Having now endeavoured to recall to you some of the great advances in science made during the last few years, it remains for me, after the distribution of the medals awarded by your Council, to retire from the Presidency in which I have so long experienced the generous support of your officers and yourselves. This support, for which I tender you my hearty thanks, together with my sense of the trust and dignity of the office, and the interest attached to its duties, has rendered my resignation of it a more difficult step than I had anticipated. My reasons are, however, strong. They are the pressure of official duties at Kew, which annually increase in amount and responsibility, together with the engagements I am under to complete scientific works, undertaken jointly with other botanists, before you raised me to the Presidency, and the indefinite postponement of which works delays the publication of the labours of my coadjutors. I am also influenced by the consideration that, though wholly opposed to the view that the term of the Presidency of the Royal Society should be either short or definitely limited, this term should not be very long; and that, considering the special nature of my own scientific studies, it should, in my case, on this as well as on other grounds, be briefer than might otherwise be desirable. Cogent as these reasons are they might not have been paramount were it not that we have among us one pre-eminently fitted to be your President by scientific attainments, by personal qualifications, and by intimate knowledge of the Society's affairs; and by calling upon whom to fill the proud position which I have occupied, you are also recognising the great services he has rendered to the Society as its treasurer for eight years, and its ofttimes munificent benefactor.

HAECKEL ON THE LIBERTY OF SCIENCE AND OF TEACHING[1]

II.

CHAPTER V. treats of the methods of teaching, and contrasts the *genetic* method, as advocated by Haeckel, with the *dogmatic* one recommended by Virchow. The sensation which Virchow's address caused in wider circles was only partly the result of his opposition to the descent theory; its principal cause was his surprising conclusions with regard to the liberty of teaching. Virchow demands that in the school—from the elementary school up to the university—*nothing should be taught which is not absolutely certain;* only *objective* but no *subjective* knowledge is to be communicated to the pupils by the teacher; only facts, no hypotheses. Haeckel remarks that rarely has an eminent representative of science made such an attack upon the liberty of science as did Virchow at Munich. "Where," he asks, "are we to find the limits between subjective and objective knowledge?" According to his conviction no such limit exists, and all human knowledge as such is subjective. "An objective science consisting only of facts, without subjective theories, cannot be imagined." He then proceeds to review various sciences in turn, and to point out how much objective knowledge and "facts," and how much subjective knowledge and "hypotheses" they contain. He begins with *Mathematics* as the science which is eminently the most *certain* one of all: "What about the simplest and deepest maxims upon the firm basis of which the whole proud building of mathematics rests? Can they be proved for certain? Certainly not! The most fundamental maxims are indeed 'maxims,' and incapable of 'proof.' Only in order to show by an example how even the first mathematical maxims may be attacked by sceptics and shaken by philosophical speculation we recall the recent discussions regarding the three dimensions of space and the possibility of a fourth dimension, discussions which are still continued by a number of the most illustrious mathematicians, physicists, and philosophers. So much is certain that mathematics is absolutely objective as little as any other science, but has a subjective basis in man's own nature. . . . But even if we own that mathematics is an absolutely certain and objective science, how about all other sciences? No doubt those are 'most certain' amongst the 'exact' sciences, the maxims of which are founded on pure mathematics, in the first line therefore a great part of *physics*. We say a great part, because another great part—upon close examination by far the greater—is incapable of an exact mathematical foundation. Or what we do know with certainty about the essence of *matter* or the essence of *force?* What do we know for certain about gravitation, about mass-attraction, about action at a distance, &c.? We look upon Newton's gravitation theory, the basis of mechanics, as the most important and most certain theory of physics, and yet gravitation itself is only a hypothesis. And then the other branches of physics—electricity and magnetism, for instance. The whole knowledge of these important branches is based upon the hypothesis of 'electric fluids' or of imponderable substances, the existence of which is certainly not proved. Or optics? No doubt optics belongs to the most important and most complete branches of physics, yet the vibration theory, which to-day we consider to be its indispensable basis, rests upon a hypothesis which cannot be proved, viz., upon the 'subjective' supposition of the light-ether, the existence of which nobody can objectively prove. Nay, even more; before Young established the vibration theory of light, the emanation theory taught by Newton reigned supreme in physics for centuries; this theory has to-day been abandoned as untenable. According to our view the mighty Newton acquired the greatest merit with regard to the development of optics, as he made the first attempt to connect and explain the mass of objective optical facts by a subjective leading hypothesis. But according to Virchow's view Newton sinned most heavily by teaching this false hypothesis; because in 'exact' physics only *single* and *certain facts* are to be taught and to be ascertained by 'experiment as the highest means of proof;' but physics as a *whole*, resting as it does upon a number of unproved hypotheses, may be the object of research, but must not be taught!" Turning to *Chemistry*, Haeckel shows that its objectiveness stands upon still weaker feet than that of physics. Here the whole of the science is built upon the hypothesis of the existence of atoms, a hypothesis as unproved and as incapable of proof as any. No chemist has ever seen an atom, and yet he thinks the mechanics of atoms the highest problem of his science, and describes and constructs the positions and groupings of atoms, as if they were before him on his dissecting table. According to Virchow, we therefore ought *to banish chemistry from the school* and teach only the properties of bodies and their reactions, which can be shown to the pupils as "certain facts." This matter becomes still more ludicrous when we turn to the other sciences, which are all more or less *historical*, and therefore do not possess that "half-exact" basis upon which chemistry and physics rest. Geology, for instance, would, according to Virchow, have to confine itself to the description of certain facts, *i.e.*, the structure of rocks, the forms of fossils, the shape of crystals, &c., but would in the school have completely to abandon all speculation regarding the development of the earth's crust, *i.e.*, nothing but unproved hypotheses from beginning to end. We might not even teach that fossils are the actual remains of organisms which existed in former periods, because even this is an "unproved" hypothesis. Even down to the eighteenth century many eminent naturalists believed fossils to be "freaks of nature," an enigmatic "*lusus naturæ*." In a later part of his address Virchow admits fossils as "objective material proofs;" but even here we may go no further than our actual experience allows, and we may not draw subjective deductions from the objective facts. Virchow's remark about quaternary man being an "accepted fact" affords Haeckel an opportunity for pointing out his inconsistency, and the uncertainty and vagueness of most hypotheses concerning the age and the first geological occurrence of man; indeed, the distinction of a tertiary and a quartery age in itself is nothing but a *geological hypothesis*. "Virchow tells us that never has a fossil ape skull been found which really belonged to a human proprietor, and that we cannot consider it as a revelation of science, we cannot teach, that man descends from the ape or from any other animal. If that be true, then nothing remains but the descent from a god or from a clod of earth."

Zoology, botany, and other biological doctrines do not fare better, if we consider them in the light in which Virchow would have them taught. Haeckel shows the utter untenability of Virchow's demands, since no science, not even history, and certainly not philosophy, could be tolerated in our schools; indeed, the only one which could remain would be theology. "Incredible as it seems, Virchow, the sceptical antagonist of dogmas, the combatant for the liberty of science, now finds the only certain basis of instruction in the dogma of Church religion. After all that has happened the following phrase leaves no doubt on this point:—'All attempts to transform our problems into doctrines, to introduce our theories as the basis of a plan of education, par-

[1] Freie Wissenschaft und freie Lehre. Eine Entgegnung auf Rudolf Virchow's Münchener Rede über "die Freiheit der Wissenschaft im modernen Staat." Von Ernst Haeckel. Continued from p. 115.

ticularly the attempt simply to depose the Church, and to replace its dogma by a religion of descent without further trouble—these attempts, I say, must fail, and their failure would at the same time bring the greatest dangers upon the position of science generally.' After this every one will easily understand the joyful outbursts of the whole clerical press after Virchow's Munich address. It is known that there is ten times more joy in heaven over one repentant sinner than oven ten just men. If Rudolf Virchow, the 'renowned materialist,' the 'radical progressist,' the principal representative of the 'atheism of science,' is suddenly so completely converted, if openly and loudly he proclaims the 'dogmas of the Church' as the only certain 'basis of instruction,' then, indeed, the combatant Church may sing 'Hosanna in excelsis!' There is only one point to be regretted, and that is that Virchow has not stated which of the many different Church religions is the only true one, and which of the numberless and contradicting dogmas are to become the certain basis of education. We all know that each Church thinks itself the only one leading to eternal bliss, and its dogma the only true one. Now whether it is Protestantism or Catholicism, Reformed or Lutheran confession, Anglican or Presbyterian dogma, Roman or Greek doctrine, Mosaic or Islamitic tenets, Buddhaism or Bramahism, or one of the fetish creeds of the Indians or coloured tribes which is to become the lasting and certain 'basis of instruction,' this, no doubt, Virchow will not hesitate to state at the next meeting of the German Association of Naturalists and Physicians."

"At all events, the instruction of the future," according to Virchow, "will be very much simplified. Because the dogma of the Trinity as the basis of mathematics, the dogma of the resurrection of the flesh as the basis of medicine, the dogma of the infallibility as the basis of psychology, the dogma of the Immaculate Conception as the basis of the science of generation, the dogma of the stoppage of the sun as the basis of astronomy, the dogma of the creation of the earth, animals, and plants, as the basis of geology and phylogeny, these or some other dogmas from other creeds, will make all further doctrines rather superfluous. Virchow, this 'critical nature,' of course knows as well as I do, that these dogmas are *not true*, and yet, according to his view, they are not to be replaced as 'bases of instruction' by the theories and hypotheses of modern natural science, of which Virchow says himself that they *may* be true, probably *are* true to a great extent, but have not been 'proved for certain' as yet."

Finally, Haeckel points out that it seems to be bitter irony if Virchow, at the opening address, recalls the memory of Oken, whom he celebrates as the martyr of free science, and at the end of the same address demands that this "liberty of science" shall apply only to *research*, but not to *instruction*, and that no problems, no theories, no hypotheses are to be taught.

In Chapter VI. the application of the theory of descent to socialism is discussed. The author entirely endorses Prof. Oscar's Schmidt's view on the subject, and shows that the theory of descent and the socialistic theory are "like fire and water to one another." The theory of descent is, on the contrary, aristocratic in the highest sense of the word. Of course, from any theory, be it ever so true and sound, the most absurd deductions may be drawn if it is misapplied, and the author warns particularly against the misapplication of scientific theories to political or social questions. Theory and practice rarely correspond in human life. Haeckel points to the history of Christendom to illustrate his argument. "It is certain that the Christian religion, as well as the Buddhistic doctrine, if freed from all dogmatic fables, contain an excellent humane kernel; now it is just this humane and truly social-democratic part of the Christian creed, which proclaims the equality of all men before God, and preaches the 'Love thy neighbour as thyself,' in fact 'love' in its noblest sense, compassion with the poor and unfortunate, &c., —we say these truly humane sides of the Christian faith are so natural, so pure and noble, that we comprise them with pleasure amongst the moral laws of our monistic natural religion. . . . But what, we must ask, have the chosen representatives, the 'God-taught' (Gottgelehrte) priests, made of this 'religion of love'? It is written with letters of blood upon the pages of the history of mankind for the last 1,800 years! All that different Church religions have done for the forcible propagation of their creeds and for annihilation of 'heretics,' all that Jews have done against heathens, Roman Emperors against Christians, Mohammedans against Christians and Jews, all that is surpassed by the hecatombs of human victims which Christianity has slaughtered for the propagation of its doctrine. And indeed Christians against Christians. Rightly-believing Christians against wrongly-believing Christians. We need only think of the middle ages, of the Inquisition, of the unheard-of and inhuman cruelties which the '*most Christian kings*' of Spain and their worthy colleagues in France, Italy, &c., have committed. Hundreds of thousands then died the most cruel death of fire, simply because they did not bend their reason beneath the yoke of the most flagrant superstition, and because their dutiful conviction forbade them to deny what they had recognised to be natural *truths*. There exists no detestable, abominable, or inhuman action which was not then and up to the present day committed in the name of and on account of 'true Christianity.' And what about the *morals of priests*, who designate themselves as servants of God's word, and whose duty first of all should be to regulate their own lives according to the teachings of Christianity? The long, uninterrupted, and horrible chain of crimes of all kinds which forms the history of the Roman pontiffs, gives the best reply to this question. And as these 'representatives of God upon earth' have done, so did their helpmates and subordinates, so did the 'rightly-believing' priests of other confessions, not failing to establish as glaring as possible a contrast between the practices of their own lives and the noble teachings of Christian love which they always talk about. What we have just said of Christianity applies to all other religious and moral doctrines, indeed to all doctrines which in the wide domain of practical philosophy, in the education of the young, and the civilisation of the masses, are to show their power. The theoretical kernel of these doctrines can always and everywhere form the greatest contrast with its practical application, according to the contradictory nature of man. But what does all this matter to the scientific investigator? His sole and only task is to find out *truth*, and to *teach* that what he has *found to be true*, unheeding what consequences may be drawn from his teachings by the various parties in the State or Church."

In the last chapter Haeckel compares the "Ignorabimus" speech of Dubois-Reymond (delivered at the Leipzig meeting in 1872) with Virchow's "Restringamur" address of Munich, and refutes some of the views expressed by Dubois-Reymond, particularly the view that there are two *insurmountable* obstacles in the way of our completely understanding nature and the world, viz., the essence of matter and force and the human consciousness. Haeckel points out that even if the problems in question are not solved at present, no one has a right to declare them unsolvable. He then proceeds to explain the reasons why the opposition to the theory of descent has mainly originated amongst the Berlin biologists, and adduces examples from the history of science to show that a similar opposition to what have now become established truths, has repeatedly sprung from the same quarter. "It seems, indeed, to be the fate of the most interesting of all sciences, of the *history of evolution*, that its most important steps of progress and its greatest discoveries meet with the most powerful and lasting resistance. Just as Wolf's fundamental epigenesis theory, which was founded in 1759, but was acknowledged only in 1812, so Lamarck's theory of descent, founded in 1809, had to wait during full fifty years before Darwin, in 1859, transformed it into the most important acquisition of modern science. And how was this most comprehensive of all biological theories fought against during this time, in spite of all progress of the empirical sciences? Let us only remember how, in 1830, the celebrated George Cuvier silenced the most eloquent advocate of this theory, Geoffroy Saint Hilaire, in the midst of the Paris Academy, and how almost at the same time, in 1829, its founder, the great Lamarck, ended his laborious life, blind and in misery and poverty, while his antagonist, Cuvier, enjoyed the highest honour and the greatest splendour. And yet to-day we know that the despised and derided doctrines of Lamarck and of Geoffroy Saint Hilaire then contained the most important truths, while Cuvier's much-admired and generally-adopted creation doctrine has been now abandoned generally as an absurd and empty error. Now if neither Haller against Wolff, nor Cuvier against Lamarck, could permanently impede the progress of free research, then still less will Virchow succeed in crushing Darwin's admirable theory, even if he be assisted in an unenviable manner by the noisy Capuchin sermons of his friend Bastian. Much as we regret Virchow's hostile position in this great 'combat for truth,' we do not underrate the effect of his well-founded authority upon wider circles. No doubt the hostile attitude

which the greatest part of the Berlin press has assumed with regard to the doctrine of evolution must be attributed to this authority. But much as we must regret the reactionary current in this and other intelligent Berlin circles, yet we must point out that by this evil we are guarded from a far greater one. This greater, indeed the greatest, evil which could befall German science would be a Berlin 'monopoly of knowledge,' the *centralisation of science*. What highly disastrous fruit this centralisation has borne in France, for instance; how the Paris 'monopoly of knowledge' causes a constant degradation of French science, and has led it downwards from the greatest heights for the last half-century, is well known. Probably the wide-spread differentiation and the many-sided individuality of the German national spirit, the often-decried German particularism, will save us from a centralisation of science of this kind, which particularly in our capital, Berlin, would be doubly dangerous. Little as our 'small states' could be politically of any duration or could lead to a useful state-form, they have certainly been most beneficial and fertile for German science. Because this owes its principal advantages over others to the numerous little centres of education, which the capitals of the German small states formed, and to the many little universities which were always in healthy competition with one another. Let us hope that this beneficial decentralisation of science in our politically united Fatherland will continue permanently. Next to the centrifugal striving of our German national spirit, nothing will further this object so much as an energetic resistance to the free progress of science, just as now again it begins to show itself in the capital of the empire. Because at the same rate as this will remain behind in the mighty current of free and unimpeded mental progress, other numerous centres of education in Germany which follow this current enthusiastically, or at least willingly, will outrun it."

"If Emil Dubois Reymond wanted to make his 'Ignorabimus' the watchword of science, and Rudolf Virchow his still further-reaching 'Restringamur,' then from Jena and from a hundred other educational centres they are met with the call—

"*Impavidi progrediamur!*"

UNIVERSITY AND EDUCATIONAL INTELLIGENCE

STUDENTS of Natural Science who would much rather know French and German than Greek will be glad to learn that a very strong memorial against the retention of Greek as a subject for all honour candidates has been presented to Cambridge University. It is signed by ten heads of public schools, including Drs. Hornby (Eton), Butler (Harrow), and Abbott (City of London), Messrs. Matthew Arnold, Carlyle, W. E. Forster, the Bishops of Exeter and Manchester, Dean Cowie, Dean Stanley, and Dr. Vaughan, Prof. Jebb, and Mr. Roby, to say nothing of such bulwarks of science as Mr. Darwin, Prof. Huxley, Sir Joseph Hooker, Mr. Spottiswoode, and Prof. Tyndall.

THE Board of Musical Studies at Cambridge have applied for the appointment of a University Reader in Acoustics.

THE sum in the hands of the Sedgwick Memorial Committee for the erection of a new building for the geological collection is 12,000*l.*, not 1,200*l.* as we stated last week.

King's College (London) *Magazine*, No. 5, vol. ii. of which has been sent us, contains some pleasant reading, but no one would infer from its contents that the College was an important centre of scientific instruction and research.

DR. J. COSSAR EWART has been appointed by the Crown to the Chair of Natural History in the University of Aberdeen.

MR. F. GUTHRIE, formerly of Graaf-Reinet College, has been appointed to the Chair of Mathematics at the South African College, Capetown.

THE *Journal de St. Pétersbourg* gives the following particulars concerning the public provision for education in Russia:—The sum assigned in the Budget of this year for education is 15,971,289 roubles (about 2,395,000*l.*). There are eight Universities (not reckoning that of Helsingfors for Finland), with 5,629 students. Of these 85 are divinity students, 583 belong to the philological faculty, 1,629 to the faculty of law, 30 to that of Eastern languages, 622 to the mathematical faculty, 550 to that of natural science, and 2,130 to the medical faculty. There are 53 ecclesiastical seminaries, with 12,227 pupils; 195 gymnasia and pro-gymnasia, with 50,701 pupils; 56 middle-class schools, with 10,888 scholars. There are 19 military gymnasia, but the number of pupils is not given. For females there are 223 gymnasia and pro-gymnasia, having 34,878 pupils; and this does not include the many institutions which are subject to the control of the Fourth Division of the Imperial Chancellery. There are 68 normal schools and training colleges for teachers, having 4,968 students. There are 10 other such institutions supported by non-public funds. The number of elementary schools in operation this year is 25,491, with 1,074,559 pupils.

SOCIETIES AND ACADEMIES

LONDON

Royal Society, December 5.—"On the Illumination of Lines of Molecular Pressure, and the Trajectory of Molecules," by William Crookes, F.R.S., V.P.C.S.

Induction Spark through Rarefied Gases. Dark Space round the Negative Pole

The author has examined the dark space which appears round the negative pole of an ordinary vacuum tube when the spark from an induction coil is passed through it. He describes many experiments with different kinds of poles, a varying intensity of spark, and different gases, and arrives at the following propositions:—

Illumination of Lines of Molecular Pressure

a. Setting up an intense molecular vibration in a disk of metal by electrical means excites a molecular disturbance which affects the surface of the disk and the surrounding gas. With a dense gas the disturbance extends a short distance only from the metal; but as rarefaction continues, the layer of molecular disturbance increases in thickness. In air at a pressure of ·078 mm. this molecular disturbance extends for at least 8 mm. from the surface of the disk, forming an oblate spheroid around it.

b. The diameter of this dark space varies with the exhaustion; with the kind of gas in which it is produced; with the temperature of the negative pole; and, in a slight degree, with the intensity of the spark. For equal degrees of exhaustion it is greatest in hydrogen and least in carbonic acid, as compared with air.

c. The shape and size of this dark space do not vary with the distance separating the poles; nor, only very slightly, with alteration of battery power; nor with intensity of spark. When the power is great the brilliancy of the unoccupied parts of the tube overpowers the dark space, rendering it difficult of observation; but, on careful scrutiny, it may still be seen unchanged in size, nor does it alter even when, with a very faint spark, it is scarcely visible. On still further reduction of the power, it fades entirely away, but without change of form.

The author describes numerous experiments, devised to ascertain if this visible layer of molecular disturbance is identical with the invisible layer of molecular pressure or stress, the investigation of which has occupied him for some years.

The Electrical Radiometer

One of these experiments is as follows:—An ordinary radiometer is made, with aluminium disks for vanes, each disk coated with a film of mica. The fly is supported by a hard steel cup instead of a glass cup, and the needle point on which it works is connected by means of a wire with a platinum terminal sealed into the glass. At the top of the radiometer bulb a second terminal is sealed in. The radiometer can therefore be connected with an induction coil, the movable fly being made the negative pole.

Passing over the phenomena observed at low exhaustions, the author finds that, when connected with the coil, a halo of a velvety violet light forms on the metallic side of the vanes, the mica side remaining dark throughout these experiments. As the pressure diminishes a dark space is seen to separate the violet halo from the metal. At a pressure of half a millimetre this dark space extends to the glass, and positive rotation commences.

On continuing the exhaustion the dark space further widens out and appears to flatten itself against the glass, and the rotation becomes very rapid.

When aluminium cups are used for the vanes, instead of disks backed with mica, similar appearances are seen. The velvety violet halo forms over each side of the cup. On increasing the exhaustion the dark space widens out, retaining almost exactly the shape of the cup. The bright margin of the dark space becomes concentrated at the concave side of the cup to a luminous focus, and widens out at the convex side. On further exhaustion the dark space on the convex side touches the glass,