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EXPERIMENTS ON THE GROWTH OF WHEAT.

The Rothamsted Experiments on the Growth of Wheat, Barley, and the Mixed Herbage of Grass Land. By William Fream, B.Sc. Lond., LL.D., Professor of Natural History in the College of Agriculture, Downton. (London: Horace Cox, *Field* Office, 1888.)

THE long series of reports which have emanated from Rothamsted since 1847, and which lie buried to most readers in the Journals of the Royal Agricultural Society, as well as in those of our more purely learned Societies, have long needed an editor. Back numbers of serials are not particularly attractive to the modern reader. The laborious papers by Sir John Lawes and his indefatigable colleague Dr. Gilbert would have run some little danger of being buried alive had not an able editor and exponent been found. Happily, Dr. Fream possessed the necessary knowledge and discrimination for this task, and, with the entire concurrence of the original investigators, the upshot is a valuable digest of a certain section of the results obtained—namely, those relating to the cereals and the grasses. The volume is adapted for reference rather than for rapid reading, although the sections upon the influence of climate on the cultivation of wheat, and upon the home produce, imports, and consumption of wheat, are less close in fibre, and may be scanned with greater ease. The book is, in fact, rather for students than for the omnivorous reader, but nevertheless appeals to a very large constituency. All landlords, land agents, and farmers, as well as agricultural students (now a numerous class), will welcome it as giving, in a compendious form, and in digested condition, matter which is scattered through many periodicals.

The results of continuous wheat and barley growing year after year upon the same land—without manure of any kind, with annual dressings of dung, with annual dressings of nitrogenous manures, with annual dressings of mineral manures, and with annual dressings of mixed nitrogenous and mineral manures—are all given. The fact that wheat and barley have been grown for forty years in succession without manure upon the same land, while the entire straw and grain have been removed, is in itself striking, and still more singular is it that the average produce during all these years is equal to the average yield of Australia, and exceeds that of many of the United States of America. It is also noteworthy that the yield of the last crop comprised in these reports—that of 1883—is 13¾ bushels per acre, or within one-fourth bushel of the average during the entire period of forty years. With regard to manures, minerals alone have added very slightly to the unmanured produce; whereas, manures containing nitric acid alone, or some easily nitrifiable compound of nitrogen, have considerably increased the crop. Manures consisting of potash, phosphoric acid, and nitrogen in the form of ammonia salts or nitrates, are able to grow heavy crops of wheat continuously. It is clearly shown that such compounded fertilizers, containing both the mineral and nitrogenous constituents of plant food, can grow crops superior to what are produced by annual dressings of fourteen tons per acre of farmyard manure. Also the proportion of the nitrogen applied which is made use of by the growing crops is much higher in the case of the artificial fertilizers than in the case of the farmyard manure. A larger proportion, in fact, of the nitrogen applied is recovered by the crop in the case of the artificial dressings. On the other hand, the residuary effect of nitrogen applied in combination with carbon (as in farmyard manure) is much greater than in the case of applications of prepared salts of ammonia or of nitric acid.

The ease with which fertility can be kept up by artificial applications forms, in the opinion of many agriculturists, a reason for discarding the more cumbrous method of keeping up the fertility of land by means of live stock and the dung-cart. But it must be remembered that no artificial manure accumulates fertility in a soil like farmyard manure, and its nitrogen, being liberated gradually, is available over a long series of years, and especially so at those seasons of the year in which vegetation is most in need of it.

The grass experiments are of great interest. First, we have the different quantities of hay produced by various dressings of manurial substances; but more remarkable are the changes brought about in the species of grasses predominating on various plots by the influence of fertilizers applied during a long series of years. On the plot, for example, to which ammonia salts have been continuously applied for thirty years, the total number of the species originally extant has been much reduced, three-quarters of the produce being composed of *Festuca ovina* and *Agrostis vulgaris*. The leguminous herbage has disappeared. On the plot manured continuously with superphosphate, the number and relative predominance of the plant species is much the same as without manure, with a prevalence of *Lathyrus pratensis* among the Leguminosæ, and an increase of *Ranunculus repens*, *R. bulbosus*, *Achillea Millefolium*, and *Rumex Acetosa*. Again, when ammonia salts and mixed mineral manures are applied, *Poa pratensis* becomes the prevailing grass. These examples must suffice to show the great changes wrought by continuous applications, and the principle of the survival of the fittest under regulated alterations of the environment.

Complicated and multifarious as are these experiments, the general conclusions for the guidance of agriculturists are reducible to a few simple deductions. Thus the superior excellence of nitrate of soda as a fertilizer for cereals and for grasses is distinctly shown. The necessity of nitrogenous manures, such as nitrate of soda and ammonia salts, as means of bringing out or developing the effect of the so-called mineral manures, such as potash and phosphates, is constantly proved. The comparatively small value of many constituents of plants (owing to their already existing in sufficient quantities in most soils), such as soda, magnesia, and silica, is also placed beyond doubt. The residual effect of farmyard manure, and its consequent power of not only keeping up but indefinitely increasing the fertility of a soil, are points greatly in its favour; while the slowness of its action, and the very small proportion of its nitrogen which appears to be recoverable at any particular time, are considerations which weigh against it. The residual effect of mineral dressings applied many years ago as affected and brought out by continuous dressings of nitrogenous manures is another significant fact; while the evanescent effect of nitrates applied as salts contrasts unfavourably with the continued effects of nitrogenous matter in organic combination with carbon. Prof. Fream's book is a substantial addition to agricultural literature, and it is satisfactory to find that the editing of such important results has been carried out, with the "kind and ready" assistance of Sir John Lawes and Dr. Gilbert, by one who brings sound scientific attainments to bear upon a stupendous number of observations made during a series of forty years. There is room for a second, if not a third volume, as the experiments upon the cultivation of the root crops, the leguminous crops, and the elaborate researches made at Rothamsted upon the fattening of animals, are not touched in this first instalment.

THE JAPANESE VOLCANIC ERUPTION.

THE *Times* of Tuesday contains a long letter from its Japan Correspondent describing the scene of the recent volcanic explosion in the Bandai-san region in Northern Japan. This is the first account by a foreign eye-witness that has reached the outside world. The writer appears to have started immediately from Tokio for the scene of the disaster, where he spent four days going carefully over the ground, examining the phenomena connected with the outburst, and hearing the stories of the survivors. The communication which is the result of these investigations, and which was evidently written while the powerful impression left by the scene of awful desolation was still fresh in the writer's mind, is probably one of the most graphic and detailed accounts of the immediate results of a stupendous volcanic explosion that has ever been published. Bandai-san is a mountain about 5800 feet high, and has shown no sign of activity for about eleven hundred years. On its north-eastern flank was a subordinate peak known as Little Bandai-san, which rose directly above a group of three solfataras.

At about 8 o'clock on the morning of July 15 (here, as throughout almost the whole of this article, we quote the *Times* Correspondent), almost in the twinkling of an eye, Little Bandai-san was blown into the air and wiped out of the map of Japan. A few minutes later its *débris* had buried or devastated an area about half the size of London. A dozen or more of upland hamlets had been overwhelmed in the earthen deluge, or wrecked by other phenomena attending the outburst. Several hundreds of people had met with sudden and terrible death. Scores of others had been injured; and the long roll of disaster included the destruction of horses and cattle, damming up of rivers, and laying waste of large tracts of rice-land and mulberry-groves. A small party was organized in Tokio to visit the scene. As the travellers approached the mountain, they were told that twenty miles in a straight line from Bandai-san no noise or earthquake was experienced on the 15th, but mist and gloom prevailed for about seven hours, the result of a shower of impalpable blue-gray ash, which fell to a depth of half an inch, and sorely puzzled the inhabitants. An ascent of about 3000 feet was made to the back of the newly-formed crater, so as to obtain a clear view of it and of the country which had been overwhelmed. Only on nearing the end of the ascent were they again brought face to face with signs of the explosion. Here, besides the rain of fine gray ashen mud which had fallen on and still covered the ground and all vegetation, they came upon a number of freshly-opened pits, evidently in some way the work of the volcano. Ascending the last steep rise to the ridge behind Little Bandai-san, signs of the great disaster grew in number and intensity. "Fœtid vapours swept over us, emanating from evil-looking pools. Great trees torn up by their roots lay all around; and the whole face of the mountain wore the look of having been withered by some fierce and baleful blast. A few minutes further and we had gained the crest of the narrow ridge, and now, for the first time, looked forth upon the sight we had come to see. I hardly know which to pronounce the more astonishing, the prospect that now opened before our eyes or the suddenness with which it burst upon us. To the former, perhaps, no more fitting phrase can be applied than that of absolute, unredeemed desolation—so intense, so sad, and so bewildering, that I despair of describing it adequately in detail. On our right, a little above us, rose the in-curved rear wall of what, eight days before, had been Sho-Bandai-san, a ragged, almost sheer, cliff, falling, with scarce a break, to a depth of fully 600 feet. In front of this cliff everything had been blown away and scattered over the face of the country before it in a roughly fan-shaped deposit of for the most part unknown depth—deep enough, however, to erase every landmark and conceal every feature of the deluged area. At the foot of the cliff, clouds of suffocating steam rose ceaselessly and angrily, and with loud roaring, from two great fissures in the crater bed, and now and then assailed us with their hellish odour. To our eyes, the base denuded by the explosion seemed to cover a space of between three and four square miles. This, however, can only be rough conjecture. Equally vague must be all present attempts to determine the volume of the disrupted matter. Yet, if we assume, as a very moderate calculation, that the mean depth of the *débris* covering the buried area of thirty square miles is not less than 15 feet, we find that the work achieved by this last great mine of Nature's firing was the upheaval and wide distribution of no fewer than 700,000,000 tons of earth, rocks, and other ponderous material. The real figure is probably very much greater."

The desolation beyond the crater, and the mighty mass thrown out by the volcano which covered the earth were almost incredible. "Down the slopes of Bandai-san, across the valley of the Nakasegawa, choking up the river, and stretching beyond it to the foot-hills five or six miles away, spread a vast billowy sheet of ash-covered earth or mud, obliterating every foot of the erstwhile smiling landscape. Here and there its surface was dotted or streaked with water. Elsewhere the eye rested on huge disordered heaps of rocky *débris*, in the distance resembling nothing so much as the giant concrete block substructure of some modern breakwater. It was curious to see on the farther side the sharp line of demarcation between the brown sea of mud and the green forests on which it had encroached; or, again, the lakes formed in every tributary glen of the Nakasegawa by the massive dams so suddenly raised against the passage of their stream waters. One lake was conspicuous among the rest. It was there that the Nakasegawa itself had been arrested at its issue from a narrow pass by a monster barrier of disrupted matter thrown right across its course. Neither living thing nor any sign of life could be descried over the whole expanse. All was dismally silent and solitary. Beneath it, however, lay half a score of hamlets, and hundreds of corpses of men, women, and children, who had been overtaken by swift and painful deaths."

Near by two houses, built for the accommodation of visitors to the hot springs were overwhelmed, and a little lower down two spa-hamlets were absolutely buried in mud. From various indications, especially a comparison of the places destroyed with those saved, it appears that the disruptive force must, in the main, have been directed outwards from the hill-face at a considerable inclination to the vertical. On no other hypothesis is it possible to account for some of the most startling phenomena, for the great distances reached by the waves of *ejectamenta*, and for the incredibly brief intervals that elapsed between the short-lived explosion and the submersion of large tracts many miles away from the crater. It must not, however, be supposed that the havoc wrought by the volcano's fury was limited to the fall of disrupted matter, or to the area covered by it. Besides the rain of scalding earth and mud, heated rocks and stones, sand, and hot softly-falling ashes, there were the awful shocks of the explosion, accompanied by winds or whirlwinds, which every survivor describes as of intense and extraordinary vehemence. Nowhere, of course, were the effects of these concomitants more fierce than on the heights of Bandai-san. The forests on the unburied slopes above and near the crater presented a weird spectacle. In these hardly a stick was left standing. As if some giant reaper had mown down whole acres with a sweep of his sickle, the trees lay literally in hundreds on the ground, all felled in a direction away from the crater, stripped of branches, leaves, and even of their bark, and twisted into the most grostesque contortions.

One day was given to exploring the buried area at its lower levels in the valley of the Nakasegawa, and also the outskirts of the volcanic deluge. At one place, a secondary earth-wave, issuing from the crater by a lateral gap, had rushed swiftly down the mountain-side, burying a large party of grass-cutters and horses, and reaching, but only half destroying, the little hamlet of Mine. Its energy seems to have exactly spent at this point. It was strange to see the great wall of earth and stones, with its vertical face some 7 or 8 feet high, brought up all-standing, as it were, by a frail farm outbuilding. A yet stranger sight was it to see the enormous masses of rock that were strewn about on the surface of the neighbouring field of mud. One of them, which was measured, weighed at least 200 tons. Higher up, on the far side of the river, a couple of large villages, in which, though not reached by any mud-stream, not a house was whole, many had been levelled to the ground; others were tottering on the verge of destruction; and of the rest, all were cracked, mutilated, unroofed, twisted, tilted up, or otherwise injured or partially wrecked. A scene of more ruthless and utter desolation could hardly be conceived. Beyond this, the route entered upon the great earth-field visible from the heights of Bandai-san. Nothing could convey a more vivid idea of the destructive forces that were let loose upon that doomed region than a sight of the wild chaos of earth, rock, and mud which now reigns over its surface. The whole effect in some places is much as if a raging sea of those materials, on a gigantic scale, had been suddenly congealed and made to stand still. At one spot there is a long mud precipice, said by some observers to be fully 200 feet high.

Although the little village of Nagasaka was comparatively uninjured, nearly all its able-bodied inhabitants lost their lives in a manner which shows the extraordinary speed with which the mud-stream flowed. When Little Bandai-san blew up, and hot ashes and sand began to fall, the young and strong fled panic-stricken across the fields, making for the opposite hills by paths well known to all. A minute later came a thick darkness, as of midnight. Blinded by this, and dazed by the falling *débris* and other horrors of the scene, their steps, probably also their senses, failed them. And before the light returned every soul was caught by a swift bore of soft mud, which, rushing down the valley bed, overwhelmed them in a fate more horrible and not less sudden than that of Pharaoh and his host. None escaped save those who stayed at home—mostly the old and very young.

From the stories told by the survivors, as well as from his own observations, the writer sketches the following sequence of events connected with the outburst:—

It seems clear from every account that one of the most terrible features of the catastrophe must have been its appalling suddenness. Though there had been, it is said, slight shocks of earthquake for a couple of days before, and, according to some witnesses, strange subterranean rumblings and suspicious variations in the temperature and volume of the hot springs, these caused no grave alarm. Nothing worthy to be called a serious warning occurred until about 7.30 a.m. on the 15th. Then came a violent earthquake, followed a quarter of an hour later by a second, yet more intense. Ten minutes after there ensued throes of such terrible severity that the ground heaved and fell, people were thrown down, and houses demolished or wrecked. To all it seemed that their last hour had come. Instantly upon this arose a fearful noise, described by some as like that of a hundred thunders, by others as the most unearthly sound that ever startled the ears of men. Little Bandai-san was seen to be lifted bodily into the air and spread abroad, and after it leaped forth tongues of flame and dense dark clouds of vapour of *ejectamenta*. Of the ensuing phenomena it is hard to gain any clear idea from the tales of the distracted survivors. Apparently, however, a quick succession of reports, accompanied by violent earth-throes and winds of hurricane force, lasted for about a minute. Then began the shower of ashes, dust, hot water, and leaves. The light quickly faded as the exploded matter spread over the firmament, so that day was soon changed into night, and did not return for a space of several minutes. Meanwhile, the avalanches of earth and mud must have already done much of their deadly work. The interval between the explosion and the arrival of the mud-torrent which swept past that hamlet cannot have been more than from ten to fifteen minutes. Before the light was restored, all the flower of the village had been swallowed up. How that long journey of some ten miles from the crater had been performed by the mud at such an astonishing speed it is impossible to say. There is evidence that in places the earth-flow lasted for about an hour. But in the above we have the clearest proof that some at least of the destroying matter was hurled over the country at railroad speed, even after being deflected through wide angles from its original line of motion.

We may, perhaps, hope to learn something hereafter that will throw a clear light on the immediate cause of the explosion (the agent, it cannot be doubted, was steam), on the approximate volume of the projected matter, on the partiality of the effects, and on the many and most bewildering mysteries connected with the propagation and distribution of the earth-waves, rocks, &c. Meanwhile we have before us the fact that a massive mountain peak has been blown to bits by an explosion within its bowels powerful enough to toss many hundred millions of tons of material high into the air, and to change the face of nature over an area of some thirty square miles. While whole forests were levelled by the shock, the disrupted matter dammed up rivers, deluged and drowned the land and crops, and buried a dozen hamlets. Earthquakes and *coups de vent* added their quota to the work of destruction. Nearly 600 people perished by horrible deaths in their mountain homes and valleys. Four times that number have been reduced to destitution or dire poverty. With one possible exception, it is the gravest disaster of its class that has happened, even in that land of volcanoes, since the famous eruption of Asamayama in 1783, and it cannot but be ranked among the most startling volcanic explosions of which history has any record.

It is interesting to know that experts are already at work investigating some of the problems here sketched out by the *Times* Correspondent, and happily Japan is well provided with experts in the science of seismology, at their head being Prof. Milne, the leading seismologist of the day. Seeing also the countenance given to the study of these phenomena by the Japanese Government, it may be anticipated that no volcanic eruption of modern times will have been so carefully and scientifically investigated as this of Bandai-san, as none has been so graphically and eloquently described.

CALCULATION OF RANGES, ETC., OF ELONGATED PROJECTILES.

FROM time to time it has been suggested to me that some reduction in the coefficients of resistance deduced from my experiments made in 1867–68, is required to adapt them for use in connection with the improved guns of more recent times. I do not agree with those suggestions. My coefficients were most carefully deduced from experiments made with ogival-headed shot fired at very low elevations so as to secure ranges of about 500 or 600 yards, and the observations were made near the gun. The 5-inch gun was a remarkably good gun, and from the numerous records it gave had a preponderating effect on the final result; while an unsteady shot cut only a few screens, and had a very trifling influence. It seems, therefore, that the coefficients were derived from shot moving very nearly in the direction of their axes. I have applied these coefficients to calculate ranges for comparison with Commander May's (R.N.) range-table for the 12-inch muzzle-loading gun (based on practice 1885); muzzle velocity, 1892 f.s.; "jump," 6 minutes.

Elevation		1°	2°	3°	4°	
Exp. range	...	1200	2267	3200	4057	yards.
Calc. range	...	1206	2249	3192	4039	,,
Difference	...	+6	−18	−8	−18	,,

I will now do the same for the 4-inch breech-loading gun, which was the gun chosen by the authorities to be used in testing my coefficients on a long range; muzzle velocity, 1900 f.s.; range-table founded on experiments made in 1884; "jump," 6 minutes.

Elevation		1°	2°	3°	4°	
Exp. range	...	1086	1811	2400	2917	yards.
Calc. range	...	1049	1817	2410	2895	,,
Difference	...	−37	+6	+10	−22	,,

Thus it appears that my coefficients give very satisfactory results when applied under the conditions of the original experiments. Commander May's table stops at a range of 4000 yards. As the elevation of the 4-inch gun was gradually increased, the calculated ranges fell shorter and shorter of the experimental ranges. At an elevation of 15° the calculated range was 6364 yards, and the experimental range 6608 yards, giving a difference of 244 yards. The explanation of this seems to me to be as follows:—

When an elongated shot is fired from a rifled gun at high elevations, the shot endeavours to preserve the parallelism of its axis. This causes the axis of the shot to become sensibly inclined to the direction of the motion of its centre of gravity. Thus the pressure of the air acts from below and raises the shot bodily, so as to give its trajectory an increased elevation. This would naturally increase the range of the shot. After a short time the shot inclines sideways, as explained by Magnus, and the shot continues to move with its axis inclined to the direction of its motion, which is the cause of the lateral "drift" of the shot. This shot having had its axis so much inclined to the direction of its motion, would encounter a greater resistance from the air than another shot fired at a lower elevation, because this latter would move with its axis more nearly in the direction of its motion.

Hence it is clear that, in order to apply any rational correction to the calculated ranges for high elevations, it would be necessary slightly to *increase* both (1) the elevation, and (2) the values of the coefficients of resistance.

Major Mackinlay, R.A., warns us that the published range-tables are not to be "blindly followed," a very necessary caution, when it is considered that we cannot be quite certain about the muzzle velocity, the "jump," the elevation, and the precise form of the head. The height of the barometer is seldom mentioned. My only surprise is that such good agreement between calculation and experiment should be found as above. The only question seems to be whether it is worth while to trouble about the correction of calculated ranges for high velocities and high elevations, when the reason for some little discrepancy is so evident. But to *reduce* coefficients would be to make matters worse.

Having been requested to calculate the range of a 9·2-inch shot weighing 380 pounds, fired at an elevation of 40° with a muzzle velocity of 2360 f.s., I could not feel satisfied till I had completed the calculation of a range-table for elevations 0° to 45° on a horizontal plane 27 feet below the muzzle. I give the result. Gravity and the temperature of the air were considered constant. The air was supposed to be at rest, and the shot was assumed to move in the direction of its axis; head ogival, struck with a radius of 1½ diameter. When the results of experiment are published I shall be ready to discuss the matter, but there are so many things uncertain at heights of 10,000, 15,000 feet, &c., that I doubt whether any theoretical advantages will result. It will, however, be interesting to know what can be done in an extremity.

It will be seen that the ranges go on increasing up to an elevation of 45°, and would probably go on beyond an elevation of 50° before reaching a maximum.

Elevation.	Range.	Height of Vertex.	Time of Flight.	Angle of Descent.		Striking Velocity.	Horizontal Striking Velocity.
°	Yards.	Feet.	Seconds.	°	′	f.s.	y.s.
0	969	0	1·3	1	4	2,154	718
1	2,115	25	3·0	1	35	1,931	643
2	3,416	94	5·1	2	47	1,708	569
3	4,611	237	7·1	4	20	1,528	508
4	5,600	343	9·4	5	52	1,399	464
5	6,475	517	11·4	7	38	1,291	426
6	7,271	716	13·4	9	30	1,200	395
7	7,999	937	15·3	11	28	1,128	368
8	8,669	1,180	17·1	13	28	1,075	349
9	9,291	1,445	18·9	15	28	1,040	334
10	9,876	1,731	20·6	17	23	1,022	325
11	10,430	2,036	22·3	19	9	1,015	320
12	10,952	2,360	23·9	20	54	1,009	314
13	11,448	2,703	25·5	22	38	1,003	309
14	11,922	3,065	27·0	24	21	998	303
15	12,379	3,443	28·5	26	2	993	297
16	12,804	3,835	30·0	27	40	990	292
17	13,217	4,242	31·5	29	15	987	287
18	13,618	4,663	33·0	30	48	985	282
19	14,007	5,099	34·4	32	19	984	277
20	14,385	5,550	35·9	33	48	984	273
21	14,750	6,015	37·3	35	15	985	268
22	15,103	6,489	38·8	36	40	987	264
23	15,445	6,970	40·2	38	3	990	260
24	15,775	7,459	41·6	39	24	993	256
25	16,092	7,956	43·0	40	41	996	252
26	16,398	8,461	44·4	41	54	1,000	248
27	16,691	8,974	45·7	43	2	1,004	245
28	16,973	9,494	47·1	44	6	1,009	242
29	17,242	10,022	48·4	45	7	1,014	239
30	17,501	10,558	49·7	46	5	1,019	236
31	17,747	11,102	51·0	47	1	1,025	233
32	17,981	11,654	52·2	47	56	1,031	230
33	18,203	12,214	53·5	48	50	1,037	228
34	18,413	12,782	54·7	49	43	1,044	225
35	18,612	13,357	56·0	50	35	1,051	222
36	18,799	13,941	57·2	51	27	1,058	220
37	18,973	14,534	58·5	52	18	1,065	217
38	19,136	15,136	59·7	53	8	1,072	214
39	19,287	15,747	61·0	53	58	1,079	212
40	19,426	16,368	62·2	54	47	1,086	209
41	19,553	17,001	63·4	55	36	1,092	206
42	19,668	17,646	64·7	56	24	1,099	203
43	19,772	18,302	65·9	57	11	1,105	200
44	19,864	18,969	67·1	57	57	1,111	197
45	19,944	19,648	68·3	58	43	1,117	193

F. BASHFORTH.

THE BRITISH ASSOCIATION.

BATH, *Tuesday Evening.*

SO far as numbers are concerned, the Bath meeting has been below the average. The number of tickets sold has been about 50 less than 2000. This is a marked contrast to last year's meeting, which beat the record; and is even less by some hundreds than the former Bath meeting. But then it should be remembered that that meeting presented attractions of an unusual kind: the lion-hunters who form so large a section of these annual gatherings had such prey presented to them as Livingstone, Burton, and Speke. As will be seen, the diminished attendance has told to some extent on the grants, several of which have had unfortunately to be reduced below the sums originally proposed and approved of. All sorts of reasons have been put forward to account for the comparatively small attendance, and probably there is a little truth in each. Probably the excursions have had as much to do with it as anything else; those of Saturday presented few attractions, except that to the Severn Tunnel and the Barry Docks. Curiously enough, however, scarcely anyone entered for that excursion, and had the enterprising secretaries of Section G not taken it in hand, it would have fallen through. As it was, it turned out one of the most successful of Saturday's excursions. Small as the attendance has been, the accommodation of the town has been strained, and several of the guests of the Local Committee speak somewhat disrespectfully of their quarters. But the Local Committee have done their best, and they have no reason to be dissatisfied with their success. The reception-room accommodation has certainly been limited, and members have missed the smoking-room, refreshment-rooms, and other amenities with which they were indulged at Manchester last year. Fortunately the weather has been, on the whole, good, so that people have not greatly felt the want of indoor accommodation. Notwithstanding the small attendance, the crush at the two *soirées* was excessive, mainly arising from the smallness of the Assembly Rooms. The Drill Hall has proved satisfactory for all the public lectures. Sir Frederick Bramwell's address was, as might have been expected, received with universal appreciation; while the public lectures were all well attended. Prof. Ayrton's address on the transmission of power was so highly appreciated that he has been asked to repeat it for the benefit of the working classes. Tickets for Sir John Lubbock's lecture to the "working classes" were so greatly in demand, that many of those for free distribution were being sold throughout the town at 2*s.* 6*d.* and 5*s.*

One of the great attractions at the present meeting has been the recently unearthed Roman baths. They are in almost complete preservation; the lead lining and lead piping nearly perfect, the steps, the columns, the carvings, in wonderful preservation, the whole probably forming a more complete specimen of this class of Roman work than exists anywhere else. Even greater, however, has been the excitement over the phonograph and graphophone. Crowds have been besieging Section G in order to see and hear the wonderful little cylinders; and daily receptions have been given both by Colonel Gouraud and Mr. Edmunds of the rival instruments. Each has its strong body of partisans, but the general result seems to be that law and not science will be the final arbiter of the merits of the two.

In the ordinary work of the Sections there have been various exciting episodes. The discussion between Sections B and D, on the chemistry of certain physiological processes, was one of great importance, and it is hoped it will be well reported. The discussion on stays and waist-bands was probably more entertaining than instructive; while that on coral-reefs, though valuable, suffered from the absence of some of the leading authorities on the subject. The discussion in Section H, on the few remarks by Mr. Park Harrison on the question "What is a Nation?" had somewhat of a political flavour about it. It was taken part in by General Pitt-Rivers, Sir John Lubbock, Prof. Sayce, and Dr. John Evans. Another discussion which, like the papers on the phonograph and graphophone, nearly emptied the other Sections, was that on lightning-conductors, on Tuesday, in Section G. These various discussions, combined with the fact that so many foreign geologists were present in Section C, have contributed to keep the second Bath meeting up to a good average.

It seems to be generally admitted that the Presidential Address in Section D, by Mr. Thiselton Dyer, was the weightiest from a scientific point of view. It was the longest, all the addresses this year being marked by brevity. Some little amusement has been caused by the very modified admission made by Sir William Thomson, in his paper in Section A, on "A Simple Hypothesis for Electro-magnetic Induction of Incomplete Circuits," that, after all, Clerk Maxwell may have been to some extent not altogether wrong.

The meeting next year will be presided over by Prof. Flower. Leeds will receive the Association in 1890, while Edinburgh and Cardiff compete for the honour of a visit in 1891; there can be little doubt of the result if the Corporation and the University of Edinburgh give snbstantial evidence of their zeal.

The following is the list of grants which have been allotted by the General Council:—

A.—*Mathematics and Physics.*	£
Ben Nevis Observatory	50
Electrical Standards	100
Electrolysis	20
Solar Radiation	10
Differential Gravity Meter	10
Uniform Nomenclature in Mechanics	10
Calculating Tables of Certain Mathematical Functions	10
Seasonal Variations in the Temperature of Lakes, Rivers, and Estuaries	30
B.—*Chemistry.*	
The Influence of the Silent Discharge of Electricity on Oxygen and other Gases	10
Methods of Teaching Chemistry	10
Oxidation of Hydracids in Sunlight	10
C.—*Geology.*	
Geological Record	80
Erratic Blocks	10
Volcanic Phenomena of Japan	25
Volcanic Phenomena of Vesuvius	20
Fossil Phyllopoda of the Palæozoic Rocks	20
Higher Eocene Beds of the Isle of Wight	15
Fossil Plants of the Tertiary and Secondary Beds of the United Kingdom	15
D.—*Biology.*	
Zoology and Botany of the West India Islands	100
Marine Biological Association	200
Flora of China	25
Naples Zoological Station	100
Physiology of the Lymphatic System	25
To Improve and Experiment with a Deep-sea Tow-net for opening and closing under Water	10
Natural History of the Friendly Islands	100
E.—*Geography.*	
Geography and Geology of the Atlas Ranges	100
F.—*Economic Science and Statistics.*	
Precious Metals in Circulation	20
Variations in the Value of the Monetary Standard	10
G.—*Mechanical Science.*	
Investigation of Estuaries by means of Models	100
Development of Graphic Methods in Mechanical Science	25

H.—*Anthropology.*	£
Effect of Occupations on Physical Development	20
North-Western Tribes of Canada	150
Editing a New Edition of Anthropological Notes and Queries	50
Calculating the Anthropological Measurements taken at Bath	5
Exploration of Roman Baths at Bath	100
Characteristics of Nomad Tribes of Asia Minor	30
For carrying on the Work of the Corresponding Societies Committee	20
Total	£1645

SECTION B.

CHEMICAL SCIENCE.

OPENING ADDRESS BY PROF. WILLIAM A. TILDEN, D.Sc. LOND., F.R.S., F.C.S., PRESIDENT OF THE SECTION.

A PART of the duty which devolves upon the President of a Section of the British Association consists in delivering an address, and the knowledge that a pretty full liberty of choice is permitted in regard to the selection of a subject is the only source of comfort which serves to alleviate the onerous nature of the task.

It seemed to me that the time is gone by when an attempt to review progress over the whole field of chemical science is likely to be useful or even possible, and an account of what is being done within the narrow limits of those parts of the science to which I have been able to give special attention would be ill-adapted to the character of a speech addressed to the members of the Section collectively. The fact that at the last meeting of the Association a Committee was appointed to inquire into the methods at present adopted for teaching chemistry suggested that, as I had not been able to accept an invitation to join this Committee, I might make use of this opportunity for contributing to the discussion. The first report of the Committee will be received with much interest by the Section. As might be expected, it embodies the expression of many varieties of opinion.

The existence of chemistry as a department of science not merely requiring the observation of facts that are to be made useful, but seeking in the accumulated stores of observation to discover law, is a thing of comparatively recent growth. How chemistry arose out of alchemy I need not remind you, but the connection between the study of chemistry and that of medicine, and the maintenance of this connection down to even the present generation, is illustrated by the fact that a large number of men who have become eminent as chemists began their career in the surgery or the pharmacy. Black, Davy, Berzelius, Wollaston, Wöhler, Wurtz, Andrews, and W. A. Miller began by the study of medicine, whilst Scheele, H. Rose, and the great names of Liebig and Dumas are to be found in the long roll of those who received their earliest notions of chemistry in the pharmaceutical laboratory. Chemistry has been gradually emancipated from these associations with enormous advantage to both sides. So long as technical purposes alone were held in view a scientific chemistry could not exist, but no sooner did the study take an independent form and direction than multitudes of useful applications of the facts discovered became apparent.

It is only within a comparatively few years, however, that universities, in this country at least, have ceased to deal with chemistry as a kind of poor relation or humble follower of medicine, and have permitted her to emerge from the cellars of a museum or school of anatomy and have given her a commodious dwelling in the fair light of day.

In the old time such instruction in chemistry as was given in the universities and mining or technical schools seems to have taken the form of lectures read by the Professor, and access to a laboratory for practical manipulation seems to have been a high privilege accorded only under exceptional circumstances to the few. We are told, for example, that when Liebig went to Paris in 1823 he applied to Gay-Lussac for practical instruction at first without success, and that admission to the laboratory of the Ecole Polytechnique was ultimately granted him only through the intervention of Von Humboldt.

In a great many cases the student of chemistry must have been almost entirely dependent upon private study, though books were scarce and materials more costly than now. Davy, for example, seems to have had no instruction whatever previous to his appointment as assistant to Dr. Beddoes at the Pneumatic Institute at Bristol.

Doubtless, therefore, the recollection of his own early difficulties when seeking instruction contributed largely to influence Liebig in the establishment of the laboratory in the University of Giessen, and in the adoption of the principles which guided his teaching there. For the first time in the history of chemistry students met not merely to listen to the discourse of a professor concerning his own experiments and conclusions, but to examine for themselves the basis of the theories taught, to learn the processes of analysis, and by independent investigation to extend the boundaries of existing knowledge.

The fame of the new school spread fast and far, and soon men from every part of the civilized world assembled to share in the advantages offered. The influence of the new method can be estimated when we reflect that nearly all the now passing generation of chemists in England and America obtained the greater part of their training in Liebig's laboratory; and as a large number of them have been teachers, it may be assumed that they transplanted into their own countries the methods they had learnt from the great German master.

It was not till 1846, long after the school at Giessen had risen into fame, that in England a sense of our deficiencies in respect to provision for teaching chemistry was felt strongly enough to lead to the establishment of a College of Chemistry. At that time the Professor of Chemistry at Oxford was also Professor of Botany. At Cambridge it was thought praise and boast enough that the occupant of the chair of chemistry had, during more than thirty years, frequently resided at the University and every year gave a course of lectures. The Jacksonian professorship was not then, as now, in the possession of a chemist. University College, London, had at this period a very distinguished man in the chair of chemistry, but it was only in 1848 that a commodious laboratory was provided by public subscription, raised in commemoration of the services of Dr. Birkbeck in promoting popular education. In that year Fownes was appointed to co-operate with Graham in the work of teaching, though his premature death soon after left but little time for the fulfilment of the rich promise of his earlier years. At Manchester, John Owens had died in 1846, leaving the bulk of his estate for the purpose of establishing a university in Manchester, but as yet the Owens College was not.

The foundation of the College of Chemistry in 1846 was therefore an event of supreme importance in the history of chemical teaching in this country; and though at the time some dissatisfaction was expressed at the choice of the professor selected to direct the work, who, though a distinguished pupil of Liebig, was not an Englishman, all British chemists now concur in believing the choice to have been a most fortunate one. The great majority of my contemporaries having begun, continued, or ended their studies in Oxford Street, they and all who have come under Dr. Hofmann's teaching know how vast was his capacity for work and how marvellous was the power he possessed of communicating his own enthusiasm to his pupils.

Since the time of which I have been speaking the means of instruction in science in England have multiplied enormously. In University College, London, founded in 1828, and in Owens College, Manchester, founded in 1851, not only have chairs of chemistry existed from the first, but they have been occupied by a succession of chemists of the highest eminence. But long after 1846 the whole of the serious teaching of scientific chemistry was accomplished at the College of Chemistry, and it was nigh upon twenty years before the Manchester school began to attract considerable notice.

In 1872-73 the movement set in which has resulted in the erection of colleges for higher instruction at a number of important English and Welsh towns. These, together with the pre-existent Queen's Colleges in Ireland and the Universities of more ancient foundation in the three kingdoms, are for the most part provided with pretty good laboratories and a competent staff. We have also the Normal School of Science and the Institute raised by the City and Guilds of London at South Kensington, and its Associate College at Finsbury. England is therefore at the present time as well provided with *places* of instruction for the study of chemistry as any country in the world.

And a very large proportion of the professors or heads of the chemical schools in the colleges and universities of the United Kingdom have shown by their own activity in research that they are qualified to give instruction of the highest kind, and are ready to train young chemists in the art as well as in the theory of their subject.

It is therefore no longer true that a student desiring to become a scientific chemist must needs choose between a single institution in London and another in Manchester, or must seek the instruction which he cannot get at home in the laboratory of a foreign university. As an element in a liberal education the position of chemistry is also considerably in advance of what it was twenty years ago.

It is nevertheless true that increased opportunities for study, a considerable supply of capable teachers, and an enormous body of students, have not produced such an amount of original investigation, or even of accurate analytical work, as might reasonably be expected. A full and complete explanation of all the influences which contribute to this result would be difficult; but I think the apparent inactivity of the chemical schools in this country is not generally the fault of the professors, but is chargeable in the main to the ignorance, and partly to the indifference, of the public. There exists as yet no intelligent feeling in favour of learning, nor indeed in favour of any sort of education, unless there is expectation of direct returns in the form of obvious practical results. It is this which animates the present popular movement in favour of so-called "technical" education. That part of the attention of the nation which can be spared from the contemplation of Irish affairs is concentrated upon the problem of how to make every little boy learn the rudiments of chemistry, whether he likes it or not, whilst there are comparatively few people interested in the question of how to provide means and instruction for those who are capable and desirous of attaining to a mastery of the subject. Moreover, the public have not yet grasped this truth, that, so far as chemistry is concerned, it is of very little consequence to the great metallurgical and chemical industries whether the workpeople do or do not know a little chemistry, though it is important that they should be intelligent enough to obey orders. What is wanted is that every manufacturer and manager should himself be an accomplished engineer and chemist, trained to observe, to reason, and to solve problems for himself.

In the case of chemistry this absence of sentiment in favour of concentration and thoroughness, and the demand for superficiality, if only it can be had wholesale, tells in a variety of ways. The governing bodies who control the various colleges and universities, and the public generally, cannot understand that good and useful work is being done unless it can be shown in the form of passes at examinations. Though I most firmly believe in the necessity for examinations, serious mischief begins when they are regarded as the end itself, and not as mere incidents in the student's career towards the end, which should be knowledge.

In respect to chemistry this is the disadvantage which attends the operation of such a system as that of the Science and Art Department, or of any system under which certificates in connection with individual subjects are granted on easy terms. Especial objection I also feel to such expressions as "advanced," used in reference to a particular stage, so commonly misunderstood as they are by the student and his friends, and operating against his further progress.

Reflect also upon the fact that there are only two or three colleges in this country which can boast of more than one professor of chemistry. In nearly all cases one man is called upon to discharge the duty of teaching classes both elementary and advanced, in pure and applied chemistry, inorganic and organic, theoretical and practical. This is a kind of thing which kills specialism, and without specialists we can have not only no advance, but no efficient teaching of more than rudiments.

That teachers ought to engage in research at all is by no means clear to the public and to those representatives of the public who are charged with the administration of these new institutions. This was illustrated very painfully a few years ago by the conditions under which professors were engaged at a certain college founded, according to the declaration of its promoters, "by the people for the people," wherein it was announced in round terms that original research was not wanted, as the college was "for the good of the many and not for the advantage of the few." This example of ignorance is only remarkable by reason of its audacity. Probably many people hold a similar view, though few are bold enough to declare it.

Without going far into the discussion of the general question, which is a large one, I may perhaps be allowed to offer a few remarks for the consideration of any of my audience who may perchance incline towards that opinion.

It is only when a teacher occupies himself with research that the most complete guarantee is given that he is interested in his subject and that he is a learner. A popular mistake consists in regarding a professor as a living embodiment of science—complete, infallible, mysterious; whereas in truth he is, or ought to be, only a senior student who devotes the greater part of his time to extending and consolidating his own knowledge for the benefit of those who come to learn of him, not only what lies within the boundaries of the known, but how to penetrate into the far greater region of the unknown. Moreover, the man who has no intellectual independence, and simply accepts other people's views without challenge, is pretty certain to make the stock of knowledge with which he sets out in life do service to the end. That one may be fitted to form a sound judgment conçerning new theories he must be familiar with the methods by which progress is accomplished. The work of investigation then reacts beneficially upon the work of teaching; that is why teachers should be encouraged, nay even required, to investigate, and not because their discoveries may haply prove to be practically useful.

Of course it may be said that there have been distinguished investigators who could not teach, but the converse is not true; every teacher who has attained to eminence as a teacher, who has drawn men after him, who has founded a school of thought, and has left his mark upon his generation, has been an industrious worker in research of some kind. All teachers cannot be expected to reach the same high standard, but this is the ideal after which all must strive, or fail utterly.

The fact that there is as yet little demand among schoolmasters for high attainments in chemistry is another reason why so little is accomplished in the chemical schools. Here, again, the public is really to blame. It is disgraceful that in all classes of schools, even where chemistry is supposed to be taught, there are but few places where serious employment is found for the well-trained chemist. I could point to several schools which claim the position of first-rate, where chemistry is taught by masters who have never studied the subject at all, but who are, I suppose, allowed the traditional "ten minutes' start" with the book. Would the head masters of such places dare to employ a person to teach mathematics who did not know the four first rules of arithmetic, or another to teach Latin who had not even got through the accidence? I fancy not. This, however, is without exaggeration the exact parallel of the position in which chemistry is placed in the majority of schools. I have heard the excuse that there is a lack of competent teachers. Of course the demand and the supply will react upon each other. When you offer a reasonable stipend, reasonable accommodation for teaching effectively, reasonable leisure for the master's own studies, and a position on the staff not inferior to that of the classical and mathematical masters, I believe that then, but not till then, there will be as many good school teachers of chemistry as there are of other subjects.

I could point to other prominent schools where the chemistry and other branches of science are taught by a peripatetic South Kensington teacher, who arrives weekly with his box of tricks. Not long ago I was invited to distribute the prizes given in connection with the evening classes in a town not far from Birmingham, and I took the opportunity of advising the teachers present on the occasion to read. One of them said to me afterwards, "When do you suppose I can read? I am engaged in going round to my schools from nine in the morning till ten at night." People of this kind do the greater part of the so-called science teaching sustained by the Science and Art Department, and the worthy town councillors and committees who employ them think that these are the people who are going to help the British manufacturer in his struggle against foreign competition under the guidance of the highly-trained chemists from the German universities. This would be ludicrous if it were not so very serious.

There is an opportunity at the present time of correcting some of these mistakes, but no advantage is being taken of it. I refer now to the "technical schools" which are springing up everywhere. There may be a few competent teachers of chemistry employed in some of them, but I find it difficult to think of many examples. The sort of person who is put in charge of these places is usually a schoolmaster, who is allowed, sometimes even after his appointment, to get a short course of qualitative analysis in order to enable him to obtain a certificate which will entitle him to earn grants from the Science and Art Department.

And manufacturers are much to blame. Instead of employing trained chemists, the greater number of those who want chemical assistance are satisfied to engage the services of boys who have been to an evening class for a winter or two.

The difficulty of finding a satisfactory career in connection with the subject also accounts for the fact, which I fear must be admitted, that chemistry does not attract its due share of the intellect of the nation. Clever young men can usually do better at the law, in medicine, or in commerce, than in teaching chemistry or in manufactures in which chemical skill is applicable. So badly educated are many of the young men who commence the study with professional objects in view, that it is quite impossible to teach them anything beyond routine analysis, if so much.

I heard lately from a friend of mine a story of a young groom in his employ who cannot read or write; and who declines to be taught to read on the ground that, considering himself pretty smart, he is afraid that "learning might dull him." This idea seems to be rather prevalent among certain classes of people, but I can assure those who wish to be chemists that some familiarity with the rule of three, and such a command of English as will enable them to understand words of more than one syllable, will be no obstacle to the acquisition of chemical knowledge.

Three years has hitherto been regarded as the normal period of study. The question arises, can a young man, previously well educated, expect to become an accomplished chemist, competent to apply his knowledge usefully, by giving the whole of his time to study during *three years?* I believe not.

By reason of the enormous development of science the position of the student of chemistry is nowadays very different from what it was thirty years ago. Since that time we have not only got a few new elements, a matter of small importance in itself, but new views of the nature of the elements and of their mutual relations. This could hardly have come about but for the recognition of the law of Avogadro as a fundamental principle, upon which we rely as the ultimate criterion by which the true distinction between so-called equivalent weights and molecular ratios has been established. By the gradual evolution of ideas having reference successively to electro-chemical relations of elements and compounds, the theory of types, and atomicity or valency, we have arrived at notions of chemical constitution based upon the hypothesis of the orderly linking together of atoms. Thirty years ago isomerism had scarcely attracted notice, and carbon compounds were only just beginning to be arranged in homologous series. The general use at the present day of the language of the molecular kinetic theory shows how deeply this theory influences our ideas of the internal constitution of matter. Within the period referred to, dissociation has been studied and a vast body of thermo-chemical data have been accumulated. And although the larger portion of the results of this work still await interpretation, dynamical ideas of chemical action are now generally accepted. We have also new methods of investigation, including spectroscopic analysis with all its vast train of results.

When I began chemistry many of these subjects and others had not been heard of. Of course we had our difficulties, and I well remember the puzzles met with in the endeavour to refer compounds to their appropriate types, also the consternation caused in the student's mind and the confusion in his note-book by the successive changes in the atomic weights of carbon, oxygen, sulphur, and the metals. But on the whole there was much less to learn.

It has always been thought essential that a student of chemistry should have some knowledge of physics. It is now more than ever necessary that this knowledge should be extensive, sound, and based upon a good foundation of mathematics. Thirty years ago a hundred pages of Fownes contained all that was thought necessary, but no one nowadays could be satisfied with that. It is now asserted that a young chemist who expects to find a career in industrial chemistry should also have learnt drawing, and more important still that he should have a good general knowledge of mechanics, steam, and building construction. I suppose everyone will agree in adding French and especially German. You see how the requirements expand.

The inference from all this is that it now takes longer to make a chemist than formerly. This is a point of considerable practical importance.

My estimate that a well-educated and intelligent young man will now require five years for the study of chemistry and accessory subjects before he is likely to be of much use will not appear extravagant.

Here one may remark that in order to become a chemist it is before all things necessary to study chemistry. If the greater part of a student's time is to be taken up with other things, it is not very clear how this is to be done.

A reform all round is wanted. The mathematics, modern languages, and drawing properly belong to the antecedent school period, and I believe the Institute of Chemistry would greatly promote the interests of the profession if it would impose upon candidates for the Associateship not only a three years' course of training with an examination in practical chemistry at the end, but a severe examination in mathematics, in the English, French, and German languages, and perhaps drawing, before matriculation or registration.

A consideration of the present position of the student of chemistry leads naturally to a review of the methods of teaching the subject. Speaking broadly, I suppose nearly all professional chemists who have had the advantage of systematic training have, up to the present time, passed through very much the same kind of course. This consists, as everybody knows, very largely of analytical work, qualitative and quantitative, preceded or followed by the preparation of a number of definite chemical compounds, besides practice in certain very necessary physical determinations, *e.g.* relative density of solids, liquids, and gases, melting-points, boiling-points, and so forth. There seems now to be a disposition in some quarters to depart from this time-honoured curriculum in favour of a course in which the student is early engaged in some semblance of investigation, and in which he is encouraged to attack difficult problems, which from their fundamental importance offer considerable temptation. I venture to express a hope that this will not be carried too far. Already we are in danger of losing the art of accurate analysis. One constantly meets with young chemists who are ready enough to discuss the constitution of benzene, but who cannot make a reliable combustion. And, according to my own experience, attempts at research among inexperienced chemists become abortive more frequently in consequence of deficient analytical skill than from any other cause.

One modification I should gladly see generally adopted. I think an unnecessary amount of time is often spent upon qualitative mineral analysis, and an acquaintance with the properties of common and important carbon compounds ought to be acquired at an early stage. Quantitative work might with advantage be taken up sooner than usual. By that, however, I mean serious work, in which good methods are used and every effort made to secure accuracy. I do not believe in the use of rough methods because they are easy; the use of such leads the student to be satisfied with approximations, which, after all, he will learn soon enough are all that is possible to man. I am very glad to know that I have the support of one of my predecessors in this chair (Sir Henry Roscoe), whose opinion will carry far greater weight than mine, in deprecating premature efforts to engage students in research.[1]

But though it does not appear to me to be wise to encourage beginners, without sufficient experience or manipulative skill, to attempt original work, one of the best possible exercises preparatory to original work is to select suitable memoirs, and not only to read them but to work conscientiously through the whole of the preparations and analyses described, following the instructions given. Many of Dr. Hofmann's papers afford excellent examples. So also do the writings of Dr. Perkin and Dr. Frankland, besides those of many other chemists which could easily be selected by the teacher.

An intelligent student, possessing the requisite preliminary knowledge, would obtain much instruction by repeating the work contained in such papers as the following, for example:—Emerson Reynolds on the missing sulphur urea (J. Chem. Soc. 1869, i.); Fittig and Tollens on the synthesis of hydrocarbons of the benzol series (*Liebig's Annalen*, 1864, cxxxi. 303); L. Claisen and Pupils on the introduction of acid radicles into

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[1] See Address to Section B, Montreal meeting.

ketones, &c. (*Berichte*, xx.); Lawson and Collie on the action of heat on salts of tetramethyl-ammonium (J. Chem. Soc., June 1888); Thorpe and Hambly on manganic trioxide (J. Chem. Soc., March 1888); besides many others, including papers on analytical processes. To such as these there might subsequently be added the determination of an atomic weight on the model of one of the best masters, as a discipline which could not fail to be impressive, and full of instruction.

When chemistry is taught, not with professional or technical objects in view, but for the sake of educational effects, as an ingredient in a liberal education, the primary object is to make the pupil observe and think. But with young students it is very important to proceed slowly, for chemistry is really a very difficult subject at first, owing to the variety of strange materials with uncouth names. To reason from particulars to generals is for the unpractised always a difficult process, and in chemistry this is specially the case. With young students it is, in my experience, preferable to adopt a somewhat dogmatic style, which should of course be exchanged for a more cautious one as the pupil proceeds.

Thus the law of Avogadro can only be given at first as a recognized physical law, without much explanation, since the full apprehension of the evidence upon which it rests can only be secured at a late stage of the learner's progress. There is of course great advantage in the use of an inductive method if only it is employed judiciously. Otherwise the result is only confusion.

A number of papers, pamphlets, and text-books have lately appeared, professing to teach the principles of the science practically and by new methods. Most of these turn out, upon inspection, to be very old methods indeed, but there is a small residue of distinctly original character which are sure to attract, as they deserve, considerable attention. The systems I refer to provide a series of problems which the pupils are called upon to solve. According to this plan the student is not allowed peaceably to examine the properties of oxygen or sulphur which he now sees for the first time. He must weigh, and measure, and observe, and then infer. All this coming at once upon the head of a beginner seems to me to be well fitted to drive him to despair.

I well remember the first experiment in chemistry I ever made. It consisted in dissolving zinc in diluted sulphuric acid in an evaporating dish, lighting with a match the bubbles of hydrogen as they rose, and afterwards leaving the solution to crystallize. I was about sixteen, and the bubbles of gas, as well as the crystals I afterwards got, interested me very much. If at that time I had been made to weigh the zinc and acid, and measure the hydrogen with the object of answering some question about the composition of zinc and hydrogen sulphates, I should have been pretty much in the position of a boy ignorant of geometry shut up with the propositions of Euclid and ordered to give the demonstrations.

I think when we recall such a fact as that Priestley, who discovered oxygen in 1774, failed to the end of his days to understand the process of combustion, and actually wrote, in 1800, a pamphlet in defence of "phlogiston," we ought not to be surprised when young people, though born a century later, fail to perceive at once the full significance of facts to which they are introduced for the first time. At the outset you cannot reasonably expect a young student both to observe accurately and infer justly. These two things must be kept separate at first, and for this reason among others I believe that attempts to make young students verify for themselves the fundamental propositions of chemistry will not be successful. One has only to trace the origin of one's own convictions in reference to any important fact or principle to perceive that they very seldom spring into existence suddenly, but almost always commence in vagueness and hesitation, acquiring consistency and solidity only as the result of accumulated experience.

I will not pretend to determine what may be included within the wide circle of the functions of the British Association; but I think I cannot be mistaken in assuming that the advancement of science is dependent in no small degree upon the provision for the efficient teaching of science. I have traced an outline of what has been done in the past, and have endeavoured to show in what respects I think we are deficient at the present time. No matter how ardent may be the aspirations, how earnest the endeavours of the few, progress will be slow unless they are sustained by the sympathy of the many. On one principle the public must surely insist, that only those shall be allowed to teach who know.

SECTION D.

BIOLOGY.

Opening Address by W. T. Thiselton-Dyer, C.M.G., M.A., B.Sc., F.R.S., F.L.S., President of the Section.

Before we commence the formal business of the Section, I propose to invite your attention to several points which have suggested themselves to me from a consideration of the present position and progress of the study of botany in this country.

It is not so very long ago that at English Universities, at least, the pursuit of botany was regarded rather as an elegant accomplishment than as a serious occupation. This is the more remarkable because at every critical point in the history of botanical science the names of our countrymen will be found to occupy an honourable place in the field of progress and discovery. In the seventeenth century, Hooke and Grew laid the foundation of the cell-theory, while Millington, by discovering the function of stamens, completed the theory of the flower. In the following century, Morison first raised ferns from spores, Lindsay detected the fern prothallus, Ray laid the foundations of a natural classification, Hales discovered root-pressure, and Priestley the absorption of carbon dioxide and the evolution of oxygen by plants. In the early part of the present one we have Knight's discovery of the true cause of geotropism, Daubeny's of the effect upon the processes of plant-life of rays of light of different refrangibility, and, finally, the first description of the cell-nucleus by R. Brown. I need not attempt to carry the list through the last half-century. I have singled out these discoveries as striking landmarks, the starting-points of important developments of the subject. It is enough for my purpose to show that we have always had an important school of botany in England, which has contributed at least its share to the general development of the science.

I think at the moment, however, we have little cause for anxiety. The academic chairs throughout the three kingdoms are filled, for the most part, with young, enthusiastic, and well-trained men. Botany is everywhere conceded its due position as the twin branch with zoology of biological science. We owe to the enlightened administration of the Oxford University Press the possession of a journal which allows of the prompt and adequate publication of the results of laboratory research. The excellent work which is being done in every part of the botanical field has received the warm sympathy of our colleagues abroad. I need only recall to your recollection, as a striking evidence of this, the remarkable gathering of foreign botanists which will ever make the meeting of this Association at Manchester a memorable event to all of us. The reflection rises sadly to the mind that it can never be repeated. Not many months, as you know, had passed before the two most prominent figures in that happy assemblage had been removed from us by the inexorable hand of death. In Asa Gray we miss a figure which we could never admit belonged wholly to the other side of the Atlantic. In technical botany we recognized him as altogether in harmony with the methods of work and standard of excellence of our own most distinguished taxonomists. But, apart from this, he had that power of grasping large and far-reaching ideas, which, I do not doubt, would have brought him distinction in any branch of science. We owe to him the classical discussion of the facts of plant distribution in the northern hemisphere which is one of the corner-stones of modern geographical botany. He was one of the earliest of distinguished naturalists who gave his adhesion to the theory of Mr. Darwin. A man of simple and sincere piety, the doctrine of descent never presented any difficulty to him. He will remain in our memories as a figure endowed with a sweetness and elevation of character which may be compared even with that of Mr. Darwin himself.

In De Bary we seem to have suffered no less a personal loss than in the case of Gray. Though, before last year, I do not know that he had ever been in England, so many of our botanists had worked under him that his influence was widely felt amongst us. And it may be said that this was almost equally so in every part of the civilized world. His position as a teacher was in this respect probably unique, and the traditions of his methods of work must permanently affect the progress of botany, and, indeed, have an even wider effect. This is not the occasion to dwell on each of his scientific achievements. It is sufficient to say that we owe to him the foundations of a rational vegetable pathology. He first grasped the true conditions of parasitism in plants, and not content with working out the complex phases of the life-history of the invading organism, he never lost sight of the conditions which permitted or inhibited its invasion. He treated the problem, whether on the side of the host or of the parasite, as a whole—as a biological problem, in fact, in the widest sense. It is this thorough grasp of the conditions of the problem that gives such a peculiar value to his last published book, the "Lectures on Bacteria," an admirable translation of which we owe to Prof. Balfour. To this I shall have again to refer. I must content myself with saying now, that in this and all his work there is that note of highest excellence which consists in lifting detail to the level of the widest generality. To a weak man this is a pitfall, in which a firm grasp of fact is lost in rash speculation. But when, as in De Bary's case, a true scientific insight is inspired by something akin to genius, the most fruitful conceptions are the result. Yet De Bary never sacrificed exactness to brilliancy, and to the inflexible love of truth which pervaded both his work and his personal intercourse we may trace the secret of the extraordinary influence which he exerted over his pupils.

As the head of one of the great national establishments of the country devoted to the cultivation of systematic botany, I need hardly apologize for devoting a few words to the present position of that branch of the science. Of its fundamental importance I have myself no manner of doubt. But as my judgment may seem in such a matter not wholly free from bias, I may fortify myself with an opinion which can hardly be minimized in that way. The distinguished chemist, Prof. Lothar Meyer, perhaps the most brilliant worker in the field of theoretical chemistry, finds himself, like the systematic botanist, obliged to defend the position of descriptive science. And he draws his strongest argument from biology. "The physiology of plants and animals," he tells us, "requires systematic botany and zoology, together with the anatomy of the two kingdoms: each speculative science requires a rich and well-ordered material, if it is not to lose itself in empty and fruitless fantasies." No one, of course, supposes that the accumulation of plant specimens in harbaria is the mere outcome of a passion for accumulating. But to do good systematic work requires high qualities of exactitude, patience, and judgment. As I had occasion to show at the Linnean centenary, the world is hardly sensible of the influence which the study of the subject has had on its affairs. The school of Jeremy Bentham has left an indelible mark on the social and legislative progress of our own time. Mill tells us that "the proper arrangement of a code of laws depends on the same scientific conditions as the classifications in natural history; nor could there," he adds, "be a better preparatory discipline for that important function than the principles of a natural arrangement, not only in the abstract, but in their actual application to the class of phenomena for which they were first elaborated, and which are still the best school for learning their use." He further tells us that of this Jeremy Bentham was perfectly aware, and that his "Fragment on Government" contains clear and just views on the meaning of a natural arrangement which reflect directly the influence of Linnæus and Jussieu. Mill himself possessed a competent knowledge of systematic botany, and therefore was well able to judge of its intellectual value. For my part, I do not doubt that precisely the same qualifications of mind which made Jeremy Bentham a great jurist, enabled his nephew to attain the eminence he reached as a botanist. As a mere matter of mental gymnastic, taxonomic science will hold its own with any pursuit. And, of course, what I say of botany is no less true of other branches of natural history. Mr. Darwin devoted eight or nine years to the systematic study of the *Cirripedia.* "No one," he himself tells us, "has a right to examine the question of species who has not minutely described many." And Mr. Huxley has pointed out, in the admirable memoir of Mr. Darwin which he has prepared for the Royal Society, that "the acquirement of an intimate and practical knowledge of the process of species-making . . ." was "of no less importance to the author of the 'Origin of Species' than was the bearing of the Cirripede work upon the principles of a natural classification."

At present the outlook for systematic botany is somewhat discouraging. France, Germany, and Austria no longer possess anything like a school in the subject, though they still supply able and distinguished workers. That these are, however, few, may be judged from the fact that it is difficult to fill the place of the lamented Eichler in the direction of the Botanic Garden and Herbarium at Berlin. Outside our own country, Switzerland is the most important seat of general systematic study, to which three generations of De Candolles have devoted themselves. The most active centres of work at the moment are, however, to be found in our own country, in the United States, and in Russia. And the reason is, in each case, no doubt the same. The enormous area of the earth's surface over which each country holds sway brings to them a vast amount of material which peremptorily demands discussion.

No country, however, affords such admirable facilities for work in systematic botany as are now to be found in London. The Linnean Society possesses the Herbarium of Linnæus; the Botanical Department of the British Museum is rich in the collections of the older botanists; while at Kew we have a constantly increasing assemblage of material, either the results of travel and expeditions, or the contributions of correspondents in different parts of the Empire. A very large proportion of this has been worked up. But I am painfully impressed with the fact that the total of our available workers bears but a small proportion to the labour ready to their hands.

This is the more a matter of concern, because for the few official posts which are open to botanists at home or abroad a practical knowledge of systematic botany is really indispensable. For suitable candidates for these one naturally looks to the Universities. And so far, I am sorry to say, in great measure one looks in vain. It would be, no doubt, a great impulse to what is undoubtedly an important branch of national scientific work if Fellowships could occasionally be given to men who showed some aptitude for it. But these should not be mere prizes for undergraduate study, but should exact some guarantee that during the tenure of the Fellowship the holder would seriously devote himself to some definite piece of work. At present, undoubtedly, the younger generation of botanists show a disposition to turn aside to those fields in which more brilliant and more immediate results can be attained. Their neglect of systematic botany brings to some extent its own Nemesis. A first principle of systematic botany is that a name should denote a definite and ascertainable species of plant. But in physiological literature you will find that the importance of this is entirely overlooked. Names are employed which are either not to be found in the books, or they are altogether misapplied. I call to mind the case of an English physiologist who wrote a highly ingenious paper on the movement of water in plants. He was content to refer to the plant upon which he experimented as the "bay-laurel." I ascertained that the plant he really used was the cherry-laurel. Now the bay is truly a laurel, while the cherry-laurel is a plum. Anyone repeating his experiments would therefore be led wholly astray. But if proper precautions are taken to ascertain the accurate botanical name of a plant, no botanist throughout the civilized world is at a loss to identify it.

But precision in nomenclature is only the necessary apparatus of the subject. The data of systematic botany, when properly discussed, lend themselves to very important generalizations. Perhaps those which are yielded by the study of geographical distribution are of the most general interest. The mantle of vegetation which covers the surface of the earth, if only we could rightly unravel its texture, would tell us a good deal about geological history. The study of geographical distribution, rightly handled, affords an independent line of attack upon the problem of the past distribution of land and sea. It would probably never afford sufficient data for a complete independent solution of the problem; but it must always be extremely useful as a check upon other methods. Here, however, we are embarrassed by the enormous amount of work which has yet to be accomplished. And unfortunately this is not of a kind which can be indefinitely postponed. The old terrestrial order is fast passing away before our eyes. Everywhere the primitive vegetation is disappearing as more and more of the earth's surface is brought into cultivation, or, at any rate, denuded of its forests.

A good deal, however, has been done. We owe to the indomitable industry of Mr. Bentham and of Sir Ferdinand Mueller a comprehensive flora of Australia, the first large area of the earth's surface of which the vegetation has been completely worked out. Sir Joseph Hooker, in his retirement, has pushed on within sight of completion the enormous work of describing so much of the vast Indo-Malayan flora as is comprised within the British possessions. To the Dutch botanists we owe a tolerably complete account of the Malayan flora proper. But New Guinea still remains botanically a *terra incognita*, and till within the last year or two the flora of China has been an absolute blank to us. A Committee of the British Association (whose report will be presented to you) has, with the aid of a small grant of money, taken in hand the task of gathering up the scanty data which are available in herbaria and elsewhere. This has stimulated European residents in China to collect more material, and the fine collections which are now being rapidly poured in upon us will, if they do not overwhelm us by their very magnitude, go a long way in supplying data for a tentative discussion of the relations of the Chinese flora to that of the rest of Asia. I do not doubt that this will in turn explain a good deal that is anomalous in the distribution of plants in India. The work of the Committee has been practically limited to Central and Eastern China. From the west, in Yunnan, the French botanists have received even more surprising collections, and these supplement our own work in the most fortunate manner. I have only to add, for Asia, Boissier's "Flora Orientalis," which practically includes the Mediterranean basin. But I must not omit the invaluable report of Brigade-Surgeon Aitchison on the collections made by him during the Afghan Delimitation Expedition. This has given an important insight into the vegetation of a region which had never previously been adequately examined. Nor must I forget the recent publication of the masterly report by Prof. Bayley Balfour on the plants collected by himself and Schweinfurth in Socotra, an island with which the ancient Egyptians traded, but the singularly anomalous flora of which was almost wholly unknown up to our time.

The flora of Africa has been at present but imperfectly worked up, but the materials have been so far discussed as to afford a tolerably correct theory of its relations. The harvest from Mr. Johnston's expedition to Kilimanjaro was not as rich as might have been hoped. Still, it was sufficient to confirm the conclusions at which Sir Joseph Hooker had arrived, on very slender data, as to the relations of the high-level vegetation of Africa generally. The flora of Madagascar is perhaps, at the moment, the most interesting problem which Africa presents to the botanist. As the rich collections, for which we are indebted to Mr. Baron and others, are gradually worked out, it can hardly be doubted that it will be necessary to modify in some respects the views which are generally received as to the relation of the island to the African continent. My colleague, Mr. Baker, communicated to the York meeting of the Association the results which, up to that time, he had arrived at, and these subsequent material has not led him to modify. The flora as a whole presents a large proportion of endemic genera and species, pointing to isolation from a very ancient date. The tropical element is, however, closely allied to that of Tropical Africa and of the Mascarene Islands, and there is a small infusion of Asiatic types which do not extend to Africa. The high-level flora, on the other hand, exhibits an even closer affinity with that temperate flora the ruins of which are scattered over the mountainous regions of Central Africa, and which survives in its greatest concentration at the Cape.

The American botanists at Harvard are still systematically carrying on the work of Torrey and Gray in the elaboration of the flora of Northern America. The Russians are, on their part, continually adding to our knowledge of the flora of Northern and Central Asia. The whole flora of the North Temperate Zone can only be regarded substantially as one. The identity diminishes southwards and increases in the case of the Arctic and Alpine regions. A collection of plants brought us from high levels in Corea by Mr. James might, as regards a large proportion of the species, have been gathered on one of our own Scotch hills.

We owe to the munificence of two English men of science the organization of an extensive examination of the flora and fauna of Central America and the publication of the results. The work, when completed, can hardly be less expensive that of the results of the *Challenger* voyage, which has severely taxed the liberality of the English Government. The problems which geographical distribution in this region presents will doubtless be found to be of a singularly complicated nature, and it is impossible to over-estimate the debt of gratitude which biologists of all countries must owe to Messrs. Godman and Salvin when their arduous undertaking is completed. I am happy to say that the botanical portion, which has been elaborated at Kew, is all but finished.

In South America, I must content myself with referring to the great "Flora Brasiliensis," commenced by Martius half a century ago, and still slowly progressing under the editorship of Prof. Urban, at Berlin. Little discussion has yet been attempted of the mass of material which is enshrined in the mighty array of volumes already published. But the travels of Mr. Ball in South America have led him to the detection of some very interesting problems. The enormous pluvial denudation of the ancient portions of the continent has led to the gradual blending of the flora of different levels with sufficient slowness to permit of adaptive changes in the process. The tropical flora of Brazil, therefore, presents an admixture of modified temperate types which gives to the whole a peculiar character not met with to the same degree in the tropics of the Old World. On the other hand, the comparatively recent elevation of the southern portion of the continent accounts, in Mr. Ball's eyes, for the singular poverty of its flora, which we may regard indeed as still in progress of development.

The botany of the *Challenger* Expedition, which was also elaborated at Kew, brought for the first time into one view all the available facts as to the floras of the older oceanic islands. To this was added a discussion of the origin of the more recent floras of the islands of the Western Pacific, based upon material carefully collected by Prof. Moseley, and supplemented by the notes and specimens accumulated with much judgment by Dr. Guppy. For the first time we were enabled to get some idea how a tropical island was furnished with plants, and to discriminate the littoral element due to the action of oceanic currents from the interior forest almost wholly due to frugivorous birds. The recent examination of Christmas Island by the English Admiralty has shown the process of island flora-making in another stage. The plants collected by Mr. Lister prove, as might be expected, to be closely allied to those of Java. But the effect of isolation has begun to tell; and I learn from my colleague, Prof. Oliver, that the plants from Christmas Island cannot be for the most part exactly matched with their congeners from Java, but yet do not differ sufficiently to be specifically distinguished. We have here, therefore, it appears to me, a manifest case of nascent species.

The central problem of systematic botany I have not as yet touched upon: this is to perfect a natural classification. Such a classification, to be perfect, must be the ultimate generalization of every scrap of knowledge which we can bring to bear upon the study of plant affinity. In the higher plants experience has shown that we can obtain results which are sufficiently accurate for the present without carrying our structural analysis very far. Yet even here, the correct relations of the Gymnosperms would never have been ascertained without patient and minute microscopic study of the reproductive processes. Upon these, indeed, the correct classification of the Vascular Cryptogams wholly depends, and generally, as we descend in the scale, external morphology becomes more and more insecure as a guide, and a thorough knowledge of the minute structure and life-history of each organism becomes indispensable to anything like a correct determination of its taxonomic position. The marvellous theory of the true nature of lichens would never have been ascertained by the ordinary methods of examination which were held to be sufficient by lichenologists.

The final form of every natural classification—for I have no doubt that the general principles I have laid down are equally true in the field of zoology—must be to approximate to the order of descent. For the theory of descent became an irresistible induction as soon as the idea of a natural classification had been firmly grasped.

In regard to flowering plants we owe, as I have said, the first step in a natural classification to our own great naturalist, John Ray, who divided them into Monocotyledons and Dicotyledons. The celebrated classification of Linnæus was avowedly purely artificial. It was a temporary expedient, the provisional character of which no one realized more thoroughly than himself. He, in fact, himself gave us one of the earliest outlines of a truly natural system. Such a system is based on affinity, and we know of no other explanation of affinity than that which is implied in the word—namely, common parentage. No one finds any difficulty in admitting that, where a number of individual organisms closely resemble one another, they must have been derived from the same stock. I allow that, in cases where external form is widely different, the conclusion to one who is not a naturalist is by no means so obvious. But in such cases it rests on the profound and constant resemblance of internal points of structure. Anyone who studies the matter with a perfectly open mind finds it impossible to draw a line. If genetic relationship or heredity is admitted to be the explanation of affinity in the most obvious case, the stages are imperceptible by which the same conclusion is seen to be inevitable when the evidence is fairly examined, even in cases where at the first glance it seems least likely.

This leads me to touch on the great theory which we owe to Mr. Darwin. That theory, I need hardly say, was not merely a theory of descent. This had suggested itself to naturalists in the way I have indicated long before. What Mr. Darwin did was to show how by perfectly natural causes the separation of living organisms into races which at once resemble and yet differ from one another so profoundly came about. Heredity explains the resemblance; Mr. Darwin's great discovery was that variation worked upon by natural selection explained the difference. That explanation seems to me to gather strength every day, and to continually reveal itself as a more and more efficient solvent of the problems which present themselves to the student of natural history. At the same time, I am far from claiming for it the authority of a scientific creed or even the degree of certainty which is possessed by some of the laws of astronomy. I only affirm that as a theory it has proved itself a potent and invaluable instrument of research. It is an immensely valuable induction; but it has not yet reached such a position of certitude as has been attained by the law of gravitation; and I have myself, in the field of botany, felt bound to protest against conclusions being drawn deductively from it without being subjected to the test of experimental verification. This attitude of mine, which I believe I share with most naturalists, must not, however, be mistaken for one of doubt. Of doubt as to the validity of Mr. Darwin's views I have none: I shall continue to have none till I come across facts which suggest doubt. But that is a different position from one of absolute certitude.

It is therefore without any dissatisfaction that I observe that many competent persons have, while accepting Mr. Darwin's theory, set themselves to criticize various parts of it. But I must confess that I am disposed to share the opinion expressed by Mr. Huxley, that these criticisms really rest on a want of a thorough comprehension.

Mr. Romanes has put forward a view which deserves the attention due to the speculations of a man of singular subtlety and dialectic skill. He has startled us with the paradox that Mr. Darwin did not, after all, put forth, as I conceive it was his own impression he did, a theory of the origin of species, but only of adaptations. And inasmuch as Mr. Romanes is of opinion that specific differences are not adaptive, while those of genera are, it follows that Mr. Darwin only really accounted for the origin of the latter, while for an explanation of the former we must look to Mr. Romanes himself. For my part, however, I am altogether unable to accept the premises, and therefore fail to reach the conclusion. Specific differences, as we find them in plants, are for the most part indubitably adaptive, while the distinctive characters of genera and of higher groups are rarely so. Let anyone take the numerous species of some well-characterized English genus—for example, *Ranunculus*; he will find that one species is distinguished by having creeping stems, one by a tuberous root, one by floating leaves, another by drawn-out submerged ones, and so on. But each possesses those common characters which enables the botanist almost at a glance, notwithstanding the adaptive disguise, to refer them to the common genus *Ranunculus*. It seems to me quite easy to see, in fact, why specific characters should be usually adaptive, and generic not so. Species of any large genus must, from the nature of things, find themselves exposed to anything rather than uniform conditions. They must acquire, therefore, as the very condition of their existence, those adaptive characters which the necessities of their life demand. But this rarely affects those marks of affinity which still indicate their original common origin. No doubt these were themselves once adaptive, but they have long been overlaid by newer and more urgent modifications. Still, Nature is ever conservative, and these reminiscences of a bygone history persist; significant to the systematic botanist as telling an unmistakable family story, but far removed from the stress of a struggle in which they no longer are called upon to bear their part.

Another episode in the Darwinian theory is, however, likely to occupy our attention for some time to come. The biological world now looks to Prof. Weismann as occupying the most prominent position in the field of speculation. His theory of the continuity of the germ-plasm has been put before English readers with extreme lucidity by Prof. Moseley. That theory, I am free to confess, I do not find it easy to grasp clearly in all its concrete details. At any rate, my own studies do not furnish me with sufficient data for criticizing them in any adequate way. It is, however, bound up with another theory—the non-inheritance of acquired characters—which is more open to general discussion. If with Weismann we accept this principle, it cannot be doubted that the burden thrown on natural selection is enormously increased. But I do not see that the theory of natural selection itself is in any way impaired in consequence.

The question, however, is, Are we to accept the principle? It appears to me that it is entirely a matter of evidence. It is proverbially difficult to prove a negative. In the analogous case of the inheritance of accidental mutilations, Mr. Darwin contents himself with observing that we should be "cautious in denying it." Still, I believe that, though a great deal of pains has been devoted to the matter, there is no case in which it has been satisfactorily proved that a character acquired by an organism has been transmitted to its descendants; and there is, of course, an enormous bulk of evidence the other way.

The consideration of this point has given rise to what has been called the new Lamarckism. Now, Lamarck accounted for the evolution of organic Nature by two principles—the tendency to progressive advancement and the force of external circumstances. The first of these principles appears to me, like Nägeli's internal modifying force, to be simply substituting a a name for a thing. Lamarck, like many other people before him, thought that the higher organisms were derived from others lower in the scale, and he explained this by saying that they had a tendency to be so derived. This appears to me much as if we explained the movement of a train from London to Bath by attributing it to a tendency to locomotion. Mr. Darwin lifted the whole matter out of the field of mere transcendental speculation by the theory of natural selection, a perfectly intelligible mechanism by which the result might be brought about. Science will always prefer a material *modus operandi* to anything so vague as the action of a tendency.

Lamarck's second principle deserves much more serious consideration. To be perfectly fair, we must strip it of the crude illustrations with which he hampered it. To suggest that a bird became web-footed by persistently stretching the skin between its toes, or that the neck of a giraffe was elongated in the perpetual attempt to reach the foliage of trees, seems almost repugnant to common-sense. But the idea that changes in climate and food—*i.e.* in the conditions of nutrition generally—may have some slow but direct influence on the organism seems, on a superficial view, so plausible, that the mind is very prone to accept it. Mr. Darwin has himself frankly admitted that he thought he had not attached sufficient weight to the direct action of the environment. Yet it is extremely difficult to obtain satisfactory evidence of effects produced in this way. Hoffmann experimented with much pains on plants, and the results were negative. And Mr. Darwin confessed that Hoffmann's paper had "staggered" him.

Organic evolution still, therefore, seems to me to be explained in the simplest way as the result of variation controlled by natural selection. Now, both these factors are perfectly intelligible things. Variation is a mere matter of every-day observation, and the struggle for existence, which is the cause of which natural selection is the effect, is equally so. If we state in a parallel form the Lamarckian theory, it amounts to a tendency controlled by external forces. It appears to me that there is no satisfactory basis of fact for either factor. The practical superiority of the Darwinian over the Lamarckian theory is, as a working hypothesis, immeasurable.

The new Lamarckian school, if I understand their views correctly, seek to re-introduce Lamarck's "tendency." The fact has been admitted by Mr. Darwin himself that variation is not illimitable. No one, in fact, has ever contended that any type can be reached from any point. For example, as Weismann puts it, "Under the most favourable circumstances, a bird can never become transformed into a mammal." It is deduced from this that variation takes place in a fixed direction only, and this is assumed to be due to an innate law of development, or, as Weismann has termed it, a "phyletic vital force." But the introduction of any such directive agency is superfluous, because the limitation of variability is a necessary consequence of the physical constitution of the varying organism.

It is supposed, however, by many people that a necessary part of Mr. Darwin's theory is the explanation of the phenomenon of variation itself. But really this is not more reasonable than to demand that it should explain gravitation or the source of solar energy. The investigation of any one of these phenomena is a matter of first-rate importance. But the cause of variation is perfectly independent of the results that flow from it when subordinated to natural selection.

Though it is difficult to establish the fact that external causes promote variation directly, it is worth considering whether they may not do so indirectly. Weismann, like Lamarck before him, has pointed out, as others have also done, the remarkable persistence of the plants and animals of Egypt; and the evidence of this is now even stronger. We, at Kew, owe to the kindness of Dr. Schweinfurth, a collection of specimens of plants from Egyptian tombs, which are said to be as much as 4000 years old. They are still perfectly identifiable, and, as one of my predecessors in this chair has pointed out, they differ in no respect from their living representatives in Egypt at this day. The explanation which Lamarck gave of this fact "may well," says Sir Charles Lyell, "lay claim to our admiration." He attributed it, in effect, to the persistence of the physical geography, temperature, and other natural conditions. The explanation seems to me adequate. The plants and animals, we may fairly assume, were, 4000 years ago, as accurately adjusted to the conditions in which they then existed as the fact of their persistence in the country shows that they must be now. Any deviation from the type that existed then would either, therefore, be disadvantageous or indifferent. In the former case it would be speedily eliminated, in the latter it would be swamped by cross-breeding. But we know that if seeds of these plants were introduced into our gardens we should soon detect varieties amongst their progeny. Long observation upon plants under cultivation has always disposed me to think that a change of external conditions actually stimulated variation, and so gave natural selection wider play and a better chance of re-establishing the adaptation of the organism to them. Weismann explains the remarkable fact that organisms may for thousands of years reproduce themselves unchanged by the principle of the persistence of the germ-plasm. Yet it seems hard to believe that the germ-plasm, while enshrined in the individual whose race it is to perpetuate, and nourished at its expense, can be wholly indifferent to all its fortunes. It may be so, but in that case it would be very unlike other living elements of organized beings.

I am bound, however, to confess that I am not wholly satisfied with the data for the discussion of this question which practical horticulture supplies. That the contents of our gardens do exhibit the results of variation in a most astonishing degree no one will dispute. But for scientific purposes any exact account of the treatment under which these variations have occurred is unfortunately usually wanting. A great deal of the most striking variation is undoubtedly due to wide crossing, and these cases must, of course, be eliminated when the object is to test the independent variation of the germ-plasm. Hoffmann, whose experiments I have already referred to, doubts whether plants do as a matter of fact vary more under cultivation than in their native home and under natural conditions. It would be very interesting if this could be tested by the concerted efforts of two cultivators, say, for example, in Egypt and in England. Let some annual plant be selected, native of the former country, and let its seed be transmitted to the latter. Then let each cultivator select any variations that arise in regard to some given character; set to work, in fact, exactly as any gardener would who wanted to "improve" the plant, but on a preconcerted plan. A comparison of the success which each obtained would be a measure of the effect of the change of the environment on variability. If it proved that, as Hoffmann supposed, the change of conditions did not affect what we may call the rate of variation, then, as Mr. Darwin remarks in writing to Prof. Semper, "the astonishing variations of almost all cultivated plants must be due to selection and breeding from the varying individuals. This idea," he continues, "crossed my mind many years ago, but I was afraid to publish it, as I thought that people would say, 'How he does exaggerate the importance of selection.'" From an independent consideration of the subject I also find my mind somewhat shaken about it. Yet I feel disposed to say with Mr. Darwin, "I still *must* believe that changed conditions give the impulse to variability, but that they act *in most cases* in a very indirect manner."

Whatever conclusions we arrive at on these points, everyone will agree that one result of the Darwinian theory has been to give a great impulse to the study of organisms, if I may say so, as "going concerns." Interesting as are the problems which the structure, the functions, the affinity, or the geographical distribution of a plant may afford, the living plant in itself is even more interesting still.

Every organ will bear interrogation to trace the meaning and origin of its form and the part it plays in the plant's economy. That there is here an immense field for investigation there can be no doubt. Mr. Darwin himself set us the example in a series of masterly investigations. But the field is well-nigh inexhaustible. The extraordinary variety of form which plants exhibit has led to the notion that much of it may have arisen from indifferent variation. No doubt, as Mr. Darwin has pointed out, when one of a group of structures held together by some morphological or physiological *nexus* varies, the rest will vary correlatively. One variation then may, if advantageous, become adaptive, while the rest will be indifferent. But it appears to me that such a principle should be applied with the greatest caution; and from what I have myself heard fall from Mr. Darwin, I am led to believe that in the later years of his life he was disposed to think that every detail of plant structure had some adaptive significance, if only the clue could be found to it. As regards the forms of flowers an enormous body of information has been collected, but the vegetative organs have not yielded their secret to anything like the same extent. My own impression is that they will be found to be adaptive in innumerable ways which at present are not even suspected. At Kew we have probably a larger number of species assembled together than are to be found anywhere on the earth's surface. Here, then, is ample material for observation and comparison. But the adaptive significance will doubtless often be found by no means to lie on the surface. Who, for example, could possibly have guessed by inspection the purpose of the glandular bodies on the leaves of *Acacia sphærocephala* and on the pulvinus of *Cecropia peltata* which Belt in the one case, and Fritz Müller in the other, have shown to serve as food for ants? So far from this explanation being far-fetched, Belt found that the former "tree is actually unable to exist without its guard," which it could not secure without some attraction in the shape of food. One fact which strongly impresses me with a belief in the adaptive significance of vegetative characters is the fact that they are constantly adopted in almost identical forms by plants of widely different affinity. If such forms were without significance one would expect them to be infinitely varied. If, however, they are really adaptive, it is intelligible that different plants should independently avail themselves of identical appliances and expedients.

Although this country is splendidly equipped with appliances for the study of systematic botany, our Universities and Colleges fall far behind a standard which would be considered even tolerable on the Continent in the means of studying morphological and physiological botany or of making researches in these subjects. There is not at the moment anywhere in London an adequate botanical laboratory, and though at most of the Universities matters are not quite so bad, still I am not aware of any one where it is possible to do more than give the routine instruction, or to allow the students, when they have passed through this, to work for themselves. It is not easy to see why this should be, because on the animal side the accommodation and appliances for teaching comparative anatomy and physiology are always adequate and often palatial. Still less explicable to me is the tendency on the part of those who have charge of medical education to eliminate botanical study from the medical curriculum, since historically the animal histologists owe everything to botanists. In the seventeenth century, as I have already mentioned, Hooke first brought the microscope to the investigation of organic structure, and the tissue he examined was cork. Somewhat later, Grew, in his "Anatomy of Plants," gave the first germ of the cell-theory. During the eighteenth century the anatomists were not merely on a hopelessly wrong tack themselves, but they were bent on dragging botanists into it also. It was not till 1837, a little more than fifty years ago, that Henle saw that the structure of epithelium was practically the same as that of the *parenchyma plantarum* which Grew had described 150 years before. Two years later Schwann published his immortal theory, which comprised the ultimate facts of plant and animal anatomy under one view. But it was to a botanist, Von Mohl, that, in 1846, the biological world owed the first clear description of protoplasm, and to another botanist, Cohn (1851), the identification of this with the sarcode of zoologists.

Now the historic order in discovery is not without its significance. The path which the first investigators found most accessible is doubtless that which beginners will also find easiest to tread. I do not myself believe that any better access can be obtained to the structure and functions of living tissues than by the study of plants. However, I am not without hopes that the serious study of botany in the laboratory will be in time better cared for. I do not hesitate to claim for it a position of the greatest importance in ordinary scientific education. All the essential phenomena of living organisms can be readily demonstrated upon plants. The necessary appliances are not so costly, and the work of the class-room is free from many difficulties with which the student of the animal side of biology has to contend.

Those, however, who have seriously devoted themselves to the pursuit of either morphological or physiological botany need not now be wholly at a loss. The splendid laboratory on Plymouth Sound, the erection of which we owe to the energy and enthusiasm of Prof. Ray Lankester, is open to botanists as well as to zoologists, and affords every opportunity for the investigation of marine plants, in which little of late years has been done in this country. At Kew we owe to private munificence a commodious laboratory in which much excellent work has already been done. And this Association has made a small grant in aid of the establishment of a laboratory in the Royal Botanic Garden at Peradeniya, in Ceylon. It may be hoped that this will afford facilities for work of the same kind as has yielded Dr. Treub such a rich harvest of results in the Buitenzorg Botanic Garden in Java.

Physiological botany, as I have already pointed out, is a field in which this country in the past has accomplished great things. It has not of late, however, obtained an amount of attention in any way proportionate to that devoted to animal physiology. In the interests of physiological science generally, this is much to be deplored; and I believe that no one was more firmly convinced of this than Mr. Darwin. Only a short time before his death, in writing to Mr. Romanes on a book that he had recently been reading, he said that the author had made "a gigantic oversight in never considering plants: these would simplify the problem for him." This goes to the root of the matter. There is, in my judgment, no fundamental biological problem which is not exhibited in a simpler form by plants than animals. It is possible, however, that the distaste which seems to exist amongst our biologists for physiological botany may be due in some measure to the extremely physical point of view from which it has been customary to treat it on the Continent. It is owing in great measure to the method of Mr. Darwin's own admirable researches that in this country we have been led to a more excellent way. The work which has been lately done in England seems to me full of the highest promise. Mr. Francis Darwin and Mr. Gardiner have each in different directions shown the entirely new point of view which may be obtained by treating plant phenomena as the outcome of the functional activity of protoplasm. I have not the least doubt that by pursuing this path English research will not merely place vegetable physiology, which has hitherto been too much under the influence of Lamarckism, on a more rational basis, but that it will also sensibly react, as it has done often before, on animal physiology.

There is no part of the field of physiological botany which has yielded results of more interest and importance than that which relates to the action of ferments and fermentation; and I could hardly give you a better illustration of the purely biological method of treating it. I believe that these results, wonderful and fascinating as they are, afford but a faint indication of the range of those that are still to be accomplished. The subject is one of extreme intricacy, and it is not easy to speak about it briefly. To begin with, it embodies two distinct groups of phenomena which have in reality very little which is essential in common.

What are usually called ferments are perhaps the most remarkable of all chemical bodies, for they have the power of effecting very profound changes in the chemical constitution of other substances, although they may be present in very minute quantity; but, and this is their most singular and characteristic property, they themselves remain unchanged in the process. It may be said without hesitation that the whole nutrition of both animals and plants depends on the action of ferments. Organisms are incapable of using solid nutrient matter for the repair and extension of their tissues; this must be first brought into a soluble form before it can be made available, and this change is generally brought about by the action of a ferment. Animal physiology has long been familiar with the part played by ferments, and it may be said that no small part of the animal economy is made up of organs required either for the manufacture of ferments or for the exposure of ingested food to their action. It may seem strange at first sight to speak of analogous processes taking place in plants. But it must be remembered that plant nutrition includes two very distinct stages. Certain parts of plants build up, as everyone knows, from external inorganic materials substances which are available for the construction of new tissues. It might be supposed that these are used up as fast as they are formed. But it is not so; the life of the plant is not a continuous balance of income and expenditure. On the contrary, besides the general maintenance of its structure, the plant has to provide from time to time for enormous resources to meet such exhausting demands as the renewal of foliage, the production of flowers, and the subsequent maturing of fruit.

In such cases the plant has to draw on an accumulated store of solid food which has rapidly to be converted into the soluble form in which alone it is capable of passing through the tissues to the seat of consumption. And I do not doubt for my part that in such cases ferments are brought into play of the same kind and in the same way as in the animal economy. Take such a simple case as a potato-tuber. This is a mass of cellular tissue, the cells of which are loaded with starch. We may either dig up the tuber and eat the starch ourselves, or we may leave it in the ground, in which case it will be consumed in providing material for the growth of a potato-plant next year. But the processes by which the insoluble starch is made available for nutrition are, I cannot doubt, closely similar in either case.

When we inquire further about these mysterious and all-important bodies, the answer we can give is extremely inadequate. It is very difficult to obtain them in amount sufficient for analysis, or in a state of purity. We know, however, that they are closely allied to albuminoids, and contain nitrogen in varying proportion. Papain, which is a vegetable ferment derived from the fruit of the papaw, and capable of digesting most animal albuminoids, is said to have the same ultimate composition as the pancreatic ferment and as peptones, bodies closely allied to proteids; the properties of all three bodies are, however, very different. It seems clear, nevertheless, that ferments must be closely allied to proteids, and, like these bodies, they are, no doubt, directly derived from protoplasm.

I need not remind you that, unlike other constituents of plant tissues, protoplasm, as a condition of its vitality, is in a constant state of molecular activity. The maintenance of this activity involves the supply of energy, and this is partly derived from the waste of its own substance. This "self-decomposition" of the protoplasm liberates energy, and in doing so gives rise to a number of more stable bodies than protoplasm. Some of these are used up again in nutrition; others are thrown aside, and are never drawn again into the inner circle of vital processes. In the animal organism, where the strictest economy of bulk is a paramount necessity, they are promptly got rid of by the process of excretion. In the vegetable economy these residual products usually remain. And it is for this reason, I may point out, that the study of the chemistry of plant nutrition appears to me of such immense importance. The record of chemical change is so much more carefully preserved; and the probability of our being able to trace the course it has followed is consequently far more likely to be attended with success.

This preservation in the plant of the residual by-products of protoplasmic activity no doubt accounts for the circumstance which otherwise is extremely perplexing—the profusion of substances which we meet with in the vegetable kingdom to which it is hard to attribute any useful purpose. It seems probable that ferments, in a great many cases, belong to the same category. I imagine that it is in some degree accidental that some of them have been made use of, and thus the plant has been able to temporarily lock up accumulations of food to be drawn upon in future phases of its life with the certainty that they would be available. Without the ferments the key of the storehouse would be lost irretrievably.

Plants, moreover, are now known to possess ferments, and the number will doubtless increase, to which it is difficult to attribute any useful function. Papain, to which I have already alluded, abounds in the papaw, but it is not easy to assign to it any definite function; still less is it easy, on teleological grounds, to account for the rennet ferment contained in the fruits of an Indian plant, *Withania coagulans*, and admirably investigated by Mr. Sheridan Lea.

Having dwelt so far on the action of ferments, we may now turn to fermentation, and that other kind of change in organic matter called "putrefaction," which is known to be closely allied to fermentation. Ferments and fermentation, as I have already remarked, have very little to do with one another; and it would save confusion and emphasize the fact if we ceased to speak of ferments but used some of the alternative names which have been proposed for them, such as *zymases* or *enzymes*.

The classical case of fermentation, which is the root of our whole knowledge of the subject, is that of the conversion of sugar into alcohol. Its discovery has everywhere accompanied the first stages of civilization in the human race. Its details are now taught in our text-books; and I should hardly hope to be excused for referring to it in any detail if it were not necessary for my purpose to draw your attention more particularly to one or two points connected with it.

Let us trace what happens in a fermenting liquid. It becomes turbid, it froths and effervesces, the temperature sensibly increases; this is the first stage. After this it begins to clear, the turbidity subsides as a sediment; the sugar which the fluid at first contained has in great part disappeared, and a new ingredient, alcohol, is found in its place.

It is just fifty years ago that the great Dutch biologist Schwann made a series of investigations which incontrovertibly demonstrated that both fermentation and putrefaction were due to the presence of minute organisms which live and propagate at the expense of the liquids in which they produce as a result these extraordinary changes. The labours of Pasteur have confirmed Schwann's results, and—what could not have been foreseen—have extended the possibilities of this field of investigation to those disturbances in the vital phenomena of living organisms themselves which we include under the name of "disease," and which, no one will dispute, are matters of the deepest concern to every one of us.

Now, at first sight, the conversion of starch into sugar by means of diastase seems strikingly analogous to the conversion of sugar into alcohol. It is for this reason that the phenomena have been so long associated. But it is easy to show that they are strikingly different. Diastase is a chemical substance of obscure composition it is true, but inert and destitute of any vital properties, nor is it affected by the changes it induces. Yeast, on the other hand, which is the active agent in alcoholic fermentation, is a definite organism; it enormously increases during the process, and it appears to me impossible to resist the conclusion that fermentation is a necessary concomitant of the peculiar conditions of its life. Let me give you a few facts which go to prove this. In the first place, you cannot ferment a perfectly pure solution of sugar. The fermentable fluid must contain saline and nitrogenous matters necessary for the nutrition of the yeast protoplasm. In pure sugar the yeast starves. Next, Schwann found that known protoplasmic poisons, by killing the yeast-cells, would prohibit fermentation. He found the same result to hold good of putrefaction, and this is the basis of the whole theory of antiseptics. Nor can the action of yeast be attributed to any ferment which the yeast secretes. It is true that pure cane-sugar cannot be fermented, and that yeast effects the inversion of this, as it is called, into glucose and lævulose. It does this by a ferment which can be extracted from it, and which is often present in plants. But you can extract nothing from yeast which will do its peculiar work apart from itself. Helmholtz made the crucial experiment of suspending a bladder full of boiled grape-juice in a vat of fermenting must; it underwent no change; and even a film of blotting-paper has been found a sufficient obstacle to its action. We are driven, then, necessarily to the conclusion that in the action of "ferments" or zymases we have to do with a chemical—*i.e.* a purely physical process; while in the case of yeast we encounter a purely physiological one.

How, then, is this action to be explained? Pasteur has laid stress on a fact which had some time been known, that the production of alcohol from sugar is a result of which yeast has not the monopoly. If ripening fruits, such as plums, are kept in an atmosphere free from oxygen, Bérard found that they, too, exhibit this remarkable transformation; their sugar is converted appreciably into alcohol. On the other hand, Pasteur has shown that, if yeast is abundantly supplied with oxygen, it feeds on the sugar of a fermentable fluid without producing alcohol. But, under the ordinary circumstances of fermentation, its access to oxygen is practically cut off; the yeast, then, is in exactly the same predicament as the fruit in Bérard's experiment. Sugar is broken up into carbon dioxide and alcohol in an amount far in excess of the needs of mere nutrition. In this dissociation it can be shown that an amount of energy is set free in the form of heat equal to about one-tenth of what would be produced by the total combustion of an equivalent amount of grape-sugar. If the protoplasm of the yeast could, with the aid of atmospheric oxygen, completely decompose a unit of grape-sugar, it would get ten times as much energy in the shape of heat as it could get by breaking it up into alcohol and carbon dioxide. It follows, then, that to do the same amount of growth in either case, it must break up ten times as much sugar without a supply of oxygen as with it. And this throws light on what has always been one of the most remarkable facts about fermentation—the enormous amount of change which the yeast manages to effect in proportion to its own development.

There are still two points about yeast which deserve attention before we dismiss it. When a fermenting liquid comes to contain about 14 per cent. of alcohol, the activity of the yeast ceases, quite independently of whether the sugar is used up or not. In other cases of fermentation the same inhibiting effect of the products of fermentation is met with. Thus, lactic fermentation soon comes to an end unless calcium carbonate or some similar substance be added, which removes the lactic acid from the solution as fast as it is formed.

The other point is that in all fermentations, besides what may be termed the primary products of the process, other bodies are produced. In the case of alcoholic fermentation the primary bodies are alcohol and carbon dioxide; the secondary, succinic acid and glycerine. Delpino has suggested that these last are residual products derived from that portion of the fermentable matter which is directly applied to the nutrition of the protoplasm.

Yeast, itself the organism which effects the remarkable changes on which I have dwelt, is somewhat of a problem. It is clear that it is a fungus, the germs of which must be ubiquitous in the atmosphere. It is difficult to believe that the simple facts, which are all we know about it, constitute its entire life-history. It is probably a transitory stage of some more complicated organism.

I can only briefly refer to putrefaction. This is a far more complex process than that which I have traced in the case of alcoholic fermentation. In that, nitrogen is absent, while it is an essential ingredient in albuminoids, which are the substances which undergo putrefactive changes. But the general principles are the same. Here, too, we owe to Schwann the demonstration of the fact that the effective agents in the process are living organisms. If we put into a flask a putrescible liquid such as broth, boil it for some time, and during the process of boiling plug the mouth with some cotton-wool, we know that the broth will remain long unchanged, while if we remove the wool putrescence soon begins. Tyndall has shown that, if we conduct the experiment on one of the high glaciers of the Alps, the cotton-wool may be dispensed with. We may infer, then, that the germs of the organisms which produce putrefaction are abundant in the lower levels of the atmosphere and are absent from the higher. They are wafted about by currents of air; but they are not imponderable, and in still air they gradually subside. Dr. Lodge has shown that air is rapidly cleared of suspended dust by an electric discharge, and this, no doubt, affords a simple explanation of the popular belief that thunderous weather is favourable to putrefactive changes.

Cohn believes that putrefaction is due to due to an organism called *Bacterium termo*, which plays in it the same part that yeast does in fermentation. This is probably too simple a statement; but the general phenomena are nevertheless similar. There is the same breaking down of complex into simpler molecules; the same evolution of gas, especially carbon dioxide; the same rise of temperature. The more or less stable products of the process are infinitely more varied, and it is difficult, if not impossible, to say, in the present state of our knowledge, whether in most cases they are the direct outcome of the putrefactive process, or residual products of the protoplasmic activity of the organisms which induce it. Perhaps, on the analogy of the higher plants, in which some of them also occur, we may attribute to the latter category certain bodies closely resembling vegetable alkaloids; these are called ptomaines, and are extremely poisonous. Besides such bodies, Bacteria undoubtedly generate true ferments and peculiar colouring-matters. But there are in most cases of putrefaction a profusion of other substances, which represent the various stages of the breaking up of the complex proteid molecule, and are often themselves the outcome of subsidiary fermentations.

These results are of great interest from a scientific point of view. But their importance at the present moment in the study of certain kinds of disease can hardly be exaggerated. I have already mentioned Henle as having first found the true clue to animal histology in the structure of plants. As early as 1840 the same observer indicated the grounds for regarding contagious diseases as due to living organisms. I will state his argument in the words of De Bary, whose "Lectures on Bacteria," the last work which we owe to his gifted hand, I can confidently recommend to you as a luminous but critical discussion of a vast mass of difficult and conflicting literature.

It was, of course, clear that contagion must be due to the communication of infectious particles or contagia. These contagia, although at the time no one had seen them, Henle pointed out, "have the power, possessed, as far as we know, by living creatures only, of growing under favourable conditions, and of multiplying at the expense of some other substance than their own, and therefore of assimilating that substance." Henle enforced his view by comparison with the theory of fermentation, which had then been promulgated by Schwann. But for many years his views found no favour. Botanists, however, as in so many other cases, struck on the right path, and from about the year 1850 steady progress, in which De Bary himself took a leading part, was made in showing that most of the diseases of plants are due to parasitic infection. The reason of this success was obvious: the structure of plants makes them more accessible to research, and the invading parasites are larger than animal contagia. On the animal side all real progress dates from about 1860, when Pasteur, having established Schwann's theory of fermentation on an impregnable basis, took up Henle's theory of living contagia.

The only risk now is that we may get on too fast. To put the true theory of any one contagious disease on as firm a basis as that of alcoholic fermentation is no easy matter to accomplish. But I believe that this is, notwithstanding a flood of facile speculation and imperfect research, slowly being done.

There are two tracts in the body which are obviously accessible to such minute organisms as Bacteria, and favourable for their development. These are the alimentary canal and the blood. In the case of the former there is evidence that every one of us possesses quite a little flora of varied forms and species. They seem for the most part, in health, to be comparatively innocuous; indeed, it is believed that they are ancillary to and aid digestion. But it is easy to see that other kinds may be introduced, or those already present may be called into abnormal activity, and fermentative processes may be set up of a very inconvenient kind. These may result in mere digestive disorder, or in the production of some of those poisonous derivatives of proteids of which I have spoken, the effect of which upon the organism may be most disastrous.

The access of Bacteria to the blood is a far more serious matter. They produce phenomena the obvious analogy of which to fermentative processes has led to the resulting diseases being called zymotic. Take, for example, the disease known as "relapsing fever." This is contagious. After a period of incubation, violent fever sets in, which lasts for something less than a week, is then followed by a period of absence, to be again followed in succession by one or more similar attacks, which ultimately cease. Now you will observe that the analogy to a fermentative process is very close. The period of incubation is the necessary interval between the introduction of the germ and its vegetative multiplication in sufficient numbers to appreciably affect the total volume of the blood. The rise in temperature and the limited duration of the attack are equally, as we have seen, characteristic of fermentative processes, while the bodily exhaustion which always follows fever is the obvious result of the dissipation by the ferment organisms of nutritive matter destined for the repair of tissue waste. During the presence of this fever there is present in the blood an organism, *Spirochæte obermeieri*, so named after its discoverer. This disappears when the fever subsides. It is found that if other individuals are inoculated with blood taken from patients during the fever attack, the disease is communicated, but that this is not the case if the inoculation is made during the period of freedom. The evidence, then, seems clear that this disease is due to a definite organism. The interesting point, however, arises, why does the fever recur, and why eventually cease? The analogy of fermentation leads to the hypothesis that, as in the case of yeast, the products of its action inhibit after a time the further activity of the *Spirochæte*. The inhibiting substance is, no doubt, eventually removed partially from the blood by its normal processes of depuration, and the surviving individuals of *Spirochæte* can then continue their activity, as in lactic fermentation. With regard to the final cessation of the disease, there are facts which may lead one to suppose that in this as in other cases sufficient of the inhibiting substance ultimately remains in the organism to protect it against any further outbreak of activity on the part of the *Spirochæte*.

Here we have an example of a disease which, though having a well-marked zymotic character, is comparatively harmless. In anthrax, which is known to be due to *Bacillus anthracis*, we have one which is, on the contrary, extremely fatal. I need not enter into the details. It is sufficient to say that there is reason to believe that the *Bacillus* produces, as one of those by-products of protoplasmic destruction to which I have already alluded, a most virulent poison. But the remarkable thing is that this *Bacillus*, which can be cultivated externally to the body, if kept at a heightened temperature, can be attenuated in its virulence. It drops, in fact, the excretion of the poison. It is then found that, if injected into the blood, it does no mischief, and, what is more extraordinary, if the *Bacillus* in its most lethal form is subsequently introduced, it too has lost its power. The explanation of the immunity in this case is entirely different from that which was suggested by a consideration of the facts of relapsing fever. The researches of Metschnikoff have led to the hypothesis that in the present case the white blood-corpuscles destroy the *Bacillus*. When they first come into contact with these in their virulent form, they are unable to touch them. But if they have been educated by first having presented to them the attenuated form, they find no difficulty in grappling with the malignant. This is a very remarkable view. I should not have put it before you had there not been solid reasons for regarding the idea of the education of protoplasm with scientific respect. The plasmodia of the Myxomycetes, which consist of naked protoplasm, are known to become habituated to food which they at first reject, and the researches of Beyerinck on the disease known as "gumming" in plants have apparently shown that healthy cells may be taught, as it were, to produce a ferment which otherwise they would not excrete.

If Metschnikoff's theory be true, we have a rational explanation of vaccination and of preventive inoculation generally. It is probably, however, not the only explanation. And the theory of the inhibitive action upon itself of the products of the ferment-organism's own activity is still being made the basis of experiment. In fact, the most recent results point to the possibility of obtaining protection by injecting into the blood substances artificially obtained entirely independent of the organisms whose development they inhibit.

It is impossible for me to touch on these important matters at any greater length, but I doubt if the theory of fermentation, as applied to the diseases of organisms, has as yet more than opened its first page. It seems to me possible that, besides the rational explanation of zymotic diseases, it may throw light on others where, owing to abnormal conditions, the organism, as in the case of Bérard's plums, is itself the agent in its own fermentative processes.

And now I must conclude. I have led you, I am afraid, a too lengthy and varied a journey in the field of botanical study. But to sum up my argument. I believe I have shown you that at the bottom of every great branch of biological inquiry it has never been possible to neglect the study of plants; nay, more, that the study of plant-life has generally given the key to the true course of investigation. Whether you take the problems of geographical distribution, the most obscure points in the theory of organic evolution, or the innermost secrets of vital phenomena, whether in health or disease, not to consider plants is still, in the words of Mr. Darwin, "a gigantic oversight, for these would simplify the problem."

SECTION E.

GEOGRAPHY.

Opening Address by Colonel Sir C. W. Wilson, R.E., K.C.B., K.C.M.G., D.C.L., LL.D., F.R.S., F.R.G.S., Director-General of the Ordnance Survey, President of the Section.

On opening the present session of the Geographical Section of the British Association I cannot refrain from alluding to the last occasion, now nearly a quarter of a century ago, upon which it met in this city. The chair was then filled by one to whom I, in common with others of the younger generation of that day, must ever owe a deep debt of gratitude for many kindly words of advice and encouragement. Then, as now, popular interest centred in Africa, and Sir Roderick Murchison, on taking the chair, was accompanied by a group of distinguished African explorers. Some amongst us may remember the enthusiastic greeting accorded to Livingstone, and the heart-felt sorrow caused by the announcement that the gallant, chivalrous officer, whose name will ever live in history as the discoverer of the sources of the Nile, had been cut off in the fullness of his strength and vigour.

The African travellers who have honoured us with their presence to-day, have shown the same pluck, the same perseverance, the same disregard of personal risk and comfort as their predecessors. One African traveller, a distinguished officer of the German army, who hoped to have been with us, has this year been awarded the highest honour which the Royal Geographical Society can confer—its gold medal. Lieut. Wissman, who possesses all Livingstone's indomitable courage, his constancy of purpose, and his kindly feeling towards the natives, has twice crossed Africa, in its widest extent, without firing a shot in anger. He returned recently to Europe, filled, like the great English traveller, with indignation at the atrocities perpetrated by the Arabs on the blacks; and eager to find means, if such there be, of putting an end to, or at least mitigating, the unspeakable horrors of the slave trade. He is now organizing an expedition which has the double object of opening up the territory in Eastern Africa that falls within the sphere of German influence, and of bearing relief to Emin Pasha. In both enterprises we may heartily wish him "God speed!"

The light thrown upon the interior of the Dark Continent is the most striking feature of geographical exploration during the last twenty-five years; and it is really the work of the last eleven years, for it was only in 1877 that Mr. Stanley, by his remarkable journey, gave a new continent to the world. If Sir Roderick Murchison were now alive he would feel more than gratified at results which have been so largely due to his initiative. I propose, presently, to return to the interesting subject of Africa; but I would first draw attention to the influence which the natural features of the earth's surface have had, and are still having, in conjunction with other causes, on the trade routes and commercial relations between the West and the East, and more especially with India.

The great civilizations of high antiquity appear to have risen and expanded in four riverain districts: Chinese in the basins of the Hoang-ho and the Yang-tse-kiang; Hindu in those of the Indus and the Ganges; Chaldæan and Assyro-Babylonian in those of the Tigris and Euphrates; and Egyptian in that of the Nile. India is separated from China, on the one hand, by rugged, lofty mountain ranges, and the high-lying plateau of Tibet; and from Mesopotamia, on the other, by the Suleiman Mountains and the Perso-Afghan plateau. Intercommunication between these early seats of man's activity must, therefore, have been of slow growth. From Mesopotamia, on the contrary, there is easy access to the Nile basin by way of Syria and Palestine, and there are indications of traffic between these districts at a very remote period. Inquiry into the causes which first led to intercommunication and into the means by which it was effected is needlesss. Desire of gain, lust of power, were as much a part of human nature in the earliest ages as they are now. The former induced the pioneers of commerce to feel their way across trackless deserts, and to brave the hidden dangers of the sea; and for nearly three hundred years it led gallant men to seek a way to the wealth of India through the ice-laden seas of the Arctic region. The latter brought the great empires of Assyria and Egypt into hostile conflict, and carried Alexander to the banks of the Oxus and the Indus; and it is largely answerable for the land-hunger of European States in our own generation.

Nations rise, fall, and disappear, but commerce extends in ever-widening circles, and knows no limits. Efforts are constantly being made to discover and open up new fields of commercial activity and to connect the great centres of commerce by quicker and shorter trade routes. The earliest traffic was conducted by land: men travelled together in caravans for mutual protection, and rested where food and water were to be obtained; at the most important of these halting-places cities were founded. As trade extended, it became necessary to carry goods through independent tribes or countries which often insisted on retaining the transit trade in their own hands, and this led to the rise of cities at points convenient for the transfer of loads and the exchange of commodities of one country for those of another. Generally speaking this early overland trade was co-extensive with the geographical limit of the camel. Next in order to land traffic came that by water, first on rivers, then on the sea; and cities naturally sprang up at places on the coast where the merchandise brought down the rivers in boats could, conveniently and safely, be transferred to galleys or ships suitable for coasting. After a knowledge of the monsoons had been acquired, men began to trust themselves to the open sea; the ships were improved, and a system was established under which voyages were made, with great regularity, at certain seasons of the year, so that advantage might be taken of the periodic winds. Increased knowledge of the globe, improvements in the art of shipbuilding, and the invention of the steam-engine, have gradually led to the ocean traffic of the present day, conducted by large steamers which, regardless of wind and tide, follow the most direct course from one point to another. The trade routes of the world are subject to two great modifying influences, one physical, the other political. The inland trade of India, for instance, can only reach Central Asia and the West by way of Herat or Bamian; caravan roads across the deserts of Asia and Africa must follow lines of springs or wells; climatic conditions render all Polar routes impracticable; and the removal of a physical obstacle, by the construction of the Suez Canal, is now causing a remarkable redistribution of the channels of commerce. So, too, disturbance of traffic by war, or its designed destruction by conquerors; and great political changes, such as the establishment of the Persian Empire, the rise of Rome, the disruption of the Roman Empire, and the advent of the Arabs to power in Wsstern Asia, divert trade from its accustomed routes and force it into new channels, to the ruin of some cities and States and the enrichment of others. The general tendency of trade so diverted is to seek, where possible, a maritime route, for water transport is not only less costly but less liable to interruption than land transport.

India, partly from its geographical position, partly from the character of its people, has always played a passive *rôle* in commerce, and allowed the initiative in commercial enterprise to rest with the West. The greatest advantages have always been derived from the possession of the trade between the East and the West, and from a remote period the nations of the world have contended for this rich prize. One State after another has obtained and lost the prize; England now holds it, but if she is to keep what she has obtained there must be a far closer study than there has hitherto been of geography and terrestrial phenomena in their relation to commerce. Trade between the East and the West may be divided into three periods: the *first*, during which the limits of Oriental commerce were the eastern and south-eastern shores of the Mediterranean, closed with the foundation of Carthage about 800 B.C.; the *second*, or Mediterranean period, ended in the fifteenth century; the *third*, or Oceanic period, has lasted to the present day. In the first period there were two principal lines of traffic: the southern sea route, following the coast line, and the northern land route, traversing Asia in its whole extent from east to west. There are indications of communication between China and the West so early as 2698 B.C.; and in 2353 B.C. an embassy arrived in China from a country which is supposed to have been Chaldæa. There is also an early notice of caravan traffic in the company of Ishmaelites, bearing spicery, and balm, and myrrh to Egypt, to whom Joseph was sold (Genesis xxxvii. 25–28). The earliest maritime people to appreciate the value of trade between the East and West were, apparently, those living along the south coast of Arabia. Happily situated between the Persian Gulf and the Red Sea, and separated by vast deserts from the great nations of Asia, the Sabæans were free from those alternations of industry and war which are so unfavourable to commercial pursuits; for centuries they possessed the commerce of India, and they became famous for their opulence and luxury. Sabæan ships visited Ceylon and the Malabar coast, and Sabæan merchants supplied Indian goods to Mesopotamia and Syria, as well as to Egypt and Ethiopia. The ships trading to the Persian Gulf discharged their cargoes near the mouth of the Euphrates; whence the traffic passed partly by river, partly by land, to the coast towns of Syria and Palestine, and through the Syrian and Cilician gates to Mazaca (*Kaisariyeh*), and Pterium (*Boghazkeui*); from the last place Indian goods found their way to Sardis and Sinope. The ships visiting the Red Sea landed goods at Elath, at the head of the gulf of Akabah, for carriage by land to Tyre and Sidon, and on the western shores of the

Red Sea for transmission to Meroë, Thebes, and Memphis. At the same time silks from China, and gems from India, were carried overland to Chaldæa and Assyria; and Bactra (*Balkh*), "the mother of cities," rose and flourished at the central point of the transit trade. Egypt, with no timber for shipbuilding, a distrust of all foreigners, especially when they came by sea, and a settled dislike of maritime pursuits amongst her people, long neglected the opportunities afforded by her favourable geographical position. Tyre, Sidon, and other Phœnician towns, reached by easy roads from the Euphrates and the Red Sea, and from their situation commanding the Mediterranean, became centres of distribution for Indian goods; and the Phœnicians, gradually extending their operations to the Red Sea, traded with the ports of Southern Arabia, and even ventured to the shores of India. It was in this first period that the Jewish kingdom reached its widest extent. During the long wars of David's reign the Jews obtained possession of the land routes over which the rich products of India were carried to Tyre and Sidon; and Solomon did all in his power, by building Tadmor in the Wilderness (Palmyra), by improving the port of Elath, and by carrying out other great works, to protect and facilitate the transit trade from which such large profits were derived. The Jews do not appear to have been the actual carriers, but many of them no doubt, following the example of their merchant-king, engaged in commercial pursuits, and wealth poured into the kingdom so that silver was made to be as stones in Jerusalem.

In the early portion of the second period the commercial prosperity of the Phœnicians reached its culminating point. Their colonies dotted the shores of the Mediterranean, and their ships passed the "Pillars of Hercules" to Great Britain and the western shores of Africa, and floated on the waters of the Red Sea, the Persian Gulf, and the Indian Ocean. The sea-borne trade of the known world was in their hands; wealth flowed into their cities, and in the markets of Tyre tin from Cornwall and amber from the Baltic were exposed for sale with the silks, gems, and spices of the far-distant East. The decline of Phœnicia dates from the establishment of the Persian Empire in the sixth century B.C., and after the capture of Tyre by Alexander its commerce gradually passed into the hands of the Greeks. The Persian policy of closing the Persian Gulf to commerce forced the Indian traffic along the land routes. Babylon, which had become the emporium of Eastern trade, declined, whilst Susa and Ecbatana were enriched by the transit trade which passed through them and crossed the whole extent of the empire to the Mediterranean ports. The policy of Alexander was to secure the carrying and distribution trade of the world to the Greeks; and with this object he founded Alexandria, and intended, had he lived, to restore Babylon to her former splendour. Ptolemy, his successor in Egypt, used every means in his power to draw trade to Alexandria, and the new city soon rose to opulence and splendour. The Greek merchants obtained their Indian goods from the Arab traders whom they met in the ports of Southern Arabia; they landed them at Myos Hormos and Berenice on the western shore of the Red Sea, carried them by camel across the desert, and floated them down the Nile and by canal to Alexandria, whence they were distributed to the neighbouring parts of Africa and the coasts of the Mediterranean. This trade route remained unaltered until Egypt became a Roman province. Another stream of commerce passed by way of the Persian Gulf to Seleucia on the Tigris, and thence, partly by water and partly by land, through Aleppo to Antioch and Seleucia at the mouth of the Orontes; and a third followed the ancient highway from Central Asia to the ports of the Euxine and Ægean Seas.

After the rise of Rome all trade routes were directed upon the Imperial City, which became a centre of distribution for the merchandise of the East. The Greeks still monopolized the sea-borne trade; and those of Egypt, recognizing the advantage of their geographical position, took the direct trade to India into their hands, and extended their voyages to Kattigara, the port of the Sinæ, in the Gulf of Tongking. Alexandria became the commercial capital of the Roman Empire, the distributing centre of the world for Indian and Asiatic goods, and a place of such wealth that one of the merchants is said to have been able to maintain an army. At the same time the old ports of Tyre, Beirût, Antioch, Ephesus, Byzantium, and Trebizonde maintained their position as *termini* of the land traffic. The extent of the intercourse between the East and the West during the Roman Empire is shown by the embassy of the Seres (Chinese) to Rome in the reign of Augustus, and by the several embassies to China, which followed that sent by Marcus Aurelius in 166 A.D., until the Arab Empire interposed; as well as by the fact that in the time of Pliny the Roman imports from Asia each year were valued at 100,000,000 sesterces (about £800,000). Trade followed well-established routes which remained in use, with but slight modification, till the fifteenth century. There were three principal lines of communication through Central Asia, all leading from China across the Desert of Gobi. The northern ran to the north of the Thien-Shan by Lake Balkash to the Jaxartes (*Syr Darya*); the central passed along the southern slopes of the Thien-Shan and crossed the mountains by the Terek Pass to Samarcand and the Oxus (*Amu Darya*); and the southern passed over the Pamir and through Badakhshan to Balkh. The northern route apparently went on from the Jaxartes, through Khiva, to the Caspian, which it crossed, and then ran on to the Black Sea. Even at this early period trade filtered round the northern shores of the Caspian, and later, during the Middle Ages, there was a well-established trade route in this direction through Khiva to Novgorod and the Baltic, by which the northern countries received Indian goods. From the Oxus region reached by the central and southern lines there were two routes to the West. One passed through Merv, crossed the Caspian, ascended the Araxes to reach Artaxates and Trebizonde, or to descend the Phasis (*Rion*) to Poti, and then coasted the shores of the Black Sea to Byzantium. The other also passed through Merv, and, running along the northern frontier of Persia, reached the shores of the Black Sea through Artaxates, or continued on through Mesopotamia, Syria, and Asia Minor to Byzantium. The land trade from India passed through the Bamian Pass to Balkh, and through Kandahar and Herat to Merv or Sarrakhs to join the great stream of Central Asian traffic. The greater portion of the carrying trade on these long lines was in the hands of the people dwelling between the Jaxartes and the Oxus, who had their centre at Samarcand; and these Sogdians, or Asi as they are called in the Chinese annals, fearing lest they should lose the profit on the transit trade, threw every obstacle in the way of direct communication between China and the Roman Empire. The difficulties which thus interrupted the land traffic gave an impetus to the trade by sea, and so benefited Alexandria and the cities in the Persian Gulf. The sea trade at this time was carried by way of the Persian Gulf and the Red Sea. In the first case the cargoes were landed at some port on the Euphrates or Tigris, whence the goods were carried by river and caravan up the valleys of those rivers and then through Syria to Beirût and Antioch, and through Asia Minor to Ephesus, Smyrna, Constantinople, and Samsûn. In the second case the merchandise was landed either near Suez, whence it was conveyed by caravan, canal, and river to Alexandria, and at a later date to Pelusium, or at the head of the Gulf of Akabah for transport to Syria and Palestine. The sea trade was to a great extent a coasting trade, and it appears to have been shared by the Greeks and the Arabs, and perhaps by the Chinese, whose junks were to be seen at Hira, on the Euphrates, in the fifth century.

On the disruption of the Roman Empire the Byzantines, with their capital situated on the confines of Europe and Asia, naturally became the intermediaries between the East and the West, and they retained this position until the maritime towns of Italy, France, and Spain became sufficiently strong to engage in direct trade with the Mediterranean ports to which the produce of the East found its way. Until the seventh century the Sassanians held the lines of communication by land, and they did all they could to prevent Eastern produce from being carried over any other roads than those passing through their territory or by any other hands than theirs. In the sixth century they allowed an exchange of produce between the East and the West to take place at only three points: Artaxates for goods arriving from Central Asia; Nisibis for those from Central Asia and by the Tigris route; and Callinicum (*Rakka*) for those coming by way of the Persian Gulf and the Euphrates. Justinian attempted to free Oriental commerce from its dependence on the Sassanians by opening up new trade routes. The Sogdian silk merchants passed, outside of Persian territory, round the north end of the Caspian to meet those of Byzantium on the shores of the Sea of Azov and the Black Sea; the products of India were obtained from Ethiopian traders at Adulis, on the Red Sea; and Greek navigators, taking advantage of the monsoons, sailed direct from the southern end of the Red Sea to the Malabar coast and Ceylon.

In the seventh and eighth centuries the Arabs overran the whole of Central Asia, and the carrying trade by sea and by land passed into their hands. Profound modifications were thus introduced into the commercial intercourse between the East and the West. All land traffic from the East was directed upon Baghdad, which became the distributing centre whence goods were despatched by the ancient trade routes to the West, and which almost rose to the splendour of Babylon. On the sea the Arabs regained their old reputation; they sailed direct from the Red Sea to Cape Comorin, and from Ceylon to the Malay Peninsula, and extended their voyages to Kanpu, on a delta arm of the Yang-tse-Kiang; they established factories in the Indian Ocean, and, in the eighth century, were so numerous in Canton as to be able to attack and pillage that city. Their only rivals were the Chinese, whose junks visited the Euphrates and Aden, and brought silks and spices to the Malabar coast to be there exchanged for the raw material and manufactures of the West.

The Eastern produce brought by the Arabs to the ports of the Mediterranean was conveyed to Europe by the merchants of Venice, Genoa, Pisa, and other towns, who also traded to Constantinople and the Black Sea. Venice from its geographical position was well adapted to be the intermediary between the East and Central Europe, and even before the rise of Islam a large share of the carrying trade of the Mediterranean had fallen into its hands through the apathy and luxurious indolence of the Byzantines. It is unnecessary to trace the rise of Venice or discuss the impetus given by the Crusades to commercial intercourse between the East and Western Europe; it will be sufficient to note that in the first quarter of the fifteenth century the carrying trade of the Mediterranean was wholly in the hands of the Venetians, and Venice had become the distributing centre for all Europe. Venetian fleets, well guarded by war galleys, sailed at stated times for Constantinople and the Black Sea; for Syria and Egypt; for France; for Spain and Portugal, and for Holland. From the ports in those countries, as well as from Venice herself, the products of the East were carried inland over well-defined trade routes, and cities such as Pavia, Nürnberg, and Bruges, the emporium of the Hanseatic League, rose to importance as *entrepots* of Eastern commerce.

The victorious advance of the Turks, the fall of Constantinople, the piracy in the Mediterranean, and the termination of all intercourse with China on the decline of the Mongol dynasty in the fourteenth century, combined with other circumstances to turn men's minds towards the discovery of a more convenient way to the East. India was the dream of the fifteenth-century merchant, and how to reach it by a direct sea voyage was the problem of the day. The problem was solved when Vasco de Gama reached the shores of India on May 20, 1498; and its solution was due to the wise policy of a great grandson of Edward III., Prince Henry of Portugal, "the Navigator," who unfortunately died before success was attained. The discovery of the Cape route was no mere accident, but the result of scientific training, deep study, careful preparation, and indomitable perseverance. Prince Henry having determined to find a direct sea route to India, invited the most eminent men of science to instruct a number of young men who were educated under his own eye, and in a few years he made the Portuguese the most scientific navigators in Europe. The successful voyage of Vasco de Gama soon produced important results; the saving in freight by the direct sea route was enormous, and when it became generally known that the products of the East could be obtained much cheaper in Lisbon than anywhere else, that city became the resort of traders from every part of Europe. From Lisbon, Indian commodities were carried to Antwerp, which soon became the emporium of Northern Europe. By these changes the trade of Venice was almost annihilated, and Lisbon became the richest commercial city in Europe. The Venetians had endeavoured to confine commerce within its existing limits, and to keep to the trade routes then in use. They had never made any attempt to enlarge the sphere of nautical and commercial enterprise, and the consequence was that their ablest seamen, imbued with the spirit of adventure, took service in the Western States. When the Cape route was discovered, instead of attempting to secure a share in the direct sea trade, they entered into an alliance with the Sultan of Egypt to crush the Portuguese, and built a fleet for him at Suez which was defeated by Almeida in 1508. After this defeat the trade of Venice soon passed away.

Since the discovery of the Cape route there has been one long struggle for the possession of the commerce of India; who should be the carriers and distributors of Indian commodities was for more than two and a half centuries a much contested point amongst the maritime nations of the West. At first there seems to have been a general acquiescence in the claim of the Spaniards and Portuguese to a monopoly of the southern sea-routes, and this led to those heroic efforts to find a north-east or north-west passage to India which have so greatly added to our geographical knowledge. Failure in this direction was followed by attempts to reach India by the Cape in the face of the hostile attitude of Spain and Portugal. The mighty events which in turn transferred wealth and commerce from Lisbon to Antwerp, Amsterdam, and the banks of the Thames are matter of history, and it is scarcely necessary to say that at the close of the Napoleonic wars England remained undisputed mistress of the sea, and had become not only the carrier of all ocean-borne traffic, but the distributing centre of Indian goods to the whole world. A period of keen competition for a share in the commerce of India has again commenced amongst the States of Europe, and symptoms of a coming change in the carrying and distributing trade have been increasingly apparent since Africa was separated from Asia, nearly twenty years ago, by the genius of M. de Lesseps.

The opening of the Suez Canal, by diverting trade from the Cape route to the Mediterranean, has produced and is still producing changes in the intercourse between the East and the West which affect this country more nearly, perhaps, than any other European State. The changes have been in three directions.

First. An increasing proportion of the raw material and products of the East is carried direct to Mediterranean ports, by ships passing through the Canal, instead of coming, as they once did, to England for distribution. Thus Odessa, Trieste, Venice, and Marseilles are becoming centres of distribution for Southern and Central Europe, as Antwerp and Hamburg are for the North; and our merchants are thus losing the profits they derived from transmitting and forwarding Eastern goods to Europe. It is true that the carrying trade is still, to a very great extent, in English hands; but should this country be involved in a European war, the carrying trade, unless we can efficiently protect it, will pass to others, and it will not readily return. Continental manufacturers have always been heavily handicapped by the position England has held since the commencement of the century, and the distributing trade would doubtless have passed from us in process of time. The opening of the Canal has accelerated the change, to the detriment of English manufactures, and consequently of the national wealth; and it must tend to make England less and less each year the emporium of the world. We are experiencing the results of a natural law that a redistribution of the centres of trade must follow a rearrangement of the channels of commerce.

Second. The diversion of traffic from the Cape route has led to the construction of steamers for special trade to India and the East through the Canal. On this line coaling-stations are frequent, and the seas, excepting in the Bay of Biscay, are more tranquil than on most long voyages. The result is that an inferior type of vessel, both as regards coal-stowage, speed, endurance, and seaworthiness, has been built. These "Canal wallahs," as they are sometimes called, are quite unfitted for the voyage round the Cape, and should the Canal be blocked by war or accident they would be practically useless in carrying on our Eastern trade. Since the Canal has deepened they have improved, for it has been found cheaper to have more coal-stowage, but they are still far from being available for the long voyage round the Cape. Had the Canal not been made, a large number of fine steamers would gradually have been built for the Cape route, and though the sailing-ships which formerly carried the India and China trade would have held their own longer, we should by this time have had more of the class of steamer that would be invaluable to us in war time, and our trade would not have been liable, as it is now, to paralysis by the closing of the Canal.

Third. Sir William Hunter has pointed out that, since the opening of the Canal, India has entered the market as a competitor with the British workman; and that the development of that part of the Empire as a manufacturing and food-exporting country will involve changes in English production which must for a time be attended by suffering and loss. Indian trade has advanced by rapid strides, the exports of merchandise have risen from an average of 57 millions for the five years preceding 1874 to 88 millions in 1884, and there has been an immense expansion in the export of bulky commodities. Wheat, which occupied an insignificant place in the list of exports, is now a great staple of Indian commerce, and the export has risen since

1873 from 1¾ to 21 million hundredweights. It is almost impossible to estimate the ultimate dimensions of the wheat trade, and it is only the forerunner of other trades in which India is destined to compete keenly with the English and European producers.

The position in which England has been placed by the opening of the Canal is in some respects similar to that of Venice after the discovery of the Cape route; but there is a wide difference in the spirit with which the change in the commercial routes was accepted. Venice made no attempt to use the Cape route, and did all she could to prevent others from taking advantage of it: England, though by a natural instinct she opposed the construction of the Canal, was one of the first to take advantage of it when opened, and so far as the carrying trade is concerned she has hitherto successfully competed with other countries.

It is only natural to ask what the result of the opening of the Panama Canal will be. To this it may be replied that the Canal, when completed as a maritime canal, without locks, will promote commercial intercourse between the eastern and western coasts of America; will benefit merchants by diminishing distances, and reducing insurance charges; and possibly divert the course of some of the trade between the East and West; but it will produce no such changes as those which have followed the construction of the Suez Canal.

The increasing practice of the present day is for each maritime country to import and carry the Indian and other commodities it requires, and we must be prepared for a time when England will no longer be the emporium of Eastern commerce for Europe, or possess so large a proportion as she now does of the carrying trade. So great, however, is the genius of the English people for commercial enterprise, and so imbued are they with the spirit of adventure, that we may reasonably hope loss of trade in one direction will be compensated by the discovery of new fields of commercial activity. The problem of sea-carriage has virtually been solved by the construction of the large ocean steamers which run direct from port to port without regard to winds or currents; and the only likely improvement in this direction is an increase of speed which may possibly rise to as much as thirty knots an hour. The tendency at present is to shorten sea-routes by maritime canals; to construct canals for bringing ocean-going ships to inland centres of industry; and to utilize water carriage, wherever it may be practicable, in preference to carriage by land. For a correct determination of the lines which these shortened trade routes and great maritime canals should follow, a sound knowledge of geography and of the physical condition of the earth is necessary; and instruction in this direction should form an important feature in any educational course of commercial geography. The great problem of the future is the inland carrying trade, and one of the immediate commercial questions of the day is, Who is to supply the interiors of the great continents of Asia and Africa, and other large areas not open to direct sea traffic? Whether future generations will see

> "The heavens fill with commerce, argosies of magic sails,
> Pilots of the purple twilight, dropping down with costly bales,"

or some form of electric carriage on land, may be matter for speculation; but it is not altogether impossible to foresee the lines which inland trade must follow, and the places which must become centres of the distributing trade, or to map out the districts which must, under ordinary conditions, be dependent upon such centres for their supply of imported commodities. The question of supplying European goods to one portion of Central Asia has been partially solved by the remarkable voyage of Mr. Wiggins last year, and by the formation of the company of the "Phœnix Merchant Adventurers." Mr. Wiggins started from Newcastle-on-Tyne for Yeniseisk, the first large town on the Yenisei, some 2000 miles from the mouth of that river, and within a few hundred versts of the Chinese frontier. On the 9th of October, 1887, he cast anchor and landed his cargo in the heart of Siberia. The exploit is one of which any man might well be proud, but in Mr. Wiggins's case there is the additional merit that success was the result of conviction arrived at by a strict method of induction, that the Gulf Stream passed through the Straits into the Kara Sea, and that its action, combined with that of the immense volume of water brought down by the Obi and Yenisei, would free the sea from ice and render it navigable for a portion of each year. The attempts of England to open up commercial relations with the interior of Africa have too often been marked by want, if not open contempt, of geographical knowledge, and by a great deficiency of foresight; but the competition with Germany is forcing this country to pay increased attention to African commerce, and the formation of such companies as the British East African Company, the African Lakes Company, and the Royal Niger Company is a happy omen for the future.

Another branch of the subject to which attention may be briefly directed is the fact that it is becoming increasingly evident that manufactures cannot profitably be carried on at a distance from the source of the raw material and the destination of the products. In India, for instance, where the first mill for the manufacture of cotton yarn and cloth was set up in 1854, there are now over 100 cotton and jute mills with 22,000 looms and 2,000,000 spindles; and similar changes are taking place elsewhere.

I am afraid that I have frequently travelled beyond the sphere of geography. My object has been to draw attention to the supreme importance to this country of the science of commercial geography. That science is not confined to a knowledge of the localities in which those products of the earth which have a commercial value are to be found, and of the markets in which they can be sold with the greatest profit. Its higher aims are to divine, by a combination of historical retrospect and scientific foresight, the channels through which commerce will flow in the future, and the points at which new centres of trade must arise in obedience to known laws. A precise knowledge of the form, size, and geological structure of the globe; of its physical features; of the topographical distribution of its mineral and vegetable products, and of the varied forms of animal life, including man, that it sustains; of the influence of geographical environment on man and the lower animals; and of the climatic conditions of the various regions of the earth, is absolutely essential to a successful solution of the many problems before us. If England is to maintain her commanding position in the world of commerce, she must approach these problems in the spirit of Prince Henry the Navigator, and by high scientific training fit her sons to play their part like men in the coming struggle for commercial supremacy. The struggle will be keen, and victory will rest with those who have most fully realized the truth of the maxim that "Knowledge is power."

I may add that if there is one point clearer than another in the history of commerce it is this: that when a State cannot effectually protect its carrying trade in time of war, that trade passes from it and does not return. If England is ever found wanting in the power to defend her carrying trade, her fate will only too surely, and I might almost say justly, be that of Venice, Spain, Portugal, and Holland.

I will now ask you to turn your attention for a few moments to another subject—Africa. In 1864, Sir Roderick Murchison alluded to the great continent in the following terms: "Looking at the most recent maps of Africa, see what enormous *lacunæ* have to be filled in, and what vast portions of it the foot of the white man has never trodden." It was then impossible to give a general sketch even of the geography of Equatorial Africa. Tanganyika and Nyassa had been discovered, and Speke and Grant had touched at a few points on the southern, western, and northern shores of the Victoria Nyanza; but we were still in ignorance of the drainage and form of the immense tract of country between the Tanganyika Lake and the Zambesi; and the heart of Africa, through which the mighty Congo rolls, was as much unknown to us as the centre of America was to our ancestors in the middle of the sixteenth century. There are now few school-boys who could not give a fairly accurate sketch of the geography of Central Africa; and a comparison of the maps published respectively in 1864 and 1888 will show how rapidly the *lacunæ* of which Sir Roderick complained are being filled in. There is still much to be done, and it is precisely in one of the few blank spots left on our maps that the man who may well be called the Columbus of Africa has so mysteriously disappeared. The discovery of the course of the Congo by Stanley has been followed by results not unlike those which attended the discovery of America by Columbus. In the latter part of the nineteenth century Africa has become to Europe what America was in the sixteenth century. Events march more rapidly now than they did then, and the efforts of the maritime nations of Europe to secure themselves some portion of African territory and some channel through which they can pour their products into Central Africa are rapidly changing the condition of the Dark Continent.

The roads over which the land trade of Equatorial Africa now passes from the coast to the interior are mere footpaths, described by Prof. Drummond, in his charming book "Tropical Africa," as being "never over a foot in breadth, beaten as hard as adamant, and rutted beneath the level of the forest bed by centuries of native traffic. As a rule these footpaths are marvellously direct. Like the roads of the old Romans, they run straight on through everything, ridge and mountain and valley, never shying at obstacles, nor anywhere turning aside to breathe. Yet with this general straightforwardness there is a singular eccentricity and indirectness in detail. Although the African footpath is on the whole a bee-line, no fifty yards of it are ever straight. And the reason is not far to seek. If a stone is encountered, no native will ever think of removing it. Why should he? It is easier to walk round it. The next man who comes that way will do the same. . . . Whatever the cause, it is certain that for persistent straightforwardness in the general, and utter vacillation and irresolution in the particular, the African roads are unique in engineering." No country in the world is better supplied with paths; every village is connected with some other village, every tribe with the next tribe, and it is possible for a traveller to cross Africa without once being off a beaten track. The existence nearly everywhere of a wide coast plain with a deadly climate, and the difficulties attending land transport in a country where the usual beasts of burden, such as the camel, the ox, the horse, and the mule, cannot be utilized, will probably for many years retard the development of the land trade. On the other hand, the Congo with its wide-reaching arms, the Niger, the Nile, the Zambesi, the Shiré, and the great lakes Nyassa, Tanganika, and the Victoria and Albert Nyanzas offer great facility for water transport, and afford easy access to the interior without traversing the pestilential plains. Already steamers ply on most of the great waterways—each year sees some improvement in this respect; and a road is in course of construction from Lake Nyassa to Tanganyika which will tend, if Arab raiders can be checked, to divert inland traffic from Zanzibar to Quilimane, and will become an important link in what must be one of the great trade routes in the future. It is possible, I believe, with our present knowledge of Africa, and by a careful study of its geographical features, to foresee the lines along which trade routes will develop themselves, and the points at which centres of trade will arise; but I have already detained you too long, and will only venture to indicate Sawákin, Mombasa, Quilimane, or some point near the mouth of the Zambesi, and Delagoa Bay, as places on the east coast of Africa which, from their geographical position, must eventually become of great importance as outlets for the trade of the interior.

The future of Africa presents many difficult problems, some of which will no doubt be brought to your notice during the discussion which, I trust, will follow the reading of the African papers; and there is one especially—the best means of putting an end to slave hunting and the slave-trade—which is now happily attracting considerable attention. It is surely not too much to hope that the nations which have been so eager to annex African soil will remember the trite saying that "Property has its duties as well as its rights," and that one of the most pressingly important of the duties imposed upon them by their action is to control the fiends in human form who, of set purpose, have laid waste some of the fairest regions of the earth, and imposed a reign of terror throughout Equatorial Africa.

NOTES.

We regret to announce that Dr. Peter Griess died very suddenly at Bournemouth on Thursday last week, apparently from an attack of apoplexy. A very skilful manipulator, enthusiastically devoted to his science, a patient and unwearying worker, his death will deprive chemical science of one of its brightest ornaments. He will be chiefly remembered for his discovery of the diazo-compounds, one of the most remarkable classes of substances known to chemistry.

A TELEGRAM from the city of Mexico states that on the night of the 6th instant there occurred the heaviest shocks of earthquake ever recorded in the city. The houses swayed, the walls cracked, and people rushed into the streets to pray. There was for a few moments much apprehension. The phenomenon was preceded by high winds and dust-storms.

A FRIGHTFUL cyclone, involving great destruction of property and loss of life, took place at Havannah on the 4th instant. It is stated to have been the most severe experienced in the West Indies for many years past.

THE inaugural address of St. Thomas's Hospital will be delivered in the theatre on Monday, October 1, at 3 p.m., by Dr. Cullingworth.

THE sixth course of twelve lectures and demonstrations for the instruction of sanitary inspectors will be delivered at the Parkes Museum on Tuesdays and Fridays at 8 p.m., commencing with the 25th instant. The lectures will deal with sanitary subjects generally, and will be delivered by the leading men in the various branches—Sir Douglas Galton, Profs. Corfield and Henry Robinson, Drs. Poore, Louis Parkes, and Charles Kelly, Messrs. Wynter Blyth, Boulnois, Cassal, and Sykes. A nominal fee of five shillings will be charged, and students attending the course will be granted free admission to the Parkes Museum and Library during September, October, and November. The last course was attended by over ninety students, and it is proposed to repeat it twice each year to suit the requirements of persons preparing for the examinations of the Sanitary Institute, as well as of others desirous of obtaining a practical knowledge of sanitary requirements and regulations.

THE September issue of the Kew *Bulletin* continues the notes on colonial fruit, including a long and most interesting report on the fruits of the Island of Dominica. There is also a report from the British Political Officer at Bahmo on the india-rubber trade of the Mogaung district of Upper Burma. The rubber forests, though worked by Chinese, are owned by the Kachins, a tribe inhabiting the borderland between Burma and China.

WE have received Parts 2 and 3 of the second volume of the Journal of the College of Science of the Imperial University of Japan. The former opens with a paper by Dr. Koto "On the so-called Crystalline Schists of Chichibu," a district lying north-west of Tokio, and, geologically speaking, a region complete in itself, and, according to Dr. Koto, typical of the geological formation of the rest of Japan. The essay, which is accompanied by five plates, occupies the greater part of the number. Prof. Okubo gives a brief account of the botany of Sulphur Island, a volcanic and uninhabited island off the Japanese coast. Dr. Ijima and Mr. Murata describe some new cases of the occurrence of *Bothriocephalus liguloides*, Lt. No. 3 is filled with the account of a magnetic survey of all Japan, carried out by order of the President of the Imperial University, the authors being Profs. Knott and Tanakadate. The paper, which is an elaborate one, is divided into five sections: (1) historical retrospect, and general description of the aim and methods of the survey; (2) particular account of the equipment and modes of operation of the northern party; (3) the same details for the southern party; (4) final reduction of the observations, and general conclusions; (5) comparison of results with those of previous observers. In an appendix, Prof. Knott gives an exceedingly interesting sketch of Ino Tadayoshi, a Japanese surveyor and cartographer of the latter half of the last century.

THE current number of the *Westminster Review* contains an article by Mr. Gundry, entitled "China; A New Departure," the "departure" in question being the introduction of mathematics into the curriculum of subjects in the competitive examinations upon which the whole system of Chinese administration is based. Various methods have been proposed from time to time to bring Chinese students into touch with Western learning. Prince Kung, who was Prime Minister in 1866, suggested the erection of a special department presided over by foreign professors for the study of "mathematics," that term being obviously meant to include all branches of physical science. This was done, but public opinion was not ripe for the change, and the result was failure. In 1875 it was proposed, not to instruct Chinese in Western learning, but to teach foreigners the ancient lore of China, and thus enable them to qualify for office. This plan was not tried. Then students were sent abroad to be educated, but they became demoralized, and returned totally out of sympathy with their national traditions. Last year the Censors, who till then were the opponents of all innovation, advocated alterations in the educational system, and the Cabinet, presided over by Prince Chun, the father of the reigning Emperor, thereupon reported in favour of introducing mathematics into the competitive examinations. For the first time, then, provision has been made for spreading through the empire a knowledge of Western science, and there can be no doubt that the ultimate result must be a complete revolution in Chinese thought. The influence of a remote past will be diminished, the necessity for change recognized, and intimacy with "barbarian" learning will do away with the present prejudices against the "barbarians" themselves. But these advantages must not be over-estimated. Though the necessity for studying foreign science is admitted, widespread and intense prejudice has to be conquered, and a new generation will probably have arisen before the full effect of the innovation is felt.

IN the last number of the *Essex Naturalist* (vol. ii., Nos. 7 and 8, p. 113), Prof. Meldola announces that he has at length detected the scent emitted by the male moth *Herminia tarsipennalis*. It has long been known that this insect possessed fan-like structures on the front legs, and it had been surmised that these were secondary sexual characters. The detection of the scent now places the function of these organs beyond doubt, and it is of interest to add that the odour has been recognized as similar to that of artificial essence of jargonelle pear—that is, to amyl acetate. Some of the males of South American butterflies, which are provided with elaborate scent organs, according to Fritz Müller, give off a distinct odour of vanilla.

THE *Oderzeitung* reports the finding in the Lossow district, near Frankfort-on-the-Oder, of about thirty clay vessels of various sizes and patterns, some urns, some pots, deep saucers, flasks, &c. They were filled with the ashes of burnt corpses mixed with sand. The colour was a brownish-yellow; some were broken, and the fractures showed that coal ashes had been mixed with the clay of which they were made. Some bronze needles were found with them, being finished at the top in a semicircular shape. The vessels seemed to have been formed on a lathe, tolerably smooth, regular in shape, and only slightly baked. The largest were about 30 centimetres in diameter at the widest part, and 26 centimetres high. The ornaments were either triangles or semicircles, scratched on the surface with points impressed on the surface. Possibly the site where they were found was a refuge and a place of sacrifice in old German times.

WE have received the Calendar of the University College, Dundee, for the forthcoming session, together with reports on the work of the past year. The progress seems to have been of the usual satisfactory character. A department of dyeing and bleaching has been added since the last session.

AN interesting article has been published in the *Cologne Gazette* from the pen of Herr Gerhard Rohlfs, the African explorer, in which the German plans for rescuing Emin Pasha are subjected to an exhaustive criticism. Herr Rohlfs is of opinion that the proposed expedition may attain its ends if the preliminary preparations are properly and not too slowly conducted, and if the necessary sum of money is subscribed; all that Emin Pasha can want being guns, small cannon, and ammunition. The advance of the expedition must take place slowly and methodically, and depots, commanded by Germans, should be established on the road at intervals from one another represented by from six to eight days' march. From Bagamoyo to Mutansige a distance of 1500 kilometres has to be covered without leaving German territory. From Mutansige to Wadelai the distance is 400 kilometres. The expeditionary force need not include more than 100 Germans, but, as it must be sent out at once if it is to do any good, State aid becomes absolutely necessary. A considerable sum is required. Herr Rohlfs estimates that the expedition conducted by Stanley to the relief of Livingstone cost 2,000,000 marks, and the process of obtaining the sum needed by subscription is far too slow. As this expedition, adds Herr Rohlfs in conclusion, is likely to assist in consolidating German colonial enterprise in Africa, no sacrifice should be spared for carrying it into execution.

WE have received from the Deutsche Seewarte at Hamburg vol. ix. of *Meteorologische Beobachtungen in Deutschland*, containing the observations, for 1886, made at twenty-five stations of the second order, in accordance with the proposal of the Meteorological Congress at Vienna, 1873, that each country should publish the individual observations for a certain number of places. We observe, however, from the preface that in future the Central Office at Berlin will undertake the publication of some of these observations. The volume also contains hourly observations for four stations, and a summary of the storms experienced on the German coasts. These useful statistics of storms have been regularly published since 1878.

THE Meteorological Section of the Report of the Governor of St. Helena on the state of the colony for the past year is interesting, if brief:—"The year under review was dry; the rainfall at Longwood, where Napoleon lived, was 28·74 inches. No lightning has occurred since 1878, and storms are unknown."

WE have received the Report and Proceedings of the Bristol Naturalists' Society for the past year. The members number 224, which seems satisfactory all things considered, yet the Council are far from content. They urge that more cordial recognition and extended support might be expected in a city like Bristol, at a time when science holds so commanding a position for a Society which aims at promoting original scientific research, and at the same time presenting its results in a form intelligible to the general public, and accordingly members are urged to make the benefits of the Society as widely known as possible, while a *conversazione* is to be held next month with a view to directing public attention afresh to its objects and claims. *Sic itur ad astra*: it is thus that a strong and successful Natural History Society is founded. The contents of the Proceedings are attractive and varied, chief amongst them being a "geological reverie" on the Mendips, by Prof. Lloyd Morgan. An Engineering Section was last year added to the Society, and its papers are also published. Looking to this number of the Proceedings it appears to us that the Council have much reason to be proud of the Society, although perhaps it would not be quite prudent to say this in the Annual Report, when more members are required, and the balance with the treasurer has fallen very low. We cannot believe that so excellent a Society, which does much good work with such small funds, can lack abundant support in a district such as Bristol and its vicinity.

FROM the Parliamentary paper which has just been issued on the British Museum, it appears that the total number of persons admitted to view the collections has undergone a very great diminution within the past few years. In the year 1882 there were 767,402 visitors to the general collections, as against 501,256 in 1887. This diminution is more than accounted for by the transfer of the natural history collections to South Kensington, for we find that in the latter year there were 358,178 visitors to the Cromwell Road collections, being an increase of 80,020 over the number admitted in 1882. With regard to the number of visitors to particular departments for the purpose of study or research it has increased from 146,891 in 1882 to 182 778 in 1887 to the reading-room, from 1452 in 1885 (when the room was opened) to 11,802 in 1887 to the newspaper-room, and from from 2709 in 1882 to 14,238 in 1887 to the various departments in the new building in Cromwell Road. The students who frequent the reading-room will agree with the principal librarian's remarks as to the inadequacy of the accommodation of that room, and will hope that his recommendation to provide a separate room for "the throng of readers for general information" may be speedily carried out. Amongst the more important donations to the Museum during the past year were the following: stone implements from Japan and Greenland, ancient Peruvian pottery and masks, presented by the trustees of the late Mr. Christy; a collection of Andamanese objects from the Colonial Exhibition, by M. V. Portman; a valuable collection of ethnological objects from the Nicobar Islands, by E. H. Man; a remarkable collection of objects of the Late Celtic period, found in graves at Aylesford; a large collection of stone implements from Japan, presented by Sir Alexander Cunningham. The arrangement of many of the sections in the ethnographical gallery has been altered in the past year. Thus several sections of Asiatic islands have been revised to make room for the two large series from the Andaman and Nicobar Islands. Amongst the Oriental and ethnographical acquisitions during the year were the following: a collection of Indian antiquities, consisting of relic caskets of various kinds with various Buddhist sculptures, &c., presented by General Sir Alexander Cunningham; a number of antiquities from Siam and Burma, presented by E. M. Satow; seventy-six specimens of Chinese porcelain with armorial devices, presented by the Rev. F. Warre; a number of ethnographical specimens collected in the Pacific Islands by H. J. Veitch; and an extensive collection of specimens from New Guinea, including models of houses, boats, &c., collected by H. H. Romilly, and presented by the Queensland Commissioners of the Colonial and Indian Exhibition.

WITH regard to the natural history collections great progress has been made in the arrangement and description. Two cases have been placed on the floor of the Great Hall, illustrating general laws in natural history. The specimens in one case have been presented by Mr. Henry Seebohm, and show that what are regarded as two distinct species of crows (the *Corvus cornix* and the *Corvus corone*) may unite and produce offspring. The second case illustrates the effect of domestication on pigeons. The great collection of birds, which was formed chiefly by the late Marquess of Tweeddale, has been given to the Museum under certain conditions by Mr. R. G. Wardlaw-Ramsay, together with his large ornithological library. The collection comprises nearly 40,000 bird-skins, and is particularly valuable to the Museum, as it is very rich in birds of the Philippine Islands, Andaman Islands, &c., in which the Museum was very deficient. A collection of butterflies, anthropological objects, skins of birds and mammals, sent from Wadelai by Emin Pasha, has reached the Museum. The Commissioners present at the Indian and Colonial Exhibition gave some fine specimens of the flora of Australia and New Zealand. The zoology department is now overcrowded, 270,000 specimens having been added in the space of four years.

THE King of Italy, acting on the recommendation of the Minister of Public Instruction, has issued a decree regulating the manner in which Italy proposes to celebrate the fourth centennial of the discovery of America by Columbus. This will consist mainly in the publication of the collected works of the great navigator, and of all the documents and charts which will throw any light upon his life and voyages. This will be accompanied by a biography of the works published in Italy upon Columbus and the discovery of America from the earliest period down to the present time. The head of the Royal Commission charged with the preparation of this edition is Cesare Correnti, President of the Italian Historical Institute; and among its members are Signors Amari, Cantu, and Desimoni, and the Marquis Doria. An appropriation of 12,000 lire has been made to cover the expenses of this work, which is now fairly undertaken for the first time. Various editors have published portions of the writings of Columbus, as Navarrete the account of his voyages, and Major his letters; but no one has yet collected all his writings into a single edition, though an index to them was published in 1864.

THE British Consul at Chicago in a recent report refers to an interesting experiment in some of the Western States in afforestation. He says that in the vast prairies of the western half of Dakota, Nebraska, and Kansas, the eastern part of Colorado, and in the plains of Dakota and Wyoming, there is an almost total absence of trees, and hence the moisture is very deficient. In the forest regions and amongst the mountains, lumber and firewood have rapidly decreased from the reckless way in which old and young trees have been cut. This waste has been restrained by various Acts, principally by the Timber Culture Law, which regulates the disposal of lands. In Nebraska, fifteen years ago, a voluntary movement was started for the encouragement of planting and forestry in general, and one day in the year, called "Arbor Day," was set apart for that purpose. On that day trees are planted by prominent persons, and by the local bodies. This example has been followed by almost every other State named above, and "Arbor Day" is now a public holiday in those regions, the date being fixed by the Governor. So great has been the progress that in Kansas alone there are now no less than 250,000 acres of artificial forest. The kind of trees planted varies very much with the district and the taste of the planters. White elm is said to be the best tree, being of rapid growth and yet hardy. Oak, walnut, maple, elm, ash, catalpa, pine, tulip-tree, linden, and others, have all been found to flourish.

THE additions to the Zoological Society's Gardens during the past week include a Squirrel Monkey (*Chrysothrix sciurea*) from Guiana, presented by Mr. George Miles; a Rhesus Monkey (*Macacus rhesus* ♀) from India, presented by Mr. J. Witham; a Kinkajou (*Cercoleptes caudivolvulus*) from Venezuela, presented by Dr. A. Batchelor, F.R.C.S.; a Black-backed Jackal (*Canis mesomelas* ♀) from South Africa, presented by Lieut. Lionel de Lautour Wells, R.N.; a Roseate Cockatoo (*Cacatua roseicapilla*) from Australia, presented by Mrs. J. de la Mare; a Sulphur and White-breasted Toucan (*Ramphastos vitellinus*) from Rio Negro, presented by Dr. C. E. Lister; an Alligator (*Alligator mississippiensis*) from Florida, presented by Mr. Michael Millard; two Sharp-nosed Crocodiles (*Crocodilus acutus*) from Nicaragua, presented by Mr. E. A. Williams; a Common Viper (*Vipera berus*), British, presented by Colonel C. S. Sturt; a Grey Lemur (*Hapalemur griseus*) from Madagascar, received in exchange; a Barbary Wild Sheep (*Ovis tragelaphus* ♀) from North Africa, deposited; a Brazilian Cariama (*Cariama cristata*) bred in the Gardens.

ASTRONOMICAL PHENOMENA FOR THE WEEK 1888 *SEPTEMBER* 16-22.

(FOR the reckoning of time the civil day, commencing at Greenwich mean midnight, counting the hours on to 24, is here employed.)

At Greenwich on September 16

Sun rises, 5h. 39m.; souths, 11h. 54m. 34·6s.; sets, 18h. 10m.: right asc. on meridian, 11h. 38·0m.; decl. 2° 23′ N. Sidereal Time at Sunset, 17h. 54m.

Moon (Full on September 20, 5h.) rises, 16h. 57m.; souths, 21h. 25m.; sets, 2h. 0m.*: right asc. on meridian, 21h. 10·2m.; decl. 17° 45′ S.

Planet.	Rises.	Souths.	Sets.	Right asc. and declination on meridian.	
	h. m.	h. m.	h. m.	h. m.	° ′
Mercury..	7 24	13 1	18 38	12 44·2	5 8 S.
Venus.....	7 20	13 3	18 46	12 46·4	3 58 S.
Mars......	12 23	16 22	20 21	16 6·5	22 29 S.
Jupiter....	11 54	16 11	20 28	15 55·0	19 45 S.
Saturn....	1 57	9 30	17 3	9 13·4	16 52 N.
Uranus...	7 43	13 17	18 51	13 0·5	5 47 S.
Neptune..	20 33*	4 20	12 7	4 2·3	18 58 N.

* Indicates that the rising is that of the preceding evening and the setting that of the following morning.

Occultations of Stars by the Moon (visible at Greenwich).

Sept.	Star.	Mag.	Disap.	Reap.	Corresponding angles from vertex to right for inverted image.	
			h. m.	h. m.	°	°
16	30 Capricorni	6	21 47	23 1	128	287
19	B.A.C. 8274	6	20 56	near approach	176	—

Sept.	h.	
19	4	Mercury in conjunction with and 1° 40′ south of Venus.
22	15	Sun in equator.

Variable Stars.

Star.	R.A.	Decl.			
	h. m.	° ′		h. m.	
U Cephei	0 52·4	81 16 N.	Sept. 21,	4 54	*M*
T Arietis	2 42·1	17 3 N.	,, 21,		*m*
Algol	3 0·9	40 31 N.	,, 17,	20 15	*m*
R Leporis	4 54·5	14 59 S.	,, 18,		*m*
T Monocerotis	6 19·2	7 9 N.	,, 21,	3 0	*M*
ζ Geminorum	6 57·5	20 44 N.	,, 19,	0 0	*m*
S Canis Minoris	7 26·6	8 33 N.	,, 19,		*M*
S Cancri	8 37·5	19 26 N.	,, 22,	1 11	*m*
V Boötis	14 25·3	39 22 N.	,, 22,		*m*
U Coronæ	15 13·6	32 3 N.	,, 16,	1 6	*m*
			,, 22,	22 48	*m*
S Libræ	15 15·0	19 59 S.	,, 22,		*M*
S Scorpii	16 11·0	22 37 S.	,, 16,		*M*
U Ophiuchi	17 10·9	1 20 N.	,, 19,	3 22	*m*
R Scuti	18 41·5	5 50 S.	,, 19,		*M*
β Lyræ	18 46·0	33 14 N.	,, 20,	21 0	m_2
η Aquilæ	19 46·8	0 43 N.	,, 18,	23 0	*m*
T Vulpeculæ	20 46·7	27 50 N.	,, 19,	21 0	*m*
			,, 20,	23 0	*M*
W Cygni	21 31·8	44 53 N.	,, 20,		*M*
δ Cephei	22 25·0	57 51 N.	,, 20,	3 0	*m*

M signifies maximum; *m* minimum; m_2 secondary minimum.

Meteor-Showers.

	R.A.	Decl.	
Near ε Tauri	64°	21° N.	Swift; streaks.
,, η Aurigæ	74	41 N.	Sept. 21. Swift; streaks.
,, χ Orionis	89	18 N.	Very swift.
	98	44 N.	Very swift; streaks.

SOCIETIES AND ACADEMIES.

PARIS.

Academy of Sciences, September 3.—M. Janssen, President, in the chair.—Microbism and abscess, by M. Verneuil. The ordinary type of abscess is studied in connection with the new light thrown on the subject by microbic researches on suppuration. The almost constant presence of the micro-organisms described by Klebs, Pasteur, and others, shows that they are in all probability the real and exclusive cause of pyogenesis, a conclusion placed almost beyond doubt by the fact that, when introduced into the animal system, these organisms invariably produce suppuration and abscesses. A classification is given of the microbes in question, which are divided into two distinct groups: (1) pyogenic microbes, properly so called, which are normally present, such as the orange, lemon, white, and other varieties of Micrococcus and Diplococcus; (2) those which occur irregularly in the purulent matter, but which may exist normally in the system apart from any pyogenic symptoms or centres of suppuration—various kinds of Bacteria, Vibriones, Bacilli, &c. A classification follows of abscesses themselves, based on the etiology of pyogenesis as well as on their pathological anatomy and physiology.—Inscription giving the details of a lunar eclipse, by M. Oppert. This inscription, the text of which was first published by Strassmaier in the *Zeitschrift für Assyriologie*, vol. ii, is referred to the year 24 B.C., 232 of the era of the Arsacides. It describes the eclipse as having been predicted by the astronomer Uruda (Orodes), and as taking place, as predicted, in the month of Nisan, on the 13th night, at the hour of 5 and 51 parts, which is reduced to Monday, March 23, 9h. 30m. p.m., Paris mean time.—The fluorescent compounds of chromium and manganese, by M. Lecoq de Boisbaudran. These substances are studied and prepared synthetically with a view to determining their several degrees of oxidation.—Note on the position of some points on the Brazilian seaboard, extracted from a memoir of the Commissão de Longitudes, by M. Cruls. The places, whose positions are here astronomically determined by the officers attached to the Brazilian Hydrographic Service, are Cape Frio, 0h. 4m. 34·05s. (with probable error 0·12s.), east of Rio de Janeiro; and Santos, 0h. 12m. 33·44s. (with probable error 0·20s.), west of Rio de Janeiro.—On the measurement of the refraction indices of crystals with double axis, by M. Charles Soret. These measurements are here effected by the observation of the limiting angles of total reflection on any facets.—Physiological action of the chloride of ethylene on the cornea, by M. Raphael Dubois. In a previous paper (*Comptes rendus*, vol. civ., No. 26, 1887) the author showed that the chloride of ethylene ($C_2H_4Cl_2$) introduced in any way into the system produces in the dog, several hours after waking, an opacity of the cornea of a very remarkable character. Here he studies the nature of this phenomenon, and determines the mechanism by which it is produced.

BOOKS, PAMPHLETS, and SERIALS RECEIVED.

Eclectic Physical Geography: R. Hinman (Cincinnati).—Solutions of the Examples in an Elementary Treatise on Conic Sections: C. Smith (Macmillan).—Chart for Great Circle Sailing, Nos. 1 and 2: R. A. Proctor (Stanford).—Les Tremblements de Terre: F. Fouqué (Baillière, Paris)—Die Structur und Zusammensetzung der Meteoreisen, Liefg. 1, 2, 3: A. Brezina and E. Cohen (Stuttgart).—The Speaking Parrots, Part 5: Dr. K. Russ (U. Gill).—The Flowering Plants of Wilts: Rev. T. A. Preston (Wilts Archæological and Natural History Society).—Results of Experiments at Rothamsted on the Growth of Root Crops: J. H. Gilbert.—Memoranda of the Origin, Plan, and Results of the Field and other Experiments at Rothamsted.—On Infant Feeding and the Value of Preparations of Pure Alpine Milk: Dr. Nachtigal (Ridgway).—Proceedings of the Bristol Naturalists' Society, vol. v. Part 3 (Bristol).—Proceedings of the American Academy of Arts and Sciences, New Series, vol. xv. Part 1 (Boston).—Meteorological Record, vol. vii. No. 28 (Stanford).—Quarterly Journal of the Royal Meteorological Society, July (Stanford).

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