NOTES ON METEORITES.[1]

V.

WE shall see next that another line of thought and inquiry was required to completely establish the cosmical hypothesis by giving us data as to the *velocities* of the meteorites.

This was that the sporadic meteors, those which made their appearance by chance, so to speak, were always more numercus in the morning than in the evening hours, and further that the numbers seen in the northern hemisphere in one half year was greater than that seen in the other. These facts, although at first they seemed to connect these phenomena with our terrestrial hours, and therefore were at first considered to militate against the cosmical hypothesis, were subsequently shown, by Bompas, A. S. Herschel, H. A. Newton, and Schiaparelli, to be a distinct proof that the bodies were moving in space with a velocity not incomparable with, but at the same time somewhat greater than, that of the earth itself; that therefore they were moving with planetary velocities, and therefore were truly members of the solar system.

The work of M. Coulvier-Gravier[2] was the first to indicate the extreme regularity with which the numbers increased from sunset to sunrise, as will be seen in the accompanying table:—

Time of Observation.	Number seen per hour.	Time of Observation.	Number seen per hour.
5 p.m.- 6 p.m.	... 7·2	12 -1 a.m.	... 10·7
6 p.m.- 7 p.m.	... 6·5	1 a.m.-2 a.m.	... 13·1
7 p.m.- 8 p.m.	... 7·0	2 a.m.-3 a.m.	... 16·8
8 p.m.- 9 p.m.	... 6·3	3 a.m.-4 a.m.	... 15·6
9 p.m.-10 p.m.	... 7·9	4 a.m.-5 a.m.	... 13·8
10 p.m.-11 p.m.	... 8·0	5 a.m.-6 a.m.	... 13·7
11 p.m.-12	... 9·5	6 a.m.-7 a.m.	... 13·0

It was the dependence of these phenomena upon certain terrestrial hours which made that eminent observer decline to consider their origin as in any way cosmical.

Mr. Bompas,[3] commenting on the numbers obtained by Coulvier-Gravier, wrote—

"The part of the heavens towards which the earth is moving at any time is always six hours from the sun. At 6 a.m. the observer's meridian is in the direction of the earth's motion; and at 6 p.m. in the opposite.

"Thus the greatest number of meteors are encountered when the observer's meridian is in the direction of the earth's motion, and the number diminishes from thence to 6 p.m., when he looks the opposite way."

The accompanying wood-cut will make this clear. The front half of the earth ploughing its way through space is unshaded; an observer is being carried along the line of the earth's motion at sunrise, the earth is behind him, so to speak, and the point towards which the earth is travelling lies 90° in longitude behind the sun.

Combining these facts, Bompas explained the results on the principle that if the meteors be distributed equally in space they would converge to the earth, if at rest, equally on all sides. But if the earth be in motion, and with a velocity one-half the average velocity of the meteors, they would converge to it more on the side towards which it is moving than the other: and in the proportion of nearly two-thirds of the number, would have an apparent motion more or less opposed to that of the earth, and apparently diverging from the point towards which the earth is moving, with a gradual increase in number from 6 p.m. to 6 a.m.

Before we proceed to show the bearing of this matter, a word must be said with regard to the actual conditions under which these bodies reach us from space, and how the fall of these bodies upon the earth and their appearance in the heavens even in the case of no fall have been investigated.

To approach the proof of the cosmical hypothesis afforded by these observations, we may begin by supposing the earth at rest. If the movements of the cosmical particles are in all directions, they will fall equally on all parts of the earth, and even the earth's *rotation* will make no difference. But if we assume the earth's movement in its orbit to be much more rapid than the movements of the meteorites, it is clear that its forward half will receive blows while the hinder half cannot.

Suppose that all the regions of space swept through by the earth in its orbit round the sun were occupied here and there by meteorites, also like the earth moving in orbits round the sun, and let us assume for the moment that they are pretty nearly equally distributed and are moving in all directions.

Under these circumstances the earth in movement in its orbit, at the rate of about 1000 miles a minute, would be sweeping through them all the year round, and we should get the appearance of a shooting-star or the fall of a meteorite every day in the year. Careful observations in climates most convenient for these researches, where the sky is freest from cloud and is purest, show, as we have seen, that there is not only no night but no hour without a falling star. We are therefore justified in considering that practically the part of the solar system which is swept through by the earth is not a vacuum, not empty space, but space peopled with meteorites here and there.

If these meteoritic bodies are equally distributed and are going in the same direction as the earth, but moving more quickly, they would follow and catch the earth; if they were travelling in the same direction as the earth, but more slowly, we should overtake them, and the two sides of the earth separated by a plane at right angles to the tangent to the part of the orbit along which it is moving at the time (see Fig. 10) would experience a different condition. One side would be bombarded by the greater number of meteorites in the former case, while in the latter the forward half only would be affected. The assumption, however, is that they are travelling in all directions; hence the numbers which fall on the front hemisphere compared with those that fall on the opposite one—in other words, the numbers seen at sunrise as compared with those seen at sunset—must depend wholly on the velocity of the earth as compared with the mean velocity of the meteorites.

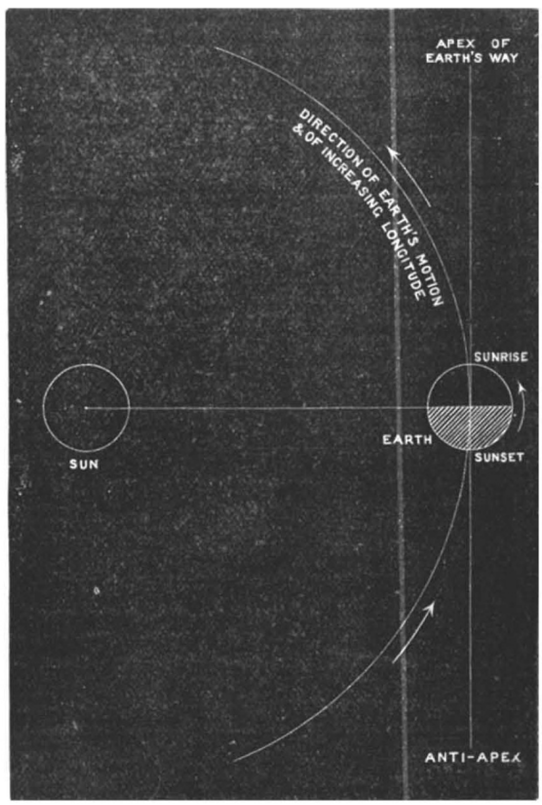

FIG. 10.

The point of space towards which the earth is travelling at any moment, shown in Fig. 10, has been called "the apex of the earth's way"; the point of space it is leaving the "anti-apex."[1]

[1] Continued from p. 559.

[2] "Recherches sur les Météores," p. 219 (Paris, 1859).

[3] *Monthly Notices*, vol. xvii. p. 148.

[1] These terms were suggested by Prof. Pritchard. In 1866, Schiaparelli suggested *point de mire*. Quite recently, Prof. Newton, of Yale, has suggested "goal" and "quit."

The apex of the earth's way is always 90° of longitude behind the sun.

Having, then, this general view of the movement of the earth in her orbit, we are in a position to discuss Mr. Bompas's argument, and we cannot do better than use the explanation given by Prof. Pritchard to the Royal Astronomical Society in 1864,[1] which really possesses an historical interest.

"Our object is to show that this hypothetical uniformity of distribution, combined with the direction and amount of the earth's motion, will have a very sensible effect on the number of meteors actually visible at a given place, at a given hour of the night, as explained (in a somewhat different way) by Mr. Bompas [and at a given season of the year, as extended by Mr. Herschel].

"For the purpose of illustration, suppose H O R (Fig. 11) to represent a flat umbrella, of which N O is the stick; suppose, also, rain to fall upon it equally, and in all directions: then, if the umbrella be at rest, as much rain will fall upon its front, looking from Z, as on its back, from N.

"But now suppose the umbrella itself has a motion from O to E in a given time, and, for the simplicity of first conception, let O E represent also the uniform velocity of the rain: very much more rain will now fall on the front of H O R, and much less on the back of H O R, than before. In fact, if O *m* be taken = O E,

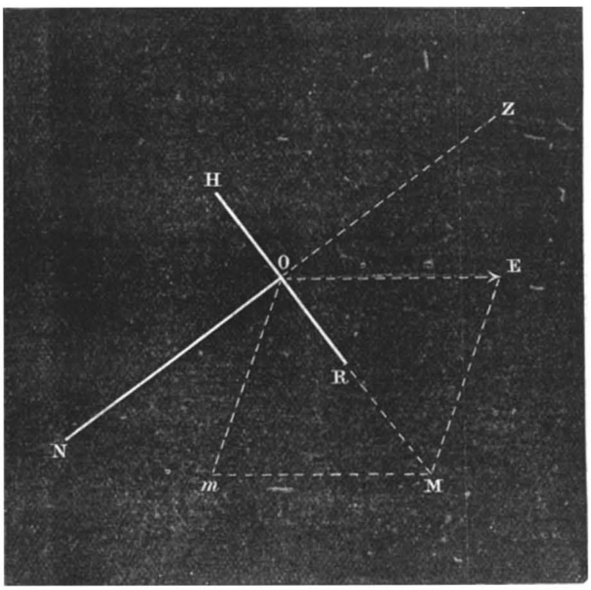

FIG. 11.

and the angle *m* O R be made = R O E, and the parallelogram *m* E be completed, then a raindrop, of which *m*'s real path is M E, would, by the motion of H O R, just graze along the front surface of H O R in the direction M R O, when it arrives at E. Moreover, all the rain which at the beginning of the motion was moving within the angle *m* O R, which would have fallen on the back of H O R at rest, will now fall on the front of H O R, if in motion.

"The application of this hypothetical case to that of meteors is obvious. H O R now represents the horizon, Z the zenith of an observer, and O E the direction and magnitude of the earth's orbital motion. The earth's diurnal motion of rotation is comparatively too small to be taken into account for our present purposes. So long, then, as O E, the direction of the earth's orbital motion, is in front of the horizon of an observer, there will thereby occur to him an additional flow (and partial combustion) of meteors against the earth's atmosphere above him; and this increased flow will become the greater as the angle R O E becomes greater. If O E be below H O R, then the number of visible meteors will thereby be diminished."

Now, if we refer to Fig. 10 we shall see that the observer does not reach the forward part of the earth (with reference to the apex of the earth's way) till midnight, and that the apex rises gradually till it is on his meridian at sunrise.

[1] *Monthly Notices*, 1864, vol. xxiv. p. 133.

Here, then, is the reason why the number increases from sunset to sunrise, based upon the theory of their cosmical origin, and really explainable in no other way.

Now for the yearly conditions as revealed by observation.

Dr. Julius Schmidt, the Director of the Observatory at Athens, observed, between the north latitudes of 49°·5 and 54°·2, during eight years from 1843 to 1850, on an average 470 meteors in every year. These were distributed among the several months as follows, taking an average of the entire series:—

Month.	Shooting-stars.	Total Shooting-stars.
July	49	
August	188	
September	41	... 400
October	37	
November	54	
December	31	
January	17	
February	5	
March	11	... 70
April	11	
May	12	
June	14	
	Total ...	470

Prof. A. Herschel was the first to point out that this yearly difference, as well as the daily difference in the hourly numbers, arrived at by Coulvier-Gravier, demonstrated the cosmical origin.

In 1864 he wrote as follows, assuming that the meteorites travelled faster than the earth:—[1]

"A season of frequency of aërolites, shooting-stars, and bolides, must be expected to succeed, in all latitudes, three months later than the summer season of the sun; but, on the other hand, a dearth of meteors, in the spring, one quarter of a year later than mid-winter. In general, and in all latitudes, the meteoric seasons, or seasons of meteoric frequency, must strictly follow the tropical seasons, and three months later in the year. Thus, in the earth's northern hemisphere, the Northern Pole remains directed to the sun from the equinox of March until that of September, and to the course of meteors from the solstice of June to the solstice of December. The greatest frequency of the meteorites will fall about the equinox of autumn, in September and October. This most nearly agrees with the European observations. The meteoric season of Arago may, therefore, be drawn as a consequence from his planetary hypothesis, if it be permitted to change the limits which he assigns to it by a small quantity—namely, from the Earth's apsides to its solstices in its orbit.

"The same fact, which appears strongly marked with regard to shooting-stars in the eight years' summary of Dr. Schmidt, is found repeated in a striking manner in the existing 'Northern Catalogues of Star-showers, Fire-balls, and Aëroliths.' The following references may be taken as examples:—

Appearances.	Number—July to December.	Number—January to June.
Star-showers from 1800 B.C. In M. Quetelet's catalogue ("Physique du Globe," 1861)	72	28
Aerolitic meteors, from the Christian era. In Mr. Greg's catalogue (British Assoc. Report, 1860) . .	216	186½
Large and small fire-balls. In same catalogue (*ibid.*) .	843	553."

It was now pointed out, by Newton[2] and Schiaparelli,[3] that, provided the actual facts of the daily and yearly variation were sufficiently assured, the true velocities of these bodies in space could not be just simply similar to the earth's velocity, nor their paths in space planetary orbits like that of the earth, and of about the same dimensions; but that as their motion was much faster their orbits would be variously distributed parabolas, and they would consequently be more akin to comets.

That the movement was really much faster was argued in

[1] *Monthly Notices*, vol. xxiv.
[2] *Silliman's Journal*, vol. xxxix., 1865; *Nat. Acad. Sci.*, vol. i.; *Annuaire de l'Observatoire de Bruxelles*, 1866, p. 201.
[3] *Les Mondes*, vol. xiii.

1865, from the duration of the flight of shooting-stars, by Prof. Newton.[1]

From Wartmann's observations of the duration of the flights of 368 shooting-stars at Geneva during one night by six observers, a mean was found of 0·49s. for each flight. The mean of 499 estimates made in August and November 1864 is 0·418s. The mean duration of the 867 flights is 0·45s.

Prof. Newton remarks:—"A mean duration of half a second, and a mean length of path between 39 and 65 kilometres, imply a mean velocity between 78 and 130 kilometres per second. The smallest of these (more than 48 miles) is twice and a half the velocity of the earth in its orbit about the sun. This cannot consist with the supposition that most of the meteoroids move in closed orbits about the sun."

Both the briefness, however, of this assumed duration, and even the least limit, accordingly, of the velocity so found, were presumed by Prof. Newton to be probably overrated.

The final step in this demonstration was taken by Schiaparelli, but before this Newton had distinctly shown that most of the meteors visible were not single in their movements round the sun, but that they belonged to systematic streams and that these streams were not rings.

With special reference to the November ring, Prof. Schiaparelli[2] came to the conclusion that the orbit, instead of being nearly circular, as Newton had at first supposed, was very elongated, like those of comets; and Prof. Adams[3] demonstrated shortly afterwards that, among several possible periods of the stream which Prof. Newton had already indicated, the true period was 33·25 years, the demonstration depending upon the increase of the longitude of the node by the action of the planets Jupiter, Saturn, and Uranus, the calculated increase amounting to 28′, while the actual increase was 29′, and he gave the following elements of the orbit of the swarm—

Period	33·25 years (assumed)
Mean distance	10·3402
Eccentricity	0·9047
Perihelion distance...	0·9855
Inclination	16° 46′
Longitude of node	57·28
Distance of perihelion from node...	6·51

Motion retrograde.

Aided by considerations suggested by observations of the conditions under which the meteors were observed—from a particular part of the sky, in a particular part of the earth's orbit, at a particular time and from a particular point of the earth's surface, we can understand at once that it was as practicable to determine the orbit of the swarm as it is to determine the orbit of a planet or of a comet.

The final step taken by Schiaparelli, to which we have referred, was a demonstration that the orbits of certain of these streams or swarms, to which reference has been made, were really identical with the elements of known comets.

Schiaparelli computed the elements of the orbit of the August meteors, supposing them to be moving along a cometary or parabolic orbit. For his calculations the data were the radiant in R.A. 44°, N. Decl. 56°, the time of the earth passing near the centre of the group in 1866, August 10·75. With the elements thus obtained he found those of the comet 1862 III., according to the latest determinations by Oppolzer,[4] to be nearly identical, as is seen in the following statement:—

	Elements of August Meteors.		Elements of Comet 1862 III.
	° ′		° ′
Long. of perihelion	343 38	...	344 41
Long. of node	138 16	...	137 27
Inclination	64 3	...	66 25
Perihelion distance	0·9643	...	0·9626
Motion	retrograde	...	retrograde
Perihelion passage	July 23·62	...	Aug. 22·9, 1860
Period			123·4 years

As remarked by Prof. Newton,[5] we come thus to the unexpected conclusion *that the comet of* 1862 *is nothing else than one of the August meteoroids, and probably the largest of them all.*

[1] *Silliman's Journal*, vol. xxxix. p. 203.
[2] *Bulletino Meteorologico dell' Osservatorio del Collegio Romano*, vol. v. 1866.
[3] *Monthly Notices*, vol. xxvi. p. 247, April 1867.
[4] *Astr. Nach*, No. 1384. [5] *Silliman's Journal*, vol. xliii., 1867.

When this relation of the comet of 1862 with the August meteors was discovered by Schiaparelli, no comet was known having similar relations with the November meteors. Oppolzer, however, shortly after,[1] published a corrected orbit of comet 1866 I., and the resemblance of its elements to those of the orbit of the November group was at once obvious, and attracted the attention of several astronomers.[2] The following table gives the details:—[3]

	Nov. Meteors.		Comet 1861 I.
Perihelion passage ...	Nov. 10·092, 1866	...	Jan. 11·160, 1866
Passage of descending node	,, 13·576		
	° ′		° ′
Long. of Perih. ...	56 25·9	...	60 28·0
,, ,, asc. node ...	231 28·2	...	231 26·1
Inclination	17 44·5	...	17 18·1
Perihelion distance ...	0·9873	...	0·9765
Eccentricity	0·9046	...	0·9054
Semi-major axis ...	10·340	...	10·324
Periodic time	33·250	...	33·176
Motion	retrograde	...	retrograde

Since this discovery of Schiaparelli's, one by one the various star showers have been shown to be due to meteorite swarms pursuing generally elliptic orbits round the sun, which orbits are identical with those of various known comets. Hence each "radiant point" is already, or will subsequently be, associated with a comet.

Distribution of Meteorites in the Solar System.

The *vide planétaire* is now ultimately abolished, and we find the solar system to be a meteoritic *plenum* in which sporadic meteorites and swarms of greater or less density are moving in orbits more or less elongated round the sun.

The demonstration that meteorites are extra terrestrial bodies has been followed by researches which, as they have become more complete and searching, have gradually driven men of science to increase their estimates, till at last the numbers acknowledged to exist in what was formerly supposed to be empty space have become enormous.

First as to the sporadic meteorites.

Observations of sporadic falling stars have been used to determine the average number of meteorites which attempt to pierce the earth's atmosphere during each twenty-four hours. Dr. Schmidt, of Athens, from observations made during seventeen years, found that the mean hourly number of luminous meteors visible on a clear moonless night by one observer was fourteen, taking the time of observation from midnight to 1 a.m.

It has been further experimentally shown that a large group of observers who might include the whole horizon in their observations would see about six times as many as are visible to one eye. Prof. H. A. Newton and others have calculated that making all proper corrections the number which might be visible over the whole earth would be a little greater than 10,000 times as many as could be seen at one place. From this we gather that not less than 20,000,000 luminous meteors fall upon our planet daily, each of which in a dark clear night would present us with the well-known phenomenon of a shooting-star.

This number, however, by no means represents the total number of sporadic meteorites that enter our atmosphere, because many entirely invisible to the naked eye are often seen in telescopes. It has been suggested that the number of meteorites if these were included would be increased at least twenty-fold; this would give us 400,000,000 of meteorites falling in the earth's atmosphere daily.

If we consider only those meteorites visible to the *naked eye* as sporadic meteors or falling stars, and if we further assume that their absolute velocity in space is equal to that of comets moving in parabolic orbits, Prof. H. A. Newton has shown that the average number of meteorites in the space that the earth traverses is in each volume equal to the earth about 30,000. This gives us as a result in round numbers that the meteorites are distributed each 250 miles away from its neighbours.[4]

[1] *Astr. Nach.*, No. 1624.
[2] Peters, *Astr. Nach.*, No. 1624; Oppolzer, *ibid.*, No. 1626; Schiaparelli, *ibid.*
[3] *Bulletino Meteor.*, February 28, 1867.
[4] Article "Meteorites," Prof. Newton, "Encyclopædia Britannica," 9th edition, vol. xvi.; and "Abstract of a Memoir on Shooting-Stars," by Prof. Newton (*Silliman's Journal*, vol. xxxix., 1865).

Next as to systematic meteorites, those, that is, that are massed in swarms.

Much still remains to be done before their greater density is known. Prof. Newton has calculated that in the Biela swarm the meteorites are thirty miles apart.

J. NORMAN LOCKYER.

(*To be continued.*)

DR. JANSSEN ON THE SPECTRUM OF OXYGEN.

THE following is an abstract of the account given by M. Janssen, in Section A of the British Association, of his researches into the different forms of oxygen, in the direction of an inquiry into the molecular constitution of that element. These experiments have been made in the laboratory which has been organized under Dr. Janssen's supervision, and at the expense of the French Government, at Meudon. The hall in which the observations have been carried out is 100 metres in length. It contains every requisite for studying the optical properties of gases; principally instruments so constructed that a long column of gas may be examined under a high pressure. One of these is a set of steel tubes varying in length from 0·42 metres to 60 metres, terminated at each end by a glass plate, perpendicular to their axes, and constructed to resist a pressure of 200 atmospheres. The chief result of this work was the discovery of a new law of the selective absorption by oxygen of any beam of light, quite independently of its origin, whether from the sun or the electric light. It was proved that oxygen produces two kinds of absorption-phenomena on the spectrum of the light—first, the known rays; and, secondly, a system of dark bands which had not, up to this time, been noticed. M. Janssen has demonstrated that the intensity of the rays varies as the products of the length of the column into the density; while that of the bands varies as the products of the length of the column into the square of the density. The principal results obtained by M. Janssen are best displayed in the following table:—

1. Metres.	2. Atmospheres.	3. Atmospheres.	4. Atmospheres.
60	6	6	6
20	10 to 12	10·4	18
5	23	20·7	72
1·47	38	38·3	240
0·75	50 to 55	53·6	480
0·42	70 to 75	71·7	858

1. Length of the tube.
2. Pressure observed.
3. Pressure calculated by formula Ld^2 (product of length of column into the square of the density).
4. Pressure calculated by the formula Ld.

These numbers are fixed by the point at which the band in the yellow first appears, this phenomenon supplying the standard term of comparison. It is easy to see how nearly the observed results in the second column agree with the figures in the third, and how far they differ from those in the fourth. The law of the square has been discovered by an analytical method, which will be published in full in the Proceedings of the British Association. Dr. Janssen has proved the exactness of this law in its application to the oxygen contained in the atmosphere, in measuring the altitude of the sun necessary for the first appearance of the band. He verified the same law by experiments on oxygen in its liquid state, and found that a thickness of 4 to 5 millimetres was sufficient. The correctness of this law must be considered as valid from 0 to 700 atmospheres. For the flutings of the group B the law of variation according to the formula Ld has been verified from 0 to 100 atmospheres by direct observation of the tubes. It is curious to notice how by the systematic variation of length of column and density it is possible to obtain either lines without bands, bands without lines, or bands and lines together. Among the astronomical applications of this law it is noted that a nebula which might have a diameter of 2000 times the distance of the earth from the sun, containing oxygen at a density of one-millionth of an atmosphere, could be traversed by the light of a star without causing the appearance of oxygen-bands in the spectrum. M. Janssen stated that he is still pursuing these investigations, and others attendant thereon, relative to the molecular construction of oxygen and its presence in the atmosphere of the planets.

At the conclusion of Dr. Janssen's paper, Sir Wm. Thomson recapitulated the main facts to the audience, stating his opinion that the discovery of the law of the square of the density was a most brilliant achievement.

THE GROWTH OF ROOT-CROPS.[1]

THIS is a pamphlet of extremely closely written matter, which purports to be a lecture delivered on July 27, 1887, to agricultural students in Cirencester College. Viewing it as a lecture we should accord it qualified praise, because a lecture must be regarded as oral instruction, and ought to be sufficiently dilute and sufficiently *moist* to allow of the process of mental deglutition. The pamphlet is really a treatise upon the effect of fertilizers on the growth of roots and their composition, and it would be presumption on our part to do more than bow respectful acquiescence to each statement made by so learned and so experienced a specialist.

Dr. Gilbert has studied turnips ever since 1843, and probably long before then, and his knowledge of their habits, their requirements, and their uses, is unequalled by that of anyone else in this country. Anyone who will read through the pamphlet now before us will find his ideas with regard to these esculents enlarged and dignified. Dr. Gilbert chiefly treats his subject from a chemical point of view—the fertilizers best suited for producing a crop, and the composition of the crop after it is grown. The extraordinary dependence of the turnip upon artificial help is shown by many tables, and the erroneous idea that the turnip acts as a *renovator* or restorer of fertility is exposed and disproved. If any crop is capable of completely exhausting a soil of all its available fertility, it is a turnip crop manured with superphosphate of lime. So far from being a renovator it is a waster. Still, circumstances control cases, and the special circumstances which accompany turnip cultivation are of an ameliorating sort. True, if your turnip is sold off the farm it may be looked upon by the landowner as a burglar making off with his goods and chattels, but consumed "on the premises" it yields up its wealth and becomes beneficent. Like John Barleycorn, it springs up again after ever such rough usage, and its spirit lives in succeeding corn crops.

The superiority of swedes over turnips is shown by the much smaller proportion of leaf existing in them in comparison with white turnips; and also in the larger proportion of dry matter in the root. White turnips, especially when dressed with nitrogenous matter, gave 600 parts in weight of leaf to 1000 of root. Swedes gave under similar circumstances 228 parts of leaf to 1000 of root. White turnips were found to contain from 7·66 to 8·54 per cent. of dry matter, while swedes contained from 10·83 to 12·04 per cent. of dry matter. In both swedes and turnips the effect of superphosphate of lime in increasing the crop is remarkable when there is a sufficient stock of nitrogen in the soil. A single crop will, however, deplenish the excess of nitrogen, and fresh applications of superphosphate will not act with the same energy. Take, for example, the series of root-crops grown in rotation with other crops, but recurring at intervals of four years in 1848, 1852, 1856, &c. The portion unmanured yielded 9 tons per acre the first year, but the fifth, ninth, thirteenth, and seventeenth, it only yielded from helf a ton to one ton per per acre. Similarly, superphosphate gave a crop of 14½ tons in 1848, and of 11 tons in 1852; but in 1856, 1860, and 1864, the yields produced by the same top dressing varied from 1½ to 6¾ tons per acre. In no crop more than in the turnip crop is a full supply of nitrogenous and mineral plant foods more essential, and hence the importance of farm-yard manure for its thorough development.

But the most interesting portion of the lecture is the second part, in which the effect of fertilizers upon the proportion of sugar and albuminoids in root-crops is dealt with. The effect of nitrogenous dressings in increasing the power of the plant to take carbon from the air, and especially to elaborate it into sugar, is much enforced. It is, however, evident that the effect of the nitrogenous manure, especially in the case of mangel-wurzel, consists in increasing the crop, and the crop being increased the amount of sugar and dry matter generally, will naturally increase also. So far indeed as percentage goes, it is higher where no nitrogenous manure is used than in any other cases. In fact, wherever nitrogenous manures are employed, the percentage of sugar is

[1] "The Growth of Root-Crops," by J. H. Gilbert, M.A., LL.D., F.R.S., Sibthorpian Professor in the University of Oxford.