 90 lbs. per square foot (corresponding to the utterly incredible velocity of 190 feet per second) was recorded at Bidstone, near Liverpool, but though the Commissioners, all eminent men of science, believed this to have been actually registered, and not due to any unforeseen action of the springs of the pressure board, they considered it was abnormal, and caused by local circumstances. Bidstone is no doubt very exposed, but the reasons which led the Commissioners to fix upon 56 lbs. per square foot as the maximum pressure of wind to which a structure should be ever exposed, are not at all clear, unless it be that some definite figure is required for calculation, and this number, which is used by some French engineers, has always proved sufficiently high. Two of their number, however, Prof. Stokes and Sir Wm. Armstrong, affixed a statement that there was no evidence to shew what the extent of the lateral pressure was—that is, of the extent of surface upon which the maximum pressure really acted at one time.

According to Mr. Hawkesley, past Pres. Inst. C.E., a pressure of 40 lbs. per square foot is unknown in these islands, as it would be sufficient to have overthrown most of the long existing factory chimneys, to have overset past wind-mills, etc., to have scattered the slighter built domestic and other structures; and this would be evident when it is remembered that 40 lbs. per square foot means, upon a building 40 feet by 30 feet, more than 20 tons. Again, it is well known that a pressure of between 30 and 40 lbs. per square foot will overturn an ordinary railway carriage, but there is not an authorised instance of this having happened. In America the confident belief of engineers is that no bridge has been exposed to more than 30 lbs. per square foot; this, moreover, in the country where there are tornados capable, it is said, of floating pianos and barrels of tar like leaves on the autumn blast. Nevertheless, in the storm of the 14th of October, according to the *Daily News*, the pressure on the square foot was as high as 53 lbs. at the Oxford Observatory; that at Bidstone Observatory, near Liverpool, no less than 77 lbs.,[1] or 37½ per cent. in excess of the maximum allowed by the Commissioners; and the paper above quoted then proceeded to calculate the pressure on the side of a building from these figures.

That the science of Wind Measurement is not in an entirely satisfactory state is thus evident,[2] and, since for meteorological purposes, continued observations of an *accurate* nature and the accumulation of facts appears to be the surest if not the only way by which further progress can be made in this subject, the question may now be asked, — what are the methods employed?

Until about 50 years ago there was, according to Sir W. Snow Harris, no record of any other elements of the wind than its direction and the time it blew. Dr. Whewell appears to have been the first to point out the slight worth of any results which did not include one at least of the two other elements, viz., its pressure or velocity. Yet from the time of Hooke, 150 years

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[1] In order to leave no room for mistake, the author communicated with the Superintendent of Bidstone Observatory, and found this number to be quite correct.

[2] Since this was written the author has come across the following words as the conclusion of a paper upon anemometers, by Mr. Richard H. Curtis, read before the Meteorological Society, May 18, 1881:—"I think I have said enough to show that anemometry is not at present in a condition which can be considered satisfactory."

before this, there had been numerous wind pressure guages invented, which have been divided by Dr. Robinson into four classes.

(1) Windmills kept facing the wind and winding on their axle a string against some form of graduated resistance.

(2) Spring pressure boards, also kept facing the wind, and acting somewhat as an ordinary spring weighing balance.

(3) Tubes in which a difference of level of a liquid due to different pressures could be seen.

(4) Pendulum anemometers, in which the extent to which the pendulum was swung out of perpendicular against the action of gravity by the force of the wind gave approximately the pressure.

Besides these, there were the musical anemometer of Dr. Hooke, which recorded the velocity by the pitch of the note emitted, and those of Leslie and Brewster, in which the rates of cooling and evaporation were respectively used to give the quantity.

Quite recently a pressure anemometer has been described[1] by C. H. Hagemann, in which the pressure of wind acts on a column of air, and is registered on a dial by an apparatus not unlike a gasometer in principle.

But the comparatively unfruitful result from these instruments, in spite of the existence of the tables of Rous, Smeaton, and Hutton, were no doubt chiefly due to their being non-recording—a defect which, in consideration of the uncertain and changeable nature of the wind, is obviously fatal, for nothing less than a continuous record can be of use for accurate scientific purposes.

About the year 1837, a self-recording instrument was invented by Mr. Osler, of Birmingham. This was a pressure

[1] Quarterly Journal Meteorological Society, Oct., 1879.

anemometer of the second of the above classes, in which a square board is made to turn by a weather vane so as always to face the wind, and the record is kept by means of a lever moving a pencil to a distance corresponding to the pressure, over a sheet of paper actuated by clockwork. This instrument—described in various publications[1]—after the expenditure of much time and money, was at last brought to a very perfect state, and has superseded all other pressure anemometers, wherever such instruments are used.

But, beside the want of self-registering instruments, there is another reason given for the small progress in Meteorological results, viz., the long continued mistake of seeking to determine the elements direction and pressure, instead of direction and velocity. This is not easy at once to understand, for there can be proved to be a direct relation existing between pressure and velocity of the wind, of which the most simple and easily remembered expression is that given by Mr. Hawkesley at the recent meeting of the British Association at York—

$$\text{by } p=\left(\frac{v}{20}\right)^2$$

when p = pressure in lb. per square foot,
v = volocity in ft. per second.

But though it is true, as stated by a writer in *Enc. Brit.*,[2] that, owing to the want of uniformity in the motion of the air, the relations between these two quantities are practically much more complex; yet, if the actual pressure were obtained, the velocity would be approximately deduced, and the real question appears to be rather as to the possibility of obtaining a correct record of pressure. For the meteorologist who requires the velocity, there can be no hesitation as to the choice between the

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[1] British Association Report, 1844.

[2] Vol. II., p. 24., Ninth Edition.

two classes of instruments, and those directly measuring that quantity have to a great extent superseded the other class; but even the engineer, who generally requires to know the pressure of wind in its effect on structures, has to consider two objections to the use of the pressure anemometer—

(1st) From the way in which the wind moves,

(2nd) From the nature of wind pressure itself.

If the wind blew steadily on any area the pressure, at any rate on that area, might be correctly given by the resistance of the springs, but this is well known to be the opposite of what occurs; the wind varies in intensity from moment to moment, to a considerable degree even in mid ocean; whilst on land it is, during a gale, in a state of continual oscillation, and its action is rather that of an impulsive blow. The result is a record in excess of a mean pressure, followed by a recoil of the springs, as appears to be shewn by the readings of Osler's anemometer, and indeed it does not appear how an accurate mean pressure is to be determined from such a curve. Now a structure differs in a material way from the pressure board of an anemometer, for though a steady pressure must affect each equally, not so a gust of wind; the two results are totally different, and they must not be confused. The maximum effect of a gust of wind in a pressure anemometer does not give any certain idea of the pressure really taking effect on a structure, unless it is known that the gust was of sufficient duration to be felt as a steady pressure, and it is conceivable that some of the conflicting views which exist may result from the effect of a gust on a pressure board being quoted, without the duration of the gust being known. Again, as already mentioned in the memorandum of Prof. Stokes and Sir W. Armstrong, the relative pressure over two areas of different amount is quite unknown, that is to say, even knowing the pressure on one square foot it is impossible to say what at the same place and time the pressure on x square feet may be. Since in a storm the wind scarcely ever blows steadily, the velocity of wind during a gust and its duration appear, therefore, to be the quantities which it is most desirable to determine. About the same time that Mr. Osler invented his pressure anemometer, Dr. Whewell invented another which measured the velocity of the wind. This instrument, which has been described elsewhere,[1] had several serious objections, and as both Prof. Airy and Sir W. Snow Harris concluded, could not be depended upon as giving accurate results, and its use was ultimately abandoned. Nevertheless its construction marks an epoch in the history of anemometers, since it was undoubtedly the first instrument of its kind, and the results obtained from it were of considerable interest. The essential portion of the instruments which have entirely superseded it was first employed by Dr. Robinson about the year 1845. This portion is the head of the instrument, and consists of a number of hemispherical cups (generally four) so arranged about the vertical spindle as to cause the wind to turn it always in one direction. Inasmuch as the only essential difference between the various velocity anemometers in use is the mode of indicating or recording the revolutions of these cups, it was therefore a matter of great importance to determine the ratio of their velocity to that of the wind. Dr. Robinson's first investigations led him to conclude that

$$V = 3v.$$

when V and v are respectively equal to the velocity of the wind and cups; but this relation, after being universally accepted for many years, was shewn by the Rev. F. N. Stow and M. Dohrandt to be far from correct, and later investigations of Dr. Robinson also confirm the fact that except at high velocities there is no such direct relation between V and v. The latter gentleman has, by

[1] Camb. Trans., Vol. IV.; and Brit. Assoc. Report, Vols. IX., X.

means of a Royal Society grant, conducted a series of very careful experiments, in order to determine the constants in an expression which his investigations led him to conclude would hold between V and v, viz.:

$$aV^2 - 2\beta Vv - \gamma v^2 - F = 0.$$

where F is the friction of the instrument and may be measured, and a, β, and γ have to be found; but the result was admitted by him to be anything but satisfactory,[1] the values for γ being so discordant as $+21{\cdot}554$, $-59{\cdot}672$, $-3{\cdot}617$ and $+9{\cdot}814$. This series of experiments, however, and also later ones, have shewn that at tolerably high velocities

$$V = 2{\cdot}5v \text{ nearly.}$$

But the relation really alters for every change of velocity and size of the cups.

There is not space to describe here the various modifications of cup anemometers. The simplest and most general mode of registering the number of revolutions of the cups is by means of a train of wheels, the last one or two of which are graduated as in a gas or water meter. But these are not truly self-recording, and their motion is assumed to be uniform during the intervals at the beginning and end of which they are observed.

Some instruments communicate the revolutions of the cups above to the observing rooms beneath by means of an electric current, in which case electric contact is made and broken every 10 or 100 revolutions, as in an instrument devised by Professor Barrett, of Dublin. The author has devised a mode of graphically representing the velocity thus obtained by causing marks to be made at each interruption of the circuit upon a strip of paper moved by clockwork. At equal distances along this strip ordinates are drawn, whose height is proportional to the number of marks in the adjacent distance or interval, and the ordinate at

[1] Phil. Trans. Royal Soc., Part II., 1878, p. 807.

any point of the curve drawn through the extremities of the equidistant ordinates will measure the velocity at the corresponding time.

Of all self-recording instruments for measuring the velocity of wind, that of Mr. Beckley is the most successful and most generally used. The original form was described by him in[1] 1858, but in its present form, at Kew, it has been somewhat modified and improved. Both direction and velocity are recorded by curves on separate strips of paper. The latter quantity is shewn at a glance by the inclination of the curve, but in practice is read by the distance moved by the tracing point or its equivalent in regular intervals of time. The embossing anemometer of Messrs. Beckley and Casella records on one strip of paper both the number of miles of wind passing the cups (measured by their revolutions) and its direction. This is attained by causing the strip to be drawn over embossed rollers by the action of the cup-vane spindle on suitable mechanism, and at regular intervals of time stamping an arrow by the side of the embossed figures, the direction of the arrow shewing the direction of the wind at that instant. There are numerous devices for obtaining a record of the revolutions of the cups, but, of course, to shew the velocity of the wind at every instant in this way the element of time must be introduced, which has been shewn to have been very satisfactorily done in Mr. Beckley's anemometer.

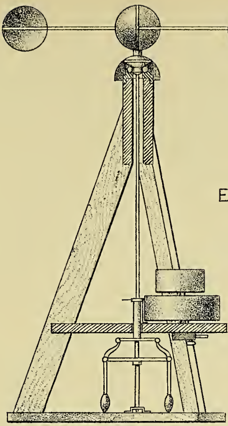
It occurred to the author that an instrument might be constructed which should directly shew the velocity at every instant by employing the principle of the pendulum governor in conjunction with Robinson's cups. If the sleeve moved by the rising and falling of the weights carried a pencil, a continuous record of velocity might be obtained on a drum moved by clock-

[1] British Association Report, 1858, Vol. 28.

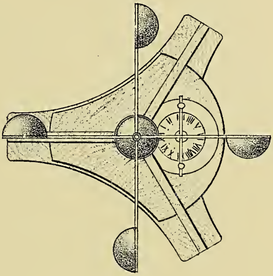
work. There were several difficulties to overcome: one was the necessity for having the weights suspended to the main spindle, in order to avoid further friction, and since in a wind of twelve miles an hour the cups and spindle at the author's disposal would only turn once in a second, this was a serious consideration; another was the form of frame to be used so as to keep the apparatus weather-tight, and yet have a short spindle in order, as before, to avoid excessive friction; a third difficulty was to devise an arrangement so that the motion of the pencil should be proportional to the change of speed of the cups—that is the ordinates of the curve described to the velocity of the wind. Figs. 1 and 2 shew two views of the experimental instrument in which these various points have been dealt with. Sensitiveness has been attained by using fairly large weights and causing the sleeve carrying the pencil to move with the application of a very small force by having it very light and in contact with the lever by means of rollers. A motion of the pencil theoretically proportional to the change of speed was obtained by first calculating the position of the weights at various velocities, and then setting out the curve of the cams on which the rollers of the sleeve rest, the distance of the sleeve from zero (its highest point) being made proportional in each case to the calculated velocity. Fig. 3 shews some of the curves obtained on the night of November 2nd, 1881, on the roof of the author's house, in which it is seen that the wind was rising during several hours, and at the same time its gusty nature is evident.[1] A particular feature in this instrument is the mode of supporting

[1] From the paper of Mr. Curtis, already referred to, it is clear that an instrument similar to this one in principle had been previously constructed by that gentleman, and very possibly by others. See Journal Meteorological Society, vol. vii., p. 212. Mr. Curtis, however, used a second spindle geared to the first, and even then found the action very sensitive.

EXPERIMENTAL ANEMOGRAPH.
SCALE,- $\frac{1}{16}$ FULL SIZE.



ELEVATION.
FIG. I.



PLAN
FIG. 2.

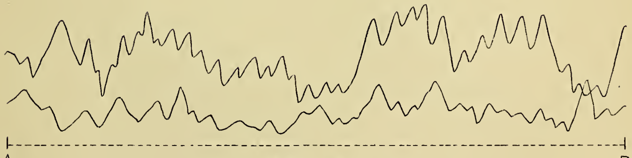


FIG. 3.

A.B.- 10 MINUTES.
PORTION OF TRACES OBTAINED,- 6 P.M. TO 10 P.M. NOV. 2ND
BY
EXPERIMENTAL ANEMOGRAPH.

LAVARS LITH: BRISTOL

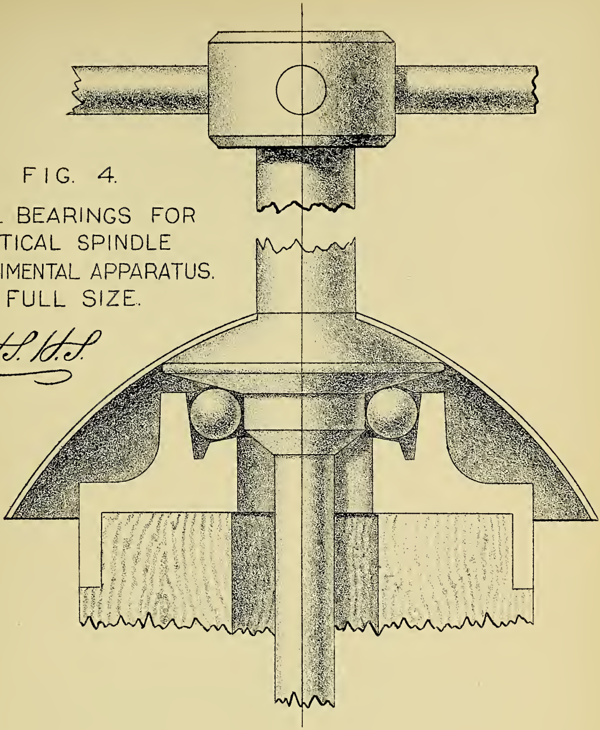


FIG. 4.

BALL BEARINGS FOR VERTICAL SPINDLE EXPERIMENTAL APPARATUS. FULL SIZE.

H.S.H.S.

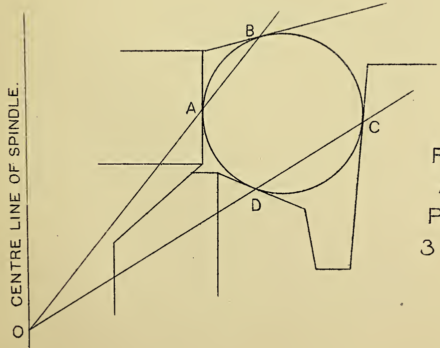


FIG. 5.

FORM OF BEARING AS SUGGESTED BY PROFR. G. G. STOKES. 3 TIMES ACTUAL SIZE

LAVARS, LITH. BRISTOL.

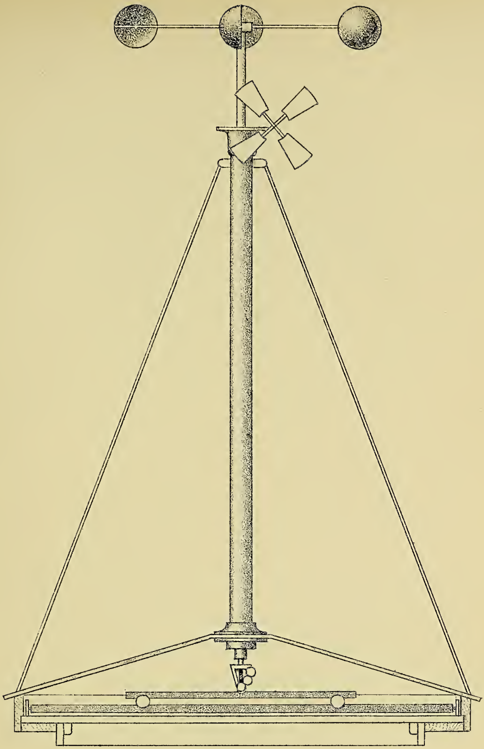


FIG. 6.
INTEGRATING ANEMOGRAPH.
(EXPERIMENTAL INSTRUMENT.)

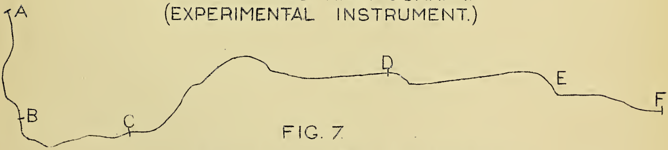


FIG. 7.

CURVE FROM INTEGRATING ANEMOGRAPH

A.B. –	SEP. 29TH ——	SEP. 30TH 3 P.M.
B.C. –	SEP. 30TH 3 P.M.	OCT. 1ST 1 P.M.
C.D –	OCT. 1ST 1 P.M.	OCT. 3RD 9 A.M.
D.E –	OCT. 3RD 9 A.M.	OCT. 4TH 9 A.M.
E.F –	OCT. 4TH 9 A.M.	OCT. 4TH 4 P.M.

LAVARS LITH. BRISTOL.

the vertical spindle. The way this is done is shewn on a larger scale in Fig. 4, and a section is given in Fig. 5 of the way in which the steel spheres (nine in number) roll, having contact at four points. The straight lines passing respectively through the two points of contact above and the two below meet in the axis of rotation of the spindle—as suggested by Professor Stokes[1]—in order to ensure rolling contact.

None of these instruments shew the direction and velocity, or direction and quantity, of wind by *one* curve, and it occurred to the Rev. J. M. Wilson, M.A., Head Master of Clifton College, to obtain these latter quantities by one continuous curve, in which the length drawn in a given time should be proportional to the quantity of wind passing in that time, and its direction should always coincide with that of the wind. How this idea has been carried into practice was described by Mr. Wilson and the author at the recent meeting of the British Association at York, and Fig. 6 shews the experimental form of instrument which acts thus:—the cups give motion to a train of wheels at the lower end of a central spindle and turn a roller which presses on the recording surface and moves it with a velocity approximately proportional to that of the wind; at the same time the windmill head is so arranged as to keep the plane of rotation of the roller always coincident with the direction of the wind. Fig. 7 is a curve formed by combining several days' observations, and agrees very well with the indications of other anemometers. A careful examination of the weather chart of *The Times* shews that the wind cannot be said always to move in parallel planes, at any rate over an area such as the United Kingdom. For instance, while in June its motion was fairly uniform, in April of this year it was on thirteen days (not consecutive) out of the thirty

[1] Proceedings of the Royal Society, No. 213, 1881.

blowing from different quarters on the same day. Yet a series of records obtained simultaneously from integrating anemometers at different points would be exceedingly interesting, and it is hoped that a Government grant may be obtained for the construction of a more perfect instrument. It is to be observed that the marks at equal intervals of time along the curve would enable the velocity to be determined, and might be graphically exhibited at every point by the width of a figure constructed along the curve.

The location of the anemometer as well as its construction is a very important matter, not only as regards the nature of the surrounding country, but also as regards its position with respect to the building or structure on which it is placed. Both the points have latterly received more attention than apparently used to be the case. That an anemometer should not be placed on a high building with vertical walls is generally acknowledged: the one at Kew, for instance, being supported on a framework above the dome of the observatory. A series of experiments have been made by Mr. F. Stevenson (Scottish Meteorological Society) with a view of determining the height above the ground at which an anemometer should be placed to record the real velocity of the wind, which he concludes should be a minimum of 50 feet, and where this is not possible the velocity V at the height H should be computed from the observed velocity at the height h (h not being less than 15 feet) by the formula

$$V = v\sqrt{\frac{H+72}{h+72}},$$

and it would be obviously desirable thus to refer all velocities to some fixed height above the ground.

The foregoing are the principal methods employed in anemometry, but only a small number of the instruments suggested, or constructed, even in this country, have been mentioned, and a glance at the text book of Weisbach, or the catalogue of the recent collection of scientific apparatus at South Kensington, shews that other countries have likewise produced a large number—many, for instance, under Class 3, p. 5. Nevertheless, the consideration which has been given of these methods appears to shew that there is yet wide room for improvement, and that the results furnished by them are yet neither as satisfactory nor in as simple form as could be desired.

On Nestor Notabilis.

By S. H. SWAYNE.

THE Genus Nestor, which has been generally considered to be intermediate between the Parrots and Cockatoos, appears to have a very limited range, being at present confined to New Zealand. Gould, in his "Birds of Australia," says, that two species only are known, one Nestor Hypopolius or Meridionalis, found in New Zealand, and the other Nestor Productus formerly in Phillip Island, a small island about 5 miles in circumference, near Norfolk Island, between New Zealand and New Caledonia; but that the Phillip Island species was no longer to be found there, and his description and drawing of the bird seems to have been taken from a living specimen, in the possession of Major Andrews, of Sydney. Gould appears not to have known the Nestor Notabilis, a species found in the Middle Island of New Zealand. The Phillip Island species, Nestor Productus, differed from the others in the extraordinary development of its long sickle-shaped beak, the upper mandible of which projected far below the lower one. In the two other species the development of the beak is less marked.

In Nestor Productus the general colour of the upper part of the body was brown; the head and back of the neck mottled with gray, each of the feathers being bordered by a darker shade. The under part of the body, rump, and under tail coverts, deep red; the cheeks, throat, and chest yellow, in some places tinged with red.

The colour of Nestor Hypopolius or Meridionalis, the longest known species, called by the natives " Kaka," is dark brown on the neck, back, and chest, the belly and rump being red.

In Nestor Notabilis the general colour of the back and belly is pale olive green, the feathers being bordered with brown; the principal feathers of the wing and tail, bluish green, varied with brown and white on the one side of the feather; the rump and inside of the arm, orange. This species is larger than Meridionalis. The beak is straighter than in either of the two other species, and somewhat reminds one of the beak of a Raptorial bird. A living specimen has lately been exhibited in the Regent's Park Gardens, and the newspapers a short time ago contained a remarkable account of its habits in its New Zealand home.

It is stated that the beak of Nestor Productus was sometimes found covered with earth, as if it had been digging; but Major Andrews's specimen was fond of vegetables and juicy food, and its beak seemed ill fitted for crushing the harder nuts which other parrots dispose of easily.

Should this bird continue to exist and maintain his carnivorous propensities, we might speculate whether he might not in time, on the principles of evolution, develope into a Raptorial bird.

Colliery Explosions.

By E. WETHERED, F.G.S., F.C.S.

THE frequent recurrence of explosions in collieries has become a matter of such grave importance, that the question of what is to be done to prevent these disasters demands serious attention.

Not that the subject has been neglected; the "Mines' Regulation Act," passed in 1872, contains provisions with a view to prevent these explosions by directing certain precautions to be taken in mines which contain explosive gas. The number of Her Majesty's Inspectors of Mines has been increased, and care has been taken that they should be properly qualified men. Notwithstanding these precautions explosions continue to occur, accompanied with appalling loss of life.

In order that the subject may be made clear, I propose to give an outline of the facts of the case.

Coal is the product of decayed vegetation which lived and died countless ages ago. As the result of the decomposition of the vegetable mass, there would be evolved, among other products of decay, a gas known as light carburetted hydrogen or fire-damp, and it is this with which we have to deal as the chief factor in colliery explosions.

Chemists look upon matter as being made up of atoms and molecules,[1] and it is by the exchange of these atoms according

[1] An atom is the smallest portion of matter which can enter into a chemical compound, whilst a molecule is the smallest quantity of an element or of a compound which can exist in the free state.

to definite laws, that the various gases, solids, and liquids are built up. In the case of fire-damp, a molecule of the gas consists of one atom of carbon combined with four of hydrogen. It is colourless, lighter than air, combustible, and becomes highly explosive when mixed with air in certain proportions. Sir Humphrey Davy found that when mixed with 3.5 volumes of air fire-damp does not explode but burns quietly in contact with the atmosphere; when mixed with 5.5 volumes it explodes slightly, but it becomes highly explosive with from 8 to 9 volumes of air. Mr. J. W. Thomas, F.C.S., in his book on "Coal Mine Gases and Ventilation" (page 170) finds, that the force of explosion is greatest when the gas is mixed with air in the proportion for complete combustion, that is, with 9.5 parts of air to 1 of gas. Mr. W. Gallaway, from observations made in No. 3 Pit, Llwynypid Colliery, found at a temperature of 57° F., humidity 79, bar. 30.15 in., that a mixture composed of 1 of fire-damp to 14 of air was slightly explosive, and that in the proportion of 1 of fire-damp to 15 of air it was inflammable.

The direct cause of an explosion is the disintegration, so to speak, of the molecules of the gas, owing to the chemical affinities of its carbon and hydrogen atoms for oxygen at a certain temperature. The tendency of the carbon atom is to combine with two atoms of oxygen and form carbonic acid gas, more generally termed "black-damp" or "after-damp." The hydrogen atoms also combine with oxygen, producing water. If, however, there is not sufficient oxygen to satisfy the full combining affinities of the carbon atom, a gas is formed having the composition of one atom of carbon combined with one atom of oxygen; this is known as carbonic oxide gas.

The "after-damp" is a very different gas to that of the explosive "fire-damp." Instead of being lighter than air, it is heavier. Its effect on animal and human life is to suffocate, and upon flame to extinguish; hence it is that the after-damp is dreaded as much or even more than the explosion. Miners may escape the latter, but unless immediately rescued, or able to obtain fresh air, death is certain.

Carbonic oxide gas differs from the two previous gases; though in chemical composition it is similar to the carbonic acid, with the exception of having one atom of oxygen the less. It is a combustible gas, burning with a blue flame, but does not readily explode when mixed with air. When inhaled, carbonic oxide combines with the hæmaglobin of the blood and becomes highly poisonous; even in very small quantities it produces a headache and giddiness.

I now pass on to consider the ventilation of collieries, upon which the safety of mines so much depends.

Suppose I take a glass cylinder (the deeper the better), and divide it into two partitions by placing a piece of cardboard down the centre, but leaving a space at the bottom of the cylinder of about an inch. Next, suspend in one of the divisions a lighted candle or lamp; the result will be that a column of air will ascend the partition in which the candle is placed, while at the same time a column of cold air will descend the other division of the cylinder. This is because the air has become rarefied (in the division in which the candle is placed) by reason of the heat; or, in other words, the air has become lighter in the one division than in the other, by reason of expansion due to the heat, and therefore rises, while the heavier column rushes to fill up the vacuum that would otherwise be created. Thus a constant current is established so long as the light burns. The rate at which this current moves will depend upon the difference in weight of the two air columns, and this again will be regulated by the temperature.

Now, it is upon this principle that ventilation by natural draught is established in collieries. The partition of the cylinder in which I represented the candle as burning may be taken as the "up-cast shaft" of a colliery, and the other partition the "down-cast shaft." In the early days of coal mining, the ventilation of coal mines was effected in a way very similar to that illustrated by the glass cylinder. A shaft was sunk and a small portion walled off (the wall doing the work of the cardboard in the glass cylinder) and formed the "down-cast," the main portion serving as the "up-cast." But the old miners did not always trouble themselves to improve their ventilation by rarefying the air of the up-cast shaft by means of heat, but trusted to the internal heat of the earth to accomplish the work for them. When, however, the ventilation became very defective, then a bucket containing burning coal was suspended for a time in the "up-cast." But, as mining operations began to develop, this primitive method of ventilation was found to be insufficient, and so the underground workings were connected with a second shaft, at the bottom of which there was a furnace. The air, on entering this shaft, which was the "up-cast," becomes rarefied, and rushes up towards the surface of the ground with increased velocity, and, on the other hand, the cold air rushes down the other shaft with increased velocity to fill up the vacuum that would otherwise be caused. Thus a current of air is established throughout the mine, and it is upon this the miner depends to dilute and remove gases, which, if allowed to accumulate, would result in disastrous consequences. The importance of good ventilation will at once become apparent.

Furnace ventilation is still extensively practised, but other methods have also been introduced. These effect their work by artificial draught. The machine consists of a fan or ventilator, which exhausts the air in the up-cast shaft, thereby producing a partial vacuum, which the air in the down-cast rushes to fill up, in the same way as with the furnace. Very effective results have been produced by these appliances, and it is a question which of the two methods of ventilation is the better.

Up to the year 1815 the only practical guarantee which the miner had for his safety in fiery mines was good ventilation. If that was defective his life was in constant danger so long as he remained in the mine, and remembering what I have said as to the older methods of ventilating a mine, it is not surprising to learn that the number of explosions began to attract attention. A committee of scientific gentlemen was appointed to inquire into the matter, among whom was Sir Humphrey Davy. At the same time, or there about, George Stephenson had set himself to invent a lamp which could be used with safety in gaseous mines. Sir Humphrey Davy also set about the same thing, and both discovered that explosion would not pass down tubes of a small diameter. After three attempts Stephenson perfected his lamp on that principle, and exhibited it before the Literary and Philosophical Society, of Newcastle, on the evening of December 30th, 1815, and it was shortly afterwards adopted in the Killingworth Colliery, where he was engaged.

Soon after the exhibition of Stephenson's lamp Sir Humphrey Davy produced his at Newcastle, and so similar was it to Stephenson's that people exclaimed,[1] "Why it is the same as Stephenson's!" There is little doubt that these two great men worked quite apart from one another, and it is not altogether an unnatural coincidence that two persons trying to attain the same object should produce the same result. There is, however, this difference between them—Sir Humphrey Davy constructed his lamp on scientific principles, knowing the cause and effect, while Stephenson constructed his from practical observation, and when his lamp was complete his idea as to the reason of the result produced was erroneous.

The safety lamp depends upon a very simple law of nature,

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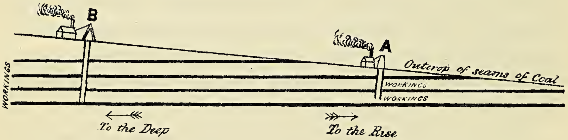
[1] Life of George Stephenson, by Smiles, p. 116.

namely, that in order to allow of combustion a certain temperature is necessary. Hence it is that combustion will not pass down small tubes, as the temperature is not maintained by reason of the cooling effect of the tubes. In the first lamps, air was admitted through small tubes at the bottom of the lamp, and the products of combustion, after passing up a glass chimney, passed out through similar tubes at the top. If air contaminated with explosive gas passed into the lamp, it might ignite within, but before the flame could pass to the outside air it must pass through the exit tubes, and in so doing it would be extinguished owing to the lowering of the temperature. Later on, Sir Humphrey Davy added the gauze chimney to his lamp, but the principle is the same, the meshes of the gauze acting the part of the tubes. It is this lamp which is known as "the Davy."

It must not be concluded that safety lamps are perfect; indeed, they must be very carefully handled. They require to be carried with care; if swung about, the contact of the flame against the gauze makes it red-hot, and when this is the case, flame passes through the meshes, and the lamp becomes worse than useless. If there be a sudden rush of air, or too strong a current of air, the flame is blown against the gauze with a like result. The Stephenson lamp, which remains unaltered from the first, goes out in the presence of firedamp.

After the invention of the safety lamp, colliery explosions became for a time less frequent, but of late they have multiplied again. I have no statistics before me to show the frequency of these catastrophes before safety lamps came into use; probably they were more frequent than now, but the loss of life was not so great. This is to be explained by the underground workings being much less extensive than at the present time and consequently fewer men were employed. It is, however, a fact, I think, that our collieries are becoming yearly more dangerous to work, owing to the extended underground workings, and I will now endeavour to explain the reason of this.

If we take a section of stratified rocks, we generally find them inclined at a certain angle. If we trace these beds, we find that they eventually reach the surface, unless faulted. The point at which the surface is reached is termed the "out-crop," and in mining language the upward inclination of the strata is termed the "rise" and the downward the "deep." (See Fig. 1.)



In the early days of mining, the workings were carried on near the out-crop as represented at shaft A. These workings, too, were mostly to the "rise," rendered necessary by the inadequate means which the old miners had for bringing coal from the "deep" workings to the bottom of the shaft. These shallow and "rise" workings were some protection against explosions, owing to seams of coal becoming less gaseous as they near the out-crop. Now, however, by the increased haulage power which has been brought into use, it is as easy to work from the deep as the rise (shaft B). But what does this involve? It means that the air current has further to travel, thus encountering greater friction. More "splits" are required to supply the numerous galleries, and a greater quantity of gas has to be encountered.

We are now, however, in a position to ask the question, whether explosions in collieries are alone due to the contamination of the air passing through the mine with explosive gas. If this be so, the atmospheric variations will exercise an important influence. Say the barometer stands at 30 inches, which is equal to 14·7 lbs. to the square inch. Suppose the mercury to fall 1 inch, then the pressure would be reduced by ·49 of a lb. The question then is, as to whether the less pressure against the coal would allow of a greater quantity of gas to issue from the coal. For my own part I do not think it would make much difference. Again, a fall of the barometer is not unfrequently attended with an increase of temperature, which means, that the column of air in the "down-cast" has become warmer. It is easier to ventilate a mine in winter than in summer, especially where furnace ventilation is the method adopted. The reason is plain. The atmosphere at the surface is colder in winter than in summer, therefore the temperature of the air descending the "down-cast" shaft is lower. Now, if colliery explosions were entirely due to fire-damp, we ought to be freer from explosions in cold weather. This, however, is not so; some of the most fatal explosions have occurred in the winter months.[1] For instance, an explosion occurred at the Risca Colliery on December 1st, 1862, in which 142 men were killed; and, again, the fearful explosion at the Oaks Colliery took place in December, 1866, when 334 miners lost their lives. In the last instance a shot was fired a few seconds before the explosion, in what appeared to be air free from gas. How are we, then, to explain this fact?

If we enter a coal mine, we cannot fail to notice the coal dust which is lying about and in the atmosphere. In the year

[1] Mr. W. Gallaway gave an elaborate table in a paper contributed to the Royal Society, in which he gives the dates of a number of explosions.—*Proc. Royal Society*, 1874, p. 441.

1845, Faraday and Lyell[1] pointed out, that after an explosion coal dust was found adhering to the props and sides of the galleries of the mine. Similar observations were published by M. du Souich ten years later, and some observations were carried out by M. Verpilleux, in 1867, on the same subject. It is, however, to Mr. William Gallaway, mining engineer, of Cardiff, and formerly one of Her Majesty's Assistant Inspectors of Mines, to whom most credit is due for bringing to notice the fact that coal dust is a factor in colliery explosions. The result of Mr. Gallaway's observations seems to be that coal dust is a very considerable factor, if not the chief, and that air contaminated with fire-damp and dry coal dust becomes explosive, even though the gas might be present in so small a quantity as not to be detected by the methods adopted in practical mining. Mr. Gallaway finds that[2] "a mixture of fire-damp and air, in the proportion of 1 volume of the former to 60, or more, volumes of the latter, give no reliable indication of the presence of inflammable gas when tested in the manner usually, if not always, adopted in mines." "2nd. A mixture of fire-damp and air, in the proportion of 1 volume of the former to 112 of the latter, becomes inflammable at ordinary pressure and temperature, when charged with fine coal dust." These experiments of Mr. Gallaway's seem to solve the problem presented by the evidence gathered as to the cause of several explosions, namely, that previous to the calamity, the mine has been pronounced free from gas.[3]

A series of investigations have also been made, at the request

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[1] *Phil. Mag.*, 1845.

[2] *Proc. Royal Society*, No. 168, 1876, p. 364.

[3] In the *Annals of Mines*, 1875, M. Vital refers to an explosion in the Campagnac Colliery, where no fire-damp had been previously discovered.

of the Secretary of State, with a view of further investigating the influence of coal dust in colliery explosions.[1] Among the points of interest elicited by this inquiry were the following:—The proportion of fire-damp required to bring dust in a mine into operation as a rapidly-burning or an exploding agent, even on a small scale, and with the application of a small source of heat or flame, is below the smallest amount which can be detected in the air of a mine by the experienced observer, with the means at present used. In air travelling at a velocity of 600 feet per minute, different coal dusts suspended in the air, containing from 2 to 2·75 per cent. of fire-damp, produce explosions. At a velocity of 100 feet per minute, the same result was obtained with air containing only 1·5 per cent. of gas; and ignitions of dust approaching explosions and extending to considerable distances were obtained with dust in air containing much smaller proportions of gas. Mixtures of fire-damp and air, bordering on those which will ignite on the approach of flame, were instantaneously inflamed by a lamp when only a few particles of dust were in suspension.

The preventative against this influence of coal dust suggested by Mr. Gallaway and M. Vital is to water the road-ways, whereby the dust would be laid. The objection to this is, that the wet causes a disturbance of the ground; the bottom rises up, and is liable to bring about serious consequences. However, we have the choice of two evils, the rising of the floor caused by the water, or the choice of an explosion. The question is, which is the lesser of the two evils? I should not hesitate to decide in favour of the watering.

Notwithstanding what has been said as to the influence of coal dust in bringing about explosions, I am still of the opinion that atmospheric variations do facilitate explosions. This opinion

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[1] *Colliery Guardian*, Oct. 28, 1881.

is expressed by the Royal Commission on Accidents in Mines.[1] They say, "the variations of atmospheric pressure exercise an undoubted effect on accumulations of gas in mines. Some few observers believe the expansion of the gas from the places where it has been pent up takes place before an indication of the barometer. Others think that the issue of the gas follows the fall of the mercury. Very few observers believe in any important influence of atmospheric pressure upon the issue of gas from the face of the coal, holding that the extra volume of fire-damp thus given off would at all events be small in comparison with the capacity for diluting gas which should exist in the air." . . . "Although there can be no doubt that with a sinking barometer an additional quantity of gas has to be guarded against, very few of our witnesses believe that there is any close relation between the atmospheric pressure and the occurrence of colliery explosions; more particularly some of the viewers from the north, who have closely watched these phonomena, are of opinion that such connection has not been made out." It is, however, a fact, that South Wales is particularly unfortunate as regards explosions. Now the west coast is much exposed to constant atmospheric changes. This may be attributed to the prevailing winds being from the west and south-west, which are charged with the vapour of the Gulf Stream. When this moisture-laden atmosphere comes in contact with the hills of Wales, the moisture is precipitated, and at the same time latent heat is liberated.

Therefore, though the actual falling of the barometer may not add to the danger, the rise of its colleague, the thermometer, may.

It is, however, probable that both the atmospheric variations and coal dust are liable to facilitate explosions, and that the

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[1] *Colliery Guardian*, October 28, 1881, p. 709.

latter depends, to some extent, upon the former. Mr. Gallaway,[1] after referring to the fact that in December, 1875, three great explosions occurred within three days when the barometer was high and the temperature at the surface low, and that it had been often observed that disastrous explosions had happened most frequently during the winter months, goes on to say:— "If we assume that the magnitude of some colliery explosions has been determined by the presence of coal dust in the workings, and that the hygrometric state of coal dust changes with the humidity of the air with which it is in contact, then it is an obvious conclusion that explosions of this kind will be most likely to occur when the air in the mine is driest; for at such times not only will the coal dust be most easily raised into the air by the local explosion (which we may always suppose to happen at any rate), but it will also be burned more easily than when it contains a larger proportion of moisture."

"As an example we may take the case of a dry mine, in which the temperature of the workings is 70° F. During warm weather the air which descends the shaft has a temperature of say 60° when it enters the intake air course; at this stage it is also saturated with vapour, for there is usually a little water trickling down the sides of a mine shaft. The temperature rises gradually as the current draws near to the "faces," and at length attains its maximum when the newly exposed face of the coal has been passed. During this process the humidity has also been increasing to some extent, always remaining below complete saturation, however, in a mine of this kind."

"In very cold weather, on the other hand, the same current may sometimes have a temperature of 32°, or less, when it reaches the bottom of the shaft; and since it passes through the same workings, its temperature rises to 70° as before. It is

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[1] *Proc. Royal Society*, No. 168, 1876, pp. 369—371.

plain, therefore, that, in the latter case, the ventilating current must either obtain an additional supply of moisture from the workings (about half pound for every 100 cubic feet of air), or it must be drier than in the former case at every point of its course."

"Primâ facie, then, this process of reasoning leads us to the conclusion that explosions, *whose magnitude is due to the influence of coal dust,* will happen most frequently during cold weather; and conversely, we might expect to find that the magnitude of these explosions which occur during cold weather is traceable, in some measure, to the influence of coal dust."

As to the practice of blasting in mines, there seems to be no doubt that the flash of the powder has been the immediate cause of explosions. This being the case, the abolishing of such modes of working has been advocated. To those familar with mining operations the difficulties which would be occasioned are at once apparent, and the ordinary reader can also form some idea of the disadvantages under which the miner would labour. If it were simply a matter of blasting the coal, the objection to the doing away with it would not be so great, but it is in making the roads and in general repairs that the use of power is required more especially. It seems to me that if Mr. Gallaway's recommendation of watering the neighbourhood where blasting is to take place (just before the shot is fired), were carried out, there would not be much to fear, provided, of course, that the lamps did not indicate the presence of gas.

On the Smoke Abatement Exhibition.

By Prof. J. F. MAIN, M.A., D.Sc., A.I.C.E.

THE subject of the abatement of smoke, both that which is produced by private houses, and that which arises from manufactories, has, within the last few years, become a matter of national importance. In the great centres of population, and more especially in London, the prevalence of fogs, which are rendered injurious to health by the presence of the imperfectly-burned gases arising from the fuel consumed, has forced upon the attention of scientific men the desirability of lessening, if possible, the magnitude of this grave peril to the health and strength of those living in our large cities.

It was, therefore, to be expected that the National Health Society should early take the matter under their consideration, and, in the spring of 1880, Mr. Hart, the Chairman of Council of that Society, introduced the question to the Society, and was requested to take steps to bring the matter into a practical form for further proceeding. He communicated with Professor Chandler Roberts, Chemist to the Mint, and Professor of Metallurgy to the School of Mines, who undertook to make an examination of existing methods of combustion of coal in household grates and in furnaces. Shortly after, the Kyrle Society, through their treasurer, Miss Octavia Hill, represented that they were contemplating steps in the same direction. A joint committee of the two societies was then formed, which proceeded to communicate with various persons interested in the abatement of the "smoke curse," and practically acquainted with the best means at present available for doing so. They also obtained from Mr. Whittle, barrister, a report on the existing state of the law regarding smoke, and the way in which it might be brought into action. It appears that no legal means exist for checking the production of smoke from private houses. But the owners of any chimney of a manufactory sending forth black smoke can be proceeded against summarily as a nuisance. In every division of the police a constable is told off to look after the smoke question. He reports on any mass of black smoke that he sees, and if, after the issuing of two notices to the offender, the nuisance is not abated, the owner of the chimney is summoned. There seems to be no doubt that the condition of Lambeth, and other parts along the Thames, has been largely improved by the action of the police, since large dense masses of black smoke, which used to be seen floating there, are not observed now. It is also provided by law, that any steamboat plying on the Thames can be compelled to consume its own smoke, and that all railways are under the same regulations.

Soon after the issue of this report, a meeting was convened at the Cannon Street Hotel to enable the Committee to confer with manufacturers, bakers, and others who come under the provision of the Smoke Act.

At this meeting it was stated that Sir Francis Knollys has estimated that of the 5,000,000 tons of coal annually consumed in London, between two and three millions of tons are wasted. This waste, although not occurring in manufactories, where the saving of coal is more carefully regarded, may very possibly occur with the 597,000 houses in London, possessing probably about three and a half millions of chimneys.

The general opinion of the speakers at this meeting, fortified in most cases by actual experience, was that a large reduction in the amount of smoke produced might be obtained by a proper admixture of anthracite and bituminous coal. Several of the towns in South Wales are smokeless by using anthracite coal, which is much preferred there, owing to the enormous saving attending its use.

Soon after, another meeting was convened by the Lord Mayor at the Mansion House.

Amongst other statements made at this meeting it was said that during the fogs of the winter of 1880 the death-rate of London rose to 40 per cent. higher than any rate since the last cholera epidemic. This mortality did not extend to the provinces, and the excess was almost wholly confined to respiratory diseases. It is calculated that a million sterling is the value of the coal wasted, and two millions more lost owing to the damage done by the smoke.

It was shewn that whereas 40 or 50 years ago roses flourished in London, their cultivation is now almost impossible, owing to the presence of smoke in fogs. Mr. Shaw Lefevre, amongst other remarks, suggested the use of gas for heating purposes.

At a subsequent meeting held at Grosvenor House, Dr. Siemens insisted on the importance, commercially, of the gas companies furnishing an inferior quality of gas for heating purposes at a lower price than that which they supply for lighting. Sir Henry Thompson spoke of the pernicious effects of the smoke in fogs on persons of delicate constitutions, and stated that he had frequently seen ladies sponging the leaves of flowers in drawing-rooms to free them from the small particles of carbon. In *post mortem* examinations, the lungs of those who had died were found to be covered with a black layer of carbon.

Such is a very brief and rapid résumé of preliminary meetings which were held, and which resulted in the formation of the Smoke Abatement Exhibition.

Before I pass on to the description of the various appliances lately exhibited at South Kensington to prevent smoke, I may shortly recall to your remembrance the conditions on which perfect combustion depends. *Combustion* or *burning* is a rapid chemical combination of two or more substances. The only kind of combustion that concerns us now is that in which the various combustibles contained in coal combine with oxygen so as to produce light and heat. The ingredients of every kind of fuel commonly used may be divided into three classes.

I.—Fixed and free carbon, which is left in the form of charcoal (from wood) or coke (from coal) when the volatile constituents of the coal have been burned away. Carbon can burn either in the solid or gaseous state, or partly in the one and partly in the other.

II.—*Hydrocarbons*, such as olefiant gas, pitch, tar, naphtha, &c., which must be converted into the gaseous state before they are burned.

If these gases, when they first issue from the burning fuel, come in contact with a larger quantity of oxygen, they burn completely with a pale transparent blue flame, producing carbonic acid and steam. When raised to a red heat, or thereabouts, before being mixed with a sufficient quantity of air the carbon which they contain is separated in the form of fine powder, and the gases pass into the state either of marsh gas or free hydrogen—the higher the temperature the greater is the amount of carbon so separated.

If this disengaged carbon, instead of being burnt by coming in contact with the requisite amount of air at the high temperature at which it is separated, is cooled below the temperature necessary for ignition, it constitutes, while floating in the air, SMOKE, and when deposited on bodies, it forms SOOT.

But if the carbon powder comes in contact with air before it has been cooled below its point of ignition, it burns while floating in the inflammable gas, and forms RED, YELLOW, or WHITE flame, the flame from the fuel being larger the more slowly its combustion is effected.

These appearances one is perfectly familiar with in the case of an ordinary fire. When the fire is fed with fresh fuel, the volatile hydrocarbons are given off in great quantity. The amount of air which can reach them is not sufficiently great to enable perfect combustion to go on, and, therefore, although a large amount of flame is observed, there is at the same time a considerable quantity of smoke produced, which would not be produced—and this is one of the most important points to be borne in mind in devising means to prevent the formation of smoke—if a sufficient supply of air could be mixed with these gases whilst still at the temperature of ignition. But after a time, these volatile hydrocarbons are driven off from the heated surface of the fuel, and the amount of air supplied being then sufficient to give complete combustion, first the amount of smoke, and then the amount of bright flame diminishes, and after a time the fire burns clear. But, we all know that flame and smoke are once more produced by poking, the explanation being that by poking more hydrocarbons are disengaged from the interior of the coal, which repeat the operations described above.

III.—Besides the two great divisions of the constituents of fuel mentioned above, viz., carbon and the hydrocarbons, oxygen and hydrogen exist in coal in such quantities as by their combination to form water. The presence of this water, or of its constituents, in fuel, promotes the formation of smoke, or of the carbonaceous flame, which is ignited smoke, as the case may be, probably by mechanically sweeping along fine particles of carbon.

The other constituents of coal are not important for present considerations, although, when the smoke is prevented from passing away into the atmosphere by the prevalence of fogs, some of these constituents, notably sulphur, may become very important from the deleterious influence which they exert on the respiratory organs.

Thus we are able to infer the conditions under which fuel will be so burned as to give no smoke.

If we can get a fuel which is almost entirely composed of carbon, such as anthracite coal is, we shall have no smoke. But there is a difficulty in lighting a fire with this coal, and if it is heated too quickly it breaks up into small pieces, which fall through the grate bars and are lost, therefore it has to be put into the fire gradually, so that it becomes slowly warmed before it is ignited. When dry, this coal gives no flame, but when moistened it gives yellowish flames. Thus we see that if a satisfactory means of burning anthracite coal could be devised, and, what is even more difficult, if people could be persuaded to use it, there would be no smoke produced from it.

But if bituminous coals are employed, smoke must be produced, and having been produced, if it is not to leave the chimney, it must in some way be consumed. It may be consumed either by leading it through the fire, so that by passing again through the ignited mass, the smoke may be burned, or it may be burned by mixing with it a proper amount of air, which, in order not to cool it below the temperature of ignition, should be previously heated.

These, then, are the only theoretical conditions required for the combustion of smoke. Let us now go to the Exhibition to find out in what way these principles have been practically applied.

The exhibits at South Kensington may be divided into eight classes, viz., domestic grates, stoves, furnaces with mechanical feeding arrangements, multiple-stage furnaces, firedoors and bars of various kinds, various devices for consuming smoke, apparatus in which gas is consumed, including gas engines and gas burners.

The grates and stoves may be conveniently described together.

One of the chief features in the Exhibition is the Siemens gas grate, in which gas is used with coke or anthracite coal, and accomplishes its purpose perfectly, producing no smoke.

A very bright cheerful fire is thus obtained, very different in appearance from most anthracite fires which do not burn so brightly as the bituminous coal fires. The largest part of the Exhibition is taken up with inventions whose object is to burn bituminous coal and consume the smoke produced.

The means by which the various inventors have sought to consume, wholly or in part, the visible products of combustion, fall mainly into two classes.

In the first class the object is attained by passing the products of combustion through the fire; and, in the second, the result is arrived at by providing a supply of *heated* air, and causing it to meet the products of combustion as they leave the fire.

Most of the exhibits belong to the first of the above classes, viz., those in which the products of combustion are made to pass through or over the fire. This object is attained in various ways. Messrs. Brown and Green make the bottom of their grate, which is solid, project and turn up slightly, so as to hold the green fuel. This is pushed forward, as required, into the fire under the live coals, and consequently the inflammable gases given off from the green fuel are consumed in passing up through the fire.

In Holland's grate, which resembles in appearance an ordinary register stove, a handle at the side, when pulled, causes a rake-like set of bars to enter from the back between the fire bars underneath the ignited fuel. The continued movement of the handle raises the ignited fuel clear of the bottom of the fire bars, the space between being for the reception of fresh fuel.

The handle, when pushed back, causes the rake-bars to return to their old position.

McMillan's grate has underneath it a box hinged about a horizontal axis, the section at right angles to which is of the form of a sector of a circle. When the fire is required to be replenished, the box is pulled out, the contents of the grate meanwhile resting on a plate fixed to the back of the box. The box is filled and replaced, and the coals are then forced up by lifting a moveable bottom.

Besides these and many others of a similar kind, an invention of W. S. Melville's, called a "Smoke Abater Shovel," may be noticed. It has for its object the introduction of coal beneath the fire in an ordinary grate. The shovel is of rectangular section, closed on all sides, and having on the top towards the front a hinged lid. When the lid is filled with coals and shut, it is, in front, of the shape of a wedge, so that it can be readily introduced under the contents of the grate. When this is done, a slide on the handle opens the lid, the piston may be pushed forward, and the green coals deposited under the live coals in the fire. This shovel is very useful for ordinary grates.

Engert's grate belongs to another kind of stove, in which the fuel is stored in a box or boxes at the side of, or behind, the fire, so that the coal is gradually coked, and the hydrocarbon evolved and consumed in passing through the fire.

Another plan is to make the capacity of the grate sufficient for a day's consumption, the coal being lighted on the top, and gradually burning downwards. In Edwards's grate this is effected by having a balanced shutter, which separates the burnt from the unburnt fuel. As the fuel burns away the shutter is pushed down, and so, if the grate is filled once, a store of coals is obtained sufficient for a whole day's consumption. This grate has already been introduced into Guy's and other hospitals.

In another series of grates the draught is taken downwards, or backwards, through the fire, so as to produce the same result, the fire being first lighted in the usual way, and the draught taken up the chimney, and then, when the fire is well lighted, the upper draught is almost entirely stopped, and the gases are taken down through the fire, and the down-draught established. This plan has the objection that if the up-draught is not entirely stopped, a considerable portion of the smoke will pass up and be deposited as soot, whilst, if the up-draught is stopped, the fire is liable to smoke.

Petter's "Nautilus Grate" is one of the best, both in appearance and design, in the Exhibition. The cross section resembles a shell, the fire being in the mouth. As the fuel becomes red-hot, it is pushed back, and fresh fuel is fed on in front. The upper part of the grate serves to regulate the amount of air admitted, and the products of combustion pass out by flues at the sides. By using this grate a very much greater proportion of the heat is utilised, for the products of combustion, instead of passing directly into the chimney, pass out by side flues, and the top of the stove, as well as the front of the fire, radiate heat out into the room. The interior of the grate being lined with firebrick, the fire does not touch the metal. There is no smoke, for what is formed in the front is burnt in passing to the back of the fire. The combustion is so perfect that the fire remains granular, and ashes do not accumulate in the bottom of the basket. In summer the grate can be entirely removed, and its place taken by flowers, if wished, and there is no difficulty in cleaning it. The expense with one of these grates is as little as 1d. per day.

In the second class of grates, in which hot air is supplied to the gases as they leave the fire in order to complete their combustion, one of the most effective is Cornforth's, in which the grate bars are hollow. The air, in passing through them, becomes heated, and passing up to mix with the gases as they leave the fire, completes the combustion and prevents smoke. The success is certainly striking in this way. At South Kensington small coal ashes were being used, and yet even when the fuel was first put in there was no trace of smoke in the gas coming from the chimney.

In the Greene stove the air is caused to pass through a perforated tubular bridge passing across the fire; this heats the air before it passes into the fire.

Other grates in this class have the draught divided into two parts, one of which goes through the fire and the other over the top. The objection to this kind of grate is that the combustion is liable to take place in the chimney, and thereby the heat so generated is useless for warming the room. But frequently the chimney is surrounded by an air chamber to which air is admitted from the outside, and so warmed before passing into the room.

The Miser stove deserves mention, for the exhibitors, Messrs. Yates, Haywood, & Co., estimate the expense of it at from ½d. to 1d. per diem.

The design is good. When first lighted the smoke passes directly to the flue, but on a damper being shut, part of the draught passes through a series of openings in the back of the fire, and part over the top of the vertical combustion chamber. It then passes down to the bottom of the stove and up through pillars at the sides to the top. This it heats and then escapes into the flue. The combustion is good; and, from the large amount of heating surface, most of the heat is given out to the room.

Many other varieties of stoves were exhibited, which want of time forbids me to speak of. This section of the Exhibition was well represented, and although there was no stove which is of such surpassing merit as to ensure its immediate adoption to the exclusion of others, there are many which, if adopted, would materially tend to lessen the evil of smoke.

A large number of machines are exhibited which are intended to feed the furnace at a uniform rate by mechanical means. The simplest and one of the best of these is Knap's Mechanical Stoker. In this the coal passes from the feeding hopper to a slowly-rotating crushing and feeding roller. From this it falls on an inclined surface, down which it slides in front of a reciprocating pusher, which sends it on to the bars. These are alternately fixed and moveable, and are driven by the slotted levers on the outside of the machine, the ends of which cause the moveable bars to move up and down, and also to move backwards and forwards, thereby breaking up the coal and preventing the formation of clinker. The apparatus is compact, and the parts are very simple and therefore little liable to get out of order. During some trials made at Muspratt's Chemical Works at Liverpool, it was found that the evaporation was 8·2 lbs. of water per lb. of coal with a Root's boiler, when furnished with one of these stokers, as against 7·1 lbs. when the same boiler was fired by hand.

In Smith's Mechanical Stoker the coal is fed from a hopper, and the bars move to and fro by gearing, whilst they are also made to move up and down; but the peculiarity of this stoker is that the fire bars are made hollow, and kept cool by a jet of steam which passes along them and then passes out, increasing the draught and therefore the combustion. It is claimed that the durability of the bars is much increased by this means.

In Proctor's Mechanical Stoker the fuel is sent on to the fire by what, practically, is a mechanical shovel. A shovel moves about a horizontal axis with a rapid forward motion, and so drives the coal before it on to the bars. The shovel is worked by a cam, which slowly brings the shovel back, the quick forward motion being given by a spring. To prevent the wear of the apparatus, the blow produced by the spring as the shovel moves forward is taken by an india-rubber buffer. The cam-wheel has three different lifts or throws, so that the coal is sent to three different parts of the fire and is thereby spread uniformly over it. This, as far as smoke consuming is concerned, is a mistake, because green fuel is fed on to the back of the furnace as well as the front.

The Helix Furnace Feeder Company supply coal to the furnace by means of two augur-like screws, which take the place of some of the fire-bars, and by turning in a chamber which is only open at the top, cause the coal to travel along and up into the fire, thereby supplying the fuel at the bottom of the live coal. It possesses the advantage too, in common with several other forms, that hand stoking can be at once resorted to if the mechanical means should fail.

In McDougall's Mechanical Stoker the fuel is pushed forward by a ram furnished with a reciprocating movement.

In Newton's Mechanical Stoker the fuel is forced on to the grate by means of a blast of hot air. The air pipes are led along the side of the boiler, the air thereby becomes heated, and it then blows the coal which has been previously crushed on to the bars.

In these various classes of Mechanical Stokers, the waste of fuel, owing to the cooling of the furnace, that arises from the entrance of cold air into the fire every time the furnace door is opened, is avoided. But it has to be remembered that a certain amount of power is required to drive the machinery which feeds the fire, and this has to be taken into account in estimating the economy of the machine, and the complication of parts in many of them is a serious objection also.

Another extremely interesting exhibit is that shown by the Great Britain Smoke-Consuming and Fuel-Saving Company. A jet of steam passes over the top of a pipe through which air is supplied, and by this means a forced draught is obtained, and air is sent into the furnace and burns the smoke.

In Chubb's atmospheric blast means are devised to open or shut, by means of levers worked at the front of the furnace, certain openings at the back of the furnace for admitting air through the bridge to the unburnt gases. The air is drawn in owing to the difference in temperature between the furnace and the ash-pit, and in passing through the bridge becomes intensely heated.

Hunter's Smoke Consumer is interesting on account of the mechanical contrivances it contains. The furnace is hand fired. Each time firing takes place, and by the opening of the furnace door, an opening is made by which air passes to the bridge. This opening is kept from closing by a valve which contains mercury. This takes some time to flow through a hole, and until it has flowed away the opening will not shut. Thus air is admitted to the bridge, and escapes through perforations in it for a certain time, which can be regulated at will, after the furnace doors have been closed.

A very convenient form of furnace front and firedoor is shewn by Mr. Thomas Henderson, of Liverpool. It has been largely used in marine boilers. It consists of a V-shaped casting, which serves as furnace door and dead plate, connected across by a perforated plate, which serves to admit air to the furnace. It is balanced by a spring, to prevent it from falling down. The length of the two parts of the V-piece is the same. To use it, the fireman pushes the door inwards. The door then serves as a dead plate, while stoking is going on. After stoking, the plate is restored to its old position, but for cleaning out, the door is pushed still further down, and a vacant space is left for the clinker to pass down, whilst, at the same time, the hot gases from the clinker pass through the vacant space to the furnace, and thence to the chimney, and the heat from the ashes is prevented from reaching the legs of the stokers by the door which, in this position, is interposed between them.

The Martin fire door is balanced by a weight, so that it remains in any position in which it is placed.

Perret's Multiple Stage Furnace is composed of four fire clay stages or shelves, slightly domed, and of an ashpan. The front is furnished with three doors, over each other. Two of these doors serve for manipulating the fires on the stages, and the third in the ashpan for extracting the ashes. The combustion is effected with hot air. The front plate is double, and in this the air is heated before it passes into the furnace. It is admitted at the bottom, and takes an upward direction. By this furnace, fuel with a very small percentage of combustible matter, can be burned. The inventor claims that any fuel, with only 25 per cent. of combustible matter, may be consumed in this apparatus. Certainly the refuse, ashes, and small coal which was disposed of in the Exhibition seem to prove that for purposes in which *rapid* combustion is not required, such as, for instance, in supplying hot water for heating purposes, this furnace would prove extremely economical.

In Barber's Smokeless Furnace the grate is sloping, the fresh fuel being fed in under the other at three different levels. After the fire is started the fresh fuel must be kept in front of the burning coals, so that the air passes first over the fresh fuel. The coal is thrown on the shelves frequently and in small quantities. It is then pushed forward, so that it carries the previously-coked fuel before it. The fuel is fed in at the bottom first, and then on the shelf above, and so on, and care must be taken that the fresh fuel shall not project above the coked fuel above it. If it does, some of the coked fuel is to be spread over it so as to cover it from the shelf above. All the sloping bars must be kept covered with fuel so that cold air may not rush in and cool the fire.

Besides those that I have described, there are many other forms of mechanical feeding apparatus which time prevents me from alluding to here. This department of the Exhibition has received much attention.

Messrs. Crossley Bros., of Manchester, exhibited their well-known gas-engine, which was being worked by Messrs. Dowson's water gas; and there was also the exhibit of Messrs. Thomson & Sterne's gas-engine. As these have only a remote connection with the abatement of the smoke nuisance, I shall not more particularly refer to them.

One of the principal features of the Exhibition was the regenerative gas burner of F. Siemens, of Dresden. The principle of this burner is that the waste gases from the gas flame are caused to heat the gas and air which supply the light by their combustion. By this means a much greater illuminating power is obtained from the same quantity of gas. These burners are used and may be seen in Holborn Viaduct. The results obtained with them are better than with any other form known, being 7 candle-power for each cubic foot of gas burned per hour.

The description which I have now given of the Smoke Abatement Exhibition will shew you that the exhibits were generally of a very interesting character, displaying a large amount of ingenuity and skill. But I am afraid that we must be reluctantly compelled to admit, notwithstanding, that there was no grate which perfectly consumed its own smoke except those that burned smokeless coal.

There was no one which had such a marked pre-eminence above its fellows for economy, simplicity, durability, and success in consuming smoke as to cause it to be universally adopted. A practical remedy for the terrible smoke nuisance is therefore still to seek. That some steps will have to be taken sooner or later to abate this terrible and growing evil there can be no doubt. A week of fog can raise the death-rate in London to a point greater by more than 54 per cent. than the average, as was the case, for instance, in the second week of February of this year.

The mortality, unlike that of cold, afflicts all persons alike, except little children under five years of age, and these are nearly free owing to their being kept indoors, when they are not so subject to its influence. The action of fogs is thus explained by Dr. Frankland. The coal burnt in London gives off large quantities of oily products. These float in the air and surround the small particles of vapour which constitute fog, preventing them from either evaporating or coalescing. Thus an impenetrable barrier is formed, which entangle and become impregnated with the noxious gases given off by the combustion of coal. The fog acts thus in two ways. In the first place, instead of pure air we breathe other gases, which, even if they were not positively harmful, would be objectionable owing to their inability to carry on the process of respiration. Hence even in a sea fog, which is free from deleterious vapours, there is a sense of oppression owing to the incomplete action of the lungs. But, in the second place, the fogs of London are charged with noxious vapours, which are in the highest degree injurious. During one of the late fogs, a chemist in the City of London, made analyses of the amount of carbonic acid in the air, and he found that it rose as high as 12 parts in 10,000, 4 parts in 10,000 being the usual amount, and 6 parts being declared by physiologists to be the greatest amount that can be present in an atmosphere without producing evil consequences to those breathing it. These facts need no comment. They shew the necessity for the application of remedial measures. The recent Exhibition has shewn the difficulty that there is not only in devising the measures, but even in determining in what directions to look for them. But, although no very great results are likely to result from it, it will have done a great service in directing public attention to this most serious evil, for we know certainly, that the first step towards the abolition of a mischief is the clear perception of its existence, its magnitude, and its disastrous consequences.

Catalogue of the Lepidoptera of the Bristol District.

PART V.

BY ALFRED E. HUDD, M.E.S.

TORTRICES.

HALIAS PRASINANA. L. Tolerably common amongst oak trees throughout the district.

,, QUERCANA. W.V. Mr. Harding tells me several specimens were taken near Dursley some years ago. Mr. Ormston Pease captured one in Tortworth Park, Glos., in July, 1876. Mr. I. W. Clarke beat one from an oak in Leigh Woods, last summer (July, 1881).

SAROTHRIPA REVAYANA. W.V. In woods near Redland, Cook's Folly, Hortham, Almondsbury, and Stapleton; Leigh Woods, Portishead, Weston-super-Mare, &c. Not common.

TORTRIX PODANA. S. (=FULVANA. St.) Rather common in woods everywhere.

The synonyms given in brackets are those by which the species are described in Stainton's "*Manual*." In this, and the remaining portions of the Catalogue, Gloucestershire localities are separated from those in Somerset by a semicolon.

TORTRIX PICEANA. L. Recorded by Mr. Allen Hill as "scarce on pine-trunks and in plantations near Almondsbury." See Mr. Barrett's notes on this species. *"E. M. M.," VIII., p. 272, & IX., p. 215.*

„ CRATAEGANA. H. (=ROBORANA. St.) Scarce in oak woods near Almondsbury; Leigh Woods.

„ XYLOSTEANA. H. Abundant everywhere.

„ SORBIANA. H. Stapleton, and Stoke Park, near Almondsbury; Leigh Woods, near Brislington, &c. Not scarce amongst oaks.

„ ROSANA. L. Common everywhere.

„ DIVERSANA. H. (=TRANSITANA. St.) Scarce near Stapleton and Wotton-under-Edge; Mr. Vaughan reports a few specimens from Leigh.

„ CINNAMOMEANA. T. Recorded from Wotton-under-Edge; and Leigh Woods. Mr. Grigg tells me the larvæ are rather common on larch trees at Leigh.

„ HEPARANA. W.V. Almondsbury, Wotton-under-Edge, and Stapleton; Leigh Woods, &c. Larvæ on oak, not scarce.

„ RIBEANA. H. Common everywhere.

„ CORYLANA. H. Amongst maples near Stapleton and in Hortham Wood, near Almondsbury; plentiful at Leigh, in June and July.

„ UNIFASCIANA. D. Generally common amongst privet.

„ SEMIALBANA. G. Mr. Vaughan tells me he used to take this species pretty freely "under St. Vincent's Rocks." The larvæ are said to feed on beech.

„ COSTANA. W.V. Scarce in marshy places near Almondsbury, Clifton, Sea Mills; Leigh Woods, Portbury, Keynsham, &c.

TORTRIX VIRIDANA. L. Abundant everywhere.

„ MINISTRANA. L. Generally distributed, but not so common as formerly.

„ FORSTERANA. F. Common everywhere ; larvæ in rolled-up leaves of ivy and privet.

DICHELIA GROTIANA. F. Mr. Vaughan has taken this species at Brislington. It is said to come freely to sugar.

LEPTOGRAMMA LITERANA. L. Scarce amongst oaks at Stapleton and in Stoke Park near Almondsbury; and Mr. Vaughan writes "not rare on tree-trunks on Leigh Downs."

„ SCABRANA. F. Scarce at ivy-bloom on Durdham Down, in October.

PERONEA SPONSANA. F. (=FAVILLACEANA. St.) Not scarce among beech-trees at Almondsbury, Coombe Dingle, Durdham Down; Leigh Woods, Portishead, &c.

„ [AUTUMNANA. H. (=RUFANA. Schff.) Mr. Duck records this species as "common in Portishead wood," but I should like further evidence before including it in my list.]

„ SCHALLERIANA. L. Plentiful in woods near Cook's Folly, Almondsbury, Wotton-under-Edge; Leigh, &c.

„ COMPARANA. H. Amongst sallows in August and September in woods near Almondsbury; and at Brislington.

„ VARIEGANA. W.V. Common everywhere; larvæ on wild rose, &c., in June.

„ CRISTANA. W.V. At ivy-bloom and in woods near Clifton, Almondsbury; Leigh, Portishead, &c. Widely distributed, but generally only single specimens found.

PERONEA HASTIANA. L. One or two specimens only in the Gully, Durdham Down, and Almondsbury.

„ FERRUGANA. W.V. Common in woods and at ivy-bloom.

„ TRISTANA. H. Common amongst *Viburnum lantana* throughout the district.

„ ASPERSANA. H. Taken on Durdham Down by Mr. Vaughan and Mr. Harding.

TERAS CAUDANA. F. Generally distributed but not common, in August and September.

„ CONTAMINANA. H. Common everywhere in the autumn amongst hawthorn.

DICTYOPTERYX LŒFLINGIANA. L. Abundant in woods.

„ HOLMIANA. L. Generally distributed and rather common amongst hawthorn.

„ BERGMANNIANA. L. Generally distributed. Mr. Vaughan tells me the larvæ are very destructive to rose-buds in his garden.

„ FORSKALEANA. L. Common among maples near Stapleton, Almondsbury, Wotton-under-Edge; Leigh, Clevedon, &c.

ARGYROTOXA CONWAYANA. F. Generally distributed. Larvæ sometimes common at Leigh, on ash trees.

PTYCHOLOMA LECHEANA. L. Common in oak woods throughout the district.

DITULA SEMIFASCIANA. H. Scarce amongst sallows at Frome Glen, near Stapleton, and Hortham, near Almondsbury; also near Brislington. Larvæ in sallow-catkins.

PENTHINA PICANA. F. (=CORTICANA. St.) Amongst birch in Leigh Woods, in July; not common.

„ BETULETANA. H. Common in birch woods in July and August, at Wotton-under-Edge; Leigh Woods, &c.

PENTHINA SORORCULANA. Z. (=PRÆLONGANA. St.) Scarce on Durdham Down, by Mr. Grigg, and at Wotton-under-Edge; a few specimens taken in Leigh Woods by Mr. Vaughan.

" PRUNIANA. H. Abundant everywhere.

" OCHROLEUCANA. H. Common amongst roses at Redland, Durdham Down, Almondsbury, Wotton-under-Edge, &c.

" CYNOSBANA. L. Common everywhere.

" " *var.* NUBIFERANA. Haw. Brislington, scarce.

" GENTIANANA. H. Wotton-under-Edge; Leigh, &c. Larvæ tolerably common in teazle-heads on the banks of the Avon.

" MARGINANA. H. Recorded by Mr. Hill, "abundant but local near Almondsbury, flying from 4 to 5 p.m. over long grass"; and by Mr. Vaughan from "under Leigh Woods."

" FULIGANA. H. (=USTULANA. St.) Scarce on Durdham Down, by Mr. Vaughan, and Hortham Wood, and Woodland Copse near Almondsbury, by Mr. Hill.

ANTITHESIA SALICANA. G. Amongst willows near Ashley Down, Stapleton, Wotton-under-Edge; and Brislington. Flies at dusk in June and July.

SPILONOTA OCELLANA. W.V. Generally distributed and abundant. Mr. Grigg tells me the larvæ are abundant in gardens on *pyracanthus*.

" LARICEANA. Z. A few specimens amongst larch trees in Leigh Woods, by Mr. GRIGG.

" ACERIANA. M. Amongst poplars throughout the district; Mr. Vaughan tells me it used to be very common under St. Vincent's Rocks.

SPILONOTA DEALBANA. F. Generally distributed and sometimes common.

„ NEGLECTANA. D. Near Stapleton, Wotton-under-Edge; and in Leigh Woods. Scarce.

„ INCARNATANA. H. (=AMÆNANA. St.) Mr. Allen Hill records this species as "rare amongst bushes in Stoke Park," near Almondsbury. If this be correct, the larvæ cannot feed exclusively on *Rosa spinosissima,* which does not grow in that neighbourhood: Mr. Hill having been such a careful observer, I do not like to exclude this species, though none of my other lists include it.

„ SUFFUSANA. K. (=TRIMACULANA. St.) Common everywhere.

„ ROSAECOLANA. D. Generally distributed and sometimes too abundant in gardens, amongst roses.

„ ROBORANA. W.V. Common amongst wild roses throughout the district.

PARDIA TRIPUNCTANA. W.V. Abundant everywhere.

ASPIS UDMANNIANA. L. Abundant everywhere.

SIDERIA ACHATANA. W.V. "Scarce and local near Almondsbury, over hawthorn hedges." Mr. Vaughan used to find this species regularly in the Gully, Durdham Down, &c., but it has not been taken near Bristol of late years.

SERICORIS EUPHORBIANA. *Z.* A single specimen of this scarce and local species was taken by Mr. W. H. Grigg, in May, 1880, on the Somersetshire bank of the Avon, near Nightingale Valley.

„ CESPITANA. H. Taken by Mr. Harding near Stapleton, and formerly in profusion at Clifton; and Leigh Downs by Mr. Vaughan.

SERICORIS CONCHANA. H. Common but local near Almondsbury, in Stoke Park, and at Wotton-under-Edge.

,, LACUNANA. W.V. Common everywhere.

,, URTICANA. H. Generally distributed and common amongst strawberries, nettles, &c.

EUCHROMIA MYGINDANA. W.V. (=FLAMMEANA. F.) One specimen at Sea Mills, by Mr. Harding; and Mr. Vaughan used to take it regularly, in meadows near Pill, Somerset.

,, PURPURANA. H. Used to be taken on Durdham Down by Mr. Harding; and in Trench Lane, near Winterbourne, and "over long grass near Baywood Brook," by Mr. Allen Hill.

ORTHOTAENIA ANTIQUANA. H. Scarce near Almondsbury and Wotton-under-Edge, and larvæ in roots of *Stachys*, at Stapleton, by Mr. Harding.

,, STRIANA. W.V. Rather common on lawns and over short grass, at Clifton, Stapleton, Redland, Almondsbury; Portishead, Clevedon, &c.

,, ERICETANA. B. Scarce, at light near Stapleton, by Mr. Harding, and "over aftermath and clover, at Hortham, near Almondsbury, flying at sunset, not common," by Mr. Hill.

ERIOPSELA FRACTIFASCIANA. H. Grassy slopes of Clifton and Durdham Downs; and at Leigh. They rarely fly, but may be found at rest on the ground, and on low plants. This species is double-brooded.

PHTHEOCHROA RUGOSANA. H. Scarce amongst bryony, on Durdham Down, near Stapleton, and Wotton-under-Edge; and at Brislington.

CNEPHASIA MUSCULANA. H. Generally distributed, and common.

SCIAPHILA NUBILANA. H. Abundant at Stapleton and near Almondsbury, flying at dusk over hawthorn, in June and July.

„ PERTERANA. G. (=CONSPERSANA. St.) One specimen in Frome Glen, by Mr. Harding, and scarce on trees in Stoke Park, near Almondsbury, by Mr. Allen Hill.

„ SUBJECTANA. G. Abundant everywhere.

„ VIRGAUREANA. T. Common everywhere.

„ CHRYSANTHEANA. D. (=ALTERNELLA. St.) Leigh Woods, scarce, by Mr. Grigg and Mr. Vaughan. The former tells me he found larvæ on *Inula conyza* at Leigh, in July, 1880, which produced this species.

„ PASIVANA. H. (=SINUANA. St.) This local and scarce species is recorded by Mr. Harding from Frome Glen, near Stapleton; also in *Stainton's Manual, Vol. II., p.* 258, from Clevedon, Somerset. I know of no recent captures.

„ ABRASANA. D. Reported from Frome Glen, near Stapleton by Mr. Harding; scarce.

„ HYBRIDANA. H. Durdham Down, Stapleton, Patchway, &c.; not common.

SPHALEROPTERA ICTERICANA. H. "Boiling Wells," and South Wales Railway banks, near Bristol, Durdham Down, Wotton-under-Edge, &c. Flies at dusk in June and July, and comes to light. Not very common.

CLEPSIS RUSTICANA. T. Scarce amongst maples near Almondsbury, in June; flies in the sunshine.

BACTRA LANCEOLANA. H. Abundant amongst rushes, and variable in colour and markings.

PHOXOPTERYX BIARCUANA. S. Scarce in Hortham Wood, Almondsbury, and near Wotton-under-Edge; also in Leigh Woods and at Brislington.

PHOXOPTERYX COMPTANA. F. Reported from Wotton-under-Edge, and abundant on Durdham Down.

„ LUNDANA. F. Durdham Down, Stapleton, Westbury, Almondsbury, Wotton-under-Edge; Leigh Woods, Weston, Clevedon, &c.

„ DERASANA. H. Reported by Mr. Vaughan from Dr. Fox's Wood at Brislington. The larvæ are said to feed on *buckthorn.*

„ DIMINUTANA. H. Hortham Wood and Almondsbury, by Mr. Hill, and Wotton-under-Edge, by Mr. Perkins. Not common.

„ MITTERBACHERIANA. S. Common everywhere in oak woods.

„ LÆTANA. F. (=A. RAMELLA. St.) Scarce amongst poplars at Almondsbury; Leigh, and Portishead.

GRAPHOLITHA RAMANA. L. (=H. PAYKULLIANA. St.) Common amongst birches in woods near Almondsbury, Wotton-under-Edge; and Leigh.

„ NISANA. L. Abundant amongst sallows at Cook's Folly, Patchway, Frome Glen, Almondsbury, Wotton-under-Edge; Leigh Woods, Brislington, &c. Larvæ in sallow-catkins in March.

„ VAR. CINERANA. "Common on aspen-stems at Almondsbury;" scarce in Leigh Woods.

„ NIGROMACULANA. H. Scarce near Stapleton, by Mr. Harding, and at Wotton-under-Edge.

„ CAMPOLILIANA. W.V. Taken Mr. Harding near Stapleton, "Common amongst sallows near Almondsbury," and Wotton-under-Edge.

„ MINUTANA. H. Amongst poplars near Stapleton, by Mr. Harding, not common.

GRAPHOLITHA TRIMACULANA. D. Common everywhere in woods, amongst elm and lime.

,, PENKLERIANA. W.V. Near Stapleton; and in Leigh Woods; sometimes common.

,, OBTUSANA. H. Reported by Mr. Sircom from Durdham Down, in July. *See Zoologist, III.*

,, NAEVANA. H. Common amongst holly.

PHLŒODES TETRAQUETRANA. H. Not scarce in woods near Almondsbury; Leigh, Portishead, &c.

,, IMMUNDANA. F.v.R. Scarce in woods near Wotton-under-Edge; Leigh, and Portishead.

HYPERMECIA CRUCIANA. L. Not scarce in marshes at Hortham, Almondsbury, Frome Glen; near Portishead, Saltford, Hanham, &c. Larvæ in sallow-catkins.

BATODES ANGUSTIORANA. H. Common in woods amongst yew-trees, in July and August. The larvæ are abundant on vines and many garden plants, and are sometimes very destructive in Clifton vineries, spinning a web amongst the ripe grapes, on which they feed.

POEDISCA BILUNANA. H. Sometimes plentiful amongst birch-trees at Almondsbury; and on Leigh Down.

,, CORTICANA. W.V. Abundant everywhere.

,, PROFUNDANA. W.V. Not scarce on oak-trunks in woods at Almondsbury; Portishead, Leigh, &c.

,, OPTHALMICANA. H. Very scarce near Bristol, though Mr. Hill records it as "common amongst aspens in Hortham Wood, near Almondsbury." I have taken it, but do not remember where.

,, OCCULTANA. D. Scarce amongst larches in Leigh woods, by Messrs. Grigg and Vaughan.

POEDISCA SOLANDRIANA. L. Common and very variable in colour and markings, amongst birches. Larvæ in rolled-up leaves.

" SORDIDANA. H. (=STABILANA. St.) Mr. Hill records this as "not scarce amongst alders in woods near Almondsbury, but local."

EPHIPPIPHORA BIMACULANA. D. On birch-trunks near Almondsbury; and in Leigh Woods.

" CIRSIANA. Z. Common in woods and fields at Almondsbury, Patchway, Stapleton; Leigh, Portishead, &c., amongst thistles.

" PFLUGIANA. H. (=SCUTULANA. St.) Abundant amongst thistles, throughout the district.

" BRUNNICHIANA. W.V. Abundant everywhere amongst coltsfoot; varies in colour.

" FŒNEANA. L. This species, and its dark variety, are reported by Mr. Perkins as rather plentiful near Wotton-under-Edge; it is also found on the Somersetshire coast of the Bristol Channel.

" NIGROCOSTANA. H. One larva in *Stachys sylvatica* root at Redland, by Mr. Grigg; scarce in Woodland Copse near Almondsbury; and by Mr. Vaughan in Leigh Woods.

" SIGNATANA. D. Scarce amongst aspens in Hortham Wood, Almondsbury, by Mr. Hill; and on Leigh Down by Mr. Vaughan.

" TRIGEMINANA. St. Common on railway banks, amongst ragwort, throughout the district.

" TETRAGONANA. S. Hortham Wood, Almondsbury, Wotton-under-Edge; and Brislington. Scarce.

" POPULANA. F. Larvæ amongst sallows in Frome Glen near Stapleton, in March, 1881, by Mr.

W. H. Grigg; and near Brislington, by Mr. Vaughan. Scarce.

EPHIPPIPHORA GALLICOLANA. Z. (=OBSCURANA. St.) Bred from oak-galls from Leigh Woods by Messrs. Grigg and Vaughan; very rare.

OLINDA ULMANA. H. Scarce in Portishead Woods by Mr. Duck, and in Leigh Woods by Mr. Vaughan and myself; a few specimens only.

SEMASIA SPINIANA. R. Woodland Copse, Almondsbury, Wotton-under-Edge; Portishead, Leigh Woods, &c. Not scarce in hedges.

„ JANTHINANA. D. Durdham Down, Almondsbury, Wotton-under-Edge, &c. Sometimes common, flying over hawthorn in the sunshine.

„ WŒBERANA. W.V. Common amongst old fruit-trees in gardens and orchards throughout the district.

COCCYX STROBILANA. L. Mr. Harding took several specimens in Leigh Woods some years since, but the species has not been met with there of late. The larvæ are said to feed in the *cones* of spruce-fir in the winter.

„ ARGYRANA. H. In oak woods near Stapleton, Almondsbury, Wotton-under-Edge; Leigh, Portishead, &c. Not very common.

„ HYRCINIANA. W. Common amongst old spruce-firs near Almondsbury; Leigh, Clevedon, &c., in May and June.

„ NANANA. T. In fir woods near Almondsbury, Wotton-under-Edge; Leigh, &c. Not common.

HEUSIMENE FIMBRIANA. S. Scarce amongst old oaks in March and April, near Stapleton, Almondsbury; Leigh, &c. Flies in the sunshine.

RETINIA BUOLINIA. W.V. Common throughout the district amongst Scotch firs. The young pines recently planted on the slopes of Durdham Down have nearly all been destroyed by the larvæ of this species, which feed in the young shoots.

RETINIA PINICOLANA. D. This species occurs amongst Scotch firs at Brockley Coombe.

„ PINIVORANA. Z. "Scarce amongst Scotch firs near Almondsbury"; and at Brockley Coombe.

CARPOCAPSA SPLENDANA. H. The larvæ of this pretty species are sometimes abundant in acorns on Purdown, near Stapleton, in Hortham and other woods near Almondsbury, and Wotton-under-Edge; also at Leigh. It is a difficult insect to rear.

„ GROSSANA. H. Mr. Harding tells me he has met with larvæ of this species at Stapleton. The moths should be looked for in June and July, flying round beech trees at dusk.

„ POMONANA. L. In orchards and gardens throughout the district, but not often common. For life-history of this destructive insect see the *Entomologist, Vol. XIII., p.* 161.

OPADIA FUNEBRANA. T. Larvæ in plums in gardens at Redland and Stapleton.

ENDOPISA NIGRICANA. F. Scarce near Almondsbury; and at Brislington.

STIGMONOTA CONIFERANA. R. Reported only from Wotton-under-Edge, by Mr. Perkins. Should be looked for in fir-woods in June.

„ PERLEPIDANA. H. Amongst fir-trees at Worcombe, by Mr. Hill, and at Wotton-under-Edge; also plentiful at Belmont, near Wraxall, by Mr. Vaughan.

STIGMONOTA INTERNANA. G. Reported from Wotton-under-Edge, by Mr. Perkins. Flies in the sunshine amongst furze.

„ COMPOSANA. F. (= COMPOSITELLA. St.) "Common at Almondsbury, flying in clover-fields in the sunshine," and at Wotton-under-Edge; abundant on flowers at Brislington, Portishead, &c. This species is double-brooded, appearing in May and August.

„ REDIMITANA. G. (= NITIDANA. St.) Not scarce on Durdham Down and near Wotton-under-Edge; also in Portishead Wood in June.

„ TRAUNIANA. W.V. Recorded from near Bristol by Mr. Sircom, late of Brislington, in the *Zoologist, Vol. II., p.* 773.

„ REGIANA. Z. Taken freely at Redland by Mr. Vaughan, and at Wotton-under-Edge by Mr. Perkins, amongst sycamores, in June and July.

„ GERMARANA. H. Hedges and banks near Almondsbury, by Mr. Hill only.

DICRORAMPHA POLITANA. W.V. Not scarce near Stapleton and Wotton-under-Edge; Mr. Grigg has met with the larvæ in roots of tansy, on the Somersetshire bank of the Avon.

„ ALPINANA. T. Amongst tansy near Brislington, Leigh, Keynsham, &c.; not very common.

„ SEQUANA. H. Sometimes abundant on railway and other dry banks near Stapleton, Almondsbury; Brislington, Keynsham, &c., flying in the sunshine.

„ PETIVERANA. L. Common at Almondsbury, Stapleton, Fishponds, Wotton; Brislington, Keynsham, &c.; larvæ in stems of yarrow.

DICRORAMPHA PLUMBANA. S. (=E. ULICANA. St.) "Common on grassy banks, and in poor pastures near Almondsbury," and near Wotton-under-Edge.

,, SATURNANA. G. Reported only by Mr. Hill as "common but local near Rudgewood, Almondsbury, &c.," in July and August.

,, PLUMBAGANA. T. "Common on grassy, sunny banks at Almondsbury," Stapleton, Bishopston; Leigh Woods, &c. Larvæ in stems of yarrow.

,, ACUMINITANA. Z. Reported from Bishopston, near Horfield, Winterbourne; and Brislington.

,, SIMPLICIANA. H. Scarce amongst mugwort (*artemisia vulgaris*) at Portishead and Brislington.

,, TANACETANA. S. Not scarce in June and July amongst tansy, on the Portishead Railway bank and near Keynsham.

PYRODES RHEDIANA. L. "Common about damp hedges and in woods near Almondsbury," Bishopston, Durdham Down, Wotton-under-Edge; and near Portishead. It flies in the sunshine in May and June, and may be found in dull weather at rest on flowers of hawthorn, &c.

CATOPTRIA ALBERSANA. H. Near Stapleton by Mr. Harding, and in Leigh Woods by Mr. Vaughan; scarce.

,, ULICETANA. H. Abundant amongst gorse everywhere.

,, JULIANA. C. Mr. Harding reports this species as having been found near Brislington by Mr. Sircom. I have no other record.

,, HYPERICANA. H. Abundant everywhere amongst *Hypericum*, in woods.

,, CANA. H. (=SCOPOLIANA. St.) Not scarce amongst thistles in woods and lanes, in June and July.

CATOPTRIA SCOPOLIANA. H. (=HOHENWARTHIANA. St.) Flies freely in the afternoon in July, in woods near Almondsbury, Wotton-under-Edge; and Leigh.

" DECOLORANA. F. Common on the Portishead Railway bank, and larvæ on golden-rod, *Solidago virgaurea*, by Mr. W. H. Grigg.

" ASPIDISCANA. H. Taken by Mr. Grigg in the Leigh Woods, and on the Portishead Railway bank, rather freely.

" EXPALLIDANA. H. "Common but local in Trench Lane and other places near Almondsbury, flying at sunset in July, amongst clover, &c." Also reported by Mr. Vaughan from Leigh.

TRYCHERIS MEDIANA. W.V. (=EUCELIS AURANA. St.) This pretty species seems to be widely distributed throughout the district, but is scarce and local. I have it recorded from Almondsbury, Hortham, Patchway, Rudgewood, Wotton-under-Edge; and from Brislington and Brockley Coombe. They fly at noon over flowers of teasle, parsnip, &c., or may be found at rest on flowers in dull weather.

CHOREUTES SCINTILULANA. H. Mr. Vaughan writes, "In great profusion on the banks of the Avon, near Clifton, but very local"; and Mr. Harding informs me it used also to be found near Brislington by Mr. Sircom.

XYLOPODA FABRICIANA. L. Abundant everywhere.

" PARIANA. L. Scarce and local, in orchards near Redland and Almondsbury.

LOBESIA RELIQUANA. H. Scarce, flying round young oaks on Durdham Down; and in Leigh Woods.

EUPŒCILIA NANA. H. Throughout the district amongst birch-trees in May and June, but not common.

" DUBITANA. H. Not uncommon in June and again in August, at Frome Glen, near Stapleton, Ashley Hill, Wotton-under-Edge; Leigh, Brislington, &c. Flies at dusk on dry banks.

" ATRICAPITANA. S. Scarce on the railway-bank near Nightingale Valley, and in Leigh Woods.

" MACULOSANA. H. Not scarce in woods, amongst blue-bells. Durdham Down, Almondsbury, Stapleton; Leigh Woods, &c Double brooded, in June and August, flying in the evening. and sometimes coming to light. Mr. Grigg has bred this species from oak-galls.

" SODALIANA. H. Scarce and local. Durdham Down, Stapleton, Aust Cliff, Wotton-under-Edge; and Portishead. The larvæ feed on buckthorn.

" HYBRIDELLANA. H. (= CARDUANA. St.) Scarce on Durdham Down, and near Wotton-under-Edge; on the Portishead Railway banks, and in Leigh Woods.

" DEGREYANA. M. Mr. W. H. Grigg has taken a few specimens on this local species on the Portishead Railway bank, under Leigh Woods. They were identified for him by Mr. C. G. Barrett.

" ANGUSTANA. H. Downs near Wotton-under-Edge, and Leigh. Not common.

" CURVISTRIGANA. W. Larvæ common on golden-rod in Leigh Woods, by Mr. W. H. Grigg.

" VECTISANA. W. One specimen taken by Mr. Grigg, amongst *aster tripolium*, on the bank of the Avon, near Sea Mills.

EUPŒCILIA AFFINITANA. D. Also found by Mr. Grigg amongst *aster tripolium* near Sea Mills, but scarce. The larvæ probably feed on this plant, as well as on *statice armeria*, which does not grow on the banks of the Avon.

,, UDANA. G. (=GRISEANA. St.) Scarce, in July, at Stapleton, in Rudge Wood, near Almondsbury; and in Leigh Woods. The larvæ are said to feed in stems of *alisma plantago*, in September and October.

,, NOTULANA. Z. "Local, but not scarce, at the end of June, in marshy places and about ditches near Almondsbury." The larvæ feed in the autumn in stems of *mentha hirsuita*, &c.

,, RUPICOLANA. C. Woodland Copse, near Almondsbury; Brislington, and the Portishead Railway bank, amongst hemp-agrimony, on which the larvæ feed.

,, ROSEANA. H. Larvæ common in heads of teasles, in the winter and spring, at Wotton-under-Edge, Horfield, Portishead Railway banks, &c.

,, SUB-ROSEANA. H. Common but local, near Almondsbury; and in the quarries on the Somersetshire bank of the Avon.

,, CILIANA. H. (=RUFICILIANA. St.) Scarce at Wotton-under-Edge; and in Leigh Woods, by Mr. Grigg. Should be looked for in cowslip-fields, in May and June.

XANTHOSETIA ZŒGANA. L. Generally distributed throughout the district on dry hill sides, but not common.

,, HAMANA. L. Common everywhere, amongst thistles.

CHROSIS TESSERANA. W.V. Common but local, on downs and dry hill-sides, throughout the district.

,, BIFASCIANA. H. (=AUDOUINANA. St.) Scarce in Leigh Woods in May and June, by Messrs Grigg and Harding.

ARGYROLEPIA BAUMANNIANA. W.V. Scarce and local. Woodland Copse near Almondsbury, and Wotton-under-Edge, by Mr. Hill, and one specimen near Sea Mills by Mr. Harding.

,, SUB-BAUMANNIANA. W. Sparingly in the gully, Durdham Down; and in Leigh Woods, in June and July,

,, ZEPHYRANA. T. (=DUBRISANA. St.) Scarce on Durdham Down by Mr. Sircom, near Wotton-under-Edge; and "one specimen, in July, 1881, on the Portishead Railway bank," by Mr. Grigg.

,, BADIANA. H. Generally distributed, amongst burdock, but never common.

CONCHYLIS DILUCIDANA. St. Common amongst carrot on the banks of the Avon, and bred from larvæ taken in stems by Messrs Grigg and Harding.

,, STRAMINEANA. H. "Common near Wotton-under-Edge, in May and June," by Mr. Perkins.

,, INOPIANA. H. (=HALONOTA INOPIANA. St.) Common on the banks of the Avon, at Almondsbury, Stapleton, Wotton-under-Edge; and on the railway-banks under Leigh Woods.

APHELIA OSSEANA. S. (=APLABIA PRATANA. St.) Scarce and local, in the beech wood at Stoke Gifford by Mr. Harding, and near Almondsbury.

TORTRICODES HYEMANA. H. Generally distributed, and common in oak woods, in March and April.

The Fungi of the Bristol District.
PART V.

By CEDRIC BUCKNALL, Mus. Bac.

	Amanita.		
837.	Agaricus strobiliformis, *Fr.*	Leigh Down,	Sept. 1881.
	Lepiota.		
838.	Agaricus acutesquamosus, *Weinm.*	Clifton Down,	,, ,,
839.	Agaricus ermineus, *Fr.*	Glen Frome,	,, ,,
	Tricholoma.		
840.	Agaricus ustalis, *Fr.*	Westridge Wood,	,, ,,
841.	,, sulphureus, *Bull.*	,, ,,	,, ,,
842.	,, carneus, *Bull.*	Durdham Down,	,, ,,
*	,, nudus, *Bull.*	Glen Frome,	Nov. 1879.
843.	,, panæolus, *Fr.*	Durdham Down,	Summer, 1881.
844.	,, brevipes, *Bull.*	Aust Cliff,	June, ,,
845.	,, sordidus, *Fr.*	Combe Hill,	Oct. 1878.
	Clitocybe.		
846.	Agaricus dealbatus, *Sow.*	Cotham (A. Leipner, Esq.),	Summer, 1881.
	Mycena.		
847.	Agaricus lineatus, *Bull.* (Plate I., fig. 1).	Leigh Down,	Nov. 1881.
848.	,, filopes, *Bull.*	Clifton,	Mar. 1880.
849.	,, hiemalis, *Osbeck.*	Glen Frome,	1881.

Pleurotus.

850. Agaricus pantoleucus, *Fr.*
Hym. Eur. p. 172, *Icon.*
t. 88, *f.* 2. Leigh Wood, Nov. 1878.

A single specimen, which had fallen from a tree, was found; it agrees well with Fries' figure except in the longer, curved stem.

Pluteus.

851. Agaricus hispidulus, *Fr.*
Hym. Eur. p. 187, *Icon.*
t. 90, *f.* 2. Stapleton Park,

On beech stumps. My specimens are larger than that figured by Fries, but I believe it to be the same species. (Plate I., fig. 2).

Leptonia.

852. Agaricus formosus, *Fr.*
Hym. Eur. p. 204, *Icon.*
t. 98, *f.* 1. Leigh Down, Sept. 1880.

Amongst furze and heather. Not agreeing perfectly with Fries' figure or description, and may prove to be a distinct species, but I think it better to refer it to the above for the present. Pileus hygrophanous, striate when moist, sericeo-squamulose; stem smooth, glabrous, base whitish-downy; margin of gills erose, darker. (Plate I., fig. 3).

Inocybe.

853. Agaricus petiginosus, *Fr.* Abbots' Leigh, Sept. 1881.

Hebeloma.

854. Agaricus testaceus, *Batsch.* Leigh Down, „ „

Tubaria.

855. Agaricus autochthonus, *B. & Br.* Durdham Down, Aug. 1877.

Crepidotus.

856. Agaricus Phillipsii, *B. & Br.* Leigh Down, May, 1881.

On a dead stem of *Pteris aquilina.*

Psathyra.

857. Agaricus pennatus, *Fr.* Leigh Wood, Oct. 1880.

Panaeolus.

858. Agaricus fimiputris, *Bull.* Abbots' Leigh, Sept. 1881.

859. Coprinus nycthemerus, *Fr.* Cotham, Apr. 1881.

860. Cortinarius (Phlegmacium) russus, *Fr.* Westridge Wood, Sept. „

A fine species of a beautiful coppery-red. My specimen has a bulbous stem, but the Rev. M. J. Berkeley, to whom I shewed my drawing, considers it to be the above species.

861. Cortinarius (Dermocybe) anomalus, *Fr.* Leigh Down, Sept. 1881.

862. Cortinarius (Dermocybe) cotoneus, *Fr.* ? Westridge Wood, Nov. 1880.

This must for the present remain doubtful, but the plant I have figured appears to be nearer *C. cotoneus* than any other species, and it is nearly allied to the next, C. *raphanoides*. It is certainly not a *Myxacium*. (Plate I., fig. 4).

863. Cortinarius (Dermocybe) raphanoides, *Fr.* Westridge Wood, Sept. 1880.

My specimen was larger and stouter than that figured by Quelet in Grevillea (Plate CXI., fig. 6), but had the characteristic odour of radishes, and agreed well in other respects. Pileus 3 inches across, stem 3 inches high, 1¼ inches thick.

864. Gomphidius stillatus, *Strauss.* Cheddar, July, 1881.

865. Lactarius pallidus, *Fr.* Westridge Wood, Sept. 1881.

866. „ camphoratus, *Fr.* Abbots' Leigh, „ „

867. Russula integra, *Fr.* Leigh Down, Summer, 1881.

868. Nyctalis parasitica, *Fr.* Blaize Castle Wood, Oct. „

869. Lenzites flaccida, *Fr.* Stapleton Park, Dec. 1878.

870. Boletus badius, *Fr.* Abbots' Leigh, Oct. 1880.

871. „ edulis, *Bull.* Leigh Wood, Autumn, 1881.

872. Polyporus lentus, *Berk.* Walton Hill, July, „

873.	Polyporus applanatus, *Fr.*	Leigh Wood,	July, 1881.
874.	,, purpureus, *Fr.*	Stapleton Park,	,, ,,
875.	,, radula, *Fr.*	Cotham (A. Leipner, Esq.),	April, ,,
876.	Craterellus cornucopioides, *Pers.*	Blaize Castle Wood,	Oct. 1880.
877.	Thelephora mollissima, *Pers.*	Leigh Wood,	Sept. ,,
878.	Cyphella Curreyi, *B. & Br.*	Leigh Down,	Mar. 1882.
879.	,, faginea, *Lib.*	Sandy Lane, Leigh Down,	May, 1878. Nov. 1879.

Gregaria, tenerrima, sessilis, minor, nivea; cupula junior globosa, dein evoluta campanulata, cernua, pilis confertis septatis obsessa.—In fagetis ad folia dejecta. Autumno.—*Lib. Fl. Crypt. Ard. 331. Desm. Ann. Sci. Nat. 1842, p. 100. Fr. Hym. Eur., p. 665. Cyphella punctiformis, Karst.*

My specimens are on birch leaves, and stems of *Epilobium.* The hairs of the cup are attenuated to an acute point and clothed with minute prickle-like bodies, which Desmasières supposed to be the spores.* The latter are found with difficulty, and are ovate with an apiculus, like those of allied species. The minute prickles are easily rubbed off, leaving the hairs smooth and even. By the kindness of Mr. Murray, I have examined specimens at the South Kensington Museum of Natural History, of *Cyphella faginea* in Libert's exsiccati, and *C. punctiformis* in Karsten's Fung. Fenn., and find that the structure under the microscope is identical. The former is on beech and the latter on birch leaves.

(Plate II., fig. 1, *Cyphella Curreyi, B. & Br.*
,, ,, ,, 2, ,, *villosa, Pers.*
,, ,, ,, 3, ,, *faginea, Lib.)*

880. Clavaria fusiformis, *Sow.* Bourton Combe, Autumn, 1881.

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* "Nous n'avons pu obtenir que très imparfaitement les sporules de cette espèce: les corps que nous avons pris pour elles étaient prodigieusement petits, et la plupart entouraient les poils, sans doute par l'effect de la dissémination."

881.	Pistillaria micans, *Fr.*	Sandy Lane,	Sept. 1881.
882.	Lycoperdon echinatum, *B. & Br.*	Westridge Wood,	,, ,,
883.	Chondrioderma difforme, *Pers.*	Leigh Down,	Mar. 1882.
884.	Hendersonia graminicola, *Lev. Ann. Sci. Nat.*, 1846, *p.* 288.	Filton,	June, 1880.

Conceptaculis gregariis minutis innatis globosis intus nigris apice pertusis, sporis elongatis 2-3-septatis.

On dead stem of *Phragmites communis*. Spores ·0007—·00095 in. long. (Plate II., fig. 6.)

885.	Vermicularia dematium, *Fr.*	Bourton Combe (A.Leipner, Esq.),	July, 1881.
886.	Septoria aceris, *B. & Br.*	Bourton Combe (A.Leipner, Esq.),	July, 1881.
887.	Melanconium sphærospermum, *Lk.*	Aust,	June, ,,
888.	Aecidium tragopogonis, *Pers.*	Clifton (Dr. Burder),	May, ,,
889.	Isaria brachiata, *Schum.*	Leigh Down,	Autumn, ,,
890.	Volutella melaloma, *B. & Br.*	Boiling Wells,	June, ,,
891.	Illosporium carneum, *Fr.*	Leigh Down,	Dec. ,,
892.	Haplographium delicatum, *B. & Br.*	Winscombe,	June, ,,
893.	Helminthosporium folliculatum, *v. B. Corda.* (Plate II., fig. 5.)	Abbots' Leigh,	Spring, ,,
894.	Helminthosporium tiliæ, *Fr.*	Leigh Wood,	May, ,,
895.	Helminthosporium oosporum, *Corda.*	Blaize Castle Wood,	Apr. 1882.
896.	Arthrinium sporophlæum, *Kze.*	Boiling Wells,	Mar. ,,

897. Zygodesmus fuscus, *Corda.*	Westridge Wood,	Sept. 1881.
898. Peziza viridaria, *B. & Br.*	Clifton,	Mar. 1882.
899. ,, Crouani, *C.*	,,	,, ,,
900. ,, gregaria, *Rehm.*	Leigh Wood,	Sept. 1881.
901. ,, Rhytismæ, *Ph.*	Leigh Wood,	May, ,,
902. ,, corticalis, *Pers.*	,, ,,	Jan. 1882.
903. ,, sulphurea, *v.* leucophæa, *Pers.*	Leigh Down,	Mar. 1881.
904. ,, filicea, *C. & Ph.*	Cheddar,	July, ,,
905. ,, fusca, *Pers.*	Winscombe,	,, ,,
906. ,, cinerea, *var.* fallax, *Desm.*	Haw Wood,	June, ,,
907. Peziza atrovirens, *Pers.*	Blaize Castle Wood,	Apr. 1882.
908. ,, hepatica, *Batsch.*	Combe Hill,	Dec. 1881.
909. Ascobolus carneus, *Pers.*	Cotham (A. Leipner, Esq.),	April, ,,
910. Stictis Berkeleyana, *Du R. & Lev.*	Sandy Lane,	May, ,,
911. Phacidium pini, *Schm.*	Combe Hill,	Mar. 1882.
912. Hysterium arundinaceum, *Schrad.*	Aust,	June, 1881.
913. Hysterium (Lophodermium) Neesii, *Duby. Hyst. p.* 45, *t. II., f.* 23.	The Gully,	Jan. 1882.

Innatum demum omnius erumpens superficiale sparsum subaggregatumve ovato-globosum lanceolatumve varius confluens utrinque obtusissimum tumidulum laeve atrum nitidum, labiis convexis latis primo conniventibus demum divergentibus et rimam profundam anguste lineari-lanceolatam relinquentibus, thecis cylindricis sessilibus, sporis filiformibus hyalinis post disruptionem strictis rectis vix divergentibus. — Ad folia Ilicis Aquifolii praesertim in pagina inferiori maculae exaridae insidens. (Plate II., fig. 8.)

914.	Lophium mytilinum, *Fr.*	Leigh Down,	Mar. 1882.
*	Hypomyces asterophora, *Tul.* (Macroconidia).	Blaize Castle Wood,	Oct. 1881.

The *Nyctalis* attacked by this parasite is itself parasitic on dead *Russulæ*, and until lately was described as a distinct species, under the name of *N. asterophora.* The stellate spores from which it took its name are now known to be the macroconidia of an *Hypomyces*, of which I have not yet found the ascophore.

915.	Nectria mammoidea, *P & Ph.*	Walton Hill,	July, 1881.
		Leigh Wood,	,, ,,
916.	,, arenula, *B & Br.*	Near Aust,	June, ,,

On dead leaves of *Iris pseudacorus;* agreeing perfectly with specimen on *Aira caespitosa*, kindly given me by Mr. Broome. (Plate II., fig. 4.)

917.	Eutypa spinosa, *Tul.*	Combe Hill,	Dec. 1881.
918.	Diaporthe lirella, *M. & N.*	Boiling Wells,	June, ,,
919.	Valsa rhodophila, *B. & Br.*	Leigh Wood,	,, ,,
920.	,, taleola, *Fr.*	Shirehampton Park,	Aug. 1881.
921.	,, platanoides, *Berk.*	Leigh Wood,	Mar. ,,
922.	,, (Authostoma) gastrinoides, *Ph. & Pl. Grevillea* 10, *p.* 71.	Leigh Wood,	Mar. 1880.

Disc concave, stroma blackish ; perithecia 8—10 ambient, half buried in the wood ; asci cylindrical, ·08×·008—·01 mm. ; sporidia eight, obliquely uniseriate, dark-brown elliptical, nucleate at first, ·015×·005 mm.

On *Viburnum Opulus.* Described by Messrs. Phillips and Plowright from my specimens. (Plate II., fig. 11.)

923.	Sphæria (Lasiosphæria) felina, *Fckl.*	Leigh Down,	Mar. 1882.
924.	Sordaria fimicola, *Rob.*	Walton Hill,	July, 1881.
925.	,, caudata, *Curr.*	Stapleton Park,	Apr. 1882.
926.	,, sparganicola, *Pl. in litt.*	Yatton,	July, 1881.

Perithecia gregarious, ovate, rugulose, olivaceous black, partly immersed in a dense, matted stratum of long, slender, brownish hairs; asci clavate, attenuated towards the apex and truncate, ·012 in.; sporidia ovate-oblong, truncate at one end, dark greenish-brown, with a hyaline appendage which ultimately becomes pale-brown, ·0013—·0016 in. × ·00055, with appendage ·0032 inches long.

On dead *Sparganium ramosum*. (Plate II., fig. 7.)

927. Sordaria microspora, *Ph. & Pl.* Leigh Down, Dec. 1881.

928. „ polyspora, *Ph. & Pl.*
Grevillea X., p. 73. „ Mar. „

Perithecia semi-immersed, scattered, globose, bristled with a few black hairs on the upper part; ostiola elongate; asci cylindrical, polysporus (128 ?), ·06 × ·01 mm.; sporidia elliptical, black, simple ·005—008 × ·004·005 mm.

On rabbits' dung. Described by Messrs. Phillips and Plowright from my specimens.

(Plate II., fig. 10.)

929. Sphaeria (Teichospora) deflectens, *Karst. Myc. Fenn. II., p.* 69. *Grevillea X., p.* 73. Stapleton Park, Dec. 1878.

Perithecia scattered or gregarious, at length nearly superficial, spherical, at length often more or less collapsing; ostiola inconspicuous, smooth, shining, black; asci cylindrical ·06—08 mm.; sporidia 6 or 8, obliquely uniseriate, oblong, thicker in front, 1—3 septate, often with one or more longitudinal septa, slightly constricted at the septa or not, brown, ·012—·06 mm. × ·008—·005 mm.

(Plate II., fig. 12.)

930. Sphaeria rhodobapha, *B.&Br.* Winscombe, July, 1881.

931. Sphæria endopteris, *Pl. in litt.* Leigh Down, Apr. 1882.

Perithecia scattered, minute, immersed, subglobose; ostiola papillate, just piercing the cuticle; asci linear ·0045 in. long; sporidia oblong, simple, uniseriate, colourless, ·0004—·0005 in. long.

On dead stem of *Pteris aquilina*.

Perithecia ·018 in. across. The stem on which it grows is quite even and not discoloured, and the ostiola are so minute that they can only be seen by the aid of a lens. (Plate II., fig. 9.)

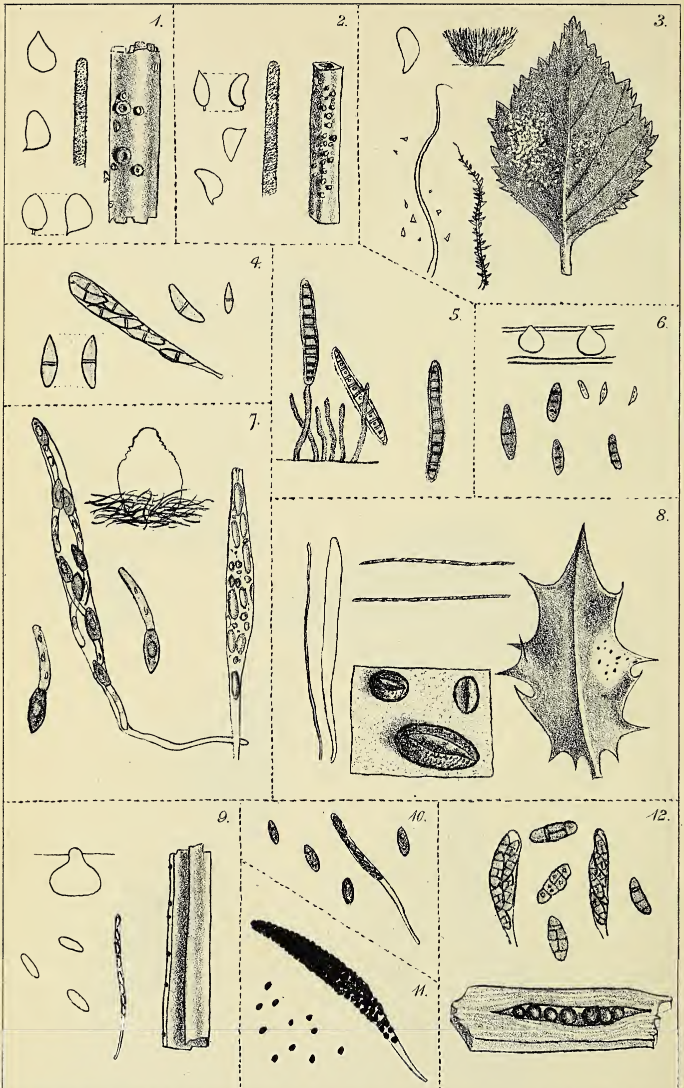
932. Sphæria cariceti, *B. & Br.*	Aust,	June, 1881.
933. ,, (Pleospora) graminis, *Fckl.*	,,	,, ,,
934. Sphæria (Pleospora) Typhæcola, *C.*, *Grevillea, V., p.* 21. *Macrospora Scirpi, Plowright, S. B. non Fckl.*	Pill,	Apr. 1882.

[illegible]

C Bucknall dell. ad nat.

LAVARS & SHARP, BRISTOL.

1. *Agaricus lineatus*, Bull.
2. " *hispidulus*, Fr.
3. *Agaricus formosus*, Fr.
4. *Cortinarius coloneus*, Fr.



C. Bucknall, del: ad nat:

LAVARS & SHARP, BRISTOL.

DESCRIPTION OF PLATES.

Plate I.

Fig. 1. Agaricus lineatus, *Bull.*
Fig. 2. ,, hispidulus, *Fr.*
Fig. 3. ,, formosus, *Fr.*
Fig. 4. Cortinarius cotoneus, *Fr.*

Plate II.

Fig. 1. Cyphella Curreyi, *B. & M.*
Fig. 2. ,, villosa, *Pers.*
Fig. 3. ,, faginea, *Lib.*
Fig. 4. Nectria arenula, *B. & Br.*
Fig. 5. Helminthosporium folliculatum, *v. B. Corda.*
Fig. 6. Hendersonia graminicola, *Lev.*
Fig. 7. Sordaria sparganicola, *Pl.*
Fig. 8. Hysterium (Lophodermium) Neesii, *Derby.*
Fig 9. Sphaeria endopteris, *Pl.*
Fig. 10. Sordaria polyspora, *Ph. & Pl.*
Fig. 11. Valsa gastrinoides, *Ph. & Pl.*
Fig. 12. Sphaeria deflectens, *Karst.*

Our Knowledge of the Nature of Chemical Phenomena.

By W. A. SHENSTONE.

THE objects of this communication are, first, to call attention to the classification of chemical bodies into simple and compound bodies, termed respectively elements and compounds, and to remind you of our imperfect knowledge of the real relations of these elements and compounds to each other; secondly, to point out more distinctly than is usually done the very decided analogies which exist between the transformations of elements into their allotropes, and the formation of chemical compounds.

Up to one hundred years ago, so far as records afford us any information, it appears that Chemistry existed rather as an Art than as a Science. Whether, at some earlier period, there was a Science of Chemistry is a question which I will not attempt to discuss now; but it seems pretty certain that from early days till the time of Lavoisier (I am disregarding the phlogistians in making this statement) no comprehensive and prolific explanation of the nature of chemical phenomena gained sufficient attention to have been transmitted to us.

I will endeavour to make the condition of this branch of knowledge, during the period I have alluded to, clearer to you by a very brief account of it.

At the time of Pliny (1st century) the ancients were acquainted with several metals, as gold, silver, copper, tin, mercury, iron—

this last being probably first familiar to the Egyptians. They had many of the pigments which we still employ, could make glass, colour it, and form it into beads, &c.; they employed indigo as a dye, understood the use of mordants in dyeing, and, in the case of the employment of the famous Tyrian purple, were more skilled than ourselves in this art. These few examples will serve to indicate that in applied chemistry considerable progress had been made. I may add that this more particularly applies to the Egyptians, among whom these things seem to have been held in high esteem. After this there is little recorded till the 8th century, when the Arabian, Geber, wrote an account, which shews the state of chemistry at his day, from which it has been ascertained that the intervening period had been one of considerable activity in chemistry as in other departments of knowledge. At that time, apparatus for distilling, subliming, and calcination, had been devised, also several furnaces, which were hardly modified for many centuries after, and the sand-bath and water-bath were in use then for moderating too great heats, as they are to-day. Further, the important substances, nitric acid, sulphuric acid, acetic acid, and aqua regia had been discovered, and their action on the metals studied, whereby many of the commoner salts had become known. Still, as these examples indicate, the advance made consisted in the invention of new apparatus and processes, and the discovery of new substances, and the Arabian chemists do not seem to have made any great progress in elucidating the nature of the phenomena with which they dealt. This may, perhaps, be ascribed partly to the alchemistic notions of the time, and partly to the circumstance that till a considerable body of facts had been established, a prolific and comprehensive theory of chemistry, or even a sound classification of chemical bodies, was a matter of vastly greater difficulty than at present.

From this time till the 16th century, when Paracelsus once more called attention to the importance of chemistry to medicine, was a period of comparative barrenness. Men were chiefly attracted, for the time, by visions of gold-making, and, in consequence of that and the obscure style of the records they have left, we have gained little by their labours. Paracelsus, however, having again directed attention to the importance of chemistry as a medical art, may in some degree be regarded as having initiated a new era. He was followed by others of similar spirit, and about two hundred years ago, (1669 to 1682,) Becher and Stahl propounded a great chemical hypothesis. This was the theory of phlogiston, which flourished exceedingly for nearly a century, but can hardly be said to have promoted chemistry, overlooking, as it unfortunately did, the fundamental law of the science, viz., the indestructibility of matter.

The phlogistians regarded all combustible substances as composed of a fixed earth or calx, and a fiery principle or phlogiston. In combustion the phlogiston was said to escape under the form of flame, (flame being phlogiston in a state of vibration,) leaving behind the ash or calx. To-day we see there was much truth in this, bodies when burnt do lose something, which we regard not as a form of matter, but as what is commonly termed "energy," which here takes the form of heat. The phlogistians knew that if the calx of iron or any other metal were heated with a highly combustible body, as, for example, oil or charcoal, it recovered its combustibility and the other properties of the metal, and hence they concluded that in each case the phlogiston of the oil or charcoal had united with the calx of the metal. Thus the hypothesis appeared for a long while to explain the nature of combustion, to show an analogy in the nature of the various combustible bodies, and also to give a satisfactory account of the chemistry of metallurgical operations.

The theory of phlogiston failed to take count of the fact that often the calx left after combustion is of greater weight than the body burnt, a circumstance quite inconsistent with the explanation of the phenomena which this theory offers. However, although Boyle in his "New Experiments to make the parts of Fire and Flame stable and ponderable," published in 1673, had shown that an increase of weight does frequently occur, and had also observed that closed vessels would often break when a metal was calcined in them, in consequence of the rarefaction of the air, these facts were quite lost sight of, and the theory flourished exceedingly until 1772, when Lavoisier turned his attention to the subject. This chemist, by numerous experiments, established the fundamental principle of modern chemistry that matter during the numerous transformations through which it passes never undergoes any loss of weight, and, further, aided by Priestley's discovery of oxygen, 1774, shewed that combustion in ordinary cases consists in the combination of the body burnt with a constituent of the air (oxygen), the weight of the products of combustion being exactly equal to the sum of the weights of the body burnt, and of the oxygen with which it had combined. This, of course, soon put an end to the phlogistic theory in its original form.

The idea of classifying known substances into compounds and elements, according as they could or could not be split up into two or more substances with distinct properties, had been grasped long before the time of Lavoisier by Boyle, but it will readily be understood that so long as the theory of phlogiston held the minds of chemists, this principle of classification was under a great disadvantage. The discoveries of Lavoisier, leading as they soon did to a more correct knowledge of the nature of many compounds before misunderstood, made its application more precise and complete.

Thus, about a century since, the fact of the indestructibility of matter was established, and the present system of classifying bodies according as their constituent parts were all alike, or of more than one kind, was also on a firm footing. Chemical combination was, for a time, regarded as the mere union of two or more unlike forms of matter.

It has, however, been shewn since, that just as the phlogistians were wrong in disregarding the weights concerned in chemical action, so Lavoisier and his immediate successors (except Richter) fell into the mistake of overlooking the importance of the heat which is evolved. Modern chemists have investigated this latter point in a vast number of cases, and it appears that when chemical combination takes place there is always heat evolved, and that the amount of heat evolved in the combination of the same bodies is constant if the weights concerned are constant. Thus one ounce of hydrogen, when burnt with oxygen, always produces enough heat to raise the temperature of 34034 ounces of water 1° C. Further, it is found that if the water be raised to a white heat, it will be reconverted into hydrogen and oxygen; and these will recombine to form water, with evolution of heat as before, whence we see that in the decomposition of the water heat was taken up, as it had been previously evolved in its formation.

Thus it seems not perfectly correct to say that water is *composed* of hydrogen and oxygen, in the sense that hydrogen and oxygen are actually in the water, for in combining a certain amount of heat is evolved, and in order to get these bodies once more in the form in which they have the properties proper to oxygen and hydrogen, it is necessary to supply the water with as much heat as was evolved at its formation. In saying this, I do not wish to be understood to state that the matter of hydrogen is not different to the matter of oxygen, and that in water these two matters may not both be present; that may or may not be so, but certainly there is an evolution of energy in the form of heat during their combination, and an equal amount of energy must be supplied to effect its reversal. That is, water has less energy stored in it than hydrogen and oxygen, and, therefore, since it has not as much energy as these bodies it cannot properly be said to contain them. It contains the matter of them undoubtedly, as there is no change of weight, but not the substances as we know them. It is desirable, therefore, to remember the statement that water is a compound of hydrogen and oxygen is only true in the sense that the disappearance of these gases in certain proportions is always accompanied by the appearance of a corresponding quantity of water, and *vice versâ*.

I now pass to the second question. Certain of the elements are peculiar in that they occur in several different forms, which are said to be allotropic. Such, for example, are phosphorus and oxygen and carbon.

I wish to make a few remarks on this point, because I have noticed that there is often an impression left on the minds of those who have studied the elements of chemistry that the question of allotropy is somehow a peculiar matter, of which it is possible to know the facts, but that at present a satisfactory explanation is not forthcoming.

The element oxygen ordinarily occurs as a colourless, transparent, odourless gas, of considerable activity, combining readily with a number of the other elements, sometimes needing the aid of heat to start the action, sometimes not. When perfectly pure, dry oxygen is well cooled and submitted to the action of the silent electric discharge, a portion of it changes to a grey-blue gas, which, when compressed, if kept cold, yields an indigo-blue liquid; this new substance has a very characteristic odour, producing a kind of influenza when smelled, and has far greater oxidizing powers than the ordinary form of oxygen. Moreover it is heavier than oxygen, equal volumes of the two gases having densities which are as 3 to 2. From its high density and from the fact that when heated it returns to the condition of oxygen again, there is strong reason for supposing that in the formation of ozone heat is evolved,[1] and that the same amount of heat is taken up again on its reconversion to oxygen.

Similarly phosphorus, when heated for a long while to 240° C., or if heated to about 200° C. with the addition of a little iodine, changes from a soft, waxy, poisonous solid, which may be ignited by the heat of the hand or by slight friction so easily that it must be kept under water, which melts at 44° C., and undergoes constant combustion in the air and so is beautifully luminous in the dark; to a purple-red non-phosphorescent powder harder than limestone, which is not poisonous and is of higher specific gravity than common phosphorus, not easy to fuse, but which changes back to common phosphorus at about 270° C. and takes fire at a rather higher temperature; and which is so little apt to burn that it may be kept in a bottle with a common cork for years, and may be handled with impunity; changes, in fact, to a distinctly different body; an altogether more stable body. This stability and its higher density strongly indicate that in its formation, as in the formation of diamond, there has been an evolution of heat.

Now these various facts seem to show that the transformation of the common forms of elementary bodies into their allotropic forms are analogous to the formation of chemical compounds. In each case we see a change of property, often a

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[1] In which case ozone is theoretically the most stable form of oxygen, being, however, at ordinary temperature, under conditions relatively similar to those which exist for water at a white heat. In a portion of space where the temperature was considerably lower than on our earth, ozone would, perhaps, be the usual form in which oxygen would exist.

very remarkable change of property, and the change is as marked in allotropy as in combination. There is in combination always a greater or less evolution of heat. In the formation of allotropes in some cases certainly, and in all probability in all cases there is also an evolution of heat. Compounds can usually be reconverted into the bodies from which they were obtained by a sufficiently high temperature, heat being absorbed in this reversal. Similarly, the allotropes of oxygen, phosphorus, and carbon, under the influence of heat, manifest a tendency to revert to the commoner form, and, it is fair to infer, absorb heat in doing so. Lastly, I may remark that I know no reason for supposing that the law of the indistructibility of matter is not followed in these transformations. In short, it is difficult to find any point in which the formation of allotropic forms of elements can be shewn to differ from the combination of dissimilar elements. Hence one is brought to the conclusion that the phenomena are of the same order. Just as hydrogen and oxygen can form two combinations—water and hydrogen peroxide—so oxygen can form two combinations, viz., common oxygen and ozone.

The fact that in the formation of compounds two or more elementary substances are concerned, whilst in the formation of allotropes only one elementary substance is concerned, does not seem to be a sufficient reason for looking on the two cases as of an essentially different nature, since the phenomena are so strikingly similar.

On Smell.

By PROFESSOR RAMSAY, Ph.D.

ALL that we know of outside nature is caused by the rapid vibration of the nerves connected with our senses. This is, perhaps, most evident with the sense of hearing, for the vibrations are fewer in number and of larger amplitude than those which cause the sensations of light and heat. The lowest tone which can be heard vibrates at the rate of sixteen times a second. It is the tone of a 32-feet organ pipe. Our range of hearing extends for eleven or twelve octaves higher; yet many ears are able to recognise a tone vibrating from 20,000 to 40,000 times a second as a tone—a distinct musical sound—while others cease to hear vibrations long before their rate becomes so rapid.

It has been calculated, exactly, too, what number of vibrations per second produces the impression on our retina, which we call colour. Thus the lowest visible red colour of the prismatic spectrum is caused by vibrations, 39½ trillions of which take place in a single second. The colours of the spectrum pass without break through orange-red, orange, orange-yellow, yellow, yellowish-green, green, greenish-blue, blue (which deepens till it becomes indigo blue), and then passes into violet.

Each geometrical point of this spectrum coincides with a definite number of vibrations per second till we reach the violet end; then the most rapid vibration which we can see is 76½ trillions per second.

I have made measurements of the distance which various eyes, belonging to about 150 individuals, have the power of seeing—in other words, their limit of vision—and in most instances there is great regularity. Some colour-blind persons, however, had the power of vision prolonged more than usually far into the violet, while one or two persons with no discoverable peculiarity of vision, were able to see colour beyond the usual limit at the red end of the spectrum. Although sound is caused by comparatively slow vibrations of air, or other gas or liquid, successive waves of which impinge on the tympanum or drum of the ear, yet there can be little doubt this vibration is communicated to the aural nerve, in which it produces some electrical and chemical changes, rapidly alternating with the original condition of the nerve, and so the sensation passes the boundary-line of our power to observe it, for it then ceases to be physical, and enters the domain of mental phenomena. Similarly, light produces certain rapidly successive changes in the retina and optic nerve, and is thus conveyed as an impression to the brain.

It may be objected that the causes of impressions are different: that air, a weighable substance, and therefore matter, produces the sensation of sound: that the vibrations are like those of a vibrating spiral spring when stretched and released in the direction of motion: whereas light is caused by the transverse vibrations, comparable to those caused by the circles of a stone thrown into water, of a hypothetical substance called ether; and that the difference in rate is so prodigious as to preclude comparison. But, I answer that these vibrations are soon communicated to the optic or aural nerve, and are then probably a series of electrical or chemical changes, recurring a certain number of times a second; and that we are ignorant of the precise nature of such vibrations, whether they are longitudinal or transverse.

As yet we have been considering the nature of two only of the six senses—I say six, for the sense of heat must be considered to be one. Let us now turn our attention to the others. Touch and heat are both recognised by all parts of the body. The network of surface nerves, which conveys the sensations to the brain, however, is not continuous. It is, perhaps, not quite generally recognised that the sense of touch is acute, or perhaps I may say experienced at all, only when the finger or other part of the body touching is moved over the object touched. Here again we have a series of vibrations produced by the inequality of the surface touched. We can recognise as rough or smooth, surfaces more or less unequal; but here again the sense of heat helps us in recognising objects by this sense. These two are so much in union, that it is doubtful whether we ever separate them in mental image. We know at once whether we touch flannel or linen, because the flannel is a worse conductor of heat than the linen, and we are conscious of its not feeling cold. Similarly, we could distinguished polished wood from polished steel, and, as I have proved experimentally, water from mercury, and, I think, from ether and other better conducting liquids. The main point I insist on is that the sense of touch is a register of vibrations, or, if it is preferred, matter in vibration, if we may give a name to what is and ever must be utterly unknown to us, the substratum which bear the qualities communicated to our senses by vibration.

The sense of heat may be experienced unaffected by that of touch. It is caused by a set of vibrations of the hypothetical ether, at a rate slower than that of light.

Thus a thermometer or thermopile, capable of registering very minute changes of temperature, placed in that portion of the spectrum beyond the visible red end, shews that the heat rays are, like the light rays, refracted by the prism, and that they extend for a considerable distance beyond the visible spectrum, besides overlapping it. Our skin nerves have the power of registering, not the number of vibrations per second, as our optic nerve does, but the amplitude of the vibration; that difference which we should express, if we were talking of light, as a dim light, or a bright light.

We thus see that four of the six senses are probably affected by vibration.

It is not my intention to speculate on the nature of taste, but to consider what arguments can be adduced to shew that the sense of smell is also caused by vibrations; what the nature of these vibrations, if they exist, is; and what is their probable number per second.

The sense of smell is caused by the contact of certain substances with the terminal organ of the olfactory nerves, which are spread as a network over a mucous membrane, lining the upper part of the nasal cavity. Each nerve consists of a number of small bundles, themselves capable of being split into extremely fine nerve fibres. There are spindle-shaped cells connected with these nerves, from which proceed two processes, one to the surface, provided with bundles of long hairlets, the other passes to the interior. It is these hairlets which are probably the proximate cause of smell.

Let us consider, first, by what are smells excited? The operation of smelling is performed by sniffing, that is, by a series of short inhalations of air bearing with it the odorous body. The first question which suggests itself is, is the substance which excites sensation a liquid, solid, or gas? It has been tried, by Weber, to fill the nose with Eau de Cologne and water, lying on the back for that purpose, and pouring the liquid into the nostrils by a funnel. No sensation is produced. I have myself tried the experiment, and can confirm his observation. There is an irritating feeling, but no smell. Of course, on washing out the nose, or blowing it, the characteristic smell is at once noticeable.

It is easy to prove that solid particles are not the cause of smell. If the air conveying the odour be filtered through a tube filled with cotton wool and inserted into the nose, a smell is still discernible, although all solid particles must thereby be kept back. But it is a very remarkable circumstance that it is so, for one would not suspect such extremely non-volatile substances as copper, iron, silver, &c., to give off gas, if indeed the smell which they most certainly evolve, when rubbed, is due to the gas of the substance.

We must, therefore, conclude that the sense of smell is excited by gases only. It is, of course, necessary to include under the name gases, the vapours of liquids or solids which have low vapour tension, and which, in consequence, give off vapour at the ordinary temperature. It has been proved that this is the case even with mercury, the boiling point of which is 360° Centigrade. We may consequently conclude that many other substances, of which it is impossible to measure the vapour tension at ordinary temperatures, owing to its extreme minuteness, also evolve gas, if only in very small quantity. But it is well known that all gases have not the power of exciting a sense of smell. Let us compare some gases which have smell, with some which have none, and endeavour to discover if those which have smell have any other property in common. The following is a list of gases which have no smell:—Hydrogen, oxygen, nitrogen, water gas, marsh gas, olefiant gas, carbon monoxide, hydrochloric acid, formic acid vapour, nitrous oxide, and ammonia. Those which possess smell are:—Chlorine, bromine, iodine, the compounds of the first two with oxygen and water, the second three oxides of nitrogen (or perhaps it is right to say nitric peroxide, for the other lower oxides are changed into it when they come in contact with air), the vapours of phosphorus and sulphur, arsenic and antimony, sulphurous acid, carbonic acid, and almost all the volatile compounds of carbon save those already mentioned, some compounds of selenium and tellurium, the compounds of chlorine, bromine, and iodine with the above-named elements, and some metals.

In considering this list, I submit, first, that the property of smell is peculiar to some elements and their compounds. Thus chlorine, bromine, iodine, sulphur, selenium, and tellurium, which are volatile, and give off vapour at ordinary temperatures, have a characteristic smell. We should expect the compounds to have a smell, and we find this to be the case. Second: those substances which have no smell, or produce simple irritation of the nostrils, have all low molecular weight. Such is the case with hydrogen, the element of lowest specific gravity. Such also is the case with oxygen and nitrogen; but this, as well as the absence of smell in water, may be ascribed to the constant presence of these gases in our atmosphere and their necessary constant presence in our nostrils, so that we may be insensible to their smells because we are always inhaling them, but I think it probable that this is not so. Hydrochloric, hydrobromic, and hydriodic acids and ammonia have purely an irritating effect, and cannot be described as smells. When ammonia is pure and free from compounds containing carbon, it has no trace of smell. Nitrous oxide is also the lowest of the oxides of nitrogen, and as such has the lowest specific gravity. But it is when we turn to compounds of carbon, that we are best able to draw general conclusions; for that element *par excellence* has the faculty of forming almost innumerable compounds, and series which resemble each other in properties, but differ in specific gravity. And here we are most struck with the fact that increase of molecular weight, *i. e.*, increase of specific gravity in the form of gas, produces, to a certain point, smell. Let us examine the simplest series, viz., the marsh-gas or methane series, commonly called the paraffins.

The first two of these have no smell. Ethane, indeed, which is 15 times as heavy as hydrogen, begins to have a faint trace, but it is not till we arrive at butane, which is 30 times heavier than hydrogen, that a distinct sensation of smell is noticed. In the same manner the olefine series, of which the first member is ethene, or olefiant gas gains in smell with rise of molecular weight. Of course the highest members of this series have no smell, for they are non-volatile, but this is the case with most carbon compounds of which the molecular weight is high.

A similar relation is noticeable among the alcohols. Methyl alcohol in a state of purity is smell-less. Ethyl, or ordinary alcohol, when freed from ethers and as much as possible from water, has a faint smell, and the odour rapidly becomes more marked as we rise in series, till the limit of volatility is reached, and we arrive at solids with such a low vapour tension that they give off no appeciable amount of vapour at the ordinary temperature. Again with the acids. Formic acid is smell-less and produces a pure sensation of irritation. Acetic acid has a slight but characteristic smell; and the higher acids of the series, propionic, butyric, valerianic acids, &c., gain in odour with increase in density in the form of gas. If we consider the nitrogenous compounds of carbon, we are led to the same conclusion. Prussic acid is not smelt by more than four persons out of every five; but the nitriles, which bear the same relation to prussic acid as the higher members of a series bear to the lower, have all very characteristic odours. Acetylene would appear to form an exception to this rule, but carefully-purified acetylene has little odour, and it is surpassed by its higher homologues. We may therefore, I think, accept this as a principle—that the intensity of the smell rises with rise in molecular weight.

It is also noticeable that the character of a smell is a property of the element or group which enters into the body producing the smell, and tends to make it generic.

Thus we can characterise the compounds of chlorine and its oxides as chlorous; indeed, we may group the three elements, chlorine, bromine, and iodine, together, and name the characteristic odour of them and their oxides haloid smells.

Similarly sulphur, selenium, and tellurium in their compounds with hydrogen have a generic smell, and likewise arsenic and antimony. The only oxide of nitrogen which is smelt is nitric peroxide, so that it is impossible to pronounce on a generic smell for this substance.

It is again easier to classify carbon compounds. The smell of the paraffins is generic; so is that of the alcohols, the acids, the nitriles, the amines, with their irritation like that of ammonia, the bases of the pyridine series, the hydro-carbons of the benzene group, the higher hydro-carbons—such as naphthalene, anthracene, and phenanthrene. Give any one of these to a chemist, familiar with the smell of any one of each series, and accustomed to use his sense of smell, and he will at once refer the body to its class.

The tendency of a rise in the series is to make the smell "heavier," less etherial, and more characteristic. It also becomes more able to affect the olfactory nerves.

The rate at which smell travels is doubtless that rate at which the vapour which gives rise to it diffuses. Still it is impossible to test this experimentally. For the ease with which a smell is perceived varies with the molecular weight of the substance. Thus, if a piece of cotton-wool is impregnated with ethyl alcohol, and placed in one end of a long tube, which is immediately corked, and a similar arrangement be adopted with amyl alcohol—the fifth of the series of which the former is the second; although their specific gravities have the ratio of 23 to 44, and the ethyl alcohol should diffuse $1\frac{2}{5}$ times as rapidly as amyl alcohol; yet the smell of the latter will be perceived first, because a much smaller quantity produces the sensation.

It is possible to make, with practice, a fairly accurate analysis by means of the sense of smell. The method is, knowing the constituents of a mixture, to prepare one which has the same smell, measuring the proportions of the ingredients. The only precaution to be observed is that the smell of no member of the mixture be so overpowering as to mask those of the others. Thus I have analysed or rather synthesised a mixture of chloroform with ether; alcohol with ether; and these liquids with carbon disulphide, provided the latter be pure, to within 2 p. c.; but I failed with members of the pyridene series. Yet it was possible to detect the proportions of members of that series to each other; and it is not difficult, however extraordinary it may appear, to guess approximately the boiling point of a mixture of members of a series, after some practice, purely by its smell.

So far as I know no theory has been brought forward to account for the sense of smell, and I therefore venture to supply this want, premising that what follows is merely a tentative explanation, and as such, will I hope not be too severely censured.

There is a probability that our sense of smell is excited by vibrations of a lower period than those which give rise to the sense of light or heat. These vibrations are conveyed by gaseous molecules to the surface network of nerves in the nasal cavity. The difference of smells is caused by the rate, and by the nature of such vibrations, just as difference in tone of musical sound depends on the rate and on the nature of the vibration; the nature being influenced by the number and pitch of the harmonies.

Let us see what evidence can be adduced for this theory.

Among the lightest substances which have smell are sulphuretted hydrogen and phosphoretted hydrogen, both of which are 17 times as heavy as hydrogen itself.

Prussic acid is fifteen times as heavy as hydrogen, and has a smell. But all persons are not able to smell it. I have remarked an average of one in every five persons who are totally unable to detect its odour. Here we reach the lowest limit of molecular weight. *To produce the sensation of smell, then, a substance must have a molecular weight at least* 15 *times that of hydrogen.* If we compare the hydrocarbons of the paraffin series with each other, and similarly the olefine series, we notice that the lower members have no smell. The specific gravity of marsh gas, CH_4, is 8; that of ethane, 15; propane is 22 times as heavy as hydrogen, and here we first notice smell. Olefiant gas has the specific gravity 14, and has no smell; propene has a faint smell with a specific gravity of 21, and the higher members of the series increase in intensity of smell with increase in specific gravity. Hydrocyanic acid is smelt by most persons, but not by all. Its specific gravity is 15. The higher members of the series, called the nitriles, have all very characteristic smell.

Formic acid vapour has the specific gravity 23, and has a purely pungent odour.

Acetic acid, 30 times as heavy as hydrogen, has a faint smell when pure; propionic, butyric, and valerianic acids have strong smells. Methyl alcohol has no smell, its specific gravity is 16. Ethyl alcohol, 23 times heavier than hydrogen, has a faint smell; and, as usual, the intensity, and if I may so term it, the flavour of the smell increases as we rise in series.

These are the most typical instances of the carbon compounds, and they suffice, I think, to show the justice of the assertion that the intensity of smell increases with rise of molecular weight. The hypothesis of vibration satisfactorily explains this. The period of vibration of the lighter molecules is too rapid to affect our sense; there is a limit to this power; and just as some people have the power of hearing more acute sounds than others, so some noses are limited by a specific gravity of 15, and cannot smell prussic acid. Such people also have difficulty in perceiving the odour of bodies of slightly higher molecular weight than prussic acid.

Let us now enquire what is the probable rate of such vibrations. Mr. Johnstone Stoney has made investigations of the ratio of the bright lines of some spectra, and has calculated their relations to each other. An analogy will make the nature of this relation more evident. When a note, say C below the treble clef, is sounded on a piano, not only the tone C is heard, but its octave C on the third space; also G above the line; C on the third leger line; E on the fourth; G on the sixth; B flat above the G; and other notes.

These are called harmonics or overtones. Now, if we knew these overtones, it would be possible to refer them to their fundamental. So with light, the light evolved by incandescent gases consists of certain colours, which have each their own rate of vibration.

Knowing these rates, it is possible to calculate the rate of vibration of the fundamental. This has been done by Mr. Stoney (Royal Irish Academy, Jan. 9th, 1871) with hydrogen with the following results:—

Wave lengths, H,	4102·37	tenth	seconds.
F,	4862·11	„	„
C,	6563·93	„	„

These are the 32nd, 27th, and 20th harmonics of a fundamental, whose wave length is 0·1313 millimetre. The time of vibration is 4·4 fourteenth seconds. It may be objected that these coincidences are not a proof. But Mr. Stoney has measured the lines of the spectrum of chromyl-chloride, and its 31 lines coincide with those calculated.

The probability of the correctness of such a calculation approaches to almost absolute certainty. Now we have no means of recognising such fundamental vibrations, unless, indeed, the sense of smell is our means of receiving them.

And it is this which appears to me probable; so probable, indeed, as to form a working theory.

But it is to radiant heat, I think, that we must look for indications of harmonics of the fundamental vibrations, which are, according to this theory, the cause of smell. And a fresh proof may be drawn from the indications already seen. Professor Tyndall has shown the power which odours have of absorbing heat rays. There is no doubt that by refracting such heat rays by means of a rock-salt prism, after they have passed through an atmosphere of odour, certain portions of the heat spectrum show colder spaces, each corresponding to one particular rate of vibration, which is absorbed by the vapour, through which the heat rays have passed. By measuring the position of such gaps in the heat spectrum, calculating the particular rate of vibration of the rays at such gaps, and referring them to their fundamental, we should arrive at the rate of vibration of the molecule which causes smell.

We may now enquire what it is which produces quality of smell. This, I think, can also be explained by the vibration theory, and depends on the harmonics of the vibration. Thus, the quality of tone of a violin differs from that of a flute by the different harmonics or overtones peculiar to each instrument.

I would ascribe to harmonics the quality of smell possessed by different substances. And it is to this that compounds of chlorine, phosphorus, &c., owe their peculiarity of odour. The odour of compounds resembles that of their elements to some extent; this may be accounted for by the similarity of overtones of compounds and their elements.

Then we notice a similarity in quality of the odour of the compounds of a series like the alcohols, and yet the quality grows flatter and heavier with increase in molecular weight.

Smell, then, may resemble sound in having its quality influenced by harmonics. And just as a piccolo has the same quality as a flute, although its harmonics are so high as to be beyond the range of the ear, so smells owe their quality to harmonics, which, if occurring alone, would be beyond the sense. It must be remembered that the harmonics are not heard separately from the fundamental, unless special means be adopted to render them audible, but they add their vibrations to those of the fundamental.

When two sounds are heard simultaneously, they give a concord or a discord, but each may be separately distinguished by the ear. Two colours, on the other hand, produce a single impression on the eye, and it is doubtful whether we can analyse them. But smell resembles sound, and not light, in this particular. For in a mixture of smells, it is possible, by practice, to distinguish each ingredient, and, as I have shown, to match the sensation by a mixture.

With regard to the mechanism by which smell is conveyed to the nerve, all that can be said is pure speculation. But as it is supposed that the vibrations of sound are conveyed to the auditory nerve through the small cirrhi, or hairs which spring out of round cylindrical nerve-cells in the superficial layer of connective tissue of the spittilleum of the internal ear, and that each is attuned to some particular rate of vibrations, so it may be imagined that the hair-like processes connected with the spindle-shaped cells, themselves communicating with the nerve fibres of the olfactory nerve, are the recipients of the vibrations causing smell. Although the rate of such vibrations is extremely rapid—no less, indeed, in the case of hydrogen, than 44,000,000,000,000,000, or the four quadrillion four billionth part of a second—yet the wave-length is by no means so small, for it averages the $\frac{2}{100}$th of an inch, a magnitude quite visible to the naked eye. And hydrogen has no smell; those bodies which have smell, and higher molecular weight, must necessarily have a slower period of vibration, and possibly greater wave-length.

It is doubtful whether there exists a lower limit to our sense of smell. The vapour of osmic acid is one of the heaviest known, and it has a most distinct smell. It is about 130 times as heavy as hydrogen. Tetrabromide of carbon is 166 times as heavy as hydrogen. The vapours of selenium, tellurium, arsenious oxide, and antimonious oxides are also extremely heavy. There appears to be a limit in practice, however, owing to the non-volatility of substances of high molecular weight, at such temperatures at which smell may be perceived.

The intense perfume of flowers is to be ascribed to the terpenes, of which common turpentine is one, or to their products of oxidation, and these bodies all possess a molecular weight of 136, and the specific gravity 68, a specific gravity which appears to excite the olfactory nerve most powerfully.

I bring forward the theory adduced with great diffidence. The problem is to be solved, in my opinion, by a careful measurement of the lines in the spectrum of heat rays, and the calculation of their fundamentals, which this theory supposes to be the cause of smell.

Such measurements and calculations, even if they proved the theory untenable, would have great value for their own sake, and labour expended in this direction would not be lost. Whether successful or not, it would at least be a first assault on what old John Bunyan called Nose-gate of the " City of Mansoul."

On Volta-Electric Inversion.

By PROFESSOR SILVANUS P. THOMSON, B.A., D.Sc.

1. THE author proposes to give the name of *Volta-Electric Inversion* to a phenomenon which, if not new in every detail, is at least new in its generality, because it is, for voltaic currents, the precise analogue of the phenomenon of thermo-electric inversion discovered by Cumming in the case of thermo-electric currents.

2. Cumming found that the electromotive force of a thermo-electric couple (for example, an iron-copper couple) varied not only with the relative excess of temperature of the heated junction over the temperatures of the rest of the circuit, but with the absolute temperature. He found, for example, that in an iron-copper pair below a temperature of about 300° C. the current through the hotter junction flowed from copper to iron, but that above that temperature it flowed the reverse way, from iron to copper.

3. If a simple voltaic cell be heated, it is well known that its current-giving power is altered—generally is improved, but sometimes the reverse. Thus the power of a Daniell's cell increases by 1½ per cent. when heated from 0° to 100° C., while that of a bichromate cell decreases by no less than 15 per cent. under similar circumstances. Such changes arise partly from the lessening of the internal resistance and of polarisation, and partly from changes in the electromotive force of the cell. In investigating recently the change of electromotive force in simple

cells when heated, the author has observed that this change also differs at different absolute temperatures, and that the amount of change per degree Centigrade is different at different parts of the scale. The author also finds that with different kinds of cells the change in the strength of the current when the cell is heated is sometimes an increase, sometimes a diminution, and that the electromotive forces vary in different senses.

4. The author was therefore led to suspect the existence of a *volta-electric inversion*, and by employing appropriate cells he has discovered that this phenomenon really exists. The difficulty in finding such cells arose from the fact that for many combinations the temperature at which the inversion occurs is above the boiling-point of the fluid. The first cell with which the author obtained inversion was one in which a pair of plates of iron and of copper dipped into a mixture of the sulphate and nitrate of soda dissolved to near saturation in water. The current flowed when cold from the iron pole through the liquid to the copper pole; but when the temperature was raised to near the boiling-point the current first ceased and then returned, but in the opposite direction. In this case, however, it was found that the iron pole had assumed the "passive" state in consequence of the action of the nitrate. Another combination not open to this objection was therefore sought.

5. A cell was made, using poles of iron and copper dipping into sulphuric acid of specific gravity 1·753. At a temperature of 25° C. this cell gave a current which flowed from the iron through the liquid to the copper, and causing a strong deflection of some 10° upon a common detector galvanoscope. The cell was then heated. At 70° C. the deflection had fallen to 2°, at 140° C. it was less than 1°, at 150° C. the needle was deflected nearly 5° in the reverse direction, at 200° C. the reverse deflection had risen to 22°, and when the liquid began to boil at about 229° C. the deflection had reached 45°. On cooling the liquid

down the phenomena reappeared in reverse order, the point of inversion, however, not being reached till a lower temperature than with an ascending temperature, owing, probably, to the concentration of the acid by evaporation.

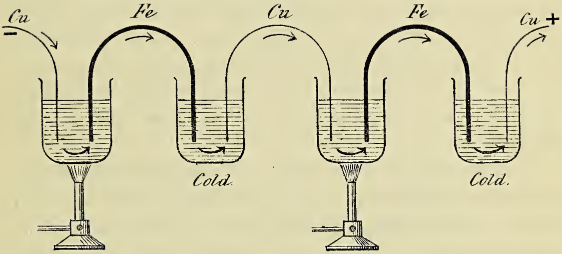
6. During the first half of the operations, or while the current was flowing through the liquid from iron to copper, the iron pole dissolved in the acid, with evolution of hydrogen bubbles at the copper pole. During the latter half of the operation, with a temperature above 150° C., the copper dissolved in the acid, and bubbles, believed to be chiefly of sulphurous acid gas, arose freely from the iron pole, which also became covered with a black-looking crust. At the temperature at which inversion occurred, bubbles appeared to be rising in small quantities from both poles, but in such small quantities that it was impossible to ascertain their nature.

It appears then that at the degree of concentration specified sulphuric acid when cold attacks iron more readily than copper; but attacks copper more readily than iron when heated above 150°; that metal which at any given temperature is the more readily attacked serving as the electropositive metal or negative pole of the pair.

7. The currents in question appear to be true voltaic currents, because (i.) their production is accompanied by chemical action in the cell; (ii.) because the electromotive forces producing them are far greater than the thermo-electromotive forces which would be produced by the contact of the metals at those temperatures, though, of course, such thermo-electromotive forces were present and contributed to the somewhat complicated phenomena. The thermo-electromotive force of an iron-copper couple is only 14 millionths of a volt for a difference of temperature of 1° C. between the junctions.

8. A further consequence of this discovery is that a battery can be made of copper, iron, and sulphuric acid without there

being any contact of dissimilar metals. This can be done by taking a number of similar cells, heating the alternate ones and connecting them in series, but with the connexions in reversed order, the copper of one cell being joined to the *copper* of the next, and the iron of one to the iron of the next. The diagram explains the connexions.



9. The only battery which has a true analogy with the above is that of Jablochkoff, in which plates of carbon and iron dipping into fused nitre yield a current in the reverse direction to that in which the current flows with the same electrodes in cells containing nitre in aqueous solution.

In the batteries invented by Louis Napoleon and by Wöhler there is no contact of dissimilar metals, there being one metal and two liquids, with contact of dissimilar liquids.

In Dr. Fleming's battery there is neither contact of dissimilar metals nor contact of dissimilar liquids, but there are two metals and two liquids.

In the battery now described there is contact neither of dissimilar metals nor of dissimilar liquids; but, unlike Dr. Fleming's battery, the battery now described employs but one liquid, the temperatures in alternate cells being different, and resulting chemical actions being different, and the differences of potential being also different.

10. The author has not yet satisfied himself what the exact state of things is chemically at the moment when the point of inversion is reached; whether there is *no* chemical action, or whether both electrodes are being dissolved at rates which are electro-chemically equal. The key to the whole reaction would appear to be in an observation made by Warburg[1] on the electrolysis of concentrated sulphuric acid. Electrolysed below 80° C., he found it to yield O and H gases only. Between 80° and 90° C., he obtained O at the anode, and at the kathode H and S. Above 90°, he found S alone to be evolved at the kathode.

11. In conclusion, the author would note that these observations have an important bearing on the theory of the voltaic cell as to whether the origin of the electromotive force be *contact* or *chemical action*. In the battery described in § 8, the copper is attacked more than the iron in the hot cells, the iron more than the copper in the cold cells.

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[1] Pogg. *Ann.* cxxxv., 114.

On Brownian or Pedetic Motion.

By PROFESSOR RAMSAY, Ph.D.

THE skipping motion of extremely small particles has been for long a subject of curiosity, but has as yet remained without explanation. The following is an attempt to ascertain its cause.

1st.—It is not dependent on the life of the particle. This would seem an absurd notion, but it was the theory first advanced to account for the phenomenon. And as it was first observed by Robert Brown when examining the pollen of plants, he had some ground for his supposition. Buffon attributed it to this cause, and Spallanzani termed the dancing particles "animaletti d'ultimo ordine." It occurs, however, with particles strictly mineral in their constitution, such as quartz, cinnabar, finely-divided gold, etc.

2nd.—Nor does it depend on the material of which the particles are composed, for all substances, if in a sufficiently fine state of division, manifest this motion.

(*a*) They may be conductors, *e.g.*, Gold, silver, platinum.

(*b*) They may be non-conductors, *e.g.*, Sulphur, gamboge, quartz.

(*c*) They may be absolutely insoluble in water.

(*d*) They may be slowly attacked by water, *e.g.*, Quartz, silicates, barium sulphate.

(*e*) They may be good conductors of heat, *e.g.*, The metals above-mentioned.

(*f*) Or bad conductors, *e.g.*, Sulphur, gamboge.

(*g*) They may be transparent, or (*h*) opaque.

3rd.—This motion does not depend on the form of the particles.

The question of pedesis is very closely connected with that of the settling of finely-divided powders in different menstrua. In a paper communicated to the Geological Society of London in 1876, on the settling of mud, I showed: 1st—What had been noticed by previous observers (W. Skey and others), that finely-divided matter does not quickly settle in pure water. 2nd—That it settles more quickly in hot than in cold water. 3rd—That the rate of settling does not depend on the density of the solution, for mud settles more quickly in strong than in weak solutions 4th—It does not depend on the chemical action of the liquid on the solid, for sulphur follows the same rule as other substances. 5th—It follows the same order as the absorption of heat when the salt is dissolved, in the solution of which the suspended particles settle. 6th—It depends on the agglomeration of the particles: when the particles acquire sufficient size to have no motion, or a very slow one, they settle quickly. This phenomenon is evidently closely allied to pedetic motion, and is to be explained by it.

Pedetic motion depends on, that is, is affected by:—

1. *The size of the particles.* Particles more than $\frac{1}{5000}$th of an inch in diameter do not jerk about suddenly, but are sometimes seen to oscillate slightly.

2. *The specific gravity of the particles.* Metals, or particles of vermilion, of similar size to particles of silica or gamboge, move much more slowly and less frequently.

3. *The nature of the liquid.* No liquid stops pedesis; but liquids which have a chemical action on the substance do. This action may be very slow, still it tends to agglomerate the particles. For instance, barium sulphate, when precipitated

from a cold solution, takes a long time to settle; whereas, when warm and in presence of hydrochloric acid, agglomeration soon occurs. Iron precipitated as hydrate in presence of salts of ammonium, and mud in salt water, are other instances. The motion does not cease, but the particles adhere together and move very slowly.

The moving particle may be either liquid or solid; but the motion of one liquid in another has a character of its own. Thus, if a little olive oil be shaken to an emulsion with a large quantity of water, the minute drops move, but slowly and not with a jerky motion. Similarly, a few drops of water mixed with a large volume of olive or other oil, display the same character of motion.

This motion cannot be attributed to currents in the liquid, for its nature is such as to preclude this explanation. It is in no sense regular, or in one direction.

I have thought it worth while to compare the relative size of such particles with those estimated for molecules, and likewise the amplitude of their motion with that of molecular vibration.

The diameter of a molecule, according to Sir W. Thomson, lies between the millionth and ten-millionth of a millimeter. The diameter of an active particle is about or below the two-thousandth of a millimeter. With this size the pedetic motion is slow and infrequent. If we take the larger diameter for the molecule, then diameter of molecule is greater than that of particle as 1 is to 500, and the mass, supposing them to be of equal specific gravity, as 1 to 125 millions.

If molecules do not coalesce and move as a whole, then they would appear to have no possible power of giving motion to a mass so much larger than themselves. But that molecules have arrangement is probable, owing to the power which some liquids possess of rotating the plane of polarised light.

Clerk-Maxwell supposed for some time that the attraction of two molecules varies inversely as the fifth power of the distance. If attraction at distance 2 is 1, attraction at distance 1 would be 64. Why do not all molecules therefore coalesce? Probably, because their own proper motion, of which heat represents the higher harmonics, causes them to fly apart again. The wave-length of that motion is not so minute, and although we possess no means of ascertaining the amplitude of such vibrations, still their rate is so prodigious as to give rise to an almost incredibly forcible impact.

On the Decrease of Rain with Elevation.

By GEORGE F. BURDER, M.D., F.M.S.

IN reading a paper before this Society ten years ago, I attempted an explanation of an observed fact in meteorology which had then, and has since, given rise to much discussion and difference of opinion. I refer to the fact that the amount of rain collected in gauges varies inversely with the elevation of the gauge above the ground. Further reflection having led me to modify the views expressed in the paper referred to, I have thought the Society might be interested in examining the question as it now stands.

But, first, it may be well to recall briefly the origin and history of the inquiry.

It was as long ago as the year 1766, that Dr. Heberden, an eminent London physician, struck with the discrepancy between the indications of two rain-gauges placed in neighbouring localities but at different heights, set up a third gauge on the roof of Westminster Abbey, and obtained the following results:—

	Inches of rain in a year.	Ratio.
"Below the top of a house"	22·61	100
"On the top of a house"	18·14	80
"On Westminster Abbey"	12·10	54[1]

After this the matter seems to have attracted little notice for many years, but Heberden's observations were not quite forgotten, and prior to the year 1819 they must have been

[1] *Phil. Trans.*, abridged, Vol. XII., p. 660.

repeated by other observers, for in that year we find, in a publication called the *Annals of Philosophy*,[1] a reference to this phenomenon as a "well-known paradox," and it is remarkable that the writer (Mr. H. Meikle), in his endeavour to explain the paradox, comes very near the solution which is now generally accepted, and a modification of which I shall presently offer.

Observations by Mr. H. Boase at Penzance, by Luke Howard near London, and by Arago at the Paris Observatory gave results all tending to confirm the fact of a decrease of rain with elevation of the gauge above the ground; and in the year 1831 a wider interest was given to the question by the adoption at the first meeting of the British Association of a resolution requesting Messrs. Phillips and Gray "to undertake a series of experiments on the comparative quantities of rain falling on the top of the great tower of York Minster, and on the ground near its base."

For the purpose of this inquiry three rain-gauges were fixed, one in the Museum garden, one on the roof of the Museum, and a third supported on a pole nine feet above the battlements of the Minster tower. The observations were continued for three years, and the following were the average annual results:—

	Feet above ground.	Inches of rain per annum.	Ratio.
Museum garden	0	21·81	100
Museum roof	44	17·39	80
Minster tower	213	12·99	60[2]

During the last twenty years the literature of the subject has become voluminous, and the difficulty now is not to find observations, but to select them. One of the most indefatigable observers has been Mr. Chrimes of Rotherham, and I have copied from *British Rainfall* for 1868 his results for eleven months of that year. They are as follows:—

1 Vol. XIV., p. 312.

2 *British Association Reports, 1833—1835.*

Feet above ground.	Inches of rain.	Ratio.
1	21·90	100
5	20·39	93
10	19·47	89
15	19·10	87
20	18·76	86
25	18·58	85

It should be added that Mr. Chrimes's observations were conducted with extraordinary care, and that his elevated gauges, being fixed on poles at a distance from buildings, were free from some sources of error which attached to the earlier observations. It will be noticed in the foregoing table how remarkably the rate of decrease itself decreases as the elevation increases.

In the year 1880 a rain-gauge was fixed on the top of the tower of Boston Church, Lincolnshire, at a height of no less than 260 feet above the ground, this being the greatest elevation at which rain-observations have yet been taken. The amount collected during eleven months was 18·01 inches, as against 34·11 inches collected by a gauge in the churchyard at three feet above the ground. The ratio of these quantities is 53 to 100, showing no very material difference from the results obtained at Westminster Abbey and York Minster. Mr. G. J. Symons, reviewing a considerable number of comparative observations made at the summits of lofty buildings, concludes that "there is no evidence of any difference between the fall of rain, at various heights, from 60 feet to 260 feet above the ground."[1] That is to say, the decrease with elevation appears practically to cease at a height of 60 feet.

So much for the history of the subject and the facts observed. I come now to speak of the explanations which have been offered. And here the first question that presents itself is a very

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[1] *British Rainfall, 1880,* p. 28.

fundamental one. Is the apparent increase of rain at a lower level as compared with a higher level a real increase, or is it only apparent? In other words, does the rain, as it approaches the earth, actually increase in quantity, or is the apparent increase due to some imperfection in our methods of measurement? Without attempting to answer this question at once, I will examine seriatim the most important theories which have been put forward, taking first those which proceed on the assumption that the increase is real.

Of this class, the theory which has attracted most attention is that which was advocated by Prof. Phillips, whose observations at York have been already referred to. According to this view, the drops of rain in their descent being colder than the lower strata of air through which they fall, condense moisture upon their surface and so increase in size. This theory appears to have been first suggested by Benjamin Franklin, who, in a letter to Dr. Thomas Percivall dated 1771,[1] compared a drop of rain to a bottle of cold water condensing dew upon itself when brought into a warm room. That rain, even in our hottest days, he adds, comes from a very cold region, is obvious from its falling sometimes in the form of ice. The same view received the support of Arago in a paper published in the *Annuaire du Bureau des Longitudes* for the year 1824. Prof. Phillips, to whom this theory appears to have occurred independently, thus states it in his first report to the British Association on the rain-gauge experiments which had been entrusted to himself and Mr. Gray:—"It is therefore rather as a matter of very probable inference than a plausible speculation that I offer the hypothesis that the whole difference in the quantity of rain at different heights above the surface of the neighbouring ground is caused by the continual augmentation of each drop of rain from the

[1] *Memoirs of Thomas Percivall, M.D.*, Appendix B.

commencement to the end of its descent, as it traverses successively the humid strata of air at a temperature so much lower than that of the surrounding medium as to cause the deposition of moisture upon its surface. This hypothesis takes account of the length of descent, because in passing through more air more moisture would be gathered; it agrees with the fact that the augmentation for given lengths of descent is greatest in the most humid seasons of the year; it accounts to us for the greater absolute size of rain-drops in the hottest months and near the ground, as compared with those in the winter and on mountains; finally, it is almost an inevitable consequence from what is known of the gradation of temperature in the atmosphere, that some effect of this kind must necessarily take place. . . . . . . Lastly, I cannot forbear remarking that this hypothesis of augmentation of size of the elementary drops agrees with the result that the increase of quantity of rain for equal lengths of descent is greatest near the ground; for whether the augmentation of each drop be in proportion to its surface or its bulk, the consequence must be an *increasing rate* of augmentation of its quantity as it approaches the ground."[1]

It seems unfortunate that a theory so plausible should not be also true, but, without spending time in detailed criticism, it may be stated that Sir John Herschel, in his *Essay on Meteorology*, showed by calculation that under no conceivable circumstances could the condensation of vapour upon the falling drops of rain amount to more than a minute fraction of the difference actually observed. This explanation must therefore be given up.

It has been generally assumed that no other method is possible by which drops of rain can increase in size as they fall but that by condensation of vapour. As a matter of theory this

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[1] *British Association Report, 1833.*

view is certainly untenable. The drops may increase in size by the aggregation of minute liquid particles. We must bear in mind the distinction between the gaseous and the liquid forms of water. Water-vapour is a dry gas, and the quantity of it that can be condensed into liquid under given circumstances is strictly limited, admitting of exact calculation. But there is no such limitation to the amount of liquid water that may be absorbed by falling drops, supposing such to be encountered by the drops in their descent. It was this view that led me ten or eleven years ago to put forward a theory which I was then sanguine enough to believe fully met the case.[1] I conceived that the lower strata of air during rain might be charged with minute watery particles which were caught up and incorporated by the falling drops of rain. I gave reasons for believing in the probable presence of these watery particles. I showed why they should not under ordinary circumstances take the form of visible cloud; why they should be most abundant in the very lowest strata, where we have seen the greatest effect to be produced; and why the operation of this cause should be most effective in windy weather—the condition under which (as I shall presently explain more fully) all observers have found the difference to be greatest.

Whatever view may be taken of the value of this theory as an explanation of the phenomenon now under discussion, there can be little doubt that it represents what takes place in the original formation of rain. The constituent particles of a cloud, it should be remembered, are not vapour, but liquid water in a finely divided state. When rain is being formed, these particles,

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[1] The author has lately found, in the *British Association Report* for 1834, p. 563, an abstract of a paper by Mr. Luke Howard, in which a theory is propounded similar in its leading feature to his own (now discarded) theory.

coalescing, generate minute drops, which, falling by their weight through the cloud, encounter and absorb fresh particles, thus continually increasing in size. But although this explanation of increase in the size of drops by aggregation of minute watery particles holds good in the clouds, I do not now think that it applies, under ordinary circumstances, to the increase (or apparent increase) in the quantity of rain which takes place in the strata of the atmosphere near the earth. Another explanation seems to me at once more simple and more complete.

But this takes me to the second group of theories, namely, those which are based upon the assumption that the observed increase in the quantity of rain at the lower levels is mainly, if not entirely, illusory.

And first among these theories comes one which may be easily shown to be fallacious, notwithstanding that it has been stoutly contended for by some able meteorologists. In the year 1871, in the columns of the *Meteorological Magazine*, it was my lot to take part in a controversy with the Rev. F. W. Stow, who had then lately broached the theory to which I am about to refer. Both Mr. Stow and myself were then under the impression that the theory was new; but in science, as in other matters, history sometimes repeats itself, and I have since found that the same view had been put forward many years before by a Frenchman named Flaugergues,[1] and that its fallacy had been more than once exposed.

The theory, stated in Mr. Stow's own words, is that the "difference of the angle at which the rain falls is the real cause of the decrease of rainfall upon a horizontal surface with elevation."[2] M. Flaugergues is still more explicit. He attempts to prove, mathematically, and with the aid of a diagram, that "the

[1] *Annals of Philosophy*, Vol. XIV., p. 114.
[2] *British Rainfall, 1870*, p. 18.

quantity of rain which enters into the rain-gauge is proportional to the sine of the angle of inclination of the rain."

Mr. Stow, in order to test his theory, instituted an elaborate series of experiments with a view to determine the angle at which rain falls. He fixed at various elevations *pairs* of rain-gauges, one of each pair being an ordinary gauge with a horizontal receiving surface, and the other being a gauge with a vertical receiving surface kept always towards the wind by the action of a vane. From the proportional quantities collected in each pair of gauges he computed the angle at which the rain fell at each elevation. As might have been expected, he found that the higher (and therefore more exposed) gauges indicated a greater inclination of the rain than the lower, and he clearly established the law that the quantity of rain collected at the different heights varied directly with the angle which the paths of the rain-drops formed with the horizon. Further, he found, in comparing the ratios of decrease at different periods, that the angle of the falling rain, depending, as he rightly said, on two factors, the force of the wind and the weight of the drops, exhibited a closer correspondence with the ratio of decrease than did the force of the wind taken alone. I hope to show immediately how this may be explained without having recourse to a theory which, however nicely it fits in with observed facts, is mathematically untenable.

That the theory is untenable will, I think, appear pretty clearly on inspection of the diagram (fig. 1). Let the lines in the upper part of this diagram be taken to represent the paths of the drops of rain as they fall vertically through a calm stratum of air, and let the inclined lines represent the paths of the same drops as they fall through a stratum of moving air. Let A and B be rain-gauges of identical size, placed, one to catch the rain as it falls vertically, the other to catch the same rain as it falls obliquely. It will be very evident that as the diameter of the receiving surface of the

Fig. 1.

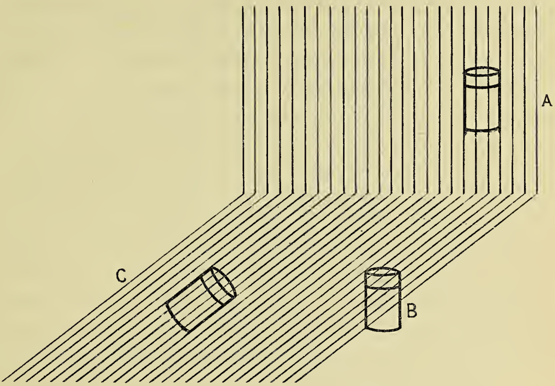
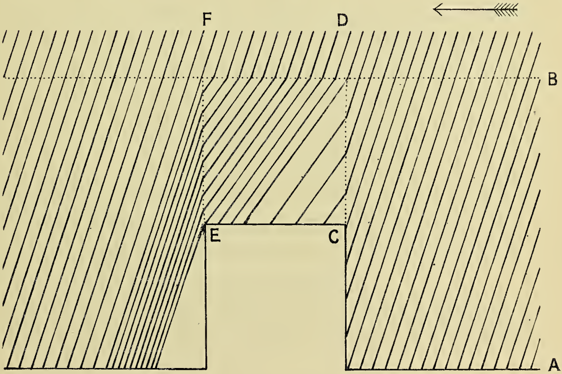


Fig. 2.



gauge is in each case exactly equal to the horizontal distance of four drops, the quantity collected in the two gauges will be identical. The angle of inclination of the rain is seen, therefore, to make no difference whatever in the quantity of rain falling upon a horizontal surface. To complete the illustration, a third rain-gauge (C) has been introduced, of the same size as the others, but tilted at such an angle that the inclined rain-drops shall fall perpendicularly to its receiving surface. A gauge in this position will clearly catch more rain than one whose receiving surface is horizontal, but the difference is due to the former catching too much, not, as some have hastily assumed, to the latter catching too little. By still further increasing the inclination of the rain and of the tilted gauge, it is obvious that the latter may be made to receive any number of drops, the quantity of rain falling over a given area remaining precisely the same.

The next theory I would mention comes recommended by no less an authority than Prof. Stanley Jevons, as we now know him—W. S. Jevons, B.A., of University College, London, as he was when he contributed a paper on this subject to the *Philosophical Magazine* for December, 1861.

Mr. Jevons recognises (as others had done before him) the undoubted fact that the decrease of rain with elevation is greatest in windy weather, and he shows in a very ingenious manner how the force of the wind may, without diminishing the true rainfall, diminish the quantity collected in a rain-gauge. Mr. Jevons's paper, which had been overlooked by meteorologists in all recent controversies on the subject, was unearthed at the last meeting of the British Association by Mr. G. J. Symons, who was understood, in a general way, to endorse Mr. Jevons's views. What these views are will best appear by an extract from his paper, and by a reproduction of one of his diagrams.

Mr. Jevons, after premising that not only the building upon which a rain-gauge may be placed, but even the rain-gauge itself, must act as an obstacle to the wind, continues:—"A stream of air, then, meeting an obstacle, leaps over it; in so doing it is forced against the adjoining parallel stream of air, which must also diverge from the straight direction, and similarly impinge upon the next stream. But the increased pressure produced by the impact causes the streams of air to move more rapidly, and to diminish in thickness at the same time; and the disturbance of the streams of air will cease at the point where the total decrease of size of the streams is equal to the height of the obstacle. It is at least obvious that when a uniform wind meets an obstacle, some parts of the air must move more rapidly, just as a river moves most rapidly in the narrowest parts of its channel. It is is quite in accordance, too, with our common experience, that an obstacle increases the velocity and force of the wind; thus the wind is always most fierce at the corner of a house, the end of a wall, or the summit of a hill."

Mr. Jevons then refers to a diagram which is copied in fig. 2. In this diagram a stream of air AB is supposed to be suddenly contracted at CD to half its previous thickness, moving in consequence with double velocity. At EF the stream dilates to its original size, and recovers its first velocity.

Mr. Jevons adds—"It is, I venture to hope, rendered quite plain that *less rain will fall upon the summit of the obstacle than elsewhere, the surplus being carried forward to the lee side of the obstacle.* I entertain no doubt that we have in this process a sufficient explanation of the observed deficiency of rain in elevated places."

Experiments made with gauges placed at the four corners of a tower are held by Mr. Symons to lend a powerful support to Mr. Jevons's views. Such experiments were first made by Prof. Bache at Philadelphia about the year 1834;[1] they have

[1] *British Association Report, 1838,* Part II., p. 25. Also quoted in *British Rainfall, 1878,* p. 25.

been repeated more recently by Mr. Dines at Hersham, Surrey;[1] and the conclusion arrived at by both these observers is that the decrease of rain at the top of the tower as compared with the ground is always most marked in the windward gauge and least marked in the leeward gauge, the latter sometimes showing no decrease at all. This is no doubt just such a result as Mr. Jevons's diagram would lead us to expect. Nevertheless I doubt if the explanation given by him is, to any material extent, a true explanation.

In discussing Mr. Jevons's theory, a question suggests itself at the outset, which, although it may admit of an answer, it may clear the ground to state. Is it actually in accordance with our experience that obstacles to the passage of the wind increase the velocity of the wind? Is not our experience the very reverse of this? The windiness of elevated situations, as the tops of hills, is surely not due so much to the obstruction occasioned by the hill, as to the comparative freedom from obstruction which is proper to stations raised above the general level of terrestrial objects. The increased force of the wind at sea or on extensive plains seems to demand a similar explanation. I believe there can be no doubt that the effect of obstacles to the passage of the wind is, on the whole, to retard the velocity of the wind. And yet I do not urge this as an objection to Mr. Jevons's theory.

Let us imagine two tubes, having their mouths exposed to the same current of air. One tube shall be free throughout, the other shall have its calibre constricted by a diaphragm at one part to half the area elsewhere. I suppose there can be no doubt that the wind will pass more slowly through the constricted tube than through the other; yet it will be equally true

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[1] *British Rainfall, 1877*, p. 15. *Meteorological Magazine, August, 1878.*

that a local acceleration will take place at the constricted part, the current there having double the velocity of the current in the other parts of the same tube. There is thus shown, as the result of the obstruction, a general retardation, combined with a local relative acceleration. And, in theory, the same thing may happen with a building on which a rain-gauge is placed, or even, to a very small extent, with a rain-gauge itself.

But the extent to which this cause may operate is an important point to consider. It must be remembered that the air about a building or a gauge is free, not confined within rigid walls, as in the constricted tube that I have supposed, or, as in Mr. Jevons's own illustration of a river between its banks. And, bearing this in mind, I should be disposed to conclude that the accelerating effect of an obstacle such as a rain-gauge upon the velocity of the wind in its neighbourhood must be infinitesimally small.

Again, it will appear from the diagram, that it is only those drops which are deflected along a vertical line (or a line more or less approaching the vertical) that will suffer the separation in horizontal distance which the theory supposes. And if the imaginary area above the obstacle be reduced in height, the effect will be proportionately diminished.

Further, if the theory be true, this curious result must follow—that in a driving rain the fall on the leeward side of a house, or similar obstacle, will be greater (at least over a certain space) than the fall on the windward side. Having no observations to determine this point, I can hardly use it as an argument, although I think it will be allowed that the result, if established, would be very surprising.

But I have a more conclusive objection to Mr. Jevons's theory than any I have yet advanced. There appears to me to be an essential link wanting in the chain of argument by which the author would connect the alleged acceleration of wind with the phenomenon to be explained. It is not enough to prove that the obstacle accelerates the wind locally, and that this local acceleration of the wind separates the drops of rain. It must be shown that this local acceleration of the wind is an operating cause powerful in proportion to the proper velocity of the wind which undergoes this local acceleration. If this can be shown—if it can be shown that the stronger the wind, the greater will be the effect produced by the local acceleration of the wind, then we have only to assume (what, indeed, we know quite well) that elevated gauges are more exposed to wind than low ones, and the theory is so far complete. But this is just the link that is missing. Mr. Jevons has made no attempt to show that the operation of the cause he assumes would be more powerful in a strong wind than in a light wind, or that it would be more powerful with an upper gauge than with a lower gauge. He appears, indeed, to have overlooked the necessity of showing this. I have endeavoured, by means of diagrams and measurements, to ascertain what would actually happen with winds of different velocities undergoing local acceleration in accordance with Mr. Jevons's theory, and I find (if I am not mistaken) this curious result, that as regards the separation of the rain-drops in horizontal distance, the effect, instead of becoming greater, becomes less and less marked as the velocity of the wind is increased.

But it is necessary now that I should give a more distinct expression to the law to which I have already more than once adverted, namely, that the deficiency of rain in elevated gauges bears a close relation to the velocity of the wind. This relation has been long recognised, and is admitted by all. Passing over the frequent references made to it by the earlier observers, I would call attention to the following table, compiled from statistics given by Mr. Chrimes of Rotherham in *British Rainfall*, 1869, p. 19. The figures represent the means of (in most cases) four years :—

	Mean velocity of wind in miles per diem on days with rain.	Rain at 1ft. being 100, rain at 25 ft. =
March - - -	221	72
February - -	199	76
April - - -	179	86
December - -	179	83
November - -	170	80
January - -	158	80
May - - - -	149	87
October - -	128	87
September - -	119	92
August - - -	118	92
June - - -	105	90
July - - - -	93	92
Year - - -	152	85

The months being arranged in order, according to the velocity of the wind which prevailed on the days on which rain fell, the close relation between this velocity and the decrease of rain with elevation is seen at a glance. Thus March, the windiest month, shows the greatest decrease; July, the calmest month, shows a decrease equal to the least; while the months which occupy intermediate positions as regards velocity of wind, exhibit, on the whole, a corresponding gradation as regards decrease of rain. Had it been possible to set down in the table the mean velocity of the wind during the time that rain actually fell instead of the mean velocity during the whole day, the accordance between the two columns would, no doubt, have been closer still.

A similar result comes out when the specially calm days of rain are compared with the specially windy days of rain. Thus Mr. Chrimes, in the article already referred to, extracting from his daily records for 1869 all entries of rainfall on days when the wind was under 75 miles per diem or above 300 miles, finds that on 17 "calm" days the mean percentage of rain at 25 feet (as compared with 1 foot) was 94·5, while on 10 "rough" days the mean percentage was only 69·8.

With these facts before us, it is impossible to doubt that the main cause of the decrease of rain with elevation is to be found in the force of the wind. Indeed, it may be said that upon this point meteorologists are now agreed; the differences of opinion yet remaining relate to the mode in which the force of the wind operates to bring about the result observed. "Eddies of wind" in and about the rain-gauge have been frequently spoken of as furnishing an explanation of the phenomenon, but if by an "eddy" is meant (as I presume is meant) a circular or rotatory motion, such as occurs in a whirlwind, the explanation seems to me imperfect; for I believe that the effect of an eddy (in this sense) would be not to diminish but to increase the quantity of rain falling in the vortex of the eddy, just as we see little heaps of dust collected in the centre of the tiny whirlwinds which are not uncommon in our streets and roads, or as, on a larger scale, we see in the deluge of a waterspout. But if we suppose that the wind, instead of eddying in circles over and within the gauge, simply *rebounds*, then I think we have an explanation which meets all the conditions of the problem. That the wind does rebound from obstacles which it meets is a familiar fact. That the force of this rebound will be proportional to the force of the wind is obvious without demonstration. And that the effect of the rebound will be to impede the entry of rain into the gauge, seems to me equally apparent.

I am not aware that there is any observed fact in connection with this question which the theory now suggested may not be made to cover. In its simplest application it explains the progressive deficiency of rain in elevated gauges by the progressive increase in the force of the wind in elevated situations, and the larger proportion of rain which will thus be blown out of the instrument by the rebound of the wind from the interior of its rim and funnel. To account for the remarkable decrease in the rate of decrease from the lowest strata upwards, we have only to suppose that a corresponding increase in the rate of increase applies to the velocity of the wind from the lowest strata upwards; and this, although it has not been experimentally proved, will not appear unreasonable when we consider that it is by contact with the earth and the objects upon it that the velocity of the wind is retarded. For the same reason it appears likely, if not inevitable, that the differences in the velocity of the wind due to elevation will be greater when the wind is strong than when the wind is light, and this explains why the deficiency of rain in elevated gauges is greatest in windy weather. Lastly, it has been observed that in heavy rains the differences are somewhat less than in light rains. This is just what we should expect if we remember that the momentum of a heavy drop will enable it better to resist the force which tends to divert it from its path. In this way I explain Mr. Stow's result, already quoted, that the inclination of the rain exhibits a closer correspondence with the elevation-difference than does the force of the wind.

Some practical inferences, as regards the measurement of rain, follow from what has been stated.

1.—The height usually adopted for the receiving surface of a rain-gauge is one foot above the soil, and I will not say that this height may not be on the whole the best, but if the views I have advanced are sound, the indications of a gauge at this level cannot be free from error. The disturbing influence of the wind is greatest, as we have seen, at the higher levels, but it continues all the way down to the ground, a gauge at one foot having been found to collect about 5 per cent. less than one whose receiving surface was level with the soil.

2.—In the construction of rain-gauges it should be an object to adopt the form least favourable to the blowing out of rain by the rebound of the wind. Probably a deep rim and a steep funnel are best from this point of view.

3.—As regards the position selected for a gauge, a spot too open must be at least as unsuitable as one too sheltered. In very exposed situations the indications in windy weather must be quite unreliable. Mr. Stow records of a gauge which he fixed within five yards of the edge of a sea-cliff, that it caught "not much with land winds, and next to nothing in gales from the sea."[1] Mr. Symons, in his inspection of rain-gauges, uses a little instrument devised by himself, which, held in the gauge, detects any tree, building, or other object rising to an angle of 45 degrees with the horizon, and he will not allow any gauge to be fairly placed which fails to pass the test of that instrument. Mr. Symons is no doubt right in the importance which he attaches to a certain degree of openness of situation, but I am disposed to think it equally important that within the angular limit of 40 or 45 degrees there should be as much shelter as possible.

[1] *British Rainfall, 1870*, p. 21.

Rainfall at Clifton in 1881.

By GEORGE F. BURDER, M.D., F.M.S.

TABLE OF RAINFALL.

	1881.	Average of 28 Years.	Departure from Average.	Greatest Fall in 24 Hours.		Number of days on which ·01 in. or more fell.
				Depth.	Date.	
	Inches.	Inches.	Inches.	Inches.		
January ...	1·714	3·325	−1·611	0·637	18th	10
February ...	3·838	2·260	+1·578	1·206	9th	14
March ...	1·935	2·223	−0·288	0·433	5th	11
April ...	0·612	2·130	−1·518	0·344	11th	6
May ...	1·516	2·408	−0·892	0·616	17th	11
June ...	3·550	2·563	+0·987	1·495	5th	17
July ...	2·469	2·861	−0·392	0·952	30th	13
August ...	5·635	3·466	+2·169	0·874	16th	20
September ...	2·100	3·423	−1·323	0·768	24th	10
October ...	2·262	3·728	−1·466	0·679	22nd	14
November ...	4·323	2·698	+1·625	0·635	24th	19
December ...	4·152	2·737	+1·415	1·420	17th	16
Year ...	34·106	33·822	+0·284	1·495	June 5th	161

Remarks.—The year 1881 was the driest year since 1873. Nevertheless, it had a rainfall above the average of 28 years, being the eighth year in succession in which the rainfall has exceeded the average.

The monthly totals present no very remarkable feature. The driest month was April, in which the rainfall was 0·612 inch. The wettest month was August, with 5·635 inches.

The heaviest diurnal falls were on the 9th of February—1·206 inch; the 5th of June—1·495 inch; and the 17th of December—1·420 inch.

A memorable snow-storm occurred on the 18th and 19th of January. The average depth of snow in this locality was about 9 inches. In South Hampshire and the Isle of Wight (where the storm was more severe than in any other part of the country) the average depth was at least 18 inches. A heavy gale accompanying the snow caused enormous drifts, which blocked the railways to a degree never before experienced. It was estimated that not less than a hundred persons lost their lives in the snow in various parts of England and Wales.

Reports of Meetings.

GENERAL.

THE first meeting of the year was held on the evening of January 6th, when two papers were read by Professor Sollas, M.A., F.G.S., F.R.S.E., the first being entitled "A Visit to the Island of Torghatten in Norway." This island had been visited by Professor Sollas in the previous July. It is remarkable in shape, resembling a conical hat with a broad brim, the latter corresponding to a table-land, which rises about 300 feet above the sea, and is surmounted by a peak reaching to a height of 900 feet. Nearly at the base of this eminence there is a natural tunnel extending right across it. It is 200 yards long and 20 in width. Professor Sollas attributed this remarkable formation to the action of rain, by which valleys had been excavated, leaving hills between them. Subsequently submersion occurred, and the chain of mountains produced the islands. As the sea continued its action, cliffs were formed leaving a plain, viz , the plain of marine denudation. In this manner the peak and table-land are accounted for. The tunnel owes its existence to two cracks extending down the side of the cone, between which we find the rocks, consisting of gneiss, more disintegrated than elsewhere. A series of caves was thus formed across the base of the peak, which eventually coalesced into a tunnel, the disintegration having been caused by the disruptive force of water while freezing.—The second paper was "On a Rare Plesiosaur from the Lias at Bridport." After a brief account of the discovery of this very fine fossil, Professor Sollas proceeded to describe some of the anatomical characteristics of Plesiosaur, more especially such as distinguished it from Ichthyosaur. In the former of these we find the head to be small in comparison with the length of the body, and the neck long. The teeth, which are large, curved, and striated, overlap when the jaws are closed. In Ichthyosaur, on the other hand, we have a large head, and no neck, and in the structure of the vertebral column we find that the arch which covers the spinal cord is separated from the main portion of the vertebra, whereas in Plesiosaur no such separation exists. The latter resembles in appearance a turtle with a long neck, though in reality it is allied to the lizard. Almost all the specimens of this fossil have been found embedded in a prone position; in the one, however, lately discovered at Bridport, the head is slightly inclined, which will greatly facilitate the study of the animal. When finally arranged it will be 16 feet long, and will surpass the one in the British Museum.

The next meeting occurred on the evening of February 3rd, when Professor Ramsay, Ph.D., contributed a paper on "The Connection between Chemical Constitution and Physiological Action," being part of the results of investigations made by the author and others at the Western Infirmary of Glasgow, regarding the action of anæsthetics. These may be summed up as follows:—1. Hydrocarbons have little, if any, action on the animal organism. 2. The introduction of oxygen, when the resulting substance does not produce local irritation, acts on the organism. A low molecular weight coincides with a transitory effect; and as it increases the effects become more marked. 3. Compounds containing chlorine all effect the organism. Its specific action consists in causing irregularity of the heart's pulsations, and in lowering the blood pressure. The peculiar action of the carbon and hydrogen in compounds containing chlorine is to produce irritation in the nerve centres, and in bodies of high molecular weight, to cause spasms. 4. Nitrogen shows great versatility in the part it plays. Many bodies containing it, such as the natural alkaloids, have their poisonous action greatly lessened by addition of methyl and similar radicals; while others become much more active by such addition. 5. Increase of molecular weight corresponds with increased toxical action. 6. Polymeric bodies have a deficient, and in some cases, a much more energetic effect on the organism than the simple compounds from which they are built up. Professor Ramsay concluded by pointing out the importance of such investigations, as tending to throw light on the action of drugs on the animal economy, and as leading the way to the discovery of new ones.

At the meeting in March, Mr. F. F. Tuckett and Dr. Beddoe made a communication regarding "The Evidence as to the recent gradual Diminution in the Dimensions of the Human Head in this Country," which appears in the foregoing pages.

At the April meeting, Mr. C. Richardson, C.E., read a paper on "The Age of the Wye," also fully reported in the present Part.

When the Society met again, in October, Professor Sollas read a paper on "The Connection between Volcanoes and Mineral Veins." He began by alluding to the misconception which existed regarding the nature of mineral veins, the prevailing idea being that they resembled the veins of the human body. A mineral vein is a great fissure in the earth's crust, lined with quartz, in which we find various metallic compounds deposited, such as sulphide of copper, &c. Large fissures are produced by what are known as "lines of fault," which are cracks in the earth's crust accompanied by dislocation in the adjacent portions. In Cornwall we find numerous examples of faults which are lined with quartz. This substance is extremely insoluble, but in order to account for its presence in these veins, it must at some period have been held in solution. A thin slice of this mineral, when examined under the microscope, exhibits a number of minute cavities filled by liquid, with the exception of a small portion occupied by a bubble, which is the cause of its milky appearance. On the application of heat, this vacant space above the liquid disappears; and by this means Sorby attempted to determine the temperature at which the quartz began to solidify, and which seems to have been a little lower than that for granite. The main agents concerned in the deposition of quartz in such fissures have been reduction of temperature and pressure. In the granite and slate of Dartmoor we find that the latter originally formed a dome over the former, and has since been removed by the denuding forces of nature, the fissures having been formed after the deposition of the slate and the consolidation of the granite. Professor Sollas next proceeded to point out in what manner these fissures are connected by volcanic agency with the various mineral and metallic deposits, which occur in different portions of the earth's crust. During the life of a volcano the shaft at its lower extremity terminates in a lake of molten rock. After a time the eruptions become less frequent, the molten matter solidifies into granite, and after a further interval thermal springs begin to appear, generally in the lines of fault. Devon and Cornwall were at one time covered with volcanoes, the remains of which exist in the form of bosses; and, as Professor Judd has shown, the Western Isles of Scotland, and especially Mull, afford similar evidence. When fissures are formed near volcanoes, and extend downwards for several thousands of feet, being filled with heated water holding various matters in solution, it follows that the solubility of these substances, being dependent on temperature and pressure, as we ascend the fissures we should expect to find the different metallic compounds deposited according to their insolubility. Mr. John Arthur Phillips has devoted much time and attention to the examination of the volcanic region of California, and the results obtained by him seem so far to support this theory. Other researches also lend weight to it.

In November, two papers were contributed: the one by Mr. H. S. H. Shaw on "The Methods of Wind Measurement," which appears in full in the Proceedings of the Society; the other by Professor S. P. Thompson, D.Sc., B.A., F.R.A.S., on "Faure's Battery and Swan's Lamps." Professor Thompson commenced by alluding to the attempts which had recently been made by various experimentors to produce small electric lights of less intensity than that of the electric arc, referring more especially to Swan's lamps, specimens of which were shown. The first attempts in this direction were made with platinum wire, but as in this case the resistance increases with the temperature, the wire soon becomes fused. Carbon filaments were next resorted to, both by Swan and Edison, and for the present they furnish the best means of producing incandescent light, as in their case the resistance instead of being increased is diminished as the temperature rises. However, the durability of these lamps is merely a question of time, seeing it is impossible to produce a perfect vacuum in the glass envelopes in which they are enclosed, so that eventually oxidation sets in. The filaments used by Swan are made from cardboard, while Edison employs a particular kind of bamboo. These, after being in use for some time, become almost metallic in appearance and hardness. The resistance of each is equal to about five miles of ordinary telegraph wire, and a current of a half to one weber per second is sufficient. Professor Thompson then passed to the consideration of accumulation of electricity by means of secondary batteries. In 1804 Planté made the first of these, the principle of which depends on the fact that if an electric current is passed through a liquid capable of being decomposed by it, and in which two metallic plates are immersed, we find after the current has been passing for some little time that these become coated, or, more properly speaking, varnished, by the gases given off: so that if the action be continued long enough we obtain a secondary battery, in which the current is generated by the chemical action of the products of decomposition effected by the original battery. The two plates, in fact, act as if they were different metals on account of their being coated with different gases; and in this condition they are said to be polarised. Planté employed plates of lead, through which he passed the current for weeks before he obtained a sufficient deposit of oxide to give a secondary current. In 1859, M. Faure, who took up the matter, conceived the idea of applying the oxide to the surface of the metal at the very outset, which has been attended with complete success, and has very greatly lessened the time required for charging the cells. His arrangement consists of sheets of lead, to which has been applied a coating of oxide, and over this again a layer of felt, or some such material, the whole being immersed in dilute sulphuric acid.

At the meeting in December, a paper on "Nestor Notabilis, a bird of degraded tastes," was read by Mr. S. H. Swayne, M.R.C.S., which appears in the foregoing pages. Mr. B. Lobb also contributed a paper on "Portishead itself, and the shores thereof, with some of its treasures." At the close, Professor Thompson exhibited a number of Swan's lamps, which were lighted by means of a Faure's battery. These were intended to have been shown at a previous meeting, but owing to some derangement of the apparatus, this was impossible.

The next meeting was held on the evening of January 5th, when Mr. E. Wethered, F.G.S., F.C.S., contributed a paper on "Colliery Explosions," which has already appeared.

In February, Mr. W. A. Shenstone, F.I.C., communicated a paper entitled "Our Knowledge of the Nature of Chemical Phenomena," which appears in the present Part.

At the meeting in March, Professor Main, B.A , D.Sc , A.I.C.E., gave a contribution on "The Smoke Abatement Exhibition," which forms part of the present number.

The last meeting of the Session, for the reception of communications, was held on the evening of April 6th, when Professor Ramsay and Dr. Burder contributed papers: that of the former being "On Smell," and that of the latter "On the Decrease of Rain with Elevation," both of which appear in the Society's Proceedings.

GEOLOGICAL SECTION.

At the meeting of this Section on February 9th, 1881, Mr. E. D. Jones read a paper on "The Geology of the Severn Basin."

At the following meeting, on March 9th, Mr. Juke gave a communication on "The Norwich Crag."

On May 21st, an excursion was made to Dundry; and at Whitsuntide, another, extending over two days, was taken to South Wales.

On November 24th, the Section again met, when Professor Sollas gave an interesting account of the "Geological History of some Domestic Animals."

On April 1st, 1882, an excursion was made to Bradford-on-Avon, and to Devizes.

On April 3rd, Mr. Wethered read a paper on the "Formation of Coal."

ENTOMOLOGICAL SECTION.

DURING the summer only two excursions took place, one to Leigh Woods, the other to Charfield.

On the latter occasion, several species were captured, which have not been found in the more central parts of the Bristol District.

At the indoor meetings, many most interesting exhibitions of species, both British and exotic, took place. Among the former may be mentioned :—

Nola Centonalis.
Ennomos Alniaria.
Geometria Smaragdaria.
Crymodes Exulis.
Pachetra Leucoptræa.
Phycis Adelphella.

The exhibition of exotic insects of different orders, but chiefly of *Coleoptera* and *Lepidoptera*, was too extensive for enumeration, but included many rare and new species.

At the January meeting of the Section, Mr. J. W. Clarke showed a specimen of *Halias Quercana*, captured in Leigh Woods, which was interesting, as being the only specimen of this fine species found near Bristol. No papers of importance have been read during the Session, with the exception of Mr. Hudd's very complete list of the Bristol *Lepidoptera*, which appears in the Proceedings of the Society.

GEORGE HARDING, *Hon. Sec.*

BOTANICAL SECTION.

THE Section has steadily occupied itself in accumulating material for the construction of the local Flora, the first portion of which was issued with the last number of the Society's Proceedings.

The Saturday excursions were continued regularly throughout the summer, and many spots hitherto unvisited were carefully explored, and their botanical features noted for future reference. The more important rambles were those to Black Down, Max Mills, Chew Magna, Thornbury, Wedmore, Hallatrow, and Yate.

JAS. W. WHITE, *Hon. Sec.*

PHYSICAL AND CHEMICAL SECTION.

List of Papers read 1881.

A. M. Worthington, Esq.—"On the Equilibrium of a Liquid Cylinder."

W. A. Shenstone, Esq.—"On the Solubility of Salts at High Temperatures."

Prof. S. P. Thompson.—"On Volta-Electric Inversion."

F. J. Culverwell, Esq.—"On the Projection of Harmonograph Figures."

Prof. W. Ramsay.—"On Brownian Motion."

January 28, 1882.

Prof. S. P. Thompson.—"On Electric Induction Machines."

Prof. W. Ramsay.—"On some large Crystals of the Nitrates of Lanthanum and Didymium."

March 24, 1882.

W. A. Shenstone, Esq., F.I.C.—'On a Modification of Grove's Cell."

M. W. Dunscombe, Esq.—"On an Absolute Barometer."

Prof. S. P. Thompson.—"On Skrivanoff's Dry Batteries."

Prof. W. Ramsay.—"On the Extraction of Selenium from Pyrites."

REPORT FOR 1881.

Owing to circumstances only two meetings of the Physical and Chemical Section have been held during the year, as against the usual number of five. Six communications were made to the Section by five members. The total number of members on the books is now 35.

The finances of the Section continue in a sound condition, there being a balance in hand of £6 14s. 4d. The balance sheet and vouchers are submitted herewith. In addition to this balance the assets of the Section include 2/10 in stamps, and 39 post cards.

The Honorary Secretary has already received promise of several communications of great value for the forthcoming year, which will, he hopes, prove a prosperous one to the Society and to the Section.

(Signed) S. P. THOMPSON, *Hon. Sec.*

List of Societies to which the Proceedings of the Bristol Naturalists' Society are sent.

Barrow Naturalists' Field Club.
Bath Natural History and Antiquarian Field Club.
Belfast Naturalists' Field Club.
Birmingham Natural History and Microscopical Society.
Calcutta, Geological Survey of India.
Cardiff Naturalists' Society.
Chester Natural Science Society.
Clifton College Scientific Society.
Cotteswold Naturalists' Field Club.
Dudley and Midland Geological Society and Field Club.
Edinburgh Geological Society.
———Botanical Society.
Epping Forest and County of Essex Naturalists' Field Club.
Falmouth, Cornwall Royal Polytechnic Society.
Glasgow Geological Society.
———Natural History Society.
———Philosophical Society,
Liverpool Geological Society.
———Literary and Philosophical Society.
London, British Museum Library.
———Geologists' Association
———Queckett Microscopical Club.
———Royal Microscopical Society.
Manchester Geological Society.
Manchester Scientific Students' Association.
———Literary and Philoscopical Society.
Marlborough College Natural History Society.
Norwich, Norkfolk, and Norwich Naturalists' Society.
Penzance, Royal Cornwall Geological Society.
Plymouth Institution and Devon and Cornwall Natural History Society.
Redruth Miners' Association of Devon and Cornwall.
Rugby School Natural History Society.
Taunton, Somersetshire Natural History and Archæological Society.

Torquay Natural History Society.
Warwick Natural History and Archæological Field Club.
Watford Natural History Society, and Hertfordshire Field Club.
Wiltshire Archæological and Natural History Society.
Winchester and Hants Literary and Scientific Society.
Woolhope Natural History Field Club.
Yorkshire Naturalists' Union.

FRANCE.

Société D'Etudes Scientifiques, Palais-des-Arts, Lyon.

NORWAY.

Det Kongelige Norsk Universite i Christiania.

GERMANY.

Cassel, Verein für Natur Kunde.
Oberhessische Gessellschaft für Natur und Heilkunde, Giessen.

SWITZERLAND.

Lausanne, Societé Vaudoise des Sciences Naturelles.

UNITED STATES.

Boston (Mass.) Natural History Society.
Salem Mass., U.S., Essex Institute.
Washington Smithsonian Institution.
——United States Geological Survey of the Territories
Philadelphia Academy of Natural Sciences