from their student days to the high positions which they all attained, with an interest which never flags. The personal relations of those who were contemporaries are also happily stated, and the book, as a whole, gives us a living picture of the growth of chemical science which differs, most fortunately, from most of the systematic treatises on the history of chemistry.

In the controversial address, inspired by Berthelot's 'La Révolution Chimique,' in which he claimed for Lavoisier the right to the discovery and coordination of those general ideas relating to the composition of air and water, Dr. Thorpe is a sturdy and convincing defender of the claims of Priestley and Cavendish. And yet we cannot help feeling that his task would have been an easier one if the English chemists had not held on so tenaciously to the fantastical idea of phlogiston, which prevented them from grasping the true and simple relation of oxygen and nitrogen in air and oxygen and hydrogen in water. That this controversy does not blind the author to seeing Lavoisier in his true position as the founder of modern chemistry is shown in his article on Lavoisier in the *Contemporary Review* of December, 1900, in which he speaks of him as 'the dominant figure in the chemical world of the last century.'

The addresses are all of such great interest and value that it is not easy to select one or more of especial merit. And yet it is perhaps noticeable that the author is most attracted by the personality of Graham among the English chemists and of Wöhler, Kopp and Victor Meyer among the German. Admirable they all are, and well worthy of collection in the permanent form now before us.

The concluding addresses on 'The Rise and Development of Synthetic Chemistry,' 'On the Progress of Chemistry in Great Britain and Ireland during the Nineteenth Century,' and 'On the Development of the Chemical Arts during the Reign of Queen Victoria' are worthy of a place in the volume, but they lack the life of the addresses which deal with the personality of the masters of the science.

The history of chemistry is not often successfully taught in our technical schools, for the reason, perhaps, that not many teachers are able to make it interesting. With this collection of essays as a basis for reading, the average teacher would find his students much more receptive of systematic instruction in the subject.

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SCIENTIFIC JOURNALS AND ARTICLES.

Contents of September, 1902, number of *Terrestrial Magnetism and Atmospheric Electricity:*

DISCUSSION AND CORRESPONDENCE.

INVESTIGATION VERSUS ERUDITION.

To the Editor of Science: It is very natural and desirable that scientific men of experience should give counsel upon the education of those to whom their labors, finished and unfinished, must be bequeathed. On the other hand, it will be a misfortune if they who have surrounded themselves with facilities for investigating their respective subjects forget the condition of the beginner and mislead him either with vain hopes or with unwarranted discouragement. Both these dangers seem to inhere in a proposition advanced in many of the addresses before scientific bodies, with which the columns of Science abound. Professor Thurston's able paper furnishes a recent and excellent example of the bogus educational axiom to which exception is taken.

Scientific research is the highest work undertaken by the man of science, and it can be undertaken with confidence only by him who has made himself familiar with the state of his art, to date, or by the genius whose inspiration may, now and then, make learning, for the time and occasion, less essential.

* * * The first step is thus the acquirement of a complete knowledge of the essential work of investigation which has been accomplished by others to date. This eliminates the primary work and permits avoidance of repetition, as well as reveals the suggestions of every great mind which has attacked the problem in its preliminary stages, and places the investigation on the level from which further advance becomes directly and effectively practicable. It also gives the proposing investigator a firm and ample foundation on which to build higher and exhibits to him the trend of the work, in advance.*

Researches directed toward the increase of detailed knowledge might be contrasted with those concerned with generalization. Professor Thurston's argument would apply to the former far better than to the latter.

That we should first learn everything known about a subject before trying to find out anything new may appear self-evident, but it is no more true for young investigators than for ordinary students whom we are now at such pains to instruct by 'laboratory methods.' The investigator who has become familiar with a specific problem may sometimes obtain valuable suggestions from the failures of his predecessors, but to canvass all the literature of a department of research may not only involve an enormous waste of time and energy, but does not constitute a preparation for the work of investigation. The academic simpleton will, of course, consider this the same as to allege that the more ignorant one may be the better he can investigate, but there is a difference which patient analysis may enable him to appreciate.

'A little learning is a dangerous thing,' and more is more dangerous. For learning, as such, the investigator has no use. Knowledge is valuable to him—the more the better—but it is as suicidal folly for him to cumber his brain with a miscellaneous assortment of the observations and theories of others as for the athlete to surfeit his stomach before a foot-race.

The first and most essential preliminary for a successful investigation is an interest in the question, and any method of procedure which tends to diminish or relax interest is false and futile. Diligence in learning the facts of a science is a distinctly unfavorable symptom in a would-be investigator when unaccompanied by a vital constructive interest. That a student hoards facts does not mean that he will build anything with them. Intellectual misers are common, and are quite as unprofitable as the monetary variety. A scientific specialist may have vast knowledge and life-long experience, and yet may never entertain an original idea or make a new rift in the wall of the unknown which baffled his predecessors. Indeed, such men commonly resent a readjustment of the bounds of knowledge as an interference with their vested capital of erudition.

Investigation is a sentiment, an instinct, a habit of mind; it is man's effort at knowing and enjoying the universe. The productive investigator desires knowledge for a purpose; he may not be eager for knowledge in general, nor for new knowledge in particular. He values details for their bearing upon the problem he hopes to solve. He can gather and sift them to advantage only in the light of a radiant interest, and his ability to utilize them for correct inferences depends on the delicacy of his perception and the strength of his mental grasp. The trainers put the athletes on a restricted diet with copious practice, but the efforts of the professors are directed toward the production of a flabby intellectual corpulence.

The investigator, like the athlete, must first be born; he can not be made to order, but his training determines the degree of excellence to which he can attain. No amount of training can remove organic defects, but bad training may be worse than none in lessening the attainment of the most capable. That education is false and injurious which puts the matter first and retards or prevents the development of constructive mental ability, a

*'Scientific Research: The Art of Revelation and of Prophecy,' SCIENCE, N. S. Vol. XVI., pp. 401–409, September 12, 1902.

power not peculiar to the investigator, but in him reaching the greatest scope and freedom of action.

The investigator must not only be born, he must be permitted to grow up. He needs nourishing food, but equally needs to retain the power of securing and digesting it for himself. Twenty years is long enough to acquire or lose any habit, and it is not strange that after a youth consumed in our modern and efficient system of kindergartens, primary, grammar and high schools, colleges and universities, the graduate, and even the post-graduate, continues to expect somebody to tell him what to do next. In Germany it has been found necessary to offset the goose-liver-stuffing experience of the primary schools and gymnasia by a return to social barbarism in the university, but the self-assertion secured through rowdyism and immorality is no true substitute for the lost integrity of the intellect. The German's confidence in a highly developed governmental and educational machinery gives him little opportunity to perceive what is very apparent in our pioneer country where a large proportion of productive investigators have not suffered the disadvantage of too intensive education. Many are not even college men, and of those who are many come from small, poorly equipped institutions whose intellectual and social demands did not completely monopolize the time and interest of the period of intellectual growth. These men did not take their colleges too seriously, and did not cease to feel responsible for their own intellectual salvation. Modern philanthropy has reared palaces of learning in which all the supposed needs of the human mind are anticipated and supplied; the question now is whether an endowed education has not the same dangers as an endowed religion.

O. F. Cook.

Washington, September 22, 1902.

SHORTER ARTICLES.

PREPOTENCY IN POLYDACTYLOUS CATS.

It has long been one of the common notions in post-Darwinian speculations that the variations which produce new species have small beginnings and increase very gradually, variations sufficiently striking to be classed as sports being considered practically incapable of modifying the species, since the number of individuals with the same abnormality would be relatively small, and the abnormal variation would be swamped by a few generations of crossing with normal, that is, average individuals. This notion seems to be based on the assumption that the characters of the offspring are the average of the characters of the two parents—that, in other words, an abnormality in either parent (the other being normal) is reduced one half in each succeeding generation.

The following observations, however, do not support this view. Not only do abnormal variations persist from generation to generation, but they even become more conspicuous, although one parent is always normal. The facts accord with Poulton's observations on a family of polydactylous cats (*Nature*, 1883 and 1887).

Some weeks ago my attention was called to three generations of cats in the possession of a Los Angeles family, many of the cats being furnished with an abnormal number of toes on both manus and pes. All are descended from a stray female of unknown pedigree, which possessed twenty-two toes, six (instead of five) on each manus, and five (instead of four) on each pes. This female, crossing with normal males, has produced several litters. In one litter there were five kittens, four of which were normal, the other having the normal number of five toes on each manus, but not the normal arrangement, the hallux being on a line with the others and equalling them in size. Each pes had six toes. The phalanges were apparently well formed, the same number to every toe.

Another litter contained several abnormal kittens (no accurate account was kept of the ratio of normal to abnormal), one of which survives and has been examined by me, as have all the other abnormal cats to be mentioned. It has six toes on the right manus, seven on the left manus, and the normal number, four, on each pes. Such a condition may be represented in the following manner:

$$\frac{7}{4}\,\Big|\,\frac{6}{4}$$