WILLIAM WHEWELL

ON THE PHILOSOPHY OF DISCOVERY, CHAPTERS HISTORICAL AND CRITICAL

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Содержание

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PREFACE

The two works which I entitled *The History of the Inductive Sciences*, and *The Philosophy of the Inductive Sciences*, were intended to present to the reader a view of the steps by which those portions of human knowledge which are held to be most certain and stable have been acquired, and of the philosophical principles which are involved in those steps. Each of these steps was a scientific *Discovery*, in which a *new* conception was applied in order to bind together observed facts. And though the conjunction of the observed facts was in each case an example of logical *Induction*, it was not the inductive process merely, but the *novelty* of the result in each case which gave its peculiar character to the History; and the Philosophy at which I aimed was not the Philosophy of Induction, but the *Philosophy of Discovery*. In the present edition I have described this as my object in my Title.

A great part of the present volume consists of chapters which

composed the twelfth Book of the Philosophy in former editions, which Book was then described as a 'Review of Opinions on the nature of Knowledge and the Method of seeking it.' I have added to this part several new chapters, on Plato, Aristotle, the Arabian Philosophers, Francis Bacon, Mr. Mill, Mr. Mansel, the late Sir William Hamilton, and the German philosophers Kant, Fichte, Schelling and Hegel. I might, if time had allowed, have added a new chapter on Roger Bacon, founded on his *Opus Minus* and other works, recently published for the first time under the direction of the Master of the Rolls; a valuable contribution to the history of philosophy. But the review of this work would not materially alter the estimate of Roger Bacon which I had derived from the *Opus Majus*.

But besides these historical and critical surveys of the philosophy of others, I have ventured to introduce some new views of my own; namely, views which bear upon the philosophy of religion. I have done so under the conviction that no philosophy of the universe can satisfy the minds of thoughtful men which does not deal with such questions as inevitably force themselves on our notice, respecting the Author and the Object of the universe; and also under the conviction that every philosophy of the universe which has any consistency must suggest answers, at least conjectural, to such questions. No *Cosmos* is complete from which the question of Deity is excluded; and all Cosmology has a side turned towards Theology. Though I am aware therefore how easy it is, on this subject,

to give offence and to incur obloquy, I have not thought it right to abstain from following out my philosophical principles to their results in this department of speculation. The results do not differ materially from those at which many pious and thoughtful speculators have arrived in previous ages of the world; though they have here, as seems to me, something of novelty in their connection with the philosophy of science. But this point I willingly leave to the calm decision of competent judges.

I have added in an Appendix various Essays, previously published at different times, which may serve perhaps to illustrate some points of the history and philosophy of science.

Trinity Lodge,
February 8, 1856.

Wär' nicht das Auge sonnenhaft
Wie könnten wir das Licht erblicken?
Lebt' nicht in uns des Gottes eigne Kraft
Wie könnte uns das Göttliche entzücken?

Goethe.

Were nothing sunlike in the Eye
How could we Light itself descry?
Were nothing godlike in the Mind
How could we God in Nature find?

CHAPTER I.
INTRODUCTION

By the examination of the elements of human thought in which I have been engaged, and by a consideration of the history of the most clear and certain parts of our knowledge, I have been led to doctrines respecting the progress of that exact and systematic knowledge which we call Science; and these doctrines I have endeavoured to lay before the reader in the History of the Sciences and of Scientific Ideas. The questions on which I have thus ventured to pronounce have had a strong interest for man from the earliest period of his intellectual progress, and have been the subjects of lively discussion and bold speculation in every age. I conceive that in the doctrines to which these researches have conducted us, we have a far better hope that we possess a body of permanent truths than the earlier essays on the same subjects could furnish. For we have not taken our examples of knowledge at hazard, as earlier speculators did, and were almost compelled to do; but have drawn our materials from the vast store of unquestioned truths which modern science offers to us: and we have formed our judgment concerning the nature and progress of knowledge by considering what such science is, and how it has reached its present condition. But though we have thus pursued our speculations concerning knowledge with

advantages which earlier writers did not possess, it is still both interesting and instructive for us to regard the opinions upon this subject which have been delivered by the philosophers of past times. It is especially interesting to see some of the truths which we have endeavoured to expound, gradually dawning in men's minds, and assuming the clear and permanent form in which we can now contemplate them. I shall therefore, in the ensuing chapters, pass in review many of the opinions of the writers of various ages concerning the mode by which man best acquires the truest knowledge; and I shall endeavour, as we proceed, to appreciate the real value of such judgments, and their place in the progress of sound philosophy.

In this estimate of the opinions of others, I shall be guided by those general doctrines which I have, as I trust, established in the histories already published. And without attempting here to give any summary of these doctrines, I may remark that there are two main principles by which speculations on such subjects in all ages are connected and related to each other; namely, the opposition of *Ideas* and *Sensations*, and the distinction of *practical* and *speculative* knowledge. The opposition of Ideas and Sensations is exhibited to us in the antithesis of Theory and Fact, which are necessarily considered as distinct and of opposite natures, and yet necessarily identical, and constituting Science by their identity. In like manner, although practical knowledge is in substance identical with speculative, (for all knowledge is speculation,) there is a distinction between the two in their history, and in

the subjects by which they are exemplified, which distinction is quite essential in judging of the philosophical views of the ancients. The alternatives of identity and diversity, in these two antitheses,—the successive separation, opposition, and reunion of principles which thus arise,—have produced, (as they may easily be imagined capable of doing,) a long and varied series of systems concerning the nature of knowledge; among which we shall have to guide our course by the aid of the views already presented.

I am far from undertaking, or wishing, to review the whole series of opinions which thus come under our notice; and I do not even attempt to examine all the principal authors who have written on such subjects. I merely wish to select some of the most considerable forms which, such opinions have assumed, and to point out in some measure the progress of truth from age to age. In doing this, I can only endeavour to seize some of the most prominent features of each time and of each step, and I must pass rapidly from classical antiquity to those which we have called the dark ages, and from them to modern times. At each of these periods the modifications of opinion, and the speculations with which they were connected, formed a vast and tangled maze, the byways of which our plan does not allow us to enter. We shall esteem ourselves but too fortunate, if we can discover the single track by which ancient led to modern philosophy.

I must also repeat that my survey of philosophical writers is here confined to this one point,—their opinions on the nature

of knowledge and the method of science. I with some effort avoid entering upon other parts of the philosophy of those authors of whom I speak; I knowingly pass by those portions of their speculations which are in many cases the most interesting and celebrated;—their opinions concerning the human soul, the Divine Governor of the world, the foundations or leading doctrines of politics, religion, and general philosophy. I am desirous that my reader should bear this in mind, since he must otherwise be offended with the scanty and partial view which I give in this place of the philosophers whom I enumerate.

CHAPTER II.
Plato

There would be small advantage in beginning our examination earlier than the period of the Socratic School at Athens; for although the spirit of inquiry on such subjects had awakened in Greece at an earlier period, and although the peculiar aptitude of the Grecian mind for such researches had shown itself repeatedly in subtle distinctions and acute reasonings, all the positive results of these early efforts were contained in a more definite form in the reasonings of the Platonic age. Before that time, the Greeks did not possess plain and familiar examples of exact knowledge, such as the truths of Arithmetic, Geometry, Astronomy and Optics became in the school of Plato; nor were the antitheses of which we spoke above, so distinctly and fully unfolded as we find them in Plato's works.

The question which hinges upon one of these antitheses, occupies a prominent place in several of the Platonic dialogues; namely, whether our knowledge be obtained by means of Sensation or of Ideas. One of the doctrines which Plato most earnestly inculcated upon his countrymen was, that we do not *know* concerning sensible objects, but concerning ideas. The first attempts of the Greeks at metaphysical analysis had given rise to a school which maintained that material objects are the only

realities. In opposition to this, arose another school, which taught that material objects have no permanent reality, but are ever waxing and waning, constantly changing their substance. "And hence," as Aristotle says[1], "arose the doctrine of ideas which the Platonists held. For they assented to the opinion of Heraclitus, that all sensible objects are in a constant state of flux. So that if there is to be any knowledge and science, it must be concerning some permanent natures, different from the sensible natures of objects; for there can be no permanent science respecting that which is perpetually changing. It happened that Socrates turned his speculations to the moral virtues, and was the first philosopher who endeavoured to give universal definitions of such matters. He wished to reason systematically, and therefore he tried to establish definitions, for definitions are the basis of systematic reasoning. There are two things which may justly be looked upon as steps in philosophy due to Socrates; inductive reasonings, and universal definitions;—both of them steps which belong to the foundations of science. Socrates, however, did not make universals, or definitions separable from the objects; but his followers separated them, and these essences they termed *Ideas*." And the same account is given by other writers[2]. "Some existences are sensible, some intelligible: and according to Plato, if we wish to understand the principles of things, we must first separate the *ideas* from the *things*, such as the ideas of Similarity,

[1] *Metaph.* xii. 4.

[2] Diog. Laert. *Vit. Plat.*

Unity, Number, Magnitude, Position, Motion: second, that we must assume an absolute Fair, Good, Just, and the like: third, that we must consider the ideas of relation, as Knowledge, Power: recollecting that the Things which we perceive have this or that appellation applied to them because they partake of this or that Idea; those things being *just* which participate in the idea of The Just, those being *beautiful*, which contain the idea of The Beautiful." And many of the arguments by which this doctrine was maintained are to be found in the Platonic dialogues. Thus the opinion that true knowledge consists in sensation, which had been asserted by Protagoras and others, is refuted in the *Theætetus*: and, we may add, so victoriously refuted, that the arguments there put forth have ever since exercised a strong influence upon the speculative world. It may be remarked that in the minds of Plato and of those who have since pursued the same paths of speculation, the interest of such discussions as those we are now referring to, was by no means limited to their bearing upon mere theory; but was closely connected with those great questions of morals which have always a practical import. Those who asserted that the only foundation of knowledge was sensation, asserted also that the only foundation of virtue was the desire of pleasure. And in Plato, the metaphysical part of the disquisitions concerning knowledge in general, though independent in its principles, always seems to be subordinate in its purpose to the questions concerning the knowledge of our duty.

Since Plato thus looked upon the Ideas which were involved in each department of knowledge as forming its only essential part, it was natural that he should look upon the study of Ideas as the true mode of pursuing knowledge. This he himself describes in the *Philebus*[3]. "The best way of arriving at truth is not very difficult to point out, but most hard to pursue. All the arts which have ever been discovered, were revealed in this manner. It is a gift of the gods to man, which, as I conceive, they sent down by some Prometheus, as by Prometheus they gave us the light of fire; and the ancients, more clear-sighted than we, and less removed from the gods, handed down this traditionary doctrine: that whatever is said to be, comes of One and of Many, and comprehends in itself the Finite and the Infinite in coalition (being One Kind, and consisting of Infinite Individuals). And this being the state of things, we must, in each case, endeavour to seize the One Idea (the idea of the Kind) as the chief point; for we shall find that it is there. And when we have seized this one thing, we may then consider how it comprehends in itself two, or three, or any other number; and, again, examine each of these ramifications separately; till at last we perceive, not only that One is at the same time One and Many, but also *how many*. And when we have thus filled up the interval between the Infinite and the One, we may consider that we have done with each one. The gods then, as I have said, taught us by tradition thus to contemplate, and to learn, and to teach one another. But the philosophers of the

[3] T. ii. p. 16, c, d. ed. Bekker, t. v. p. 437.

present day seize upon the One, at hazard, too soon or too late, and then immediately snatch at the Infinite; but the intermediate steps escape them, in which resides the distinction between a truly logical and a mere disputatious discussion."

It would seem that what the author here describes as the most perfect form of exposition, is that which refers each object to its place in a classification containing a complete series of subordinations, and which gives a definition of each class. We have repeatedly remarked that, in sciences of classification, each new definition which gives a tenable and distinct separation of classes is an important advance in our knowledge; but that such definitions are rather the last than the first step in each advance. In the progress of real knowledge, these definitions are always the results of a laborious study of individual cases, and are never arrived at by a pure effort of thought, which is what Plato appears to have imagined as the true mode of philosophizing. And still less do the advances of other sciences consist in seizing at once upon the highest generality, and filling in afterwards all the intermediate steps between that and the special instances. On the contrary, as we have seen, the ascents from particular to general are all successive; and each step of this ascent requires time, and labour, and a patient examination of actual facts and objects.

It would, of course, be absurd to blame Plato for having inadequate views of the nature of progressive knowledge, at the time when knowledge could hardly be said to have begun its progress. But we already find in his speculations, as appears

in the passages just quoted from his writings, several points brought into view which will require our continued attention as we proceed. In overlooking the necessity of a gradual and successive advance from the less general to the more general truths, Plato shared in a dimness of vision[4] which prevailed among philosophers to the time of Francis Bacon. In thinking too slightly of the study of actual nature, he manifested a bias from which the human intellect freed itself in the vigorous struggles which terminated the dark ages. In pointing out that all knowledge implies a unity of what we observe as manifold, which unity is given by the mind, Plato taught a lesson which has of late been too obscurely acknowledged, the recoil by which men repaired their long neglect of facts having carried them for a while so far as to think that facts were the whole of our knowledge. And in analysing this principle of Unity, by which we thus connect sensible things, into various Ideas, such as Number, Magnitude, Position, Motion, he made a highly important step, which it has been the business of philosophers in succeeding times to complete and to follow out.

But the efficacy of Plato's speculations in their bearing upon physical science, and upon theory in general, was much weakened by the confusion of practical with theoretical knowledge, which arose from the ethical propensities of the Socratic school. In the Platonic Dialogues, Art and Science are constantly spoken of indiscriminately. The skill possessed by the

[4] See the remarks on this phrase in the next chapter.

Painter, the Architect, the Shoemaker, is considered as a just example of human science, no less than the knowledge which the geometer or the astronomer possesses of the theoretical truths with which he is conversant. Not only so; but traditionary and mythological tales, mystical imaginations and fantastical etymologies, are mixed up, as no less choice ingredients, with the most acute logical analyses, and the most exact conduct of metaphysical controversies. There is no distinction made between the knowledge possessed by the theoretical psychologist and the physician, the philosophical teacher of morals and the legislator or the administrator of law. This, indeed, is the less to be wondered at, since even in our own time the same confusion is very commonly made by persons not otherwise ignorant or uncultured.

On the other hand, we may remark finally, that Plato's admiration of Ideas was not a barren imagination, even so far as regarded physical science. For, as we have seen[5], he had a very important share in the introduction of the theory of epicycles, having been the first to propose to astronomers in a distinct form, the problem of which that theory was the solution; namely, "to explain the celestial phenomena by the combination of equable circular motions." This demand of an ideal hypothesis which should exactly express the phenomena (as well as they could then be observed), and from which, by the interposition of suitable steps, all special cases might be deduced, falls in well with those

[5] *Hist. Ind. Sc.* b. iii. c. ii.

views respecting the proper mode of seeking knowledge which we have quoted from the *Philebus*. And the Idea which could thus represent and replace all the particular Facts, being not only sought but found, we may readily suppose that the philosopher was, by this event, strongly confirmed in his persuasion that such an Idea was indeed what the inquirer ought to seek. In this conviction all his genuine followers up to modern times have participated; and thus, though they have avoided the error of those who hold that facts alone are valuable as the elements of our knowledge, they have frequently run into the opposite error of too much despising and neglecting facts, and of thinking that the business of the inquirer after truth was only a profound and constant contemplation of the conceptions of his own mind. But of this hereafter.

CHAPTER III.
Additional Remarks on Plato

The leading points in Plato's writings which bear upon the philosophy of discovery are these:

1. The Doctrine of Ideas.
2. The Doctrine of the One and the Many.
3. The notion of the nature and aim of Science.
4. The survey of existing Sciences.

1. The Doctrine of Ideas is an attempt to solve a problem which in all ages forces itself upon the notice of thoughtful men; namely, How can certain and permanent knowledge be possible for man, since all his knowledge must be derived from transient and fluctuating sensations? And the answer given by this doctrine is, that certain and permanent knowledge is *not* derived from *Sensations*, but from *Ideas*. There are in the mind certain elements of knowledge which are not derived from sensation, and are only imperfectly exemplified in sensible objects; and when we reason concerning sensible things so as to obtain real knowledge, we do so by considering such things as partaking of the qualities of the Ideas concerning which there can be truth. The sciences of Geometry and Arithmetic show that there *are* truths which man can know; and the Doctrine of Ideas explains how this is possible.

So far the Doctrine of Ideas answers its primary purpose, and is a reply (by no means the least intelligible and satisfactory reply) to a question still agitated among philosophers: What is the ground of geometrical (and other necessary) truth?

But Plato seems, in many of his writings, to extend this doctrine much further; and to assume, not only Ideas of Space and its properties, from which geometrical truths are derived; but of Relations, as the Relations of Like and Unlike, Greater and Less; and of mere material objects, as Tables and Chairs. Now to assume Ideas of such things as these solves no difficulty and is supported by no argument. In this respect the Ideal theory is of no value in Science.

It is curious that we have a very acute refutation of the Ideal theory in this sense, not only in Aristotle, the open opponent of Plato on this subject, but in the Platonic writings themselves: namely, in the Dialogue entitled *Parmenides*; which, on this and on other accounts, I consider to be the work not of Plato, but of an opponent of Plato[6].

2. I have spoken, in the preceding chapter, of Plato's doctrine that truth is to be obtained by discerning the One in the Many. This expression is used, it would seem, in a somewhat large and fluctuating way, to mean several things; as for instance, finding the one *kind* in many *individuals* (for instance, the one idea of dog in many dogs); or the one *law* in many *phenomena* (for instance, the eccentrics and epicycles in many planets). In any

[6] This matter is further discussed in the Appendix, Essay A.

interpretation, it is too loose and indefinite a rule to be of much value in the formation of sciences, though it has been recently again propounded as important in modern times.

3. I have said, in the preceding chapter, that Plato, though he saw that scientific truths of great generality might be obtained and were to be arrived at by philosophers, overlooked the necessity of a *gradual* and *successive* advance from the less general to the more general; and I have described this as a 'dimness of vision.' I must now acknowledge that this is not a very appropriate phrase; for not only no acuteness of vision could have enabled Plato to see that gradual generalization in science of which, as yet, no example had appeared; but it was very fortunate for the progress of truth, at that time, that Plato had imagined to himself the object of science to be general and sublime truths which prove themselves to be true by the light of their own generality and symmetry. It is worth while to illustrate this notice of Plato by some references to his writings.

In the Sixth Book of the *Republic*, Plato treats of the then existing sciences as the instruments of a philosophical education. Among the most conspicuous of these is astronomy. He there ridicules the notion that astronomy is a sublime science because it makes men look *upward*. He asserts that the really sublime science is that which makes men look at the *realities*, which are suggested by the appearances seen in the heavens: namely, the spheres which revolve and carry the luminaries in their revolutions. Now it was no doubt the determined search for such

"realities" as these which gave birth to the Greek *Astronomy*, that first and critical step in the progress of science. Plato, by his exhortations, if not by his suggestions, contributed effectually, as I conceive, to this step in science. In the same manner he requires a science of *Harmonics* which shall be free from the defects and inaccuracies which occur in actual instruments. This belief that the universe was full of mathematical relations, and that these were the true objects of scientific research, gave a vigour, largeness of mind, and confidence to the Greek speculators which no more cautious view of the problem of scientific discovery could have supplied. It was well that this advanced guard in the army of discoverers was filled with indomitable courage, boundless hopes, and creative minds.

But we must not forget that this disposition to what Bacon calls *anticipation* was full of danger as well as of hope. It led Plato into error, as it led Kepler afterwards, and many others in all ages of scientific activity. It led Plato into error, for instance, when it led him to assert (in the *Timæus*) that the four elements, Earth, Air, Fire and Water, have, for the forms of their particles respectively, the Cube, the Icosahedron, the Pyramid, and the Octahedron; and again, when it led him to despise the practical controversies of the musicians of his time; which controversies were, in fact, the proof of the truth of the mathematical theory of Harmonics. And in like manner it led Kepler into error when it led him to believe that he had found the reason of the number, size and motion of the planetary orbits in the application of the

five regular solids to the frame of the universe[7].

How far the caution in forming hypotheses which Bacon's writings urge upon us is more severe than suits the present prospects of science, we may hereafter consider; but it is plainly very conceivable that a boldness in the invention and application of hypotheses which was propitious to science in its infancy, may be one of the greatest dangers of its more mature period: and further, that the happy effect of such a temper depended entirely upon the candour, skill and labour with which the hypotheses were compared with the observed phenomena.

4. Plato has given a survey of the sciences of his time as Francis Bacon has of *his*. Indeed Plato has given two such surveys: one, in the *Republic*, in reviewing, as I have said, the elements of a philosophical education; the other in the *Timæus*, as the portions of a theological view of the universe—such as has been called a *Theodicæa*, a justification of God. In the former passage of Plato, the sciences enumerated are Arithmetic, Plane Geometry, Solid Geometry, Astronomy and Harmonics[8]. In the *Timæus* we have a further notice of many other subjects, in a way which is intended, I conceive, to include such knowledge as Plato had then arrived at on the various parts of the universe. The subjects there referred to are, as I have elsewhere stated[9], these: light and heat, water, ice, gold, gems, rust and other

[7] These matters are further discussed in the Appendix, Essay B.

[8] See Appendix, Essay B.

[9] *Hist. Ind. Sc.* b. ii. Additions to 3rd Ed.

natural objects:—odours, taste, hearing, lights, colour, and the powers of sense in general:—the parts and organs of the body, as the bones, the marrow, the brain, flesh, muscles, tendons, ligaments and nerves; the skin, the hair, the nails; the veins and arteries; respiration; generation; and in short, every obvious point of physiology. But the opinions thus delivered in the *Timæus* on the latter subject have little to do with the progress of real knowledge. The doctrines, on the other hand, which depend upon geometrical and arithmetical relations are portions or preludes of the sciences which the fulness of time brought forth.

5. I may, as further bearing upon the Platonic notion of science, notice Plato's view of the constitution of the human mind. According to him the Ideas which are the constituents of science form an Intelligible World, while the visible and tangible things which we perceive by our senses form the Visible World. In the visible world we have shadows and reflections of actual objects, and by these shadows and reflections we may judge of the objects, even when we cannot do so directly; as when men in a dark cavern judge of external objects by the shadows which they cast into the cavern. In like manner in the Intelligible World there are conceptions which are the usual objects of human thought, and about which we reason; but these are only shadows and reflections of the Ideas which are the real sources of truth. And the Reasoning Faculty, the Discursive Reason, the *Logos*, which thus deals with conceptions, is subordinate to the Intuitive Faculty, the Intuitive Reason, the

Nous, which apprehends Ideas[10]. This recognition of a Faculty in man which contemplates the foundations—the *Fundamental Ideas*—of science, and by apprehending such Ideas, makes science possible, is consentaneous to the philosophy which I have all along presented, as the view taught us by a careful study of the history and nature of science. That new Fundamental Ideas are unfolded, and the Intuitive Faculty developed and enlarged by the progress of science and by an intimate acquaintance with its reasonings, Plato appears to have discerned in some measure, though dimly. And this is the less wonderful, inasmuch as this gradual and successive extension of the field of Intuitive Truth, in proportion as we become familiar with a larger amount of derived truth, is even now accepted by few, though proved by the reasonings of the greatest scientific discoverers in every age.

The leading defect in Plato's view of the nature of real science is his not seeing fully the extent to which experience and observation are the basis of all our knowledge of the universe. He considers the luminaries which appear in the heavens to be not the true objects of astronomy, but only some imperfect adumbration of them;—mere diagrams which may assist us in the study of a higher truth, as beautiful diagrams might illustrate the truths of geometry, but would not prove them. This notion of an astronomy which is an astronomy of Theories and not of Facts, is not tenable, for Theories *are* Facts. Theories and Facts are equally *real*; true Theories are Facts, and Facts are

[10] See these views further discussed in the Appendix, Essay C.

familiar Theories. But when Plato says that astronomy is a series of problems suggested by visible things, he uses expressions quite conformable to the true philosophy of science; and the like is true of all other sciences.

CHAPTER IV.
Aristotle

The views of Aristotle with regard to the foundations of human knowledge are very different from those of his tutor Plato, and are even by himself put in opposition to them. He dissents altogether from the Platonic doctrine that Ideas are the true materials of our knowledge; and after giving, respecting the origin of this doctrine, the account which we quoted in the last chapter, he goes on to reason against it. "Thus," he says[11], "they devised Ideas of all things which are spoken of as universals: much as if any one having to count a number of objects, should think that he could not do it while they were few, and should expect to count them by making them more numerous. For the kinds of things are almost more numerous than the special sensible objects, by seeking the causes of which they were led to their Ideas." He then goes on to urge several other reasons against the assumption of Ideas and the use of them in philosophical researches.

Aristotle himself establishes his doctrines by trains of reasoning. But reasoning must proceed from certain First Principles; and the question then arises, Whence are these First Principles obtained? To this he replies, that they are the

[11] *Metaph.* xii. 4.

result of *Experience*, and he even employs the same technical expression by which we at this day describe the process of collecting these principles from observed facts;—that they are obtained by *Induction*. I have already quoted passages in which this statement is made[12]. "The way of reasoning," he says[13], "is the same in philosophy, and in any art or science: we must collect the *facts* (τὰ ὑπὰρχοντα), and the things to which the facts happen, and must have as large a supply of these as possible, and then we must examine them according to the terms of our syllogisms." … "There are peculiar principles in each science; and in each case these principles must be obtained from *experience*. Thus astronomical observation supplies the principles of astronomical science. For the phenomena being rightly taken, the demonstrations of astronomy were discovered; and the same is the case with any other Art or Science. So that if the facts in each case be taken, it is our business to construct the demonstrations. For if *in our natural history* (κατὰ τὰν ἱστορί αν) we have omitted none of the facts and properties which belong to the subject, we shall learn what we can demonstrate and what we cannot." And again[14], "It is manifest that if any sensation be wanting, there must be some knowledge wanting, which we are thus prevented from having. For we acquire knowledge either *by Induction* (ἐπαγωγῆ) or

[12] *Hist. Ind. Sc.* b. i. c. iii. sect. 2.

[13] *Analyt. Prior.* i. 30.

[14] *Analyt. Post.* i. 18.

by Demonstration: and Demonstration is from universals, but Induction from particulars. It is impossible to have universal theoretical propositions except by Induction: and we cannot make inductions without having sensation; for sensation has to do with particulars."

It is easy to show that Aristotle uses the term *Induction*, as we use it, to express the process of collecting a general proposition from particular cases in which it is exemplified. Thus in a passage which we have already quoted[15], he says, "Induction, and Syllogism from Induction, is when we attribute one extreme term to the middle by means of the other." The import of this technical phraseology will further appear by the example which he gives: "We find that several animals which are deficient in bile are long-lived, as man, the horse, the mule; hence we infer that *all* animals which are deficient in bile are long-lived."

We may observe, however, that both Aristotle's notion of induction, and many other parts of his philosophy, are obscure and imperfect, in consequence of his refusing to contemplate ideas as something distinct from sensation. It thus happens that he always assumes the ideas which enter into his proposition as *given*; and considers it as the philosopher's business to determine whether such propositions are true or not: whereas the most important feature in induction is, as we have said, the *introduction* of a new idea, and not its employment when once introduced. That the mind in this manner gives unity to that which is

[15] *Analyt. Prior.* ii. 23, περι της επαγωγης.

manifold,—that we are thus led to speculative principles which have an evidence higher than any others,—and that a peculiar sagacity in some men seizes upon the conceptions by which the facts may be bound into true propositions,—are doctrines which form no essential part of the philosophy of the Stagirite, although such views are sometimes recognized, more or less clearly, in his expressions. Thus he says[16], "There can be no knowledge when the sensation does not continue in the mind. For this purpose, it is necessary both to perceive, and to have some *unity* in the mind (αἰσθανομένοις εχειν ἕν τι[17] ἐν τῇ ψυχῇ); and many such perceptions having taken place, some difference is then perceived: and from the remembrance of these arises Reason. Thus from Sensation comes Memory, and from Memory of the same thing often repeated comes Experience: for many acts of Memory make up one Experience. And from Experience, or from any Universal Notion which takes a permanent place in the mind,—from the *unity in the manifold*, the same some one thing being found in many facts,—springs the first principle of Art and of Science; of Art, if it be employed about production; of Science, if about existence."

I will add to this, Aristotle's notice of *Sagacity*; since, although little or no further reference is made to this quality in his

[16] *Analyt. Post.* ii. 19.

[17] But the best reading seems to be not ἕν τι but ἔτι: and the clause must be rendered "both to perceive and to retain the perception in the mind." This correction does not disturb the general sense of the passage, that the first principles of science are obtained by finding the One in the Many.

philosophy, the passage fixes our attention upon an important step in the formation of knowledge. "Sagacity" (ἀγχίνοια), he says[18], "is a hitting by guess (εὐστοχία τις) upon the middle term (the conception common to two cases) in an inappreciable time. As for example, if any one seeing that the bright side of the moon is always towards the sun, suddenly perceives why this is; namely, because the moon shines by the light of the sun:—or if he sees a person talking with a rich man, he guesses that he is borrowing money;—or conjectures that two persons are friends, because they are enemies of the same person."—To consider only the first of these examples;—the conception here introduced, that of a body shining by the light which another casts upon it, is not contained in the observed facts, but introduced by the mind. It is, in short, that conception which, in the act of induction, the mind superadds to the phenomena as they are presented by the senses: and to invent such appropriate conceptions, such "eustochies," is, indeed, the precise office of inductive sagacity.

At the end of this work (the *Later Analytics*) Aristotle ascribes our knowledge of principles to Intellect (νοῦς), or, as it appears necessary to translate the word, *Intuition*[19]. "Since, of our intellectual habits by which we aim at truth, some are always true, but some admit of being false, as Opinion and Reasoning, but Science and Intuition are always true; and since there is nothing which is more certain than Science except Intuition; and since

[18] *Analyt. Post.* i. 34.

[19] *Ibid.* ii. 19.

Principles are better known to us than the Deductions from them; and since all Science is connected by reasoning, we cannot have Science respecting Principles. Considering this then, and that the beginning of Demonstration cannot be Demonstration, nor the beginning of Science, Science; and since, as we have said, there is no other kind of truth, Intuition must be the beginning of Science."

What is here said, is, no doubt, in accordance with the doctrines which we have endeavoured to establish respecting the nature of Science, if by this *Intuition* we understand that contemplation of certain Fundamental Ideas, which is the basis of all rigorous knowledge. But notwithstanding this apparent approximation, Aristotle was far from having an habitual and practical possession of the principles which he thus touches upon. He did not, in reality, construct his philosophy by giving Unity to that which was manifold, or by seeking in Intuition principles which might be the basis of Demonstration; nor did he collect, in each subject, fundamental propositions by an induction of particulars. He rather endeavoured to divide than to unite; he employed himself, not in combining facts, but in analysing notions; and the criterion to which he referred his analysis was, not the facts of our experience, but our habits of language. Thus his opinions rested, not upon sound inductions, gathered in each case from the phenomena by means of appropriate Ideas; but upon the loose and vague generalizations which are implied in the common use of speech.

Yet Aristotle was so far consistent with his own doctrine of the derivation of knowledge from experience, that he made in almost every province of human knowledge, a vast collection of such special facts as the experience of his time supplied. These collections are almost unrivalled, even to the present day, especially in Natural History; in other departments, when to the facts we must add the right Inductive Idea, in order to obtain truth, we find little of value in the Aristotelic works. But in those parts which refer to Natural History, we find not only an immense and varied collection of facts and observations, but a sagacity and acuteness in classification which it is impossible not to admire. This indeed appears to have been the most eminent faculty in Aristotle's mind.

The influence of Aristotle in succeeding ages will come under our notice shortly.

CHAPTER V.
Additional Remarks on Aristotle

1. ONE of the most conspicuous points in Aristotle's doctrines as bearing upon the philosophy of Science is his account of that mode of attaining truth which is called *Induction*; for we are accustomed to consider Induction as the process by which our Sciences have been formed; and we call them collectively the *Inductive Sciences*. Aristotle often speaks of Induction, as for instance, when he says that Socrates introduced the frequent use of it. But the cardinal passage on this subject is in his *Analytics*, in which he compares Syllogism and Induction as two modes of drawing conclusions[20]. He there says that all belief arises either from Syllogism or from Induction: and adds that Induction is, when by means of one extreme term we infer the other extreme to be true of the middle term. The example which he gives is this: knowing that particular animals are long-lived, as elephant, horse, mule; and finding that these animals agree in having no gall-bladder; we infer, by *Induction*, that *all* animals which have no gall-bladder are long-lived. This may be done, he says, if the middle and the second extreme are convertible: as the following formal statement may show.

Elephant, horse, mule, &c. are long-lived.

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[20] *Analyt. Prior.* ii. 25.

Elephant, horse, mule, &c. are all gall-less.

If we might convert this proposition, and say

All gall-less animals are as elephant, horse, mule, &c.:

we might infer *syllogistically* that

All gall-less animals are long-lived.

And though we cannot infer this syllogistically, we infer it by Induction, when we have a sufficient amount of instances[21].

I have already elsewhere given this account of Induction, as a process employed in the formation of our knowledge[22]. What I have now to remark concerning Aristotle is, that it does not appear to have occurred to him, that in establishing such a proposition as that which he gives as his instance, the main difficulty is the *discovery* of a *middle term* which will allow us to frame such a proposition as we need. The zoologist who wanted to know what kind of animals are long-lived, might guess long before he guessed that the absence of the gall-bladder supplied the requisite middle term; (if the proposition were true; which it is not.) And in like manner in other cases, it is difficult to find a middle term, which enables us to collect a proposition by Induction. And herein consists the imperfection of his view of the subject; which considers the main point to be the proof of the proposition when the conceptions are *given*, whereas the main point really is, the *discovery* of conceptions which will make a

[21] See on this subject Appendix, Essay D.

[22] See the chapter on Certain Characteristics of Scientific Induction in the *Phil. Ind. Sc.* or in the *Nov. Org. Renov.*

true proposition possible.

2. Since the main characteristic of the steps which have occurred in the formation of the physical sciences, is not merely that they are propositions collected by Induction, but by the introduction of a *new* conception; it has been suggested that it is not a characteristic designation of these Sciences to call them *Inductive Sciences*. Almost every discovery involves in it the introduction of a new conception, as the element of a new proposition; and the novelty of the conception is more characteristic of the stages of discovery than the inductive application of it. Hence as bearing upon the Philosophy of Discovery, the statements of Aristotle concerning Induction, though acute and valuable, are not so valuable as they might seem. Even Francis Bacon, it has been asserted, erred in the same way (and of course with less excuse) in asserting Induction, of a certain kind, to be the great instrument for the promotion of knowledge, and in overlooking the necessity of the *Invention* which gives Induction its value.

3. The invention or discovery of a conception by which many facts of observation are conjoined so as to make them the materials of a proposition, is called in Plato, as we have seen, *finding the One in the Many*.

In the passage quoted from the *Later Analytics*, Aristotle uses the same expression, and speaks very justly respecting the formation of knowledge. Indeed the *Titles* of the chapters of this and many parts of Aristotle's works would lead us to expect just

such a Philosophy of Discovery as is the object of our study at present. Thus we have, *Anal. Post.* B. II. chap. 13: "How we are to hunt (θηρεύειν) the predications of a Definition." Chap. 14: "Precepts for the invention of Problems and of a Middle Term:" and the like. But when we come to read these chapters, they contain little that is of value, and resolve themselves mostly into permutations of Aristotle's logical phraseology.

4. The part of the Aristotelian philosophy which has most permanently retained its place in modern Sciences is a part of which a use has been made quite different from that which was originally contemplated. The "Five words" which are explained in the Introduction to Aristotle's *Categories*: namely, the words *Genus*, *Species*, *Difference*, *Property*, *Accident*, were introduced mainly that they might be used in the propositions of which Syllogisms consist, and might thus be the elements of reasoning. But it has so happened that these words are rarely used in Sciences of Reasoning, but are abundantly and commonly used in the Sciences of Classification, as I have explained in speaking of the Classificatory Sciences[23].

5. Of Aristotle's actual contributions to the Physical Sciences I have spoken in the History of those Sciences[24]. I have[25] stated that he conceived the globular form of the earth so clearly and gave so forcibly the arguments for that doctrine, that we may

[23] *Phil. Ind. Sc.* b. viii. c. i. art. 11, or *Hist. Sc. Id.* b. viii.

[24] B. i. c. xi. sect. 2.

[25] B. iii. c. i. sect. 9.

look upon him as the most effective teacher of it. Also in the Appendix to that History, published in the third edition, I have given Aristotle's account of the Rainbow, as a further example of his industrious accumulation of facts, and of his liability to error in his facts.

6. We do not find Aristotle so much impressed as we might have expected by that great monument of Grecian ingenuity, the theory of epicycles and excentrics which his predecessor Plato urged so strongly upon the attention of his contemporaries. Aristotle proves, as I have said, the globular form of the earth by good and sufficient arguments. He also proves by arguments which seem to him quite conclusive[26], that the earth is in the center of the universe, and immoveable. As to the motions of the rest of the planets, he says little. The questions of their order, and their distances, and the like, belong, he says, to Astrology[27]. He remarks only that the revolution of the heaven itself, the outermost revolution, is simple and the quickest of all: that the revolutions of the others are slower, each moving in a direction opposite to the heaven in its own circle: and that it is reasonable that those which are nearest to the first revolution should take the longest time in describing their own circle, and those that are furthest off, the least time, and the intermediate ones in the order of their distances, "as also the mathematicians show."

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[26] *De Cælo*, ii. 13.

[27] *Ibid.* ii. 10.

In the *Metaphysics*[28] he enumerates the circular movements which had been introduced by the astronomers Eudoxus and Calippus for the explanation of the phenomena presented by the sun, moon and planets. These, he says, amount to fifty-five; and this, he says, must be the number of essences and principles which exist in the universe.

7. In the Sciences of Classification, and especially in the classification of animals, higher claims have been made for Aristotle, which I have discussed in the History[29]. I have there attempted to show that Aristotle's classification, inasmuch as it enumerates all the parts of animals, may be said to contain the *materials* of every subsequent classification: but that it cannot be said to anticipate any modern system, because the different grades of classification are not made *subordinate* to one another as a *system* of classification requires. I have the satisfaction of finding Mr. Owen agreeing with me in these views[30].

8. Francis Bacon's criticism on Aristotle which I have quoted in the Appendix to the History[31], is severe, and I think evidently the result of prejudice. He disparages Aristotle in comparison with the other philosophers of Greece. 'Their systems,' he says, 'had some savour of experience, and nature, and bodily things;

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[28] xii. 8.

[29] B. xvi. c. vi.

[30] *On the Classification of Mammalia, &c.: a Lecture delivered at Cambridge*, May 10, 1859, p. 3.

[31] B. i. c. xi.

while the Physics of Aristotle, in general, sound only of Logical Terms.

'Nor let anyone be moved by this: that in his books *Of Animals*, and in his *Problems*, and in others of his tracts, there is often a quoting of experiments. For he had made up his mind beforehand; and did not consult experience in order to make right propositions and axioms, but when he had settled his system to his will, he twisted experience round and made her bend to his system.'

I do not think that this can be said with any truth. I know no instances in which Aristotle has twisted experience round, and made her bend to his system. In his *Problems*, he is so far from giving dogmatical solutions of the questions proposed, that in most cases, he propounds two or three solutions as mere suggestions and conjectures. And both in his History of Animals, as I have said, and in others of his works, the want of system gives them an incoherent and tumultuary character, which even a false system would have advantageously removed; for, as I have said elsewhere, it is easier to translate a false system into a true one, than to introduce system into a mass of confusion.

9. It is curious that a fundamental error into which Aristotle fell in his view of the conditions which determine the formation of Science is very nearly the same as one of Francis Bacon's leading mistakes. Aristotle says, that Science consists in knowing the *causes* of things, as Bacon aims at acquiring a knowledge of the *forms* or *essences* of things and their qualities. But the history

of all the sciences teaches us that sciences do not begin with such knowledge, and that in few cases only do they ever attain to it. Sciences begin by a knowledge of the *laws* of *phenomena*, and proceed by the discovery of the scientific ideas by which the phenomena are colligated, as I have shown in other works[32]. The discovery of causes is not beyond the human powers, as some have taught. Those who thus speak disregard the lessons taught by the history of Physical Astronomy, of Geology, of Physical Optics, Thermotics and other sciences. But the discovery of causes, and of the essential forms of qualities, is a triumph reserved for the later stages of each Science, when the knowledge of the laws of phenomena has already made great progress. It was not to be expected that Aristotle would discern this truth, when, as yet, there was no Science extant in which it had been exemplified. Yet in Astronomy, the theory of epicycles and excentrics had immense value, and even has still, as representing the laws of phenomena; while the attempt to find in it, as Aristotle wished to do, the ultimate causes of the motions of the universe, could only mislead. The Aristotelian maxim, which sounds so plausible, and has been so generally accepted, that "to know truly is to know the causes of things," is a bad guide in scientific research. Instead of it we might substitute this: that "though we may aspire to know at last *why* things are, we must be content for a long time with knowing *how* they are."

10. Hence if we are asked whether Plato or Aristotle had the

[32] *History of Scientific Ideas*, and *Novum Organum Renovatum*.

truer views of the nature and property of Science, we must give the preference to Plato; for though his notion of a real Intelligible World, of which the Visible world was a fleeting and changeable shadow, was extravagant, yet it led him to seek to determine the forms of the Intelligible Things, which are really the laws of visible phenomena; while Aristotle was led to pass lightly over such laws, because they did not at once reveal the causes which produced the phenomena.

11. Aristotle, throughout his works, takes numerous occasions to argue against Plato's doctrine of Ideas. Yet these Ideas, so far as they were the Intelligible Forms of Visible Things, were really fit objects of philosophical research; and the search after them had a powerful influence in promoting the progress of Science. And we may see in the effect of this search the answer to many of Aristotle's strongest arguments. For instance, Aristotle says that Plato, by way of explaining things, adds to them as many Ideas, and that this is just as if a man having to reckon a large number, were to begin by adding to it another large number. It is plain that to this we may reply, that the adopting the Ideas of Cycles, along with the motions of the Planets, does really explain the motions; and that the Cycles are not simply added to the phenomena, but include and supersede the phenomena: a finite number of Cycles include and represent an infinite number of separate phenomena.

To Aristotle's argument that Ideas cannot be the Causes or Principles of Things, we should reply, that though they cannot be this, they may nevertheless be, and must be, the Conditions and

Principles of our Knowledge, which is what we want them to be.

I have given an account of the main features of Aristotle's philosophy, so far as it concerns the Physical Sciences, in the History of the Inductive Sciences, Book I.

CHAPTER VI.
The Later Greeks

Thus while Plato was disposed to seek the essence of our knowledge in Ideas alone, Aristotle, slighting this source of truth, looked to Experience as the beginning of Science; and he attempted to obtain, by division and deduction, all that Experience did not immediately supply. And thus, with these two great names, began that struggle of opposite opinions which has ever since that time agitated the speculative world, as men have urged the claims of Ideas or of Experience to our respect, and as alternately each of these elements of knowledge has been elevated above its due place, while the other has been unduly depressed. We shall see the successive turns of this balanced struggle in the remaining portions of this review.

But we may observe that practically the influence of Plato predominated rather than that of Aristotle, in the remaining part of the history of ancient philosophy. It was, indeed, an habitual subject of dispute among men of letters, whether the sources of true knowledge are to be found in the Senses or in the Mind; the Epicureans taking one side of this alternative, and the Academics another, while the Stoics in a certain manner included both elements in their view. But none of these sects showed their persuasion that the materials of knowledge were

to be found in the domain of Sense, by seeking them there. No one appears to have thought of following the example of Aristotle, and gathering together a store of observed facts. We may except, perhaps, assertions belonging to some provinces of Natural History, which were collected by various writers: but in these, the mixed character of the statements, the want of discrimination in the estimate of evidence, the credulity and love of the marvellous which the authors for the most part displayed, showed that instead of improving upon the example of Aristotle, they were wandering further and further from the path of real knowledge. And while they thus collected, with so little judgment, such statements as offered themselves, it hardly appears to have occurred to any one to enlarge the stores of observation by the aid of experiment; and to learn what the laws of nature were, by trying what were their results in particular cases. They used no instruments for obtaining an insight into the constitution of the universe, except logical distinctions and discussions; and proceeded as if the phenomena familiar to their predecessors must contain all that was needed as a basis for natural philosophy. By thus contenting themselves with the facts which the earlier philosophers had contemplated, they were led also to confine themselves to the ideas which those philosophers had put forth. For all the most remarkable alternatives of hypothesis, so far as they could be constructed with a slight and common knowledge of phenomena, had been promulgated by the acute and profound thinkers who gave the

first impulse to philosophy: and it was not given to man to add much to the original inventions of *their* minds till he had undergone anew a long discipline of observation, and of thought employed upon observation. Thus the later authors of the Greek Schools became little better than commentators on the earlier; and the commonplaces with which the different schools carried on their debates,—the constantly recurring argument, with its known attendant answer,—the distinctions drawn finer and finer and leading to nothing,—render the speculations of those times a *scholastic* philosophy, in the same sense in which we employ the term when we speak of the labours of the middle ages. It will be understood that I now refer to that which is here my subject, the opinions concerning our knowledge of nature, and the methods in use for the purpose of obtaining such knowledge. Whether the moral speculations of the ancient world were of the same stationary kind, going their round in a limited circle, like their metaphysics and physics, must be considered on some other occasion.[33]

Mr. Grote, in his very interesting discussion of Socrates's teaching, notices also[34] the teaching of Hippocrates, which he conceives to have in one respect the same tendency as the philosophy of Socrates; namely, to turn away from the vague aggregate of doctrines and guesses which constituted the Physical Philosophy of that time, and to pursue instead

[33] The remainder of this chapter is new in the present edition.

[34] *Hist. of Greece*, Part ii. chap. 68.

a special and more practical course of inquiry: Hippocrates selecting Medicine and Socrates selecting Ethics. By this limitation of their subject, they avoided some of the errors of their predecessors. For, as Mr. Grote has also remarked, "the earlier speculators, Anaxagoras, Empedocles, Democritus, the Pythagoreans, all had still present to their minds the vast and undivided problems which have been transmitted down from the old poets; bending their minds to the invention of some system which would explain them all at once, or assist the imagination in conceiving both how the Kosmos first began and how it continued to move on." There could be no better remedy for this ambitious error of the human mind than to have a definite subject of study, such as the diseases and the health of the human body. Accordingly, we see that the study of medicine did draw its cultivators away from this ancient but unprofitable field. Hippocrates[35] condemns those who, as Empedocles, set themselves to make out what man was from the beginning, how he began first to exist, and in what manner he was constructed. This is, he says, no part of medicine. In like manner he blames and refutes those who make some simple element, Hot, or Cold, or Moist, or Dry, the cause of diseases, and give medical precepts professing to be founded on this hypothesis.

These passages are marked by the prudence which practical study suggests to a calm and clear-sighted man. They can hardly be said to have opened the way to a Science of Medicine; for

[35] *De Antiqua Medicina*, c. 20.

in the sense in which we here use the word *Science*, namely, a collection of general truths inferred from facts by successive discoverers, we have even yet no Science of Medicine. The question with regard to the number and nature of the Elements of which bodies are composed began to be agitated, as we have seen, at a very early period of Greek philosophy, and continued long to be regarded as a chief point of physiological doctrine. In Galen's work we have a treatise entitled, *On the Elements according to Hippocrates*; and the writer explains[36] that though Hippocrates has not written any work with the title *On the Elements*, yet that he has in his *Treatise on the Nature of Man* shown his opinion on that subject. That the doctrine of the Four Elements, Hot, Cold, Moist, Dry, subsisted long in the schools, we have evidence in Galen. He tells us[37] that when he was a student of nineteen years old a teacher urged this lore upon him, and regarded him as very contentious and perverse, because he offered objections to it. His account of the Dialogue between him and the teacher is curious. But in Hippocrates the doctrine of these four elements is replaced, in a great measure, by the doctrine of the Four Humours of which the human body is constituted; namely, Blood, Phlegm, Yellow Bile and Black Bile. Galen dwells with emphasis upon Hippocrates's proof that there must be more than one such element[38].

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[36] Lib. i. c. 9.

[37] *De Elem.* i. 6.

[38] In former editions I have not done justice to this passage.

"What," he asks, "is the method of finding the Elements of bodies? There can, in my opinion, be no other than that which was introduced by Hippocrates; namely, we must inquire whether there be only one element, everywhere the same in kind, or whether there are more than one, various and unlike each other. And if the Element be not one only, but several, various and dissimilar, we must inquire in the second place, how many elements there are, and what, and of what kind they are, and how related in their association.

"Now that the First Element is not one only of which both our bodies and those of all other creatures were produced, Hippocrates shows from these considerations. And it is better first to put down his own expressions and then to expound them. 'I assert that if man consisted of one element only he could not fall sick; for there would be nothing which could derange his health, if he were all of one Element.'"

The doctrine of One Element did not prevail much after the time of Hippocrates: the doctrine of Four Elements continued, as I have said, long to hold possession of the Schools, but does not appear as an important part of the doctrine of Hippocrates. The doctrine of the Four Humours (Blood, Phlegm, Yellow Bile and Black Bile) is more peculiarly his, and long retained its place as a principle of physiological Science.

But we are here not so much concerned with his discoveries in medicine as with his views respecting the method of acquiring sound knowledge, and in this respect, as has been said, he

recommends by his practice a prudent limitation of the field of inquiry, a rejection of wide, ambitious, general assertions, and a practical study of his proper field.

In ascribing these merits to Hippocrates's medical speculations as to the ethical speculations of his contemporary Socrates, we assign considerable philosophical value to Hippocrates, no less than to Socrates. These merits were at that time the great virtues of physical as well as of ethical philosophy. But, as Mr. Grote well observes, the community of character which then subsisted between the physical and ethical speculations prevailing at that time, ceased to obtain in later times. Indeed, it ceased to exist just at that time, in consequence of the establishment of scientific astronomy by the exertions of Plato and his contemporaries. From that time the Common Sense (as we call it) of a man like Socrates, though it might be a good guide in ethics, was not a good guide in physics. I have shown elsewhere[39] how the Common Sense of Socrates was worthless in matters of astronomy. From that time one of the great intellectual lessons was, that in order to understand the external world, we must indeed observe carefully, but we must also guess boldly. Discovery here required an inventive mind like Plato's to deal with and arrange new and varied facts. But in ethics all the facts were old and familiar, and the generalizations of language by which they were grouped as Virtues and Vices, and the like, were common and well-known words. Here was

[39] *Hist. Ind. Sc.* Addition to Introduction in Third Edition.

no room for invention; and thus in the ethical speculations of Socrates or of any other moral teacher, we are not to look for any contributions to the Philosophy of Discovery.

Nor do I find anything on this subject among later Greek writers, beyond the commendation of such intellectual virtues as Hippocrates and Galen, and other medical writers, schooled by the practice of their art, enjoined and praised. But before we quit the ancients I will point out some peculiarities which may be noticed in the Roman disciples of the Greek philosophy.

CHAPTER VII.
The Romans

The Romans had no philosophy but that which they borrowed from the Greeks; and what they thus received, they hardly made entirely their own. The vast and profound question of which we have been speaking, the relation between Existence and our Knowledge of what exists, they never appear to have fathomed, even so far as to discern how wide and deep it is. In the development of the ideas by which nature is to be understood, they went no further than their Greek masters had gone, nor indeed was more to be looked for. And in the practical habit of accumulating observed facts as materials for knowledge, they were much less discriminating and more credulous than their Greek predecessors. The descent from Aristotle to Pliny, in the judiciousness of the authors and the value of their collections of facts, is immense.

Since the Romans were thus servile followers of their Greek teachers, and little acquainted with any example of new truths collected from the world around them, it was not to be expected that they could have any just conception of that long and magnificent ascent from one set of truths to others of higher order and wider compass, which the history of science began to exhibit when the human mind recovered its progressive

habits. Yet some dim presentiment of the splendid career thus destined for the intellect of man appears from time to time to have arisen in their minds. Perhaps the circumstance which most powerfully contributed to suggest this vision, was the vast intellectual progress which they were themselves conscious of having made, through the introduction of the Greek philosophy; and to this may be added, perhaps, some other features of national character. Their temper was too stubborn to acquiesce in the absolute authority of the Greek philosophy, although their minds were not inventive enough to establish a rival by its side. And the wonderful progress of their political power had given them a hope in the progress of man which the Greeks never possessed. The Roman, as he believed the fortune of his State to be destined for eternity, believed also in the immortal destiny and endless advance of that Intellectual Republic of which he had been admitted a denizen.

It is easy to find examples of such feelings as I have endeavoured to describe. The enthusiasm with which Lucretius and Virgil speak of physical knowledge, manifestly arises in a great measure from the delight which they had felt in becoming acquainted with the Greek theories.

> Me vero primum dulces ante omnia Musæ
> Quarum sacra fero ingenti perculsus amore
> Accipiant, cœlique vias et sidera monstrent,
> Defectus Solis varios, Lunæque labores!…
> Felix qui potuit rerum cognoscere causas!

Ye sacred Muses, with whose beauty fir'd,
My soul is ravisht and my brain inspir'd:
Whose Priest I am, whose holy fillets wear,
Would you your Poet's first petition hear,
Give me the ways of wand'ring stars to know,
The depth of Heaven above and Earth below;
Teach me the various labours of the Moon,
And whence proceed th' eclipses of the Sun;
Why flowing Tides prevail upon the main,
And in what dark abyss they shrink again;
What shakes the solid Earth; what cause delays
The Summer Nights; and shortens Winter Days....
Happy the man who, studying Nature's Laws,
Through known effects can trace the secret cause!

Ovid[40] expresses a similar feeling.

Felices animos quibus hæc cognoscere primis
Inque domos superas scandere cura fuit!…
Admovere oculis distantia sidera nostris
Ætheraque ingenio supposuere suo.
Sic petitur cœlum: non ut ferat Ossam Olympus
Summaque Peliacus sidera tanget apex.

Thrice happy souls! to whom 'twas given to rise
To truths like these, and scale the spangled skies!

[40] Lib. i. *Fast.*

Far distant stars to clearest view they brought,
And girdled ether with their chain of thought.
So heaven is reached:—not as of old they tried
By mountains piled on mountains in their pride.

And from the whole tenour of these and similar passages, it is evident that the intellectual pleasure which arises from our first introduction to a beautiful physical theory had a main share in producing this enthusiasm at the contemplation of the victories of science; although undoubtedly the moral philosophy, which was never separated from the natural philosophy, and the triumph over superstitious fears, which a knowledge of nature was supposed to furnish, added warmth to the feeling of exultation.

We may trace a similar impression in the ardent expressions which Pliny[41] makes use of in speaking of the early astronomers, and which we have quoted in the *History*. "Great men! elevated above the common standard of human nature, by discovering the laws which celestial occurrences obey, and by freeing the wretched mind of man from the fears which eclipses inspired."

This exulting contemplation of what science had done, naturally led the mind to an anticipation of further achievements still to be performed. Expressions of this feeling occur in Seneca, and are of the most remarkable kind, as the following example

[41] *Hist. Nat.* i. 75.

will show[42]:

"Why do we wonder that comets, so rare a phenomenon, have not yet had their laws assigned?—that we should know so little of their beginning and their end, when their recurrence is at wide intervals? It is not yet fifteen hundred years since Greece,

Stellis numeros et nomina fecit,

'reckoned the stars, and gave them names.' There are still many nations which are acquainted with the heavens by sight only; which do not yet know why the moon disappears, why she is eclipsed. It is but lately that among us philosophy has reduced these matters to a certainty. The day shall come when the course of time and the labour of a maturer age shall bring to light what is yet concealed. One generation, even if it devoted itself to the skies, is not enough for researches so extensive. How then can it be so, when we divide this scanty allowance of years into no equal shares between our studies and our vices? These things then must be explained by a long succession of inquiries. We have but just begun to know how arise the morning and evening appearances, the stations, the progressions, and the retrogradations of the fixed stars which put themselves in our way;—which appearing perpetually in another and another place compel us to be curious. Some one will hereafter demonstrate in what region the comets

[42] *Quæst. Nat.* vii. 25.

wander; why they move so far asunder from the rest; of what size and nature they are. Let us be content with what we have discovered: let posterity contribute its share to truth." Again he adds[43] in the same strain: "Let us not wonder that what lies so deep is brought out so slowly. How many animals have become known for the first time in this age! And the members of future generations shall know many of which we are ignorant. Many things are reserved for ages to come, when our memory shall have passed away. The world would be a small thing indeed, if it did not contain matter of inquiry *for* all the world. Eleusis reserves something for the second visit of the worshipper. *So too Nature does not at once disclose all* HER *mysteries*. We think ourselves initiated; we are but in the vestibule. The arcana are not thrown open without distinction and without reserve. This age will see some things; that which comes after us, others."

While we admire the happy coincidence of these conjectures with the soundest views which the history of science teaches us, we must not forget that they are merely conjectures, suggested by very vague impressions, and associated with very scanty conceptions of the laws of nature. Seneca's *Natural Questions*, from which the above extract is taken, contains a series of dissertations on various subjects of Natural Philosophy; as Meteors, Rainbows, Lightnings, Springs, Rivers, Snow, Hail, Rain, Wind, Earthquakes and Comets. In the whole of these dissertations, the statements are loose, and the explanations of

[43] *Quæst. Nat.* vii. 30, 31.

little or no value. Perhaps it may be worth our while to notice a case in which he refers to an observation of his own, although his conclusion from it be erroneous. He is arguing[44] against the opinion that Springs arise from the water which falls in rain. "In the first place," he says, "I, a very diligent digger in my vineyard, affirm that no rain is so heavy as to moisten the earth to the depth of more than ten feet. All the moisture is consumed in this outer crust, and descends not to the lower part." We have here something of the nature of an experiment; and indeed, as we may readily conceive, the instinct which impels man to seek truth by experiment can never be altogether extinguished. Seneca's experiment was deprived of its value by the indistinctness of his ideas, which led him to rest in the crude conception of the water being "consumed" in the superficial crust of the earth.

It is unnecessary to pursue further the reasonings of the Romans on such subjects, and we now proceed to the ages which succeeded the fall of their empire.

[44] *Ibid.* iii. 7.

CHAPTER VIII.
Arabian Philosophers

I have noticed certain additions to Physical Science made by the Arabians; namely, in Astronomy[45]. The discovery of the motion of the Sun's Apogee by Albategnius, and the discovery of the Moon's *Variation* by Aboul-Wefa; and in Optics[46] the assertion of Alhazen that the angle of refraction is not proportional to the angle of incidence, as Ptolemy had supposed: and certain steps in the philosophy of vision. We must also suppose, as the Arabic word *alkali* reminds us, that the Arabians contributed to lay the foundations of chemistry. The question which we have here to ask is, whether the Arabians made any steps beyond their predecessors in the philosophy of discovery. And to this question, I conceive the answer must be this: that among them as among the Greeks, those who practically observed nature, and especially those who made discoveries in Science, must have had a practical acquaintance with some of the maxims which are exemplified in the formation of Science. To discover that the Apogee of the Sun was 17 degrees distant from the point where Ptolemy had placed it, Albategnius made careful observations, and referred them to the theory of the

[45] *Hist. Ind. Sc.* b. iii. c. iv. sect. 8.

[46] *Ibid.* b. ix. c. ii.

eccentric, so as to verify or correct that theory. And when, in the eleventh century, Arzachel found the Apogee to be less advanced than Albategnius had found it, he proceeded again to correct the theory by introducing a new movement of the equinoctial points, which was called the *Trepidation*. It appeared afterwards, however, that, in doing this, he had had too much confidence in the observations of his predecessors, and that no such movement as the Trepidation really existed. In like manner to correct Ptolemy's law of refraction, Alhazen had recourse to experiment: but he did not put his experiments in the form of a Table, as Ptolemy had done. If he had done this, he might possibly have discovered the law of sines, which Snell afterwards discovered.

But though the Arabian philosophers thus, in some cases, observed facts, and referred those facts to general mathematical laws, it does not appear that they were led to put in any new or striking general form such maxims as this: That the progress of Science consists in the exact observation of facts and in colligating them by ideas. Those of them who were dissatisfied with the existing philosophy as barren and useless (for instance Algazel[47]), were led to point at the faults and contradictions of that philosophy, but did not attempt, so far as I know, to substitute for it anything better. If they rejected Aristotle's *Organon*, they did not attempt to construct a new Organon for themselves.

[47] See *Hist. Ind. Sc.* b. iv. c. i.

Indeed they do not appear even to have had sufficient confidence in the real truth of the astronomical theories which they had adopted from the Greeks, always to correct and extend those where their observations showed that they required correction and extension. Sometimes they did this, but not generally enough. When Arzachel found by observation the Apogee of the Sun to be situated too far back, he ventured to correct Ptolemy's statement of its motion. But when Aboul-Wefa had really discovered the *Variation* of the Moon's motion, he did not express it by means of an epicycle. If he had done so, he would have made it unnecessary for Tycho Brahe at a later period to make the same discovery.

The moral of this incident is the same moral which we have perpetually to note as taught us at every step by the history of Science:—namely, the necessity of constant, careful and exact observation of Facts; and the advantage of devising a Theory, (even if it have to be afterwards rejected,) by which the Facts shall be bound together into a coherent whole.

CHAPTER IX.
The Schoolmen of the Middle Ages

In the *History of the Sciences* I have devoted a Book to the state of Science in the middle ages, and have endeavoured to analyse the intellectual defects of that period. Among the characteristic features of the human mind during those times, I have noticed Indistinctness of Ideas, a Commentatorial Spirit, Mysticism, and Dogmatism. The account there given of this portion of the history of man belongs, in reality, rather to the History of Ideas than to the History of Progressive Science. For, as we have there remarked, theoretical Science was, during the period of which we speak, almost entirely stationary; and the investigation of the causes of such a state of things may be considered as a part of that review in which we are now engaged, of the vicissitudes of man's acquaintance with the methods of discovery. But when we offered to the world a history of science, to leave so large a chasm unexplained, would have made the series of events seem defective and broken; and the survey of the Middle Ages was therefore inserted. I would beg to refer to that portion of the former work the reader who wishes for information in addition to what is here given.

The Indistinctness of Ideas and the Commentatorial Disposition of those ages have already been here brought under

our notice. Viewed with reference to the opposition between Experience and Ideas, on which point, as we have said, the succession of opinions in a great measure turns, it is clear that the commentatorial method belongs to the ideal side of the question: for the commentator seeks for such knowledge as he values, by analysing and illustrating what his author has said; and, content with this material of speculation, does not desire to add to it new stores of experience and observation. And with regard to the two other features in the character which we gave to those ages, we may observe that Dogmatism demands for philosophical theories the submission of mind, due to those revealed religious doctrines which are to guide our conduct and direct our hopes: while Mysticism elevates ideas into realities, and offers them to us as the objects of our religious regard. Thus the Mysticism of the middle ages and their Dogmatism alike arose from not discriminating the offices of theoretical and practical philosophy. Mysticism claimed for ideas the dignity and reality of principles of moral action and religious hope: Dogmatism imposed theoretical opinions respecting speculative points with the imperative tone of rules of conduct and faith.

If, however, the opposite claims of theory and practice interfered with the progress of science by the confusion they thus occasioned, they did so far more by drawing men away altogether from mere physical speculations. The Christian religion, with its precepts, its hopes, and its promises, became the leading subject of men's thoughts; and the great active truths thus revealed, and

the duties thus enjoined, made all inquiries of mere curiosity appear frivolous and unworthy of man. The Fathers of the Church sometimes philosophized ill; but far more commonly they were too intent upon the great lessons which they had to teach, respecting man's situation in the eyes of his Heavenly Master, to philosophize at all respecting things remote from the business of life and of no importance in man's spiritual concerns.

Yet man has his intellectual as well as his spiritual wants. He has faculties which demand systems and reasons, as well as precepts and promises. The Christian doctor, who knew so much more than the heathen philosopher respecting the Creator and Governor of the universe, was not long content to know or to teach less, respecting the universe itself. While it was still maintained that Theology was the only really important study, Theology was so extended and so fashioned as to include all other knowledge: and after no long time, the Fathers of the Church themselves became the authors of systems of universal knowledge.

But when this happened, the commentatorial spirit was still in its full vigour. The learned Christians could not, any more than the later Greeks or the Romans, devise, by the mere force of their own invention, new systems, full, comprehensive, and connected, like those of the heroic age of philosophy. The same mental tendencies which led men to look for speculative coherence and completeness in the view of the universe, led them also to admire and dwell upon the splendid and acute speculations of the Greeks.

They were content to find, in those immortal works, the answers to the questions which their curiosity prompted; and to seek what further satisfaction they might require, in analysing and unfolding the doctrines promulgated by those great masters of knowledge. Thus the Christian doctors became, as to general philosophy, commentators upon the ancient Greek teachers.

Among these, they selected Aristotle as their peculiar object of admiration and study. The vast store, both of opinions and facts, which his works contain, his acute distinctions, his cogent reasons in some portions of his speculations, his symmetrical systems in almost all, naturally commended him to the minds of subtle and curious men. We may add that Plato, who taught men to contemplate Ideas separate from Things, was not so well fitted for general acceptance as Aristotle, who rejected this separation. For although the due apprehension of this opposition of Ideas and Sensations is a necessary step in the progress of true philosophy, it requires a clearer view and a more balanced mind than the common herd of students possess; and Aristotle, who evaded the necessary perplexities in which this antithesis involves us, appeared, to the temper of those times, the easier and the plainer guide of the two.

The Doctors of the middle ages having thus adopted Aristotle as their master in philosophy, we shall not be surprised to find them declaring, after him, that experience is the source of our knowledge of the visible world. But though, like the Greeks, they thus talked of experiment, like the Greeks, they showed little

disposition to discover the laws of nature by observation of facts. This barren and formal recognition of experience or sensation as one source of knowledge, not being illustrated by a practical study of nature, and by real theoretical truths obtained by such a study, remained ever vague, wavering, and empty. Such a mere acknowledgment cannot, in any times, ancient or modern, be considered as indicating a just apprehension of the true basis and nature of science.

In imperfectly perceiving how, and how far, experience is the source of our knowledge of the external world, the teachers of the middle ages were in the dark; but so, on this subject, have been almost all the writers of all ages, with the exception of those who in recent times have had their minds enlightened by contemplating philosophically the modern progress of science. The opinions of the doctors of the middle ages on such subjects generally had those of Aristotle for their basis; but the subject was often still further analysed and systematized, with an acute and methodical skill hardly inferior to that of Aristotle himself.

The Stagirite, in the beginning of his *Physics*, had made the following remarks. "In all bodies of doctrine which involve principles, causes, or elements, Science and Knowledge arise from the knowledge of these; (for we then consider ourselves to *know* respecting any subject, when we know its first cause, its first principles, its ultimate elements.) It is evident, therefore, that in seeking a knowledge of nature, we must first know what are its principles. But the course of our knowledge is, from the

things which are better known and more manifest to us, to the things which are more certain and evident in nature. For those things which are most evident in truth, are not most evident to us. [And consequently we must advance from things obscure in nature, but manifest to us, towards the things which are really in nature more clear and certain.] The things which are first obvious and apparent to us are complex; and from these we obtain, by analysis, principles and elements. We must proceed from universals to particulars. For the whole is better known to our senses than the parts, and for the same reason, the universal better known than the particular. And thus words signify things in a large and indiscriminate way, which is afterwards analysed by definition; as we see that the children at first call all men *father*, and all women *mother*, but afterwards learn to distinguish."

There are various assertions contained in this extract which came to be considered as standard maxims, and which occur constantly in the writers of the middle ages. Such are, for instance, the maxim, "Verè scire est per causas scire;" the remark, that compounds are known to us before their parts, and the illustration from the expressions used by children. Of the mode in which this subject was treated by the schoolmen, we may judge by looking at passages of Thomas Aquinas which treat of the subject of the human understanding. In the *Summa Theologiæ*, the eighty-fifth Question is *On the manner and order of understanding*, which subject he considers in eight Articles; and these must, even now, be looked upon as exhibiting many

of the most important and interesting points of the subject. They are, *First*, Whether our understanding understands by abstracting ideas (*species*) from appearances; *Second*, Whether intelligible species abstracted from appearances are related to our understanding as that *which* we understand, or that *by which* we understand; *Third*, Whether our understanding does naturally understand universals first; *Fourth*, Whether our understanding can understand many things at once; *Fifth*, Whether our understanding understands by compounding and dividing; *Sixth*, Whether the understanding can err; *Seventh*, Whether one person can understand the same thing better than another; *Eighth*, Whether our understanding understands the indivisible sooner than the divisible. And in the discussion of the last point, for example, reference is made to the passage of Aristotle which we have already quoted. "It may seem," he says, "that we understand the indivisible before the divisible; for *the Philosopher* says that we understand and know by knowing principles and elements; but indivisibles are the principles and elements of divisible things. But to this we may reply, that in our receiving of science, principles and elements are not always first; for sometimes from the sensible effects we go on to the knowledge of intelligible principles and causes." We see that both the objection and the answer are drawn from Aristotle.

We find the same close imitation of Aristotle in Albertus Magnus, who, like Aquinas, flourished in the thirteenth century. Albertus, indeed, wrote treatises corresponding to almost all

those of the Stagirite, and was called the *Ape of Aristotle*. In the beginning of his *Physics*, he says, "Knowledge does not always begin from that which is first according to the nature of things, but from that of which the knowledge is easiest. For the human intellect, on account of its relation to the senses (*propter reflexionem quam habet ad sensum*), collects science from the senses; and thus it is easier for our knowledge to begin from that which we can apprehend by sense, imagination, and intellect, than from that which we apprehend by intellect alone." We see that he has somewhat systematized what he has borrowed.

This disposition to dwell upon and systematize the leading doctrines of metaphysics assumed a more definite and permanent shape in the opposition of the Realists and Nominalists. The opposition involved in this controversy is, in fact, that fundamental antithesis of Sense and Ideas about which philosophy has always been engaged; and of which we have marked the manifestation in Plato and Aristotle. The question, What is the object of our thoughts when we reason concerning the external world? must occur to all speculative minds: and the difficulties of the answer are manifest. We must reply, either that our own Ideas, or that Sensible Things, are the elements of our knowledge of nature. And then the scruples again occur,—how we have any *general* knowledge if our thoughts are fixed on particular objects; and, on the other hand,—how we can attain to any *true* knowledge of nature by contemplating ideas which are not identical with objects in nature. The two opposite

opinions maintained on this subject were, on the one side,—that our general propositions refer to objects which are *real*, though divested of the peculiarities of individuals; and, on the other side,—that in such propositions, individuals are not represented by any reality, but bound together by a *name*. These two views were held by the Realists and Nominalists respectively: and thus the Realist manifested the adherence to Ideas, and the Nominalist the adherence to the impressions of Sense, which have always existed as opposite yet correlative tendencies in man.

The Realists were the prevailing sect in the Scholastic times: for example, both Thomas Aquinas and Duns Scotus, the *Angelical* and the *Subtle* Doctor, held this opinion, although opposed to each other in many of their leading doctrines on other subjects. And as the Nominalist, fixing his attention upon sensible objects, is obliged to consider what is the *principle of generalization*, in order that the possibility of any general proposition may be conceivable; so on the other hand, the Realist, beginning with the contemplation of universal ideas, is compelled to ask what is the *principle of individuation*, in order that he may comprehend the application of general propositions in each particular instance. This inquiry concerning the principle of individuation was accordingly a problem which occupied all the leading minds among the Schoolmen[48]. It will be apparent from what has been said, that it is only one of the many forms

[48] See the opinion of Aquinas, in Degerando, *Hist. Com. des Syst.* iv. 499; of Duns Scotus, *ibid.* iv. 523.

of the fundamental antithesis of the Ideas and the Senses, which we have constantly before us in this review.

The recognition of the derivation of our knowledge, in part at least, from Experience, though always loose and incomplete, appears often to be independent of the Peripatetic traditions. Thus Richard of St. Victor, a writer of contemplative theology in the twelfth century, says[49], that "there are three sources of knowledge, experience, reason, faith. Some things we prove by experiment, others we collect by reasoning, the certainty of others we hold by believing. And with regard to temporal matters, we obtain our knowledge by actual experience; the other guides belong to divine knowledge." Richard also propounds a division of human knowledge which is clearly not derived directly from the ancients, and which shows that considerable attention must have been paid to such speculations. He begins by laying down clearly and broadly the distinction, which, as we have seen, is of primary importance, between *practice* and *theory*. *Practice*, he says, includes seven mechanical arts; those of the clothier, the armourer, the navigator, the hunter, the physician, and the player. *Theory* is threefold, divine, natural, doctrinal; and is thus divided into Theology, Physics, and Mathematics. *Mathematics*, he adds, treats of the invisible *forms* of visible things. We have seen that by many profound thinkers this word *forms* has been selected as best fitted to describe those relations of things which are the subject of mathematics. Again,

[49] *Liber Excerptionum*, Lib. i. c. i.

Physics discovers causes from their effects and effects from their causes. It would not be easy at the present day to give a better account of the object of physical science. But Richard of St. Victor makes this account still more remarkably judicious, by the examples to which he alludes; which are earthquakes, the tides, the virtues of plants, the instincts of animals, the classification of minerals, plants and reptiles.

> Unde tremor terris, quâ vi maria alta tumescant,
> Herbarum vires, animos irasque ferarum,
> Omne genus fruticum, lapidum quoque, reptiliumque.

He further adds[50], "Physical science ascends from effects to causes, and descends again from causes to effects." This declaration Francis Bacon himself might have adopted. It is true, that Richard would probably have been little able to produce any clear and definite instances of knowledge, in which this ascent and descent were exemplified; but still the statement, even considered as a mere conjectural thought, contains a portion of that sagacity and comprehensive power which we admire so much in Bacon.

Richard of St. Victor, who lived in the twelfth century, thus exhibits more vigour and independence of speculative power than Thomas Aquinas, Albertus Magnus, and Duns Scotus, in the thirteenth. In the interval, about the end of the twelfth century,

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[50] *Tr. Ex.* Lib. i. c. vii.

the writings of Aristotle had become generally known in the West; and had been elevated into the standard of philosophical doctrine, by the divines mentioned above, who felt a reverent sympathy with the systematizing and subtle spirit of the Stagirite as soon as it was made manifest to them. These doctors, following the example of their great forerunner, reduced every part of human knowledge to a systematic form; the systems which they thus framed were presented to men's minds as the only true philosophy, and dissent from them was no longer considered to be blameless. It was an offence against religion as well as reason to reject the truth, and the truth could be but one. In this manner arose that claim which the Doctors of the Church put forth to control men's opinions upon all subjects, and which we have spoken of in the *History of Science* as the Dogmatism of the Middle Ages. There is no difficulty in giving examples of this characteristic. We may take for instance a Statute of the University of Paris, occasioned by a Bull of Pope John XXI., in which it is enacted, "that no Master or Bachelor of any faculty, shall presume to read lectures upon any author in a private room, on account of the many perils which may arise therefrom; but shall read in public places, where all may resort, and may faithfully report what is there taught; excepting only books of Grammar and Logic, in which there can be no presumption." And certain errors of Brescian are condemned in a Rescript[51] of the papal Legate Odo, with the following

[51] Tenneman, viii. 461.

expressions: "Whereas, as we have been informed, certain Logical professors treating of Theology in their disputations, and Theologians treating of Logic, contrary to the command of the law are not afraid to mix and confound the lots of the Lord's heritage; we exhort and admonish your University, all and singular, that they be content with the landmarks of the Sciences and Faculties which our Fathers have fixed; and that having due fear of the curse pronounced in the law against him who removeth his neighbour's landmark, you hold such sober wisdom according to the Apostles, that ye may by no means incur the blame of innovation or presumption."

The account which, in the *History of Science*, I gave of Dogmatism as a characteristic of the middle ages, has been indignantly rejected by a very pleasing modern writer, who has, with great feeling and great diligence, brought into view the merits and beauties of those times, termed by him *Ages of Faith*. He urges[52] that religious authority was never claimed for physical science: and he quotes from Thomas Aquinas, a passage in which the author protests against the practice of confounding opinions of philosophy with doctrines of faith. We might quote in return the Rescript[53] of Stephen, bishop of Paris, in which he declares that there can be but one truth, and rejects the distinction of things being true according to philosophy and not according to the Catholic faith; and it might be added, that among the

[52] *Mores Catholici, or Ages of Faith*, viii. p. 247.

[53] Tenneman, viii. 460.

errors condemned in this document are some of Thomas Aquinas himself. We might further observe, that if no physical doctrines were condemned in the times of which we now speak, this was because, on such subjects, no new opinions were promulgated, and not because opinion was free. As soon as new opinions, even on physical subjects, attracted general notice, they were prohibited by authority, as we see in the case of Galileo[54].

But this disinclination to recognize philosophy as independent of religion, and this disposition to find in new theories, even in physical ones, something contrary to religion or scripture, are, it would seem, very natural tendencies of theologians; and it would be unjust to assert that these propensities were confined to the periods when the authority of papal Rome was highest; or that the spirit which has in a great degree controlled and

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[54] If there were any doubt on this subject, we might refer to the writers who afterwards questioned the supremacy of Aristotle, and who with one voice assert that an infallible authority had been claimed for him. Thus Laurentius Valla: "Quo minus ferendi sunt recentes Peripatetici, qui nullius sectæ hominibus interdicunt libertate ab Aristotele dissentiendi, quasi sophos hic, non philosophus." *Pref. in Dial.* (Tenneman, ix. 29.) So Ludovicus Vives: "Sunt ex philosophis et ex theologis qui non solum quo Aristoteles pervenit extremum esse aiunt naturæ, sed quâ pervenit eam rectissimam esse omnium et certissimam in natura viam." (Tenneman, ix. 43.) We might urge too, the evasions practised by philosophical Reformers, through fear of the dogmatism to which they had to submit; for example, the protestation of Telesius at the end of the Proem to his work, *De Rerum Natura*: "Nec tamen, si quid eorum quæ nobis posita sunt, sacris literis, Catholicæve ecclesiæ decretis non cohæreat, tenendum id, quin penitus rejiciendum asseveramus contendimusque. Neque enim *humana* modo *ratio* quævis, sed *ipse* etiam *sensus* illis *posthabendus*, et si illis non congruat, abnegandus omnino et ipse etiam est sensus."

removed such habits was introduced by the Reformation of religion in the sixteenth century. We must trace to other causes, the clear and general recognition of Philosophy, as distinct from Theology, and independent of her authority. In the earlier ages of the Church, indeed, this separation had been acknowledged. St. Augustin says, "A Christian should beware how he speaks on questions of natural philosophy, as if they were doctrines of Holy Scripture; for an infidel who should hear him deliver absurdities could not avoid laughing. Thus the Christian would be confused, and the infidel but little edified; for the infidel would conclude that our authors really entertained these extravagant opinions, and therefore they would despise them, to their own eternal ruin. Therefore the opinions of philosophers should never be proposed as dogmas of faith, or rejected as contrary to faith, when it is not certain that they are so." These words are quoted with approbation by Thomas Aquinas, and it is said[55], are cited in the same manner in every encyclopedical work of the middle ages. This warning of genuine wisdom was afterwards rejected, as we have seen; and it is only in modern times that its value has again been fully recognized. And this improvement we must ascribe, mainly, to the progress of physical science. For a great body of undeniable truths on physical subjects being accumulated, such as had no reference to nor connexion with the truths of religion, and yet such as possessed a strong interest for most men's minds, it was impossible longer to deny that there were

[55] *Ages of Faith*, viii. 247: to the author of which I am obliged for this quotation.

wide provinces of knowledge which were not included in the dominions of Theology, and over which she had no authority. In the fifteenth and sixteenth centuries, the fundamental doctrines of mechanics, hydrostatics, optics, magnetics, chemistry, were established and promulgated; and along with them, a vast train of consequences, attractive to the mind by the ideal relations which they exhibited, and striking to the senses by the power which they gave man over nature. Here was a region in which philosophy felt herself entitled and impelled to assert her independence. From this region, there is a gradation of subjects in which philosophy advances more and more towards the peculiar domain of religion; and at some intermediate points there have been, and probably will always be, conflicts respecting the boundary line of the two fields of speculation. For the limit is vague and obscure, and appears to fluctuate and shift with the progress of time and knowledge.

Our business at present is not with the whole extent and limits of philosophy, but with the progress of physical science more particularly, and the methods by which it may be attained: and we are endeavouring to trace historically the views which have prevailed respecting such methods, at various periods of man's intellectual progress. Among the most conspicuous of the revolutions which opinions on this subject have undergone, is the transition from an implicit trust in the internal powers of man's mind to a professed dependence upon external observation; and from an unbounded reverence for the wisdom of the past, to

a fervid expectation of change and improvement. The origin and progress of this disposition of mind;—the introduction of a state of things in which men not only obtained a body of indestructible truths from experience, and increased it from generation to generation, but professedly, and we may say, ostentatiously, declared such to be the source of their knowledge, and such their hopes of its destined career;—the rise, in short, of Experimental Philosophy, not only as a habit, but as a Philosophy of Experience, is what we must now endeavour to exhibit.

CHAPTER X.
The Innovators of the Middle Ages

Raymond Lully

1. *General Remarks.*—In the rise of Experimental Philosophy, understanding the term in the way just now stated, two features have already been alluded to: the disposition to cast off the prevalent reverence for the opinions and methods of preceding teachers with an eager expectation of some vast advantage to be derived from a change; and the belief that this improvement must be sought by drawing our knowledge from external observation rather than from mere intellectual efforts;—*the Insurrection against Authority*, and *the Appeal to Experience*. These two movements were closely connected; but they may easily be distinguished, and in fact, persons were very prominent in the former part of the task, who had no comprehension of the latter principle, from which alone the change derives its value. There were many Malcontents who had not the temper, talent or knowledge, which fitted them to be Reformers.

The authority which was questioned, in the struggle of which we speak, was that of the Scholastic System, the combination of

Philosophy with Theology; of which Aristotle, presented in the form and manner which the Doctors of the Church had imposed upon him, is to be considered the representative. When there was demanded of men a submission of the mind, such as this system claimed, the natural love of freedom in man's bosom, and the speculative tendencies of his intellect, rose in rebellion, from time to time, against the ruling oppression. We find in all periods of the scholastic ages examples of this disposition of man to resist overstrained authority; the tendency being mostly, however, combined with a want of solid thought, and showing itself in extravagant pretensions and fantastical systems put forwards by the insurgents. We have pointed out one such opponent[56] of the established systems, even among the Arabian schoolmen, a more servile race than ever the Europeans were. We may here notice more especially an extraordinary character who appeared in the thirteenth century, and who may be considered as belonging to the Prelude of the Reform in Philosophy, although he had no share in the Reform itself.

2. *Raymond Lully.*—Raymond Lully is perhaps traditionally best known as an Alchemist, of which art he appears to have been a cultivator. But this was only one of the many impulses of a spirit ardently thirsty of knowledge and novelty. He had[57], in his youth, been a man of pleasure, but was driven by a sudden shock of feeling to resolve on a complete change of

[56] Algazel. See *Hist. Ind. Sc.* b. iv. c. i.

[57] Tenneman, viii. 830.

life. He plunged into solitude, endeavoured to still the remorse of his conscience by prayer and penance, and soon had his soul possessed by visions which he conceived were vouchsafed to him. In the feeling of religious enthusiasm thus excited, he resolved to devote his life to the diffusion of Christian truth among Heathens and Mahomedans. For this purpose, at the age of thirty he betook himself to the study of Grammar, and of the Arabic language. He breathed earnest supplications for an illumination from above; and these were answered by his receiving from heaven, as his admirers declare, his *Ars Magna* by which he was able without labour or effort to learn and apply all knowledge. The real state of the case is, that he put himself in opposition to the established systems, and propounded a New Art, from which he promised the most wonderful results; but that his Art really is merely a mode of combining ideal conceptions without any reference to real sources of knowledge, or any possibility of real advantage. In a Treatise addressed, in A.D. 1310, to King Philip of France, entitled *Liber Lamentationis Duodecim Principiorum Philosophiæ contra Averroistas*, Lully introduced Philosophy, accompanied by her twelve Principles, (Matter, Form, Generation, &c.) uttering loud complaints against the prevailing system of doctrine; and represents her as presenting to the king a petition that she may be upheld and restored by her favourite, the Author. His *Tabula Generalis ad omnes Scientias applicabilis* was begun the 15th September, 1292, in the Harbour of Tunis, and finished in

1293, at Naples. In order to frame an Art of thus tabulating all existing sciences, and indeed all possible knowledge, he divides into various classes the conceptions with which he has to deal. The first class contains nine *Absolute Conceptions*: Goodness, Greatness, Duration, Power, Wisdom, Will, Virtue, Truth, Majesty. The second class has nine *Relative Conceptions*: Difference, Identity, Contrariety, Beginning, Middle, End, Majority, Equality, Minority. The third class contains nine *Questions*: Whether? What? Whence? Why? How great? How circumstanced? When? Where? and How? The fourth class contains the nine *Most General Subjects*: God, Angel, Heaven, Man, *Imaginativum*, *Sensitivum*, *Vegetativum*, *Elementativum*, *Instrumentativum*. Then come nine *Prædicaments*, nine *Moral Qualities*, and so on. These conceptions are arranged in the compartments of certain concentric moveable circles, and give various combinations by means of triangles and other figures, and thus propositions are constructed.

It must be clear at once, that real knowledge, which is the union of facts and ideas, can never result from this machinery for shifting about, joining and disjoining, empty conceptions. This, and all similar schemes, go upon the supposition that the logical combinations of notions do of themselves compose knowledge; and that really existing things may be arrived at by a successive system of derivation from our most general ideas. It is imagined that by distributing the nomenclature of abstract ideas according to the place which they can hold in our propositions,

and by combining them according to certain conditions, we may obtain formulæ including all possible truths, and thus fabricate a science in which all sciences are contained. We thus obtain the means of talking and writing upon all subjects, without the trouble of thinking: the revolutions of the emblematical figures are substituted for the operations of the mind. Both exertion of thought, and knowledge of facts, become superfluous. And this reflection, adds an intelligent author[58], explains the enormous number of books which Lully is said to have written; for he might have written those even during his sleep, by the aid of a moving power which should keep his machine in motion. Having once devised this invention for manufacturing science, Lully varied it in a thousand ways, and followed it into a variety of developments. Besides Synoptical Tables, he employs Genealogical Trees, each of which he dignifies with the name of the Tree of Science. The only requisite for the application of his System was a certain agreement in the numbers of the classes into which different subjects were distributed; and as this symmetry does not really exist in the operations of our thoughts, some violence was done to the natural distinction and subordination of conceptions, in order to fit them for the use of the system.

Thus Lully, while he professed to teach an Art which was to shed new light upon every part of science, was in fact employed in a pedantic and trifling repetition of known truths or truisms; and while he complained of the errors of existing methods,

[58] Degerando, iv. 535.

he proposed in their place one which was far more empty, barren, and worthless, than the customary processes of human thought. Yet his method is spoken of[59] with some praise by Leibnitz, who indeed rather delighted in the region of ideas and words, than in the world of realities. But Francis Bacon speaks far otherwise and more justly on this subject[60]. "It is not to be omitted that some men, swollen with emptiness rather than knowledge, have laboured to produce a certain Method, not deserving the name of a legitimate Method, since it is rather a method of imposture: which yet is doubtless highly grateful to certain would-be philosophers. This method scatters about certain little drops of science in such a manner that a smatterer may make a perverse and ostentatious use of them with a certain show of learning. Such was the art of Lully, which consisted of nothing but a mass and heap of the words of each science; with the intention that he who can readily produce the words of any science shall be supposed to know the science itself. Such collections are like a rag shop, where you find a patch of everything, but nothing which is of any value."

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[59] Leibnitz's expressions are, (*Op.* t. vi. p. 16): "Quand j'étais jeune, je prenois quelque a l'*Art* de Lulle, mais je crus y entrevoir bien des défectuosités, dont j'ai dit quelque chose dans un petit Essai d'écolier intitulé *De Arte Combinatoria*, publié en 1666, et qui a été réimprimé après malgré moi. Mais comme je ne méprise rien facilement, excepté les arts divinatoires que ne sont que des tromperies toutes pures, j'ai trouvé quelque chose d'estimable encore dans l'*Art* de Lulle."

[60] *Works*, vii. 296.

CHAPTER XI.
The Innovators of the Middle Ages—continued

Roger Bacon

We now come to a philosopher of a very different character, who was impelled to declare his dissent from the reigning philosophy by the abundance of his knowledge, and by his clear apprehension of the mode in which real knowledge had been acquired and must be increased.

Roger Bacon was born in 1214, near Ilchester, in Somersetshire, of an old family. In his youth he was a student at Oxford, and made extraordinary progress in all branches of learning. He then went to the University of Paris, as was at that time the custom of learned Englishmen, and there received the degree of Doctor of Theology. At the persuasion of Robert Grostête, bishop of Lincoln, he entered the brotherhood of Franciscans in Oxford, and gave himself up to study with extraordinary fervour. He was termed by his brother monks *Doctor Mirabilis*. We know from his own works, as well as from the traditions concerning him, that he possessed an intimate

acquaintance with all the science of his time which could be acquired from books; and that he had made many remarkable advances by means of his own experimental labours. He was acquainted with Arabic, as well as with the other languages common in his time. In the title of his works, we find the whole range of science and philosophy, Mathematics and Mechanics, Optics, Astronomy, Geography, Chronology, Chemistry, Magic, Music, Medicine, Grammar, Logic, Metaphysics, Ethics, and Theology; and judging from those which are published, these works are full of sound and exact knowledge. He is, with good reason, supposed to have discovered, or to have had some knowledge of, several of the most remarkable inventions which were made generally known soon afterwards; as gunpowder, lenses, burning specula, telescopes, clocks, the correction of the calendar, and the explanation of the rainbow.

Thus possessing, in the acquirements and habits of his own mind, abundant examples of the nature of knowledge and of the process of invention, Roger Bacon felt also a deep interest in the growth and progress of science, a spirit of inquiry respecting the causes which produced or prevented its advance, and a fervent hope and trust in its future destinies; and these feelings impelled him to speculate worthily and wisely respecting a Reform of the Method of Philosophizing. The manuscripts of his works have existed for nearly six hundred years in many of the libraries of Europe, and especially in those of England; and for a long period the very imperfect portions of them which were generally known,

left the character and attainments of the author shrouded in a kind of mysterious obscurity. About a century ago, however, his *Opus Majus* was published[61] by Dr. S. Jebb, principally from a manuscript in the Library of Trinity College, Dublin; and this contained most or all of the separate works which were previously known to the public, along with others still more peculiar and characteristic. We are thus able to judge of Roger Bacon's knowledge and of his views, and they are in every way well worthy our attention.

The *Opus Majus* is addressed to Pope Clement the Fourth, whom Bacon had known when he was legate in England as Cardinal-bishop of Sabina, and who admired the talents of the monk, and pitied him for the persecutions to which he was exposed. On his elevation to the papal chair, this account of Bacon's labours and views was sent, at the earnest request of the pontiff. Besides the *Opus Majus*, he wrote two others, the *Opus Minus* and *Opus Tertium*; which were also sent to the pope, as the author says[62], "on account of the danger of roads, and the possible loss of the work." These works still exist unpublished, in the Cottonian and other libraries. The *Opus Majus* is a work equally wonderful with regard to its general scheme, and to the special treatises with which the outlines of the plan are filled

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[61] *Fratris Rogeri Bacon, Ordinis Minorum*, Opus Majus, *ad Clementem Quartum, Pontificem Romanum, ex MS. Codice Dubliniensi cum aliis quibusdam collato, nunc primum edidit* S. Jebb, M.D. Londini, 1733.

[62] *Opus Majus*, Præf.

up. The professed object of the work is to urge the necessity of a reform in the mode of philosophizing, to set forth the reasons why knowledge had not made a greater progress, to draw back attention to the sources of knowledge which had been unwisely neglected, to discover other sources which were yet almost untouched, and to animate men in the undertaking, by a prospect of the vast advantages which it offered. In the development of this plan, all the leading portions of science are expounded in the most complete shape which they had at that time assumed; and improvements of a very wide and striking kind are proposed in some of the principal of these departments. Even if the work had had no leading purpose, it would have been highly valuable as a treasure of the most solid knowledge and soundest speculations of the time; even if it had contained no such details, it would have been a work most remarkable for its general views and scope. It may be considered as, at the same time, the *Encyclopedia* and the *Novum Organon* of the thirteenth century.

Since this work is thus so important in the history of Inductive Philosophy I shall give, in a note, a view[63] of its divisions and

[63] Contents of Roger Bacon's *Opus Majus*.Part I. On the four causes of human ignorance:—Authority, Custom, Popular Opinion, and the Pride of supposed Knowledge.Part II. On the source of perfect wisdom in the Sacred Scripture.Part III. On the Usefulness of Grammar.Part IV. On the Usefulness of Mathematics. (1) The necessity of Mathematics in Human Things (published separately as the *Specula Mathematica*).(2) The necessity of Mathematics in Divine Things.—1°. This study has occupied holy men: 2°. Geography: 3°. Chronology: 4°. Cycles; the Golden

contents. But I must now endeavour to point out more especially the way in which the various principles, which the reform of scientific method involved, are here brought into view.

One of the first points to be noticed for this purpose, is the resistance to authority; and at the stage of philosophical history with which we here have to do, this means resistance to the authority of Aristotle, as adopted and interpreted by the Doctors of the Schools. Bacon's work[64] is divided into Six Parts; and of these Parts, the First is, Of the four universal Causes of all Human Ignorance. The causes thus enumerated[65] are:—the force of unworthy authority;—traditionary habit;—the imperfection of the undisciplined senses;—and the disposition to conceal our ignorance and to make an ostentatious show of our knowledge. These influences involve every man, occupy every condition. They prevent our obtaining the most useful and large and fair doctrines of wisdom, the secret of all sciences and arts. He then proceeds to argue, from the testimony of philosophers

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Number, &c.: 5°. Natural Phenomena, as the Rainbow: 6°. Arithmetic: 7°. Music. (3) The necessity of Mathematics in Ecclesiastical Things. 1°. The Certification of Faith: 2°. The Correction of the Calendar.(4) The necessity of Mathematics in the State.—1°. Of Climates: 2°. Hydrography: 3°. Geography: 4°. Astrology.Part V. On Perspective (published separately as *Perspectiva*).(1) The organs of vision.(2) Vision in straight lines.(3) Vision reflected and refracted.(4) De multiplicatione specierum (on the propagation of the impressions of light, heat, &c.)Part VI. On Experimental Science.

[64] *Op. Maj.* p. 1.

[65] *Ibid.* p. 2.

themselves, that the authority of antiquity, and especially of Aristotle, is not infallible. "We find[66] their books full of doubts, obscurities, and perplexities. They scarce agree with each other in one empty question or one worthless sophism, or one operation of science, as one man agrees with another in the practical operations of medicine, surgery, and the like arts of Secular men. Indeed," he adds, "not only the philosophers, but the saints have fallen into errors which they have afterwards retracted," and this he instances in Augustin, Jerome, and others. He gives an admirable sketch[67] of the progress of philosophy from the

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[66] *Ibid.* p. 10.

[67] I will give a specimen. *Opus Majus*, c. viii. p. 35: "These two kinds of philosophers, the Ionic and Italic, ramified through many sects and various successors, till they came to the doctrine of Aristotle, who corrected and changed the propositions of all his predecessors, and attempted to perfect philosophy. In the [Italic] succession, Pythagoras, Archytas Tarentinus and Timæus are most prominently mentioned. But the principal philosophers, as Socrates, Plato, and Aristotle, did not descend from this line, but were Ionics and true Greeks, of whom the first was Thales Milesius.... Socrates, according to Augustine in his 8th book, is related to have been a disciple of Archelaus. This Socrates is called the father of the great philosophers, since he was the master of Plato and Aristotle, from whom all the sects of philosophers descended.... Plato, first learning what Socrates and Greece could teach, made a laborious voyage to Egypt, to Archytas of Tarentum and Timæus, as says Jerome to Paulinus. And this Plato is, according to holy men, preferred to all philosophers, because he has written many excellent things concerning God, and morality, and a future life, which agree with the divine wisdom of God. And Aristotle was born before the death of Socrates, since he was his hearer for three years, as we read in the life of Aristotle.... This Aristotle, being made the master of Alexander the Great, sent two thousand men into all regions of the earth, to search out the nature of things, as Pliny relates in the 8th book of his *Naturalia*, and composed a thousand books, as we read in his life."

Ionic School to Aristotle; of whom he speaks with great applause. "Yet," he adds[68], "those who came after him corrected him in some things, and added many things to his works, and shall go on adding to the end of the world." Aristotle, he adds, is now called peculiarly[69] the Philosopher, "yet there was a time when his philosophy was silent and unregarded, either on account of the rarity of copies of his works, or their difficulty, or from envy; till after the time of Mahomet, when Avicenna and Averroes, and others, recalled this philosophy into the full light of exposition. And although the Logic and some other works were translated by Boethius from the Greek, yet the philosophy of Aristotle first received a quick increase among the Latins at the time of Michael Scot; who, in the year of our Lord 1230, appeared, bringing with him portions of the books of Aristotle on Natural Philosophy and Mathematics. And yet a small part only of the works of this author is translated, and a still smaller part is in the hands of common students." He adds further[70] (in the Third Part of the *Opus Majus*, which is a Dissertation on language), that the translations which are current of these writings, are very bad and imperfect. With these views, he is moved to express himself somewhat impatiently[71] respecting these works: "If I had," he

[68] *Ibid.* p. 36.

[69] *Autonomaticè.*

[70] *Op. Maj.* p. 46.

[71] See *Pref.* to Jebb's edition. The passages, there quoted, however, are not extracts from the *Opus Majus*, but (apparently) from the *Opus Minus* (*MS. Cott.* Tib. c. 5.) "Si haberem potestatem supra libros Aristotelis, ego facerem omnes cremari; quia non

says, "power over the works of Aristotle, I would have them all burnt; for it is only a loss of time to study in them, and a cause of error, and a multiplication of ignorance beyond expression." "The common herd of students," he says, "with their heads, have no principle by which they can be excited to any worthy employment; and hence they mope and make asses of themselves over their bad translations, and lose their time, and trouble, and money."

The remedies which he recommends for these evils, are, in the first place, the study of that only perfect wisdom which is to be found in the sacred Scripture[72], in the next place, the study of mathematics and the use of experiment[73]. By the aid of these methods, Bacon anticipates the most splendid progress for human knowledge. He takes up the strain of hope and confidence which we have noticed as so peculiar in the Roman writers; and quotes some of the passages of Seneca which we adduced in illustration of this:—that the attempts in science were at first rude and imperfect, and were afterwards improved;—that the day will come, when what is still unknown shall be brought to light by the progress of time and the labours of a longer period;—that one age does not suffice for inquiries so wide and various;—

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est nisi temporis amissio studere in illis, et causa erroris, et multiplicatio ignorantiæ ultra id quod valeat explicari.... Vulgus studentum cum capitibus suis non habet unde excitetur ad aliquid dignum, et ideo languet et *asininat* circa male translata, et tempus et studium amittit in omnibus et expensas."

[72] Part ii.

[73] Parts iv. v. and vi.

that the people of future times shall know many things unknown to us;—and that the time shall arrive when posterity will wonder that we overlooked what was so obvious. Bacon himself adds anticipations more peculiarly in the spirit of his own time. "We have seen," he says, at the end of the work, "how Aristotle, by the ways which wisdom teaches, could give to Alexander the empire of the world. And this the Church ought to take into consideration against the infidels and rebels, that there may be a sparing of Christian blood, and especially on account of the troubles that shall come to pass in the days of Antichrist; which by the grace of God, it would be easy to obviate, if prelates and princes would encourage study, and join in searching out the secrets of nature and art."

It may not be improper to observe here that this belief in the appointed progress of knowledge, is not combined with any overweening belief in the unbounded and independent power of the human intellect. On the contrary, one of the lessons which Bacon draws from the state and prospects of knowledge, is the duty of faith and humility. "To him," he says[74], "who denies the truth of the faith because he is unable to understand it, I will propose in reply the course of nature, and as we have seen it in examples." And after giving some instances, he adds, "These, and the like, ought to move men and to excite them to the reception of divine truths. For if, in the vilest objects of creation, truths are found, before which the inward pride of man must bow, and

[74] *Op. Maj.* p. 476.

believe though it cannot understand, how much more should man humble his mind before the glorious truths of God!" He had before said[75]: "Man is incapable of perfect wisdom in this life; it is hard for him to ascend towards perfection, easy to glide downwards to falsehoods and vanities: let him then not boast of his wisdom, or extol his knowledge. What he knows is little and worthless, in respect of that which he believes without knowing; and still less, in respect of that which he is ignorant of. He is mad who thinks highly of his wisdom; he most mad, who exhibits it as something to be wondered at." He adds, as another reason for humility, that he has proved by trial, he could teach in one year, to a poor boy, the marrow of all that the most diligent person could acquire in forty years' laborious and expensive study.

To proceed somewhat more in detail with regard to Roger Bacon's views of a Reform in Scientific Inquiry, we may observe that by making Mathematics and Experiment the two great points of his recommendation, he directed his improvement to the two essential parts of all knowledge, Ideas and Facts, and thus took the course which the most enlightened philosophy would have suggested. He did not urge the prosecution of experiment, to the comparative neglect of the existing mathematical sciences and conception; a fault which there is some ground for ascribing to his great namesake and successor Francis Bacon: still less did he content himself with a mere protest against the authority of the schools, and a vague demand for change, which was almost all

[75] *Op. Maj.* p. 15.

that was done by those who put themselves forward as reformers in the intermediate time. Roger Bacon holds his way steadily between the two poles of human knowledge; which, as we have seen, it is far from easy to do. "There are two modes of knowing," says he[76]; "by argument, and by experiment. Argument concludes a question; but it does not make us feel certain, or acquiesce in the contemplation of truth, except the truth be also found to be so by experience." It is not easy to express more decidedly the clearly seen union of exact conceptions with certain facts, which, as we have explained, constitutes real knowledge.

One large division of the *Opus Majus* is "On the Usefulness of Mathematics," which is shown by a copious enumeration of existing branches of knowledge, as Chronology, Geography, the Calendar and (in a separate Part) Optics. There is a chapter[77], in which it is proved by reason, that all science requires mathematics. And the arguments which are used to establish this doctrine, show a most just appreciation of the office of mathematics in science. They are such as follows:—That other sciences use examples taken from mathematics as the most evident:—That mathematical knowledge is, as it were, innate in us, on which point he refers to the well-known dialogue of Plato, as quoted by Cicero:—That this science, being the

[76] *Ibid.* p. 445, see also p. 448. "Scientiæ aliæ sciunt sua principia invenire per experimenta, sed conclusiones per argumenta facta ex principiis inventis. Si vero debeant habere experientiam conclusionum suarum particularem et completam, tunc oportet quod habeant per adjutorium istius scientiæ nobilis (experimentalis)."

[77] *Op. Maj.* p. 60.

easiest, offers the best introduction to the more difficult:—That in mathematics, things as known to us are identical with things as known to nature:—That we can here entirely avoid doubt and error, and obtain certainty and truth:—That mathematics is prior to other sciences in nature, because it takes cognizance of quantity, which is apprehended by intuition, (*intuitu intellectus*). "Moreover," he adds[78], "there have been found famous men, as Robert, bishop of Lincoln, and Brother Adam Marshman (de Marisco), and many others, who by the power of mathematics have been able to explain the causes of things; as may be seen in the writings of these men, for instance, concerning the Rainbow and Comets, and the generation of heat, and climates, and the celestial bodies."

But undoubtedly the most remarkable portion of the *Opus Majus* is the Sixth and last Part, which is entitled "De Scientia experimentali." It is indeed an extraordinary circumstance to find a writer of the thirteenth century, not only recognizing experiment as one source of knowledge, but urging its claims as something far more important than men had yet been aware of, exemplifying its value by striking and just examples, and speaking of its authority with a dignity of diction which sounds like a foremurmur of the Baconian sentences uttered nearly four hundred years later. Yet this is the character of what we here find[79]. "Experimental science, the sole mistress of speculative

[78] *Ibid.* p. 64.

[79] "Veritates magnificas in terminis aliarum scientiarum in quas per nullam viam

sciences, has three great Prerogatives among other parts of knowledge: First she tests by experiment the noblest conclusions of all other sciences: Next she discovers respecting the notions which other sciences deal with, magnificent truths to which these sciences of themselves can by no means attain: her Third dignity is, that she by her own power and without respect of other sciences, investigates the secret of nature."

The examples which Bacon gives of these "Prerogatives" are very curious, exhibiting, among some error and credulity, sound and clear views. His leading example of the First Prerogative, is the Rainbow, of which the cause, as given by Aristotle, is tested by reference to experiment with a skill which is, even to us now, truly admirable. The examples of the Second Prerogative are three:—*first*, the art of making an artificial sphere which shall move with the heavens by natural influences, which Bacon trusts may be done, though astronomy herself cannot do it—"et tunc," he says, "thesaurum unius regis valeret hoc instrumentum;"—*secondly*, the art of prolonging life, which experiment may teach, though medicine has no means of securing it except by regimen[80];—*thirdly*, the art of making

possunt illæ scientiæ, hæc sola scientiarum domina speculativarum, potest dare." *Op. Maj.* p. 465.

[80] One of the ingredients of a preparation here mentioned, is the flesh of a dragon, which it appears is used as food by the Ethiopians. The mode of preparing this food cannot fail to amuse the reader. "Where there are good flying dragons, by the art which they possess, they draw them out of their dens, and have bridles and saddles in readiness, and they ride upon them, and make them bound about in the air in a violent manner, that the hardness and toughness of the flesh may be reduced, as boars are

gold finer than fine gold, which goes beyond the power of alchemy. The Third Prerogative of experimental science, arts independent of the received sciences, is exemplified in many curious examples, many of them whimsical traditions. Thus it is said that the character of a people may be altered by altering the air[81]. Alexander, it seems, applied to Aristotle to know whether he should exterminate certain nations which he had discovered, as being irreclaimably barbarous; to which the philosopher replied, "If you can alter their air, permit them to live, if not, put them to death." In this part, we find the suggestion that the fire-works made by children, of saltpetre, might lead to the invention of a formidable military weapon.

It could not be expected that Roger Bacon, at a time when experimental science hardly existed, could give any *precepts* for the discovery of truth by experiment. But nothing can be a better *example* of the method of such investigation, than his inquiry concerning the cause of the Rainbow. Neither Aristotle, nor Avicenna, nor Seneca, he says, have given us any clear knowledge of this matter, but experimental science can do so. Let the experimenter (*experimentator*) consider the cases in which he finds the same colours, as the hexagonal crystals from Ireland and India; by looking into these he will see colours like those of the rainbow. Many think that this arises from some special virtue of these stones and their hexagonal figure; let therefore

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hunted and bulls are baited before they are killed for eating." *Op. Maj.* p. 470.

[81] *Op. Maj.* p. 473.

the experimenter go on, and he will find the same in other transparent stones, in dark ones as well as in light-coloured. He will find the same effect also in other forms than the hexagon, if they be furrowed in the surface, as the Irish crystals are. Let him consider too, that he sees the same colours in the drops which are dashed from oars in the sunshine;—and in the spray thrown by a millwheel;—and in the dew-drops which lie on the grass in a meadow on a summer-morning;—and if a man takes water in his mouth and projects it on one side into a sunbeam;—and if in an oil-lamp hanging in the air, the rays fall in certain positions upon the surface of the oil;—and in many other ways, are colours produced. We have here a collection of instances, which are almost all examples of the same kind as the phenomenon under consideration; and by the help of a principle collected by induction from these facts, the colours of the rainbow were afterwards really explained.

With regard to the form and other circumstances of the bow he is still more precise. He bids us measure the height of the bow and of the sun, to show that the center of the bow is exactly opposite to the sun. He explains the circular form of the bow, —its being independent of the form of the cloud, its moving when we move, its flying when we follow,—by its consisting of the reflections from a vast number of minute drops. He does not, indeed, trace the course of the rays through the drop, or account for the precise magnitude which the bow assumes; but he approaches to the verge of this part of the explanation; and

must be considered as having given a most happy example of experimental inquiry into nature, at a time when such examples were exceedingly scanty. In this respect, he was more fortunate than Francis Bacon, as we shall hereafter see.

We know but little of the biography of Roger Bacon, but we have every reason to believe that his influence upon his age was not great. He was suspected of magic, and is said to have been put into close confinement in consequence of this charge. In his work he speaks of Astrology as a science well worth cultivating. "But," says he, "Theologians and Decretists, not being learned in such matters and seeing that evil as well as good may be done, neglect and abhor such things, and reckon them among Magic Arts." We have already seen, that at the very time when Bacon was thus raising his voice against the habit of blindly following authority, and seeking for all science in Aristotle, Thomas Aquinas was employed in fashioning Aristotle's tenets into that fixed form in which they became the great impediment to the progress of knowledge. It would seem, indeed, that something of a struggle between the progressive and stationary powers of the human mind was going on at this time. Bacon himself says[82], "Never was there so great an appearance of wisdom, nor so much exercise of study in so many Faculties, in so many regions, as for this last forty years. Doctors are dispersed everywhere, in every castle, in every burgh, and especially by the students of two Orders, (he means the Franciscans and Dominicans, who were almost

[82] Quoted by Jebb, *Pref.* to *Op. Maj.*

the only religious orders that distinguished themselves by an application to study[83],) which has not happened except for about forty years. And yet there was never so much ignorance, so much error." And in the part of his work which refers to Mathematics, he says of that study[84], that it is the door and the key of the sciences; and that the neglect of it for thirty or forty years has entirely ruined the studies of the Latins. According to these statements, some change, disastrous to the fortunes of science, must have taken place about 1230, soon after the foundation of the Dominican and Franciscan Orders[85]. Nor can we doubt that the adoption of the Aristotelian philosophy by these two Orders, in the form in which the Angelical Doctor had systematized it, was one of the events which most tended to defer, for three centuries, the reform which Roger Bacon urged as a matter of crying necessity in his own time.

[83] Mosheim, *Hist.* iii. 161.

[84] *Op. Maj.* p. 57.

[85] Mosheim, iii. 161.

CHAPTER XII.
The Revival of Platonism

1. *Causes of Delay in the Advance of Knowledge.*—In the insight possessed by learned men into the method by which truth was to be discovered, the fourteenth and fifteenth centuries went backwards, rather than forwards, from the point which had been reached in the thirteenth. Roger Bacon had urged them to have recourse to experiment; but they returned with additional and exclusive zeal to the more favourite employment of reasoning upon their own conceptions. He had called upon them to look at the world without; but their eyes forthwith turned back upon the world within. In the constant oscillation of the human mind between Ideas and Facts, after having for a moment touched the latter, it seemed to swing back more impetuously to the former. Not only was the philosophy of Aristotle firmly established for a considerable period, but when men began to question its authority, they attempted to set up in its place a philosophy still more purely ideal, that of Plato. It was not till the actual progress of experimental knowledge for some centuries had given it a vast accumulation of force, that it was able to break its way fully into the circle of speculative science. The new Platonist schoolmen had to run their course, the practical discoverers had to prove their merit by their works, the Italian innovators had to utter their

aspirations for a change, before the second Bacon could truly declare that the time for a fundamental reform was at length arrived.

It cannot but seem strange, to any one who attempts to trace the general outline of the intellectual progress of man, and who considers him as under the guidance of a Providential sway, that he should thus be permitted to wander so long in a wilderness of intellectual darkness; and even to turn back, by a perverse caprice as it might seem, when on the very border of the brighter and better land which was his destined inheritance. We do not attempt to solve this difficulty: but such a course of things naturally suggests the thought, that a progress in physical science is not the main object of man's career, in the eyes of the Power who directs the fortunes of our race. We can easily conceive that it may have been necessary to man's general welfare that he should continue to turn his eyes inwards upon his own heart and faculties, till Law and Duty, Religion and Government, Faith and Hope, had been fully incorporated with all the past acquisitions of human intellect; rather than that he should have rushed on into a train of discoveries tending to chain him to the objects and operations of the material world. The systematic Law[86] and philosophical Theology which acquired their ascendancy in men's minds at the time of which we speak, kept them engaged in a region of speculations which perhaps prepared the way for

[86] Gratian published the *Decretals* in the twelfth century; and the Canon and Civil Law became a regular study in the universities soon afterwards.

a profounder and wider civilization, for a more elevated and spiritual character, than might have been possible without such a preparation. The great Italian poet of the fourteenth century speaks with strong admiration of the founders of the system which prevailed in his time. Thomas, Albert, Gratian, Peter Lombard, occupy distinguished places in the Paradise. The first, who is the poet's instructor, says,—

> Io fui degli agni della santa greggia
> Che Domenico mena per cammino
> U' ben s'impingua se non si vaneggia.
> Questo che m'è a destra piu vicino
> Frate e maestro fummi; ed esso Alberto
> E di Cologna, ed io Tomas d'Aquino....
> Quell' altro fiammeggiar esce del riso
> De Grazian, che l'uno et l'altro foro
> Ajutò si che piace in Paradiso.

> I, then, was of the lambs that Dominic
> Leads, for his saintly flock, along the way
> Where well they thrive not swoln with vanity.
> He nearest on my right-hand brother was
> And master to me; Albert of Cologne
> Is this; and of Aquinum Thomas, I....
> That next resplendence issues from the smile
> Of Gratian, who to either forum lent
> Such help as favour wins in Paradise.

It appears probable that neither poetry, nor painting, nor the other arts which require for their perfection a lofty and spiritualized imagination, would have appeared in the noble and beautiful forms which they assumed in the fourteenth and fifteenth century, if men of genius had, at the beginning of that period, made it their main business to discover the laws of nature, and to reduce them to a rigorous scientific form. Yet who can doubt that the absence of these touching and impressive works would have left one of the best and purest parts of man's nature without its due nutriment and development? It may perhaps be a necessary condition in the progress of man, that the Arts which aim at beauty should reach their excellence before the Sciences which seek speculative truth; and if this be so, we inherit, from the middle ages, treasures which may well reconcile us to the delay which took place in their cultivation of experimental science.

However this may be, it is our business at present to trace the circumstances of this very lingering advance. We have already noticed the contest of the Nominalists and Realists, which was one form, though, with regard to scientific methods, an unprofitable one, of the antithesis of Ideas and Things. Though, therefore, this struggle continued, we need not dwell upon it. The Nominalists denied the real existence of Ideas, which doctrine was to a great extent implied in the prevailing systems; but the controversy in which they thus engaged, did not lead them to seek for knowledge in a new field and by new methods. The

arguments which Occam the Nominalist opposes to those of Duns Scotus the Realist, are marked with the stamp of the same system, and consist only in permutations and combinations of the same elementary conceptions. It was not till the impulse of external circumstances was added to the discontent, which the more stirring intellects felt towards the barren dogmatism of their age, that the activity of the human mind was again called into full play, and a new career of progression entered upon, till then undreamt of, except by a few prophetic spirits.

2. *Causes of Progress.*—These circumstances were principally the revival of Greek and Roman literature, the invention of Printing, the Protestant Reformation, and a great number of curious discoveries and inventions in the arts, which were soon succeeded by important steps in speculative physical science. Connected with the first of these events, was the rise of a party of learned men who expressed their dissatisfaction with the Aristotelian philosophy, as it was then taught, and manifested a strong preference for the views of Plato. It is by no means suitable to our plan to give a detailed account of this new Platonic school; but we may notice a few of the writers who belong to it, so far at least as to indicate its influence upon the Methods of pursuing science.

In the fourteenth century[87], the frequent intercourse of the most cultivated persons of the Eastern and Western Empire, the increased study of the Greek language in Italy, the intellectual

[87] Tenneman, ix. 4.

activity of the Italian States, the discovery of manuscripts of the classical authors, were circumstances which excited or nourished a new and zealous study of the works of Greek and Roman genius. The genuine writings of the ancients, when presented in their native life and beauty, instead of being seen only in those lifeless fragments and dull transformations which the scholastic system had exhibited, excited an intense enthusiasm. Europe, at that period, might be represented by Plato's beautiful allegory, of a man who, after being long kept in a dark cavern, in which his knowledge of the external world is gathered from the images which stream through the chinks of his prison, is at last led forth into the full blaze of day. It was inevitable that such a change should animate men's efforts and enlarge their faculties. Greek literature became more and more known, especially by the influence of learned men who came from Constantinople into Italy: these teachers, though they honoured Aristotle, reverenced Plato no less, and had never been accustomed to follow with servile submission of thought either these or any other leaders. The effect of such influences soon reveals itself in the works of that period. Dante has woven into his *Divina Commedia* some of the ideas of Platonism. Petrarch, who had formed his mind by the study of Cicero, and had thus been inspired with a profound admiration for the literature of Greece, learnt Greek from Barlaam, a monk who came as ambassador from the Emperor of the East to the Pope, in 1339. With this instructor, the poet read the works of Plato; struck by their beauty, he

contributed, by his writings and his conversation, to awake in others an admiration and love for that philosopher, which soon became strongly and extensively prevalent among the learned in Italy.

3. *Hermolaus Barbarus, &c.*—Along with the feeling there prevailed also, among those who had learnt to relish the genuine beauties of the Greek and Latin writers, a strong disgust for the barbarisms in which the scholastic philosophy was clothed. Hermolaus Barbarus[88], who was born in 1454, at Venice, and had formed his taste by the study of classical literature, translated, among other learned works, Themistius's paraphrastic expositions of the Physics of Aristotle; with the view of trying whether the Aristotelian Natural Philosophy could not be presented in good Latin, which the scholastic teachers denied. In his Preface he expresses great indignation against those philosophers who have written and disputed on philosophical subjects in barbarous Latin, and in an uncultured style, so that all refined minds are repelled from these studies by weariness and disgust. They have, he says, by this barbarism, endeavoured to secure to themselves, in their own province, a supremacy without rivals or opponents. Hence they maintain that mathematics, philosophy, jurisprudence, cannot be expounded in correct Latin;—that between these sciences and the genuine Latin language there is a great gulf, as between things that cannot be brought together: and on this ground they blame those

[88] Tenneman, ix. 25.

who combine the study of philology and eloquence with that of science. This opinion, adds Hermolaus, perverts and ruins our studies; and is highly prejudicial and unworthy in respect to the state. Hermolaus awoke in others, as for instance, in John Picus of Mirandula, the same dislike to the reigning school philosophy. As an opponent of the same kind, we may add Marius Nizolius of Bersallo, a scholar who carried his admiration of Cicero to an exaggerated extent, and who was led, by a controversy with the defenders of the scholastic philosophy, to publish (1553) a work *On the True Principles and True Method of Philosophizing*. In the title of this work, he professes to give "the true principles of almost all arts and sciences, refuting and rejecting almost all the false principles of the Logicians and Metaphysicians." But although, in the work, he attacks the scholastic philosophy, he does little or nothing to justify the large pretensions of his title; and he excited, it is said, little notice. It is therefore curious that Leibnitz should have thought it worth his while to re-edit this work, which he did in 1670, adding remarks of his own.

4. *Nicolaus Cusanus.*—Without dwelling upon this opposition to the scholastic system on the ground of taste, I shall notice somewhat further those writers who put forwards Platonic views, as fitted to complete or to replace the doctrines of Aristotle. Among these, I may place Nicolaus Cusanus, (so called from Cus, a village on the Moselle, where he was born in 1401;) who was afterwards raised to the dignity of cardinal. We might, indeed, at first be tempted to include Cusanus among those

persons who were led to reject the old philosophy by being themselves agents in the progressive movement of physical science. For he published, before Copernicus, and independently of him, the doctrine that the earth is in motion[89]. But it should be recollected that in order to see the possibility of this doctrine, and its claims to acceptance, no new reference to observation was requisite. The Heliocentric System was merely a new mode of representing to the mind facts, with which all astronomers had long been familiar. The system might very easily have been embraced and inculcated by Plato himself; as indeed it is said to have been actually taught by Pythagoras. The mere adoption of the Heliocentric view, therefore, without attempting to realize the system in detail, as Copernicus did, cannot entitle a writer of the fifteenth century to be looked upon as one of the authors of the discoveries of that period; and we must consider Cusanus as a speculative anti-Aristotelian, rather than as a practical reformer.

The title of Cusanus's book, *De Doctâ Ignorantiâ*, shows how far he was from agreeing with those who conceived that, in the works of Aristotle, they had a full and complete system of all human knowledge. At the outset of this book[90], he says, after pointing out some difficulties in the received philosophy, "If, therefore, the case be so, (as even the very profound Aristotle, in his *First Philosophy*, affirms,) that in things most manifest by

[89] "Jam nobis manifestum est terram istam in veritate moveri," &c.—*De Doctâ Ignorantiâ*, lib. ii. c. xii.

[90] *De Doct. Ignor.* lib. i. c. i.

nature, there is a difficulty, no less than for an owl to look at the sun; since the appetite of knowledge is not implanted in us in vain, we ought to desire to know that we are ignorant. If we can fully attain to this, we shall arrive at *Instructed Ignorance*." How far he was from placing the source of knowledge in experience, as opposed to ideas, we may see in the following passage[91] from another work of his, *On Conjectures*. "Conjectures must proceed from our mind, as the real world proceeds from the infinite Divine Reason. For since the human mind, the lofty likeness of God, participates, as it may, in the fruitfulness of the creative nature, it doth from itself, as the image of the Omnipotent Form, bring forth reasonable thoughts which have a similitude to real existences. Thus the Human Mind exists as a conjectural form of the world, as the Divine Mind is its real form." We have here the Platonic or ideal side of knowledge put prominently and exclusively forwards.

5. *Marsilius Ficinus, &c.*—A person who had much more influence on the diffusion of Platonism was Marsilius Ficinus, a physician of Florence. In that city there prevailed, at the time of which we speak, the greatest enthusiasm for Plato. George Gemistius Pletho, when in attendance upon the Council of Florence, had imparted to many persons the doctrines of the Greek philosopher; and, among others, had infused a lively interest on this subject into the elder Cosmo, the head of the family of the Medici. Cosmo formed the plan of founding a

[91] *De Conjecturis*, lib. i. c. iii. iv.

Platonic academy. Ficinus[92], well instructed in the works of Plato, Plotinus, Proclus, and other Platonists, was selected to further this object, and was employed in translating the works of these authors into Latin. It is not to our present purpose to consider the doctrines of this school, except so far as they bear upon the nature and methods of knowledge; and therefore I must pass by, as I have in other instances done, the greater part of their speculations, which related to the nature of God, the immortality of the soul, the principles of Goodness and Beauty, and other points of the same order. The object of these and other Platonists of this school, however, was not to expel the authority of Aristotle by that of Plato. Many of them had come to the conviction that the highest ends of philosophy were to be reached only by bringing into accordance the doctrines of Plato and of Aristotle. Of this opinion was John Picus, Count of Mirandula and Concordia; and under this persuasion he employed the whole of his life in labouring upon a work, *De Concordiâ Platonis et Aristotelis*, which was not completed at the time of his death, in 1494; and has never been published. But about a century later, another writer of the same school, Francis Patricius[93], pointing out the discrepancies between the two Greek teachers, urged the propriety of deposing Aristotle from the supremacy he had so long enjoyed. "Now all these doctrines, and others not a few,"

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[92] Born in 1433.

[93] Born 1529, died 1597.

he says[94], "since they are Platonic doctrines, philosophically most true, and consonant with the Catholic faith, whilst the Aristotelian tenets are contrary to the faith, and philosophically false, who will not, both as a Christian and a Philosopher, prefer Plato to Aristotle? And why should not hereafter, in all the colleges and monasteries of Europe, the reading and study of Plato be introduced? Why should not the philosophy of Aristotle be forthwith exiled from such places? Why must men continue to drink the mortal poison of impiety from that source?" with much more in the same strain.

The Platonic school, of which we have spoken, had, however, reached its highest point of prosperity before this time, and was already declining. About 1500, the Platonists appeared to triumph over the Peripatetics[95]; but the death of their great patron, Cardinal Bessarion, about this time, and we may add, the hollowness of their system in many points, and its want of fitness for the wants and expectations of the age, turned men's thoughts partly back to the established Aristotelian doctrines, and partly forwards to schemes of bolder and fresher promise.

6. *Francis Patricius.*—Patricius, of whom we have just spoken, was one of those who had arrived at the conviction that the formation of a new philosophy, and not merely the restoration of an old one, was needed. In 1593, appeared his *Nova de Universis Philosophia*; and the mode in which

[94] *Aristoteles Exotericus*, p. 50.

[95] Tiraboschi, t. vii. pt. ii. p. 411.

it begins[96] can hardly fail to remind us of the expressions which Francis Bacon soon afterwards used in the opening of a work of the same nature. "Francis Patricius, being about to found anew the true philosophy of the universe, dared to begin by announcing the following indisputable principles." Here, however, the resemblance between Patricius and true inductive philosophers ends. His principles are barren *à priori* axioms; and his system has one main element, *Light*, (*Lux*, or *Lumen*,) to which all operations of nature are referred. In general cultivation, and practical knowledge of nature, he was distinguished among his contemporaries. In various passages of his works he relates[97] observations which he had made in the course of his travels, in Cyprus, Corfu, Spain, the mountains of the Modenese, and Dalmatia, which was his own country; his observations relate to light, the saltness of the sea, its flux and reflux, and other points of astronomy, meteorology, and natural history. He speaks of the sex of plants[98]; rejects judicial astrology; and notices the astronomical systems of Copernicus, Tycho, Fracastoro, and Torre. But the mode in which he speaks of experiments proves, what indeed is evident from the general scheme of his system,

[96] "Franciscus Patricius, novam veram integram de universis conditurus philosophiam, sequentia uti verissima prænuntiare est ausus. Prænunciata ordine persecutus, divinis oraculis, geometricis rationibus, clarissimisque experimentis comprobavit.Ante primum nihil,Post primum omnia,A principio omnia," &c.His other works are *Panaugia*, *Pancosmia*, *Dissertations Peripateticæ*.

[97] Tiraboschi, t. vii. pt. ii. p. 411.

[98] *Dissert. Perip.* t. ii. lib. v. sub fin.

that he had no due appreciation of the place which observation must hold in real and natural philosophy.

7. *Picus, Agrippa, &c.*—It had been seen in the later philosophical history of Greece, how readily the ideas of the Platonic school lead on to a system of unfathomable and unbounded mysticism. John Picus, of Mirandula[99], added to the study of Plato and the Neoplatonists, a mass of allegorical interpretations of the Scriptures, and the dreams of the Cabbala, a Jewish system[100], which pretends to explain how all things are an emanation of the Deity. To this his nephew, Francis Picus, added a reference to inward illumination[101], by which knowledge is obtained, independently of the progress of reasoning. John Reuchlin, or Capnio, born 1455; John Baptist Helmont, born 1577; Francis Mercurius Helmont, born 1618, and others, succeeded John Picus in his admiration of the Cabbala: while others, as Jacob Bœhmen, rested upon internal revelations like Francis Picus. And thus we have a series of mystical writers, continued into modern times, who may be considered as the successors of the Platonic school; and who all exhibit views altogether erroneous with regard to the nature and origin of knowledge. Among the various dreams of this school are certain wide and loose analogies of terrestrial and spiritual things. Thus in the writings of Cornelius Agrippa (who was born 1487, at

[99] Tenneman, ix. 148.

[100] Tenneman, ix. 167.

[101] *Ibid.* 158.

Cologne) we have such systems as the following[102]:—"Since there is a threefold world, elemental, celestial, and intellectual, and each lower one is governed by that above it, and receives the influence of its powers: so that the very Archetype and Supreme Author transfuses the virtues of his omnipotence into us through angels, heavens, stars, elements, animals, plants, stones,—into us, I say, for whose service he has framed and created all these things;—the Magi do not think it irrational that we should be able to ascend by the same degrees, the same worlds, to this Archetype of the world, the Author and First Cause of all, of whom all things are, and from whom they proceed; and should not only avail ourselves of those powers which exist in the nobler works of creation, but also should be able to attract other powers, and add them to these."

Agrippa's work, *De Vanitate Scientiarum*, may be said rather to have a skeptical and cynical, than a Platonic, character. It is a declamation[103], in a melancholy mood, against the condition of the sciences in his time. His indignation at the worldly success of men whom he considered inferior to himself, had, he says, metamorphosed him into a dog, as the poets relate of Hecuba of Troy, so that his impulse was to snarl and bark. His professed purpose, however, was to expose the dogmatism, the servility, the self-conceit, and the neglect of religious truth which prevailed in the reigning Schools of philosophy. His views of the nature

[102] Agrippa, *De Occult. Phil.* lib. i. c. l.

[103] Written in 1526.

of science, and the modes of improving its cultivation, are too imperfect and vague to allow us to rank him among the reformers of science.

8. *Paracelsus, Fludd, &c.*—The celebrated Paracelsus[104] put himself forwards as a reformer in philosophy, and obtained no small number of adherents. He was, in most respects, a shallow and impudent pretender; and had small knowledge of the literature or science of his time: but by the tone of his speaking and writing he manifestly belongs to the mystical school of which we are now speaking. Perhaps by the boldness with which he proposed new systems, and by connecting these with the practical doctrines of medicine, he contributed something to the introduction of a new philosophy. We have seen in the History of Chemistry that he was the author of the system of Three Principles, (salt, sulphur, and mercury,) which replaced the ancient doctrine of Four Elements, and prepared the way for a true science of chemistry. But the salt, sulphur, and mercury of Paracelsus were not, he tells his disciples, the visible bodies which we call by those names, but certain invisible, astral, or sidereal elements. The astral salt is the basis of the solidity and incombustible parts in bodies; the astral sulphur is the source of combustion and vegetation; the astral mercury is the origin of fluidity and volatility. And again, these three elements are analogous to the three elements of man,—Body, Spirit, and Soul.

[104] Philip Aurelius Theophrastus Bombastus von Hohenheim, also called Paracelsus Eremita, born at Einsiedlen in Switzerland, in 1493.

A writer of our own country, belonging to this mystical school, is Robert Fludd, or De Fluctibus, who was born in 1571, in Kent, and after pursuing his studies at Oxford, travelled for several years. Of all the Theosophists and Mystics, he is by much the most learned; and was engaged in various controversies with Mersenne, Gassendi, Kepler, and others. He thus brings us in contact with the next class of philosophers whom we have to consider, the practical reformers of philosophy;—those who furthered the cause of science by making, promulgating, or defending the great discoveries which now began to occupy men. He adopted the principle, which we have noticed elsewhere[105], of the analogy of the Macrocosm and Microcosm, the world of nature and the world of man. His system contains such a mixture and confusion of physical and metaphysical doctrines as might be expected from his ground-plan, and from his school. Indeed his object, the general object of mystical speculators, is to identify physical with spiritual truths. Yet the influence of the practical experimental philosophy which was now gaining ground in the world may be traced in him. Thus he refers to experiments on distillation to prove the existence and relation of the regions of water, air, and fire, and of the spirits which correspond to them; and is conceived, by some persons[106], to have anticipated Torricelli in the invention of the Barometer.

We need no further follow the speculations of this school. We

[105] *Hist. Sc. Id.* b. ix. c. 2. sect. 1. The Mystical School of Biology.

[106] Tenneman, ix. 221.

see already abundant reason why the reform of the methods of pursuing science could not proceed from the Platonists. Instead of seeking knowledge by experiment, they immersed themselves deeper than even the Aristotelians had done in traditionary lore, or turned their eyes inwards in search of an internal illumination. Some attempts were made to remedy the defects of philosophy by a recourse to the doctrines of other sects of antiquity, when men began to feel more distinctly the need of a more connected and solid knowledge of nature than the established system gave them. Among these attempts were those of Berigard[107], Magernus, and especially Gassendi, to bring into repute the philosophy of the Ionian school, of Democritus and of Epicurus. But these endeavours were posterior in time to the new impulse given to knowledge by Copernicus, Kepler, and Galileo, and were influenced by views arising out of the success of these discoveries, and they must, therefore, be considered hereafter. In the mean time, some independent efforts (arising from speculative rather than practical reformers) were made to cast off the yoke of the Aristotelian dogmatism, and to apprehend the true form of that new philosophy which the most active and hopeful minds saw to be needed; and we must give some account of these attempts, before we can commit ourselves to the full stream of progressive philosophy.

[107] Tenneman, ix. 265.

CHAPTER XIII.
The Theoretical Reformers of Science

We have already seen that Patricius, about the middle of the sixteenth century, announced his purpose of founding anew the whole fabric of philosophy; but that, in executing this plan, he ran into wide and baseless hypotheses, suggested by *à priori* conceptions rather than by external observation; and that he was further misled by fanciful analogies resembling those which the Platonic mystics loved to contemplate. The same time, and the period which followed it, produced several other essays which were of the same nature, with the exception of their being free from the peculiar tendencies of the Platonic school: and these insurrections against the authority of the established dogmas, although they did not directly substitute a better positive system in the place of that which they assailed, shook the authority of the Aristotelian system, and led to its overthrow; which took place as soon as these theoretical reformers were aided by practical reformers.

1. *Bernardinus Telesius.*—Italy, always, in modern times, fertile in the beginnings of new systems, was the soil on which these innovators arose. The earliest and most conspicuous of them is Bernardinus Telesius, who was born in 1508, at Cosenza, in the kingdom of Naples. His studies, carried on with great

zeal and ability, first at Milan and then at Rome, made him well acquainted with the knowledge of his times; but his own reflections convinced him that the basis of science, as then received, was altogether erroneous; and led him to attempt a reform, with which view, in 1565, he published, at Rome, his work[108], "*Bernardinus Telesius, of Cosenza, on the Nature of Things, according to principles of his own*." In the preface of this work he gives a short account[109] of the train of reflection by which he was led to put himself in opposition to the Aristotelian philosophy. This kind of autobiography occurs not unfrequently in the writings of theoretical reformers; and shows how livelily they felt the novelty of their undertaking. After the storm and sack of Rome in 1527, Telesius retired to Padua, as a peaceful seat of the muses; and there studied philosophy and mathematics, with great zeal, under the direction of Jerome Amalthæus and Frederic Delphinus. In these studies he made great progress; and the knowledge which he thus acquired threw a new light upon his view of the Aristotelian philosophy. He undertook a closer examination of the Physical Doctrines of Aristotle; and as the result of this, he was astonished how it could have been possible that so many excellent men, so many nations, and even almost the whole human race, should, for so long a time, have

[108] Bernardini Telesii Consentini *De Rerum Natura juxta propria Principia*.

[109] I take this account from Tenneman: this Proem was omitted in subsequent editions of Telesius, and is not in the one which I have consulted. Tenneman, *Gesch. d. Phil.* ix. 280.

allowed themselves to be carried away by a blind reverence for a teacher, who had committed errors so numerous and grave as he perceived to exist in "the philosopher." Along with this view of the insufficiency of the Aristotelian philosophy, arose, at an early period, the thought of erecting a better system in its place. With this purpose he left Padua, when he had received the degree of Doctor, and went to Rome, where he was encouraged in his design by the approval and friendly exhortations of distinguished men of letters, amongst whom were Ubaldino Bandinelli and Giovanni della Casa. From Rome he went to his native place, when the incidents and occupations of a married life for a while interrupted his philosophical project. But after his wife was dead, and his eldest son grown to manhood, he resumed with ardour the scheme of his youth; again studied the works of Aristotle and other philosophers, and composed and published the first two books of his treatise. The opening to this work sufficiently exhibits the spirit in which it was conceived. Its object is stated in the title to be to show, that "the construction of the world, the magnitude and nature of the bodies contained in it, are not to be investigated by reasoning, which was done by the ancients, but are to be apprehended by the senses, and collected from the things themselves." And the Proem is in the same strain. "They who before us have inquired concerning the construction of this world and of the things which it contains, seem indeed to have prosecuted their examination with protracted vigils and great labour, but *never to have looked at it.*" And thus, he

observes, they found nothing but error. This he ascribes to their presumption. "For, as it were, attempting to rival God in wisdom, and venturing to seek for the principles and causes of the world by the light of their own reason, and thinking they had found what they had only invented, they made an arbitrary world of their own." "*We* then," he adds, "not relying on ourselves, and of a duller intellect than they, propose to ourselves to turn our regards to the world itself and its parts."

The execution of the work, however, by no means corresponds to the announcement. The doctrines of Aristotle are indeed attacked; and the objections to these, and to other received opinions, form a large part of the work. But these objections are supported by *à priori* reasoning, and not by experiments. And thus, rejecting the Aristotelian physics, he proposes a system at least equally baseless; although, no doubt, grateful to the author from its sweeping and apparently simple character. He assumes three principles, Heat, Cold, and Matter: Heat is the principle of motion, Cold of immobility, and Matter is the corporeal substratum, in which these incorporeal and active principles produce their effects. It is easy to imagine that, by combining and separating these abstractions in various ways, a sort of account of many natural phenomena may be given; but it is impossible to ascribe any real value to such a system. The merit of Telesius must be considered to consist in his rejection of the Aristotelian errors, in his perception of the necessity of a reform in the method of philosophizing, and in his persuasion that this reform

must be founded on experiments rather than on reasoning. When he said[110], "We propose to ourselves to turn our eyes to the world itself, and its parts, their passions, actions, operations, and species," his view of the course to be followed was right; but his purpose remained but ill fulfilled, by the arbitrary edifice of abstract conceptions which his system exhibits.

Francis Bacon, who, about half a century later, treated the subject of a reform of philosophy in a far more penetrating and masterly manner, has given us his judgment of Telesius. In his view, he takes Telesius as the restorer of the Atomic philosophy, which Democritus and Parmenides taught among the ancients; and according to his custom, he presents an image of this philosophy in an adaptation of a portion of ancient mythology[111]. The Celestial Cupid, who with Cœlus, was the parent of the Gods and of the Universe, is exhibited as a representation of matter and its properties, according to the Democritean philosophy. "Concerning Telesius," says Bacon, "we think well, and acknowledge him as a lover of truth, a useful contributor to science, an amender of some tenets, the first of recent men. But we have to do with him as the restorer of the philosophy of Parmenides, to whom much reverence is due." With regard to this philosophy, he pronounces a judgment which very truly

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[110] Proem.

[111] "De Principiis atque Originibus secundum fabulas Cupidinis et Cœli: sive Parmenidis et Telesii et præcipuè Democriti Philosophia tractata in Fabula de Cupidine."

expresses the cause of its rashness and emptiness. "It is," he says, "such a system[112] as naturally proceeds from the intellect, abandoned to its own impulse, and not rising from experience to theory continuously and successively." Accordingly, he says that, "Telesius, although learned in the Peripatetic philosophy (if that were anything), which indeed, he has turned against the teachers of it, is hindered by his affirmations, and is more successful in destroying than in building."

The work of Telesius excited no small notice, and was placed in the *Index Expurgatorius*. It made many disciples, a consequence probably due to its spirit of system-making, no less than to its promise of reform, or its acuteness of argument; for till trial and reflection have taught man modesty and moderation, he can never be content to receive knowledge in the small successive instalments in which nature gives it forth to him. It is the makers of large systems, arranged with an *appearance* of completeness and symmetry, who, principally, give rise to Schools of philosophy.

2. (*Thomas Campanella*).—Accordingly, Telesius may be looked upon as the founder of a School. His most distinguished successor was Thomas Campanella, who was born in 1568, at Stilo, in Calabria. He showed great talents at an early age, prosecuting his studies at Cosenza, the birth-place of the great opponent of Aristotle and reformer of philosophy. He, too, has

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[112] "Talia sunt qualia possunt esse ea quæ ab intellectu sibi permisso, nec ab experimentis continenter et gradatim sublevato, profecta videntur."

given us an account[113] of the course of thought by which he was led to become an innovator. "Being afraid that not genuine truth, but falsehood in the place of truth, was the tenant of the Peripatetic School, I examined all the Greek, Latin, and Arabic commentators of Aristotle, and hesitated more and more, as I sought to learn whether what they have said were also to be read in the world itself, which I had been taught by learned men was the living book of God. And as my doctors could not satisfy my scruples, I resolved to read all the books of Plato, Pliny, Galen, the Stoics, and the Democriteans, and especially those of Telesius; and to compare them with that *first and original writing, the world*; that thus from the primary autograph, I might learn if the copies contained anything false." Campanella probably refers here to an expression of Plato, who says, "the world is God's epistle to mankind." And this image, of the natural world as an original manuscript, while human systems of philosophy are but copies, and may be false ones, became a favourite thought of the reformers, and appears repeatedly in their writings from this time. "When I held my public disputation at Cosenza," Campanella proceeds, "and still more, when I conversed privately with the brethren of the monastery, I found little satisfaction in their answers; but Telesius delighted me, on account of his freedom in philosophizing, and because he rested upon the nature of things, and not upon the assertions of men."

With these views and feelings, it is not wonderful that

[113] Thom. Campanella *de Libris propriis*, as quoted in Tenneman, ix. 291.

Campanella, at the early age of twenty-two (1590,) published a work remarkable for the bold promise of its title: "*Thomas Campanella's Philosophy demonstrated to the senses, against those who have philosophized in an arbitrary and dogmatical manner, not taking nature for their guide; in which the errors of Aristotle and his followers are refuted from their own assertions and the laws of nature: and all the imaginations feigned in the place of nature by the Peripatetics are altogether rejected; with a true defence of Bernardin Telesius of Cosenza, the greatest of philosophers; confirmed by the opinions of the ancients, here elucidated and defended, especially those of the Platonists*."

This work was written in answer to a book published against Telesius by a Neapolitan professor named Marta; and it was the boast of the young author that he had only employed eleven months in the composition of his defence, while his adversary had been engaged eleven years in preparing his attack. Campanella found a favourable reception in the house of the Marchese Lavelli, and there employed himself in the composition of an additional work, entitled *On the Sense of Things and Magic*, and in other literary labours. These, however, are full of the indications of an enthusiastic temper, inclined to mystical devotion, and of opinions bearing the cast of pantheism. For instance, the title of the book last quoted sets forth as demonstrated in the course of the work, that "the world is the living and intelligent statue of God; and that all its parts, and particles of parts, are endowed some with a clearer, some with a

more obscure sense, such as suffices for the preservation of each and of the whole." Besides these opinions, which could not fail to make him obnoxious to the religious authorities, Campanella[114] engaged in schemes of political revolution, which involved him in danger and calamity. He took part in a conspiracy, of which the object was to cast off the tyranny of Spain, and to make Calabria a republic. This design was discovered; and Campanella, along with others, was thrown into prison and subjected to torture. He was kept in confinement twenty-seven years; and at last obtained his liberation by the interposition of Pope Urban VIII. He was, however, still in danger from the Neapolitan Inquisition; and escaped in disguise to Paris, where he received a pension from the king, and lived in intercourse with the most eminent men of letters. He died there in 1639.

Campanella was a contemporary of Francis Bacon, whom we must consider as belonging to an epoch to which the Calabrian school of innovators was only a prelude. I shall not therefore further follow the connexion of writers of this order. Tobias Adami, a Saxon writer, an admirer of Campanella's works, employed himself, about 1620, in adapting them to the German public, and in recommending them strongly to German philosophers. Descartes, and even Bacon, may be considered as successors of Campanella; for they too were theoretical reformers; but they enjoyed the advantage of the light which had, in the mean time, been thrown upon the philosophy of science,

[114] *Economisti Italiani*, t. i. p. xxxiii.

by the great practical advances of Kepler, Galileo, and others. To these practical reformers we must soon turn our attention: but we may first notice one or two additional circumstances belonging to our present subject.

Campanella remarks that both the Peripatetics and the Platonists conducted the learner to knowledge by a long and circuitous path, which he wished to shorten by setting out from the sense. Without speaking of the methods which he proposed, we may notice one maxim[115] of considerable value which he propounds, and to which we have already been led. "We begin to reason from sensible objects, and definition is the end and epilogue of science. It is not the beginning of our knowing, but only of our teaching."

3. (*Andrew Cæsalpinus.*)—The same maxim had already been announced by Cæsalpinus, a contemporary of Telesius; (he was born at Arezzo in 1520, and died at Rome in 1603). Cæsalpinus is a great name in science, though professedly an Aristotelian. It has been seen in the *History of Science*[116], that he formed the first great epoch of the science of botany by his systematic arrangement of plants, and that in this task he had no successor for nearly a century. He also approached near to the great discovery of the circulation of the blood[117]. He takes a view of science which includes the remark that we have

[115] Tenneman, ix. 305.

[116] *Hist. Ind. Sc.* b. xvi. c. iii. sect. 2.

[117] *Ibid.* b. xvii. c. ii. sect. 1.

just quoted from Campanella: "We reach perfect knowledge by three steps: Induction, Division, Definition. By Induction, we collect likeness and agreement from observation; by Division, we collect unlikeness and disagreement; by Definition, we learn the proper substance of each object. Induction makes universals from particulars, and offers to the mind all intelligible matter; Division discovers the difference of universals, and leads to species; Definition resolves species into their principles and elements[118]." Without asserting this to be rigorously correct, it is incomparably more true and philosophical than the opposite view, which represents definition as the beginning of our knowledge; and the establishment of such a doctrine is a material step in inductive philosophy[119].

4. (*Giordano Bruno.*)—Among the Italian innovators of this time we must notice the unfortunate Giordano Bruno, who was born at Nola about 1550 and burnt at Rome in 1600. He is, however, a reformer of a different school from Campanella; for he derives his philosophy from Ideas and not from Observation. He represents himself as the author of a new doctrine, which he terms the *Nolan Philosophy*. He was a zealous promulgator and defender of the Copernican system of the universe, as we have noticed in the *History of Science*[120]. Campanella also wrote in defence of that system.

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[118] *Quæst. Peripat.* i. 1.

[119] Tenneman, ix. 108.

[120] *Hist. Ind. Sc.* b. v. c. iii. sect. 2.

It is worthy of remark that a thought which is often quoted from Francis Bacon, occurs in Bruno's *Cena di Cenere*, published in 1584; I mean, the notion that the later times are more aged than the earlier. In the course of the dialogue, the Pedant, who is one of the interlocutors, says, "In antiquity is wisdom;" to which the Philosophical Character replies, "If you knew what you were talking about, you would see that your principle leads to the opposite result of that which you wish to infer;—I mean, that *we* are older, and have lived longer, than our predecessors." He then proceeds to apply this, by tracing the course of astronomy through the earlier astronomers up to Copernicus.

5.(*Peter Ramus.*)—I will notice one other reformer of this period, who attacked the Aristotelian system on another side, on which it was considered to be most impregnable. This was Peter Ramus,(born in Picardy in 1515,) who ventured to denounce the *Logic* of Aristotle as unphilosophical and useless. After showing an extraordinary aptitude for the acquirement of knowledge in his youth, when he proceeded to the degree of Master of Arts, he astonished his examiners by choosing for the subject of the requisite disputation the thesis[121], "that what Aristotle has said is all wrong." This position, so startling in 1535, he defended for the whole day, without being defeated. This was, however, only a formal academical exercise, which did not necessarily imply any permanent conviction of the opinion thus expressed. But his

[121] Tenneman, ix. 420. "Quæcunque ab Aristotele dicta essent commenticia esse." Freigius, *Vita Petri Rami*, p. 10.

mind was really labouring to detect and remedy the errors which he thus proclaimed. From him, as from the other reformers of this time, we have an account of this mental struggle[122]. He says, in a work on this subject, "I will candidly and simply explain how I was delivered from the darkness of Aristotle. When, according to the laws of our university, I had spent three years and a half in the Aristotelian philosophy, and was now invested with the philosophical laurel as a Master of Arts, I took an account of the time which I had consumed in this study, and considered on what subjects I should employ this logical art of Aristotle, which I had learnt with so much labour and noise, I found it made me not more versed in history or antiquities, more eloquent in discourse, more ready in verse, more wise in any subject. Alas for me! how was I overpowered, how deeply did I groan, how did I deplore my lot and my nature, how did I deem myself to be by some unhappy and dismal fate and frame of mind abhorrent from the Muses, when I found that I was one who, after all my pains, could reap no benefit from that wisdom of which I heard so much, as being contained in the Logic of Aristotle." He then relates that he was led to the study of the Dialogues of Plato, and was delighted with the kind of analysis of the subjects discussed which Socrates is there represented as executing. "Well," he adds, "I began thus to reflect within myself—(I should have thought it impious to say it to another)—What, I pray you, prevents me from *socratizing*; and from asking,

[122] Rami, *Animadv. Aristot.* i. iv.

without regard to Aristotle's authority, whether Aristotle's Logic be true and correct? It may be that that philosopher leads us wrong; and if so, no wonder that I cannot find in his books the treasure which is not there. What if his dogmas be mere figments? Do I not tease and torment myself in vain, trying to get a harvest from a barren soil?" He convinced himself that the Aristotelian logic was worthless: and constructed a new system of Logic, founded mainly on the Platonic process of exhausting a subject by analytical classification of its parts. Both works, his *Animadversions on Aristotle*, and his *Logic*, appeared in 1543. The learned world was startled and shocked to find a young man, on his first entrance into life, condemning as faulty, fallacious, and useless, that part of Aristotle's works which had always hitherto been held as a masterpiece of philosophical acuteness, and as the Organon of scientific reasoning. And in truth, it must be granted that Ramus does not appear to have understood the real nature and object of Aristotle's Logic; while his own system could not supply the place of the old one, and was not of much real value. This dissent from the established doctrines was, however, not only condemned but punished. The printing and selling of his books was forbidden through France; and Ramus was stigmatized by a sentence[123] which declared him rash, arrogant, impudent, and ignorant, and prohibited from teaching logic and philosophy. He was, however, afterwards restored to the office of professor: and though much attacked,

[123] See *Hist. Ind. Sc.* b. iv. c. iv. sect. 4.

persisted in his plan of reforming, not only Logic but Physics and Metaphysics. He made his position still more dangerous by adopting the reformed religion; and during the unhappy civil wars of France, he was deprived of his professorship, driven from Paris, and had his library plundered. He endeavoured, but in vain, to engage a German professor, Schegk, to undertake the reform of the Aristotelian Physics; a portion of knowledge in which he felt himself not to be strong. Unhappily for himself, he afterwards returned to Paris, where he perished in the massacre of St. Bartholomew in 1572.

Ramus's main objection to the Aristotelian Logic is, that it is not the image of the natural process of thought; an objection which shows little philosophical insight; for the course by which we obtain knowledge may well differ from the order in which our knowledge, when obtained, is exhibited. We have already seen that Ramus's contemporaries, Cæsalpinus and Campanella, had a wiser view; placing definition as the last step in knowing, but the first in teaching. But the effect which Ramus produced was by no means slight. He aided powerfully in turning the minds of men to question the authority of Aristotle on all points; and had many followers, especially among the Protestants. Among the rest, Milton, our great poet, published "Artis Logicæ plenior Institutio *ad Petri Rami methodum concinnata*;" but this work, appearing in 1672, belongs to a succeeding period.

6.(*The Reformers in general*).—It is impossible not to be struck with the series of misfortunes which assailed the

reformers of philosophy of the period we have had to review. Roger Bacon was repeatedly condemned and imprisoned; and, not to speak of others who suffered under the imputation of magical arts, Telesius is said[124] to have been driven from Naples to his native city by calumny and envy; Cæsalpinus was accused of atheism[125]; Campanella was imprisoned for twenty-seven years and tortured; Giordano Bruno was burnt at Rome as a heretic; Ramus was persecuted during his life, and finally murdered by his personal enemy Jacques Charpentier, in a massacre of which the plea was religion. It is true, that for the most part these misfortunes were not principally due to the attempts at philosophical reform, but were connected rather with politics or religion. But we cannot doubt that the spirit which led men to assail the received philosophy, might readily incline them to reject some tenets of the established religion; since the boundary line of these subjects is difficult to draw. And as we have seen, there was in most of the persons of whom we have spoken, not only a well-founded persuasion of the defects of existing systems, but an eager spirit of change, and a sanguine anticipation of some wide and lofty philosophy, which was soon to elevate the minds and conditions of men. The most unfortunate were, for the most part, the least temperate and judicious reformers. Patricius, who, as we have seen, declared himself against the Aristotelian philosophy, lived and died at

[124] Tenneman, ix. 230.

[125] *Ibid.* 108.

Rome in peace and honour[126].

7.(*Melancthon.*)—It is not easy to point out with precision the connexion between the efforts at a Reform in Philosophy, and the great Reformation of Religion in the sixteenth century. The disposition to assert (practically at least) a freedom of thinking, and to reject the corruptions which tradition had introduced and authority maintained, naturally extended its influence from one subject to another; and especially in subjects so nearly connected as theology and philosophy. The Protestants, however, did not reject the Aristotelian system; they only reformed it, by going back to the original works of the author, and by reducing it to a conformity with Scripture. In this reform, Melancthon was the chief author, and wrote works on Logic, Physics, Morals, and Metaphysics, which were used among Protestants. On the subject of the origin of our knowledge, his views contained a very philosophical improvement of the Aristotelian doctrines. He recognized the importance of Ideas, as well as of Experience. "We could not," he says[127], "proceed to reason at all, except there were by nature innate in man certain fixed points, that is, principles of science;—as Number, the recognition of Order and Proportion, logical, geometrical, physical and moral Principles. Physical principles are such as these,—everything which exists proceeds from a cause,—a body cannot be in two places at once,—time is a continued series of things or of motions,—and the

[126] Tenneman, ix. 246.

[127] Melancthon, *De Anima*, p. 207, quoted in Tenneman, ix. 121.

like." It is not difficult to see that such Principles partake of the nature of the Fundamental Ideas which we have attempted to arrange and enumerate in a previous part of this work.

Before we proceed to the next chapter, which treats of the Practical Reformers of Scientific Method, let us for an instant look at the strong persuasion implied in the titles of the works of this period, that the time of a philosophical revolution was at hand. Telesius published *De Rerum Natura juxta propria principia*; Francis Helmont, *Philosophia vulgaris refutata*; Patricius, *Nova de Universis Philosophia*; Campanella, *Philosophia sensibus demonstrata, adversus errores Aristotelis*; Bruno professed himself the author of a *Nolan Philosophy*; and Ramus of a *New Logic*. The age announced itself pregnant; and the eyes of all who took an interest in the intellectual fortunes of the race, were looking eagerly for the expected offspring.

CHAPTER XIV.
The Practical Reformers of Science

1. *Character of the Practical Reformers.*—We now come to a class of speculators who had perhaps a greater share in bringing about the change from stationary to progressive knowledge, than those writers who so loudly announced the revolution. The mode in which the philosophers of whom we now speak produced their impressions on men's minds, was very different from the procedure of the theoretical reformers. What these talked of, they did; what these promised, they performed. While the theorists concerning knowledge proclaimed that great advances were to be made, the practical discoverers went steadily forwards. While one class spoke of a complete Reform of scientific Methods, the other, boasting little, and often thinking little of Method, proved the novelty of their instrument by obtaining new results. While the metaphysicians were exhorting men to consult experience and the senses, the physicists were examining nature by such means with unparalleled success. And while the former, even when they did for a moment refer to facts, soon rushed back into their own region of ideas, and tried at once to seize the widest generalizations, the latter, fastening their attention upon the phenomena, and trying to reduce them to laws, were carried forwards by steps measured

and gradual, such as no conjectural view of scientific method had suggested; but leading to truths as profound and comprehensive as any which conjecture had dared to anticipate. The theoretical reformers were bold, self-confident, hasty, contemptuous of antiquity, ambitious of ruling all future speculations, as they whom they sought to depose had ruled the past. The practical reformers were cautious, modest, slow, despising no knowledge, whether borrowed from tradition or observation, confident in the ultimate triumph of science, but impressed with the conviction that each single person could contribute a little only to its progress. Yet though thus working rather than speculating,—dealing with particulars more than with generals,—employed mainly in adding to knowledge, and not in defining what knowledge is, or how additions are to be made to it,—these men, thoughtful, curious, and of comprehensive minds, were constantly led to important views on the nature and methods of science. And these views, thus suggested by reflections on their own mental activity, were gradually incorporated with the more abstract doctrines of the metaphysicians, and had a most important influence in establishing an improved philosophy of science. The indications of such views we must now endeavour to collect from the writings of the discoverers of the times preceding the seventeenth century.

Some of the earliest of these indications are to be found in those who dealt with Art rather than with Science. I have already endeavoured to show that the advance of the arts which give us

a command over the powers of nature, is generally prior to the formation of exact and speculative knowledge concerning those powers. But Art, which is thus the predecessor of Science, is, among nations of acute and active intellects, usually its parent. There operates, in such a case, a speculative spirit, leading men to seek for the reasons of that which they find themselves able to do. How slowly, and with what repeated deviations men follow this leading, when under the influence of a partial and dogmatical philosophy, the late birth and slow growth of sound physical theory shows. But at the period of which we now speak, we find men, at length, proceeding in obedience to the impulse which thus drives them from practice to theory;—from an acquaintance with phenomena to a free and intelligent inquiry concerning their causes.

2. *Leonardo da Vinci.*—I have already noted, in the History of Science, that the Indistinctness of Ideas, which was long one main impediment to the progress of science in the middle ages, was first remedied among architects and engineers. These men, so far at least as mechanical ideas were concerned, were compelled by their employments to judge rightly of the relations and properties of the materials with which they had to deal; and would have been chastised by the failure of their works, if they had violated the laws of mechanical truth. It was not wonderful, therefore, that these laws became known to *them* first. We have seen, in the *History*, that Leonardo da Vinci, the celebrated painter, who was also an engineer, is the first writer

in whom we find the true view of the laws of equilibrium of the lever in the most general case. This artist, a man of a lively and discursive mind, is led to make some remarks[128] on the formation of our knowledge, which may show the opinions on that subject that already offered themselves at the beginning of the sixteenth century[129]. He expresses himself as follows:—"Theory is the general, Experiments are the soldiers. The interpreter of the artifices of nature is Experience: she is never deceived. Our judgment sometimes is deceived, because it expects effects which Experience refuses to allow." And again, "We must consult Experience, and vary the circumstances till we have drawn from them general rules; for it is she who furnishes true rules. But of what use, you ask, are these rules; I reply, that they direct us in the researches of nature and the operations of art. They prevent our imposing upon ourselves and others by promising ourselves results which we cannot obtain.

"In the study of the sciences which depend on mathematics, those who do not consult nature but authors, are not the children of nature, they are only her grandchildren. She is the true teacher of men of genius. But see the absurdity of men! They turn up their noses at a man who prefers to learn from nature herself rather than from authors who are only her clerks."

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[128] His works have never been published, and exist in manuscript in the library of the Institute at Paris. Some extracts were published by Venturi, *Essai sur les Ouvrages de Leonard da Vinci*. Paris, 1797.

[129] Leonardo died in 1520, at the age of 78.

In another place, in reference to a particular case, he says, "Nature begins from the Reason and ends in Experience; but for all that, we must take the opposite course; begin from the Experiment and try to discover the Reason."

Leonardo was born forty-six years before Telesius; yet we have here an estimate of the value of experience far more just and substantial than the Calabrian school ever reached. The expressions contained in the above extracts, are well worthy our notice;—that experience is never deceived;—that we must vary our experiments, and draw from them general rules;—that nature is the original source of knowledge, and books only a derivative substitute;—with a lively image of the sons and grandsons of nature. Some of these assertions have been deemed, and not without reason, very similar to those made by Bacon a century later. Yet it is probable that the import of such expressions, in Leonardo's mind, was less clear and definite than that which they acquired by the progress of sound philosophy. When he says that theory is the general and experiments the soldiers, he probably meant that theory directs men what experiments to make; and had not in his mind the notion of a theoretical Idea ordering and brigading the Facts. When he says that Experience is the interpreter of Nature, we may recollect, that in a more correct use of this image, Experience and Nature are the writing, and the Intellect of man the interpreter. We may add, that the clear apprehension of the importance of Experience led, in this as in other cases, to an unjust depreciation of the value of what science

owed to books. Leonardo would have made little progress, if he had attempted to master a complex science, astronomy for instance, by means of observation alone, without the aid of books.

But in spite of such criticism, Leonardo's maxims show extraordinary sagacity and insight; and they appear to us the more remarkable, when we see how rare such views are for a century after his time.

3. *Copernicus.*—For we by no means find, even in those practical discoverers to whom, in reality, the revolution in science, and consequently in the philosophy of science, was due, this prompt and vigorous recognition of the supreme authority of observation as a ground of belief; this bold estimate of the probable worthlessness of traditional knowledge; and this plain assertion of the reality of theory founded upon experience. Among such discoverers, Copernicus must ever hold a most distinguished place. The heliocentric theory of the universe, established by him with vast labour and deep knowledge, was, for the succeeding century, the field of discipline and exertion of all the most active speculative minds. Men, during that time, proved their freedom of thought, their hopeful spirit, and their comprehensive view, by adopting, inculcating, and following out the philosophy which this theory suggested. But in the first promulgation of the theory, in the works of Copernicus himself, we find a far more cautious and reserved temper. He does not, indeed, give up the reality of his theory, but he expresses himself

so as to avoid shocking those who might (as some afterwards did) think it safe to speak of it as an *hypothesis* rather than a truth. In his preface addressed to the Pope[130], after speaking of the difficulties in the old and received doctrines, by which he was led to his own theory, he says, "Hence I began to think of the mobility of the earth; and although the opinion seemed absurd, yet because I knew that to others before me this liberty had been conceded, of imagining any kinds of circles in order to explain the phenomena of the stars, I thought it would also be readily granted me, that I might try whether, by supposing the earth to be in motion, I might not arrive at a better explanation than theirs, of the revolutions of the celestial orbs." Nor does he anywhere assert that the seeming absurdity had become a certain truth, or betray any feeling of triumph over the mistaken belief of his predecessors. And, as I have elsewhere shown, his disciples[131] indignantly and justly defended him from the charge of disrespect towards Ptolemy and other ancient astronomers. Yet Copernicus is far from compromising the value or evidence of the great truths which he introduced to general acceptance; and from sinking in his exposition of his discoveries below the temper which had led to them. His quotation from Ptolemy, that "He who is to follow philosophy must be a freeman in mind," is a grand and noble maxim, which it well became him to utter.

4. *Fabricius.*—In another of the great discoverers of this

[130] Paul III. in 1543.

[131] *Hist. Ind. Sc.* b. v. c. ii.

period, though employed on a very different subject, we discern much of the same temper. Fabricius of Acquapendente[132], the tutor and forerunner of our Harvey, and one of that illustrious series of Paduan professors who were the fathers of anatomy[133], exhibits something of the same respect for antiquity, in the midst of his original speculations. Thus in a dissertation[134] *On the Action of the Joints*, he quotes Aristotle's Mechanical Problems to prove that in all animal motion there must be some quiescent fulcrum; and finds merit even in Aristotle's ignorance. "Aristotle," he says[135], "did not know that motion was produced by the muscle; and after staggering about from one supposition to another, at last is compelled by the facts themselves to recur to an innate spirit, which, he conceives, is contrasted, and which pulls and pushes. And here we cannot help admiring the genius of Aristotle, who, though ignorant of the muscle, invents something which produces nearly the same effect as the muscle, namely, contraction and pulling." He then, with great acuteness, points out the distinction between Aristotle's opinions, thus favourably interpreted, and those of Galen. In all this, we see something of the wish to find all truths in the writings of the ancients, but nothing which materially interferes with freedom of inquiry. The anatomists have in all ages and countries been practically

[132] Born 1537, died 1619.

[133] *Hist. Ind. Sc.* b. xvii. c. ii. sect. 1.

[134] Fabricius, *De Motu Locali*, p. 182.

[135] p. 199.

employed in seeking knowledge from observation. Facts have ever been to them a subject of careful and profitable study; while the ideas which enter into the wider truths of the science, are, as we have seen, even still involved in obscurity, doubt, and contest.

5. *Maurolycus.*—Francis Maurolycus of Messana, whose mathematical works were published in 1575, was one of the great improvers of the science of optics in his time. In his Preface to his Treatise on the Spheres, he speaks of previous writers on the same subject; and observes that as they have not superseded one another, they have not rendered it unfit for any one to treat the subject afresh. "Yet," he says, "it is impossible to amend the errors of all who have preceded us. This would be a task too hard for Atlas, although he supports the heavens. Even Copernicus is tolerated, who makes the sun to be fixed, and the earth to move round it in a circle, and who is more worthy of a whip or a scourge than of a refutation." The mathematicians and astronomers of that time were not the persons most sensible of the progress of physical knowledge; for the basis of their science, and a great part of its substance, were contained in the writings of the ancients; and till the time of Kepler, Ptolemy's work was, very justly, looked upon as including all that was essential in the science.

6. *Benedetti.*—But the writers on Mechanics were naturally led to present themselves as innovators and experimenters; for all that the ancients had taught concerning the doctrine of motion was erroneous; while those who sought their knowledge from experiment, were constantly led to new truths. John

Baptist Benedetti, a Venetian nobleman, in 1599, published his *Speculationum Liber*, containing, among other matter, a treatise on Mechanics, in which several of the Aristotelian errors were refuted. In the Preface to this Treatise, he says, "Many authors have written much, and with great ability, on Mechanics; but since nature is constantly bringing to light something either new, or before unnoticed, I too wished to put forth a few things hitherto unattempted, or not sufficiently explained." In the doctrine of motion he distinctly and at some length condemns and argues against all the Aristotelian doctrines concerning motion, weight, and many other fundamental principles of physics. Benedetti is also an adherent of the Copernican doctrine. He states[136] the enormous velocity which the heavenly bodies must have, if the earth be the centre of their motions; and adds, "which difficulty does not occur according to the beautiful theory of the Samian Aristarchus, expounded in a divine manner by Nicolas Copernicus; against which the reasons alleged by Aristotle are of no weight." Benedetti throughout shows no want of the courage or ability which were needed in order to rise in opposition against the dogmas of the Peripatetics. He does not, however, refer to experiment in a very direct manner; indeed most of the facts on which the elementary truths of mechanics rest, were known and admitted by the Aristotelians; and therefore could not be adduced as novelties. On the contrary, he begins with *à priori* maxims, which experience would not

[136] *Speculationum Liber*, p. 195.

have confirmed. "Since," he says[137], "we have undertaken the task of proving that Aristotle is wrong in his opinions concerning motion, there are certain absolute truths, the objects of the intellect known of themselves, which we must lay down in the first place." And then, as an example of these truths, he states this: "Any two bodies of equal size and figure, but of different materials, will have their natural velocities in the same proportion as their weights;" where by their natural velocities, he means the velocities with which they naturally fall downwards.

7. *Gilbert.*—The greatest of these practical reformers of science is our countryman, William Gilbert; if, indeed, in virtue of the clear views of the prospects which were then opening to science, and of the methods by which her future progress was to be secured, while he exemplified those views by physical discoveries, he does not rather deserve the still higher praise of being at the same time a theoretical and a practical reformer. Gilbert's physical researches and speculations were employed principally upon subjects on which the ancients had known little or nothing; and on which therefore it could not be doubtful whether tradition or observation was the source of knowledge. Such was magnetism; for the ancients were barely acquainted with the attractive property of the magnet. Its polarity, including repulsion as well as attraction, its direction towards the north, its limited variation from this direction, its declination from the horizontal position, were all

[137] *Ibid.* p. 169.

modern discoveries. Gilbert's work[138] on the magnet and on the magnetism of the earth, appeared in 1600; and in this, he repeatedly maintains the superiority of experimental knowledge over the physical philosophy of the ancients. His preface opens thus: "Since in making discoveries and searching out the hidden causes of things, stronger reasons are obtained from trustworthy experiments and demonstrable arguments, than from probable conjectures and the dogmas of those who philosophize in the usual manner," he has, he says, "endeavoured to proceed from common magnetical experiments to the inward constitution of the earth." As I have stated in the History of Magnetism[139], Gilbert's work contains all the fundamental facts of that science, so fully stated, that we have, at this day, little to add to them. He is not, however, by the advance which he thus made, led to depreciate the ancients, but only to claim for himself the same liberty of philosophizing which they had enjoyed[140]. "To those ancient and first parents of philosophy, Aristotle, Theophrastus, Ptolemy, Hippocrates, Galen, be all due honour; from them it was that the stream of wisdom has been derived down to posterity. But our age has discovered and brought to light many things which they, if they were yet alive, would gladly embrace.

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[138] Gulielmi Gilberti, *Colcestriensis, Medici Londinensis, De Magnete, Magneticisque Corporibus, et de Magno Magnete Tellure, Physiologia Nova, plurimis et Argumentis et Experimentis demonstrata*.

[139] *Hist. Ind. Sc.* b. xii. c. i.

[140] Pref.

Wherefore we also shall not hesitate to expound, by probable hypotheses, those things which by long experience we have ascertained."

In this work the author not only adopts the Copernican doctrine of the earth's motion, but speaks[141] of the contrary supposition as utterly absurd, founding his argument mainly on the vast velocities which such a supposition requires us to ascribe to the celestial bodies. Dr. Gilbert was physician to Queen Elizabeth and to James the First, and died in 1603. Some time after his death the executors of his brother published another work of his, *De Mundo nostro Sublunari Philosophia Nova*, in which similar views are still more comprehensively presented. In this he says, "The two lords of philosophy, Aristotle and Galen, are held in worship like gods, and rule the schools;—the former by some destiny obtained a sway and influence among philosophers, like that of his pupil Alexander among the kings of the earth;—Galen, with like success, holds his triumph among the physicians of Europe." This comparison of Aristotle to Alexander was also taken hold of by Bacon. Nor is Gilbert an unworthy precursor of Bacon in the view he gives of the History of Science, which occupies the first three chapters of his Philosophy. He traces this history from "the simplicity and ignorance of the ancients," through "the fabrication of the fable of the four elements," to Aristotle and Galen. He mentions with due disapproval the host of commentators which succeeded,

[141] *De Magnete*, lib. vi. c. 3, 4.

the alchemists, the "shipwreck of science in the deluge of the Goths," and the revival of letters and genius in the time of "our grandfathers." "This later age," he says, "has exploded the Barbarians, and restored the Greeks and Latins to their pristine grace and honour. It remains, that if they have written aught in error, this should be remedied by better and more productive processes (*frugiferis* institutis), not to be contemned for their novelty; (for nothing which is true is really new, but is perfect from eternity, though to weak man it may be unknown;) and that thus Philosophy may bear her fruit." The reader of Bacon will not fail to recognize, in these references to "fruit-bearing" knowledge, a similarity of expression with the *Novum Organon*.

Bacon does not appear to me to have done justice to his contemporary. He nowhere recognizes in the labours of Gilbert a community of purpose and spirit with his own. On the other hand, he casts upon him a reflection which he by no means deserves. In the *Advancement of Learning*[142], he says, "Another error is, that men have used to infect their meditations, opinions, and doctrines, with some conceits which they have most admired, or some sciences to which they have most applied; and given all things else a tincture according to them, utterly untrue and improper.... So have the alchemists made a philosophy out of a few experiments of the furnace; and Gilbertus, our countryman, hath made a philosophy out of the observations of a loadstone," (in the Latin, philosophiam etiam e magnete

[142] *Nov. Org.* b. i.

elicuit). And in the same manner he mentions him in the *Novum Organon*[143], as affording an example of an empirical kind of philosophy, which appears to those daily conversant with the experiments, probable, but to other persons incredible and empty. But instead of blaming Gilbert for disturbing and narrowing science by a too constant reference to magnetical rules, we might rather censure Bacon, for not seeing how important in all natural philosophy are those laws of attraction and repulsion of which magnetical phenomena are the most obvious illustration. We may find ground for such a judgment in another passage in which Bacon speaks of Gilbert. In the Second Book[144] of the *Novum Organon*, having classified motions, he gives, as one kind, what he calls, in his figurative language, *motion for gain*, or *motion of need*, by which a body shuns heterogeneous, and seeks cognate bodies. And he adds, "The Electrical operation, concerning which Gilbert and others since him have made up such a wonderful story, is nothing less than the appetite of a body, which, excited by friction, does not well tolerate the air, and prefers another tangible body if it be found near." Bacon's notion of an appetite in the body is certainly much less philosophical than Gilbert's, who speaks of light bodies as drawn towards amber by certain material radii[145]; and we might perhaps venture to say that Bacon here manifests a want of clear

[143] B. i. Aph. 64.

[144] Vol. ix. 185.

[145] *De Magnete*, p. 60.

mechanical ideas. Bacon, too, showed his inferior aptitude for physical research in rejecting the Copernican doctrine which Gilbert adopted. In the *Advancement of Learning*[146], suggesting a history of the opinions of philosophers, he says that he would have inserted in it even recent theories, as those of Paracelsus; of Telesius, who restored the philosophy of Parmenides; or Patricius, who resublimed the fumes of Platonism; or Gilbert, who brought back the dogmas of Philolaus. But Bacon quotes[147] with pleasure Gilbert's ridicule of the Peripatetics' definition of heat. They had said, that heat is that which separates heterogeneous and unites homogeneous matter; which, said Gilbert, is as if any one were to define *man* as that which sows wheat and plants vines.

Galileo, another of Gilbert's distinguished contemporaries, had a higher opinion of him. He says[148], "I extremely admire and envy this author. I think him worthy of the greatest praise for the many new and true observations which he has made, to the disgrace of so many vain and fabling authors; who write, not from their own knowledge only, but repeat everything they hear from the foolish and vulgar, without attempting to satisfy themselves of the same by experience; perhaps that they may not diminish the size of their books."

8. *Galileo.*—Galileo was content with the active and

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[146] B. iii. c. 4.

[147] *Nov. Org.* b. ii. Aph. 48.

[148] Drinkwater's *Life of Galileo*, p. 18.

successful practice of experimental inquiry; and did not demand that such researches should be made expressly subservient to that wider and more ambitious philosophy, on which the author of the *Novum Organon* employed his powers. But still it now becomes our business to trace those portions of Galileo's views which have reference to the theory, as well as the practice, of scientific investigation. On this subject, Galileo did not think more profoundly, perhaps, than several of his contemporaries; but in the liveliness of expression and illustration with which he recommended his opinions on such topics, he was unrivalled. Writing in the language of the people, in the attractive form of dialogue, with clearness, grace, and wit, he did far more than any of his predecessors had done to render the new methods, results, and prospects of science familiar to a wide circle of readers, first in Italy, and soon, all over Europe. The principal points inculcated by him were already becoming familiar to men of active and inquiring minds; such as,—that knowledge was to be sought from observation, and not from books;—that it was absurd to adhere to, and debate about, the physical tenets of Aristotle and the rest of the ancients. On persons who followed this latter course, Galileo fixed the epithet of Paper Philosophers[149]; because, as he wrote in a letter to Kepler, this sort of men fancied that philosophy was to be studied like the *Æneid* or *Odyssey*, and that the true reading of nature was to be detected by the collation of texts. Nothing so much

[149] *Life of Galileo*, p. 9.

shook the authority of the received system of Physics as the experimental discoveries, directly contradicting it, which Galileo made. By experiment, as I have elsewhere stated[150], he disproved the Aristotelian doctrine that bodies fall quickly or slowly in proportion to their weight. And when he had invented the telescope, a number of new discoveries of the most striking kind (the inequalities of the moon's surface, the spots in the sun, the moon-like phases of Venus, the satellites of Jupiter, the ring of Saturn,) showed, by the evidence of the eyes, how inadequate were the conceptions, and how erroneous the doctrines of the ancients, respecting the constitution of the universe. How severe the blow was to the disciples of the ancient schools, we may judge by the extraordinary forms of defence in which they tried to intrench themselves. They would not look through Galileo's glasses; they maintained that what was seen was an illusion of witchcraft; and they tried, as Galileo says[151], with logical arguments, as if with magical incantations, to charm the new planets out of the sky. No one could be better fitted than Galileo for such a warfare. His great knowledge, clear intellect, gaiety, and light irony, (with the advantage of being in the right,) enabled him to play with his adversaries as he pleased. Thus when an Aristotelian[152] rejected the discovery of the irregularities in the moon's surface, because, according to the ancient doctrine, her

[150] *Hist. Ind. Sc.* b. vi. c. ii. sect. 5.

[151] *Life of Galileo*, p. 29.

[152] *Ibid.* p. 33.

form was a perfect sphere, and held that the apparent cavities were filled with an invisible crystal substance, Galileo replied, that he had no objection to assent to this, but that then he should require his adversary in return to believe that there were on the same surface invisible crystal mountains ten times as high as those visible ones which he had actually observed and measured.

We find in Galileo many thoughts which have since become established maxims of modern philosophy. "Philosophy," he says[153], "is written in that great book, I mean the Universe, which is constantly open before our eyes; but it cannot be understood, unless we first know the language and learn the characters in which it is written." With this thought he combines some other lively images. One of his interlocutors says concerning another, "Sarsi perhaps thinks that philosophy is a book made up of the fancies of men, like the *Iliad* or *Orlando Furioso*, in which the matter of least importance is, that what is written be true." And again, with regard to the system of authority, he says, "I think I discover in him a firm belief that, in philosophizing, it is necessary to lean upon the opinion of some celebrated author; as if our mind must necessarily remain unfruitful and barren till it be married to another man's reason."—"No," he says, "the case is not so.—When we have the decrees of Nature, authority goes for nothing; reason is absolute[154]."

In the course of Galileo's controversies, questions of the logic

[153] *Il Saggiatore*, ii. 247.

[154] *Il Saggiatore*, ii. 200.

of science came under discussion. Vincenzio di Grazia objected to a proof from induction which Galileo adduced, because *all* the particulars were not enumerated; to which the latter justly replies[155], that if induction were required to pass through all the cases, it would be either useless or impossible;—impossible when the cases are innumerable; useless when they have each already been verified, since then the general proposition adds nothing to our knowledge.

One of the most novel of the characters which Science assumes in Galileo's hands is, that she becomes cautious. She not only proceeds leaning upon Experience, but she is content to proceed a little way at a time. She already begins to perceive that she must rise to the heights of knowledge by many small and separate steps. The philosopher is desirous to know much, but resigned to be ignorant for a time of that which cannot yet be known. Thus when Galileo discovered the true law of the motion of a falling body[156], that the velocity increases proportionally to the time from the beginning of the fall, he did not insist upon immediately assigning the cause of this law. "The cause of the acceleration of the motions of falling bodies is not," he says, "a necessary part of the investigation." Yet the conception of this acceleration, as the result of the continued action of the force of gravity upon the falling body, could hardly fail to suggest itself to one who had formed the idea of force. In like manner, the

[155] *Ibid.* i. 501.

[156] *Hist. Ind. Sc.* b. vi. c. ii. sect. 2.

truth that the velocities, acquired by bodies falling down planes of equal heights, are all equal, was known to Galileo and his disciples, long before he accounted for it[157], by the principle, apparently so obvious, that the momentum generated is as the moving force which generates it. He was not tempted to rush at once, from an experimental truth to a universal system. Science had learnt that she must move step by step; and the gravity of her pace already indicated her approaching maturity and her consciousness of the long path which lay before her.

But besides the genuine philosophical prudence which thus withheld Galileo from leaping hastily from one inference to another, he had perhaps a preponderating inclination towards facts; and did not feel, so much as some other persons of his time, the need of reducing them to ideas. He could bear to contemplate laws of motion without being urged by an uncontrollable desire to refer them to conceptions of force.

9. *Kepler.*—In this respect his friend Kepler differed from him; for Kepler was restless and unsatisfied till he had reduced facts to laws, and laws to causes; and never acquiesced in ignorance, though he tested with the most rigorous scrutiny that which presented itself in the shape of knowledge to fill the void. It may be seen in the History of Astronomy[158] with what perseverance, energy, and fertility of invention, Kepler pursued his labours, (enlivened and relieved by the most curious freaks

[157] *Hist. Ind. Sc.* b. vi. c. ii. sect. 4.

[158] *Ibid.* b. v. c. iv. sect. 1.

of fancy,) with a view of discovering the rules which regulate the motions of the planet Mars. He represents this employment under the image of a warfare; and describes[159] his object to be "to triumph over Mars, and to prepare for him, as for one altogether vanquished, tabular prisons and equated eccentric fetters;" and when, "the enemy, left at home a despised captive, had burst all the chains of the equations, and broken forth of the prisons of the tables;"—when "it was buzzed here and there that the victory is vain, and that the war is raging anew as violently as before;"—that is, when the rules which he had proposed did not coincide with the facts;—he by no means desisted from his attempts, but "suddenly sent into the field a reserve of new physical reasonings on the rout and dispersion of the veterans," that is, tried new suppositions suggested by such views as he then entertained of the celestial motions. His efforts to obtain the formal laws of the planetary motions resulted in some of the most important discoveries ever made in astronomy; and if his physical reasonings were for the time fruitless, this arose only from the want of that discipline in mechanical ideas which the minds of mathematicians had still to undergo; for the great discoveries of Newton in the next generation showed that, in reality, the next step of the advance was in this direction. Among all Kepler's fantastical expressions, the fundamental thoughts were sound and true; namely, that it was his business, as a physical investigator, to discover a mathematical rule which governed and included all

[159] *De Stell. Mart.* p. iv. c. 51 (1609); Drinkwater's *Kepler*, p. 33.

the special facts; and that the rules of the motions of the planets must conform to some conception of causation.

The same characteristics,—the conviction of rule and cause, perseverance in seeking these, inventiveness in devising hypotheses, love of truth in trying and rejecting them, and a lively Fancy playing with the Reason without interrupting her,—appear also in his work on Optics; in which he tried to discover the exact law of optical refraction[160]. In this undertaking he did not succeed entirely; nor does he profess to have done so. He ends his numerous attempts by saying, "Now, reader, you and I have been detained sufficiently long while I have been attempting to *collect into one fagot* the measures of different refractions."

In this and in other expressions, we see how clearly he apprehended that *colligation of facts* which is the main business of the practical discoverer. And by his peculiar endowments and habits, Kepler exhibits an essential portion of this process, which hardly appears at all in Galileo. In order to bind together facts, theory is requisite as well as observation,—the cord as well as the fagots. And the true theory is often, if not always, obtained by trying several and selecting the right. Now of this portion of the discoverer's exertions, Kepler is a most conspicuous example. His fertility in devising suppositions, his undaunted industry in calculating the results of them, his entire honesty and candour in resigning them if these results disagreed with the facts, are a very instructive spectacle; and are fortunately exhibited to us in the

[160] Published 1604. *Hist. Ind. Sc.* b. ix. c. ii.

most lively manner in his own garrulous narratives. Galileo urged men by precept as well as example to begin their philosophy from observation; Kepler taught them by his practice that they must proceed from observation by means of hypotheses. The one insisted upon facts; the other dealt no less copiously with ideas. In the practical, as in the speculative portion of our history, this antithesis shows itself; although in the practical part we cannot have the two elements separated, as in the speculative we sometimes have.

In the *History of Science*[161], I have devoted several pages to the intellectual character of Kepler, inasmuch as his habit of devising so great a multitude of hypotheses, so fancifully expressed, had led some writers to look upon him as an inquirer who transgressed the most fixed rules of philosophical inquiry. This opinion has arisen, I conceive, among those who have forgotten the necessity of Ideas as well as Facts for all theory; or who have overlooked the impossibility of selecting and explicating our ideas without a good deal of spontaneous play of the mind. It must, however, always be recollected that Kepler's genius and fancy derived all their scientific value from his genuine and unmingled love of truth. These qualities appeared, not only in the judgment he passed upon hypotheses, but also in matters which more immediately concerned his reputation. Thus when Galileo's discovery of the telescope disproved several opinions which Kepler had published and strenuously maintained, he did

[161] *Hist. Ind. Sc.* b. v. c. iv. sect. i.

not hesitate a moment to retract his assertions and range himself by the side of Galileo, whom he vigorously supported in his warfare against those who were incapable of thus cheerfully acknowledging the triumph of new facts over their old theories.

10. *Tycho.*—There remains one eminent astronomer, the friend and fellow-labourer of Kepler, whom we must not separate from him as one of the practical reformers of science. I speak of Tycho Brahe, who is, I think, not justly appreciated by the literary world in general, in consequence of his having made a retrograde step in that portion of astronomical theory which is most familiar to the popular mind. Though he adopted the Copernican view of the motion of the planets about the sun, he refused to acknowledge the annual and diurnal motion of the earth. But notwithstanding this mistake, into which he was led by his interpretation of Scripture rather than of nature, Tycho must ever be one of the greatest names in astronomy. In the philosophy of science also, the influence of what he did is far from inconsiderable; and especially its value in bringing into notice these two points:—that not only are observations the beginning of science, but that the progress of science may often depend upon the observer's pursuing his task regularly and carefully for a long time, and with well devised instruments; and again, that observed facts offer a *succession* of laws which we discover as our observations become better, and as our theories are better adapted to the observations. With regard to the former point, Tycho's observatory was far superior to all that had preceded

it[162], not only in the optical, but in the mechanical arrangements; a matter of almost equal consequence. And hence it was that his observations inspired in Kepler that confidence which led him to all his labours and all his discoveries. "Since," he says[163], "the divine goodness has given us in Tycho Brahe an exact observer, from whose observations this error of eight minutes in the calculations of the Ptolemaic hypothesis is detected, let us acknowledge and make use of this gift of God: and since this error cannot be neglected, these eight minutes alone have prepared the way for an entire reform of Astronomy, and are to be the main subject of this work."

With regard to Tycho's discoveries respecting the moon, it is to be recollected that besides the first inequality of the moon's motion, (the *equation of the centre*, arising from the elliptical form of her orbit,) Ptolemy had discovered a second inequality, the *evection*, which, as we have observed in the History of this subject[164], might have naturally suggested the suspicion that there were still other inequalities. In the middle ages, however, such suggestions, implying a constant progress in science, were little attended to; and, we have seen, that when an Arabian astronomer[165] had really discovered another inequality of the moon, it was soon forgotten, because it had no place in

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[162] *Hist. Ind. Sc.* b. vii. c. vi. sect 1.

[163] *De Stell. Mart.* p. 11. c. 19.

[164] *Hist. Ind. Sc.* b. ii. c. iv. sect. 6.

[165] *Ibid.* sect. 8.

the established systems. Tycho not only rediscovered the lunar inequality, (the *variation*,) thus once before won and lost, but also two other inequalities; namely[166], the *change of inclination* of the moon's orbit as the line of nodes moves round, and an inequality in the motion of the line of nodes. Thus, as I have elsewhere said, it appeared that the discovery of a rule is a step to the discovery of deviations from that rule, which require to be expressed in other rules. It became manifest to astronomers, and through them to all philosophers, that in the application of theory to observation, we find, not only the stated phenomena, for which the theory does account, but also *residual phenomena*, which are unaccounted for, and remain over and above the calculation. And it was seen further, that these residual phenomena might be, altogether or in part, exhausted by new theories.

These were valuable lessons; and the more valuable inasmuch as men were now trying to lay down maxims and methods for the conduct of science. A revolution was not only at hand, but had really taken place, in the great body of real cultivators of science. The occasion now required that this revolution should be formally recognized;—that the new intellectual power should be clothed with the forms of government;—that the new philosophical republic should be acknowledged as a sister state by the ancient dynasties of Aristotle and Plato. There was needed some great Theoretical Reformer, to speak in the name of the Experimental Philosophy; to lay before the world a declaration of

[166] Montucla, i. 566.

its rights and a scheme of its laws. And thus our eyes are turned to Francis Bacon, and others who like him attempted this great office. We quit those august and venerable names of discoverers, whose appearance was the prelude and announcement of the new state of things then opening; and in doing so, we may apply to them the language which Bacon applies to himself[167]:—

Χαίρετε Κήρυκες Διὸ ς ἄγγελοι ἠδὲ καὶ ἀνδρῶν

Hail, Heralds, Messengers of Gods and Men!

[167] *De Augm.* lib. iv. c. 1.

CHAPTER XV.
Francis Bacon

(I.) 1. *General Remarks.*—It is a matter of some difficulty to speak of the character and merits of this illustrious man, as regards his place in that philosophical history with which we are here engaged. If we were to content ourselves with estimating him according to the office which, as we have just seen, he claims for himself[168], as merely the harbinger and announcer of a sounder method of scientific inquiry than that which was recognized before him, the task would be comparatively easy. For we might select from his writings those passages in which he has delivered opinions and pointed out processes, then novel and strange, but since confirmed by the experience of actual discoverers, and by the judgments of the wisest of succeeding philosophers; and we might pass by, without disrespect, but without notice, maxims and proposals which have not been found available for use;—views so indistinct and vague, that we are even yet unable to pronounce upon their justice;—and boundless anticipations, dictated by the sanguine hopes of a noble and comprehensive intellect. But if we thus reduce the philosophy of Bacon to that portion which the subsequent progress of science

[168] And in other passages: thus, "Ego enim buccinator tantum pugnam non ineo." *Nov. Org.* lib. iv. c. i.

has rigorously verified, we shall have to pass over many of those declarations which have excited most notice in his writings, and shall lose sight of many of those striking thoughts which his admirers most love to dwell upon. For he is usually spoken of, at least in this country, as a teacher who not only commenced, but in a great measure completed, the Philosophy of Induction. He is considered, not only as having asserted some general principles, but laid down the special rules of scientific investigation; as not only one of the Founders, but the supreme Legislator of the modern Republic of Science; not only the Hercules who slew the monsters that obstructed the earlier traveller, but the Solon who established a constitution fitted for all future time.

2. Nor is it our purpose to deny that of such praise he deserves a share which, considering the period at which he lived, is truly astonishing. But it is necessary for us in this place to discriminate and select that portion of his system which, bearing upon *physical* science, has since been confirmed by the actual history of science. Many of Bacon's most impressive and captivating passages contemplate the extension of the new methods of discovering truth to intellectual, to moral, to political, as well as to physical science. And how far, and how, the advantages of the inductive method may be secured for those important branches of speculation, it will at some future time be a highly interesting task to examine. But our plan requires us at present to omit the consideration of these; for our purpose is to learn what the genuine course of the formation of science is, by

tracing it in those portions of human knowledge, which, by the confession of all, are most exact, most certain, most complete. Hence we must here deny ourselves the dignity and interest which float about all speculations in which the great moral and political concerns of men are involved. It cannot be doubted that the commanding position which Bacon occupies in men's estimation arises from his proclaiming a reform in philosophy of so comprehensive a nature;—a reform which was to infuse a new spirit into every part of knowledge. Physical Science has tranquilly and noiselessly adopted many of his suggestions; which were, indeed, her own natural impulses, not borrowed from him; and she is too deeply and satisfactorily absorbed in contemplating her results, to talk much about the methods of obtaining them which she has thus instinctively pursued. But the philosophy which deals with mind, with manners, with morals, with polity, is conscious still of much obscurity and perplexity; and would gladly borrow aid from a system in which aid is so confidently promised. The aphorisms and phrases of the *Novum Organon* are far more frequently quoted by metaphysical, ethical, and even theological writers, than they are by the authors of works on physics.

3. Again, even as regards physics, Bacon's fame rests upon something besides the novelty of the maxims which he promulgated. That a revolution in the method of scientific research was going on, all the greatest physical investigators of the sixteenth century were fully aware, as we have shown

in the last chapter. But their writings conveyed this conviction to the public at large somewhat slowly. Men of letters, men of the world, men of rank, did not become familiar with the abstruse works in which these views were published; and above all, they did not, by such occasional glimpses as they took of the state of physical science, become aware of the magnitude and consequences of this change. But Bacon's lofty eloquence, wide learning, comprehensive views, bold pictures of the coming state of things, were fitted to make men turn a far more general and earnest gaze upon the passing change. When a man of his acquirements, of his talents, of his rank and position, of his gravity and caution, poured forth the strongest and loftiest expressions and images which his mind could supply, in order to depict the "Great Instauration" which he announced;—in order to contrast the weakness, the blindness, the ignorance, the wretchedness, under which men had laboured while they followed the long beaten track, with the light, the power, the privileges, which they were to find in the paths to which he pointed;—it was impossible that readers of all classes should not have their attention arrested, their minds stirred, their hopes warmed; and should not listen with wonder and with pleasure to the strains of prophetic eloquence in which so great a subject was presented. And when it was found that the prophecy was verified; when it appeared that an immense change in the methods of scientific research really *had* occurred;—that vast additions to man's knowledge and power had been acquired, in modes

like those which had been spoken of;—that further advances might be constantly looked for;—and that a progress, seemingly boundless, was going on in the direction in which the seer had thus pointed;—it was natural that men should hail him as the leader of the revolution; that they should identify him with the event which he was the first to announce; that they should look upon him as the author of that which he had, as they perceived, so soon and so thoroughly comprehended.

4. For we must remark, that although (as we have seen) he was not the only, nor the earliest writer, who declared that the time was come for such a change, he not only proclaimed it more emphatically, but understood it, in its general character, much more exactly, than any of his contemporaries. Among the maxims, suggestions and anticipations which he threw out, there were many of which the wisdom and the novelty were alike striking to his immediate successors;—there are many which even now, from time to time, we find fresh reason to admire, for their acuteness and justice. Bacon stands far above the herd of loose and visionary speculators who, before and about his time, spoke of the establishment of new philosophies. If we must select some one philosopher as the Hero of the revolution in scientific method, beyond all doubt Francis Bacon must occupy the place of honour.

We shall, however, no longer dwell upon these general considerations, but shall proceed to notice some of the more peculiar and characteristic features of Bacon's philosophy; and

especially those views, which, occurring for the first time in his writings, have been fully illustrated and confirmed by the subsequent progress of science, and have become a portion of the permanent philosophy of our times.

(II.) 5. *A New Era announced.*—The first great feature which strikes us in Bacon's philosophical views is that which we have already noticed;—his confident and emphatic announcement of a *New Era* in the progress of science, compared with which the advances of former times were poor and trifling. This was with Bacon no loose and shallow opinion, taken up on light grounds and involving only vague, general notions. He had satisfied himself of the justice of such a view by a laborious course of research and reflection. In 1605, at the age of forty-four, he published his Treatise of the *Advancement of Learning*, in which he takes a comprehensive and spirited survey of the condition of all branches of knowledge which had been cultivated up to that time. This work was composed with a view to that reform of the existing philosophy which Bacon always had before his eyes; and in the Latin edition of his works, forms the First Part of the *Instauratio Magna*. In the Second Part of the Instauratio, the *Novum Organon*, published in 1620, he more explicitly and confidently states his expectations on this subject. He points out how slightly and feebly the examination of nature had been pursued up to his time, and with what scanty fruit. He notes the indications of this in the very limited knowledge of the Greeks who had till then been the teachers of Europe, in the complaints

of authors concerning the subtilty and obscurity of the secrets of nature, in the dissensions of sects, in the absence of useful inventions resulting from theory, in the fixed form which the sciences had retained for two thousand years. Nor, he adds[169], is this wonderful; for how little of his thought and labour has man bestowed upon science! Out of twenty-five centuries scarce six have been favourable to the progress of knowledge. And even in those favoured times, natural philosophy received the smallest share of man's attention; while the portion so given was marred by controversy and dogmatism; and even those who have bestowed a little thought upon this philosophy, have never made it their main study, but have used it as a passage or drawbridge to serve other objects. And thus, he says, the great Mother of the Sciences is thrust down with indignity to the offices of a handmaid; is made to minister to the labours of medicine or mathematics, or to give the first preparatory tinge to the immature minds of youth. For these and similar considerations of the errors of past time, he draws hope for the future, employing the same argument which Demosthenes uses to the Athenians: "That which is worst in the events of the past, is the best as a ground of trust in the future. For if you had done all that became you, and still had been in this condition, your case might be desperate; but since your failure is the result of your own mistakes, there is good hope that, correcting the error of your course, you may reach a prosperity yet unknown to you."

[169] Lib. 1. Aphor. 78 *et seq.*

(III.) 6. *A change of existing Method.*—All Bacon's hope of improvement indeed was placed in an entire *change of the Method* by which science was pursued; and the boldness, and at the same time (the then existing state of science being considered), the definiteness of his views of the change that was requisite, are truly remarkable.

That all knowledge must begin with observation, is one great principle of Bacon's philosophy; but I hardly think it necessary to notice the inculcation of this maxim as one of his main services to the cause of sound knowledge, since it had, as we have seen, been fully insisted upon by others before him, and was growing rapidly into general acceptance without his aid. But if he was not the first to tell men that they must collect their knowledge from observation, he had no rival in his peculiar office of teaching them *how* science must thus be gathered from experience.

It appears to me that by far the most extraordinary parts of Bacon's works are those in which, with extreme earnestness and clearness, he insists upon a *graduated and successive induction*, as opposed to a hasty transit from special facts to the highest generalizations. The nineteenth Axiom of the First Book of the *Novum Organon* contains a view of the nature of true science most exact and profound, and, so far as I am aware, at the time perfectly new. "There are two ways, and can only be two, of seeking and finding truth. The one, from sense and particulars, takes a flight to the most general axioms, and from those principles and their truth, settled once for all, invents and judges

of intermediate axioms. The other method collects axioms from sense and particulars, ascending *continuously and by degrees*, so that in the end it arrives at the most general axioms; this latter way is the true one, but hitherto untried."

It is to be remarked, that in this passage Bacon employs the term *axioms* to express any propositions collected from facts by induction, and thus fitted to become the starting-point of deductive reasonings. How far propositions so obtained may approach to the character of axioms in the more rigorous sense of the term, we have already in some measure examined; but that question does not here immediately concern us. The truly remarkable circumstance is to find this recommendation of a continuous advance from observation, by limited steps, through successive gradations of generality, given at a time when speculative men in general had only just begun to perceive that they must begin their course from experience in some way or other. How exactly this description represents the general structure of the soundest and most comprehensive physical theories, all persons who have studied the progress of science up to modern times can bear testimony; but perhaps this structure of science cannot in any other way be made so apparent as by those Tables of successive generalizations in which we have exhibited the history and constitution of some of the principal physical sciences, in the Chapter of a preceding work which treats of the Logic of Induction. And the view which Bacon thus took of the true progress of science was not only new, but, so far as I am

aware, has never been adequately illustrated up to the present day.

7. It is true, as I observed in the last chapter, that Galileo had been led to see the necessity, not only of proceeding from experience in the pursuit of knowledge, but of proceeding cautiously and gradually; and he had exemplified this rule more than once, when, having made one step in discovery, he held back his foot, for a time, from the next step, however tempting. But Galileo had not reached this wide and commanding view of the successive subordination of many steps, all leading up at last to some wide and simple general truth. In catching sight of this principle, and in ascribing to it its due importance, Bacon's sagacity, so far as I am aware, wrought unassisted and unrivalled.

8. Nor is there any wavering or vagueness in Bacon's assertion of this important truth. He repeats it over and over again; illustrates it by a great number of the most lively metaphors and emphatic expressions. Thus he speaks of the successive *floors* (*tabulata*) of induction; and speaks of each science as a *pyramid*[170] which has observation and experience for its basis. No images can better exhibit the relation of general and particular truths, as our own Inductive Tables may serve to show.

(IV.) 9. *Comparison of the New and Old Method.* Again; not less remarkable is his contrasting this true Method of Science

[170] *Aug. Sc.* Lib. iii. c. 4. p. 194. So in other places, as *Nov. Org.* i. Aph. 104. "De scientiis tum demum bene sperandum est quando per scalam veram et per gradus continuos, et non intermissos aut hiulcos a particularibus ascendetur ad axiomata minora, et deinde ad media, alia aliis superiora, et postremo demum ad generalissima."

(while it was almost, as he says, yet untried) with the ancient and *vicious Method*, which began, indeed, with facts of observation, but rushed at once and with no gradations, to the most general principles. For this was the course which had been actually followed by all those speculative reformers who had talked so loudly of the necessity of beginning our philosophy from experience. All these men, if they attempted to frame physical doctrines at all, had caught up a few facts of observation, and had erected a universal theory upon the suggestions which these offered. This process of illicit generalization, or, as Bacon terms it, Anticipation of Nature (*anticipatio naturæ*), in opposition to the Interpretation of Nature, he depicts with singular acuteness, in its character and causes. "These two ways," he says[171] "both begin from sense and particulars; but their discrepancy is immense. The one merely skims over experience and particulars in a cursory transit; the other deals with them in a due and orderly manner. The one, at its very outset, frames certain general abstract principles, but useless; the other gradually rises to those principles which have a real existence in nature."

"The former path," he adds[172], "that of illicit and hasty generalization, is one which the intellect follows when abandoned to its own impulse; and this it does from the requisitions of logic. For the mind has a yearning which makes it dart forth to generalities, that it may have something to rest in; and after a

[171] *Nov. Org.* 1. Aph. 22.

[172] *Ib.* Aph. 20.

little dallying with experience, becomes weary of it; and all these evils are augmented by logic, which requires these generalities to make a show with in its disputations."

"In a sober, patient, grave intellect," he further adds, "the mind, by its own impulse, (and more especially if it be not impelled by the sway of established opinions) attempts in some measure that other and true way, of gradual generalization; but this it does with small profit; for the intellect, except it be regulated and aided, is a faculty of unequal operation, and altogether unapt to master the obscurity of things."

The profound and searching wisdom of these remarks appears more and more, as we apply them to the various attempts which men have made to obtain knowledge; when they begin with the contemplation of a few facts, and pursue their speculations, as upon most subjects they have hitherto generally done; for almost all such attempts have led immediately to some process of illicit generalization, which introduces an interminable course of controversy. In the physical sciences, however, we have the further inestimable advantage of seeing the other side of the contrast exemplified: for many of them, as our inductive Tables show us, have gone on according to the most rigorous conditions of gradual and successive generalization; and in consequence of this circumstance in their constitution, possess, in each part of their structure, a solid truth, which is always ready to stand the severest tests of reasoning and experiment.

We see how justly and clearly Bacon judged concerning the

mode in which facts are to be employed in the construction of science. This, indeed, has ever been deemed his great merit: insomuch that many persons appear to apprehend the main substance of his doctrine to reside in the maxim that facts of observation, and such facts alone, are the essential elements of all true science.

(V.) 10. *Ideas are necessary.*—Yet we have endeavoured to establish the doctrine that facts are but one of two ingredients of knowledge both equally necessary;—that *Ideas* are no less indispensable than facts themselves; and that except these be duly unfolded and applied, facts are collected in vain. Has Bacon then neglected this great portion of his subject? Has he been led by some partiality of view, or some peculiarity of circumstances, to leave this curious and essential element of science in its pristine obscurity? Was he unaware of its interest and importance?

We may reply that Bacon's philosophy, in its effect upon his readers in general, does *not* give due weight or due attention to the ideal element of our knowledge. He is considered as peculiarly and eminently the asserter of the value of experiment and observation. He is always understood to belong to the experiential, as opposed to the ideal school. He is held up in contrast to Plato and others who love to dwell upon that part of knowledge which has its origin in the intellect of man.

11. Nor can it be denied that Bacon has, in the finished part of his *Novum Organon*, put prominently forwards the necessary dependence of all our knowledge upon Experience, and said

little of its dependence, equally necessary, upon the Conceptions which the intellect itself supplies. It will appear, however, on a close examination, that he was by no means insensible or careless of this internal element of all connected speculation. He held the balance, with no partial or feeble hand, between phenomena and ideas. He urged the Colligation of Facts, but he was not the less aware of the value of the Explication of Conceptions.

12. This appears plainly from some remarkable Aphorisms in the *Novum Organon*. Thus, in noticing the causes of the little progress then made by science[173], he states this:—"In the current Notions, all is unsound, whether they be logical or physical. *Substance*, *quality*, *action*, *passion*, even *being*, are not good Conceptions; still less are *heavy*, *light*, *dense*, *rare*, *moist*, *dry*, *generation*, *corruption*, *attraction*, *repulsion*, *element*, *matter*, *form*, and others of that kind; all are fantastical and ill-defined." And in his attempt to exemplify his own system, he hesitates[174] in accepting or rejecting the notions of *elementary*, *celestial*, *rare*, as belonging to fire, since, as he says, they are vague and ill-defined notions (*notiones vagæ nec bene terminatæ*). In that part of his work which appears to be completed, there is not, so far as I have noticed, any attempt to fix and define any notions thus complained of as loose and obscure. But yet such an undertaking appears to have formed part of his plan; and in the

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[173] 1 Ax. 15.

[174] *Nov. Org.* lib. ii. Aph. 19.

Abecedarium Naturæ[175], which consists of the heads of various portions of his great scheme, marked by letters of the alphabet, we find the titles of a series of dissertations "On the Conditions of Being," which must have had for their object the elucidation of divers Notions essential to science, and which would have been contributions to the Explication of Conceptions, such as we have attempted in a former part of this work. Thus some of the subjects of these dissertations are;—Of Much and Little;—Of Durable and Transitory;—Of Natural and Monstrous;—Of Natural and Artificial. When the philosopher of induction came to discuss these, considered as *conditions of existence*, he could not do otherwise than develope, limit, methodize, and define the Ideas involved in these Notions, so as to make them consistent with themselves, and a fit basis of demonstrative reasoning. His task would have been of the same nature as ours has been, in that part of this work which treats of the Fundamental Ideas of the various classes of sciences.

13. Thus Bacon, in his speculative philosophy, took firmly hold of both the handles of science; and if he had completed his scheme, would probably have given due attention to Ideas, no less than to Facts, as an element of our knowledge; while in his view of the general method of ascending from facts to principles, he displayed a sagacity truly wonderful. But we cannot be surprised, that in attempting to exemplify the method which he recommended, he should have failed. For the method

[175] *Inst. Mag.* par. iii. (vol. viii. p. 244).

could be exemplified only by some important discovery in physical science; and great discoveries, even with the most perfect methods, do not come at command. Moreover, although the general structure of his scheme was correct, the precise import of some of its details could hardly be understood, till the actual progress of science had made men somewhat familiar with the kind of steps which it included.

(VI.) 14. *Bacon's Example.*—Accordingly, Bacon's *Inquisition into the Nature of Heat*, which is given in the Second Book of the *Novum Organon* as an example of the mode of interrogating Nature, cannot be looked upon otherwise than as a complete failure. This will be evident if we consider that, although the exact nature of heat is still an obscure and controverted matter, the science of Heat now consists of many important truths; and that to none of these truths is there any approximation in Bacon's essay. From his process he arrives at this, as the "forma or true definition" of heat;—"that it is an expansive, restrained motion, modified in certain ways, and exerted in the smaller particles of the body." But the steps by which the science of Heat really advanced were (as may be seen in the history[176] of the subject) these;—The discovery of a *measure* of heat or temperature (the thermometer); the establishment of the *laws* of conduction and radiation; of the *laws* of specific heat, latent heat, and the like. Such steps have led to Ampère's *hypothesis*[177], that heat consists

[176] *Hist. Ind. Sc.* b. x. c. i.

[177] *Ib.* c. iv.

in the vibrations of an imponderable fluid; and to Laplace's *hypothesis*, that temperature consists in the internal radiation of such a fluid. These hypotheses cannot yet be said to be even probable; but at least they are so modified as to include some of the preceding laws which are firmly established; whereas Bacon's hypothetical motion includes no laws of phenomena, explains no process, and is indeed itself an example of illicit generalization.

15. One main ground of Bacon's ill fortune in this undertaking appears to be, that he was not aware of an important maxim of inductive science, that we must first obtain the *measure* and ascertain the *laws* of phenomena, before we endeavour to discover their *causes*. The whole history of thermotics up to the present time has been occupied with the *former* step, and the task is not yet completed: it is no wonder, therefore, that Bacon failed entirely, when he so prematurely attempted the *second*. His sagacity had taught him that the progress of science must be gradual; but it had not led him to judge adequately how gradual it must be, nor of what different kinds of inquiries, taken in due order, it must needs consist, in order to obtain success.

Another mistake, which could not fail to render it unlikely that Bacon should really exemplify his precepts by any actual advance in science, was, that he did not justly appreciate the sagacity, the inventive genius, which all discovery requires. He conceived that he could supersede the necessity of such peculiar endowments. "Our method of discovery in science," he says[178], "is of such

[178] *Nov. Org.* lib. i. Aph. 61.

a nature, that there is not much left to acuteness and strength of genius, but all degrees of genius and intellect are brought nearly to the same level." And he illustrates this by comparing his method to a pair of compasses, by means of which a person with no manual skill may draw a perfect circle. In the same spirit he speaks of proceeding by *due rejections*; and appears to imagine that when we have obtained a collection of facts, if we go on successively rejecting what is false, we shall at last find that we have, left in our hands, that scientific truth which we seek. I need not observe how far this view is removed from the real state of the case. The necessity of a *conception* which must be furnished by the mind in order to bind together the facts, could hardly have escaped the eye of Bacon, if he had cultivated more carefully the ideal side of his own philosophy. And any attempts which he could have made to construct such conceptions by mere rule and method, must have ended in convincing him that nothing but a peculiar inventive talent could supply that which was thus not contained in the facts, and yet was needed for the discovery.

(VII.) 16. *His Failure.*—Since Bacon, with all his acuteness, had not divined circumstances so important in the formation of science, it is not wonderful that his attempt to reduce this process to a *Technical Form* is of little value. In the first place, he says[179], we must prepare a natural and experimental history, good and sufficient; in the next place, the instances thus collected are to be arranged in Tables in some orderly way; and then we must

[179] *Nov. Org.* lib. ii. Aph. 10.

apply a legitimate and true induction. And in his example[180], he first collects a great number of cases in which heat appears under various circumstances, which he calls "a Muster of Instances before the intellect," (*comparentia instantiarum ad intellectum*,) or a *Table of the Presence* of the thing sought. He then adds a *Table of its Absence* in proximate cases, containing instances where heat does not appear; then a *Table of Degrees*, in which it appears with greater or less intensity. He then adds[181], that we must try to exclude several obvious suppositions, which he does by reference to some of the instances he has collected; and this step he calls the *Exclusive*, or the *Rejection of Natures*. He then observes, (and justly,) that whereas truth emerges more easily from error than from confusion, we may, after this preparation, *give play to the intellect*, (fiat permissio intellectus,) and make an attempt at induction, liable afterwards to be corrected; and by this step, which he terms his *First Vindemiation*, or *Inchoate Induction*, he is led to the proposition concerning heat, which we have stated above.

17. In all the details of his example he is unfortunate. By proposing to himself to examine at once into the *nature* of heat, instead of the laws of special classes of phenomena, he makes, as we have said, a fundamental mistake; which is the less surprising since he had before him so few examples of the right course in the previous history of science. But further, his collection of

[180] Aph. 11.

[181] Aph. 15, p. 105.

instances is very loosely brought together; for he includes in his list the *hot* taste of aromatic plants, the *caustic* effects of acids, and many other facts which cannot be ascribed to heat without a studious laxity in the use of the word. And when he comes to that point where he permits his intellect its range, the conception of *motion* upon which it at once fastens, appears to be selected with little choice or skill, the suggestion being taken from flame[182], boiling liquids, a blown fire, and some other cases. If from such examples we could imagine heat to be motion, we ought at least to have some gradation to cases of heat where no motion is visible, as in a red-hot iron. It would seem that, after a large collection of instances had been looked at, the intellect, even in its first attempts, ought not to have dwelt upon such an hypothesis as this.

18. After these steps, Bacon speaks of several classes of instances which, singling them out of the general and indiscriminate collection of facts, he terms *Instances with Prerogative*: and these he points out as peculiar aids and guides to the intellect in its task. These Instances with Prerogative have generally been much dwelt upon by those who have commented on the *Novum Organon*. Yet, in reality, such a classification, as has been observed by one of the ablest writers of the present day[183], is of little service in the task of induction. For the instances are, for the most part, classed, not according to the ideas which they involve, or to any obvious circumstance in

[182] Page 110.

[183] Herschel, *On the Study of Nat. Phil.* Art. 192.

the facts of which they consist, but according to the extent or manner of their influence upon the inquiry in which they are employed. Thus we have Solitary Instances, Migrating Instances, Ostensive Instances, Clandestine Instances, so termed according to the degree in which they exhibit, or seem to exhibit, the property whose nature we would examine. We have Guide-Post Instances, (*Instantiæ Crucis*,) Instances of the Parted Road, of the Doorway, of the Lamp, according to the guidance they supply to our advance. Such a classification is much of the same nature as if, having to teach the art of building, we were to describe tools with reference to the amount and place of the work which they must do, instead of pointing out their construction and use:—as if we were to inform the pupil that we must have tools for lifting a stone up, tools for moving it sideways, tools for laying it square, tools for cementing it firmly. Such an enumeration of ends would convey little instruction as to the means. Moreover, many of Bacon's classes of instances are vitiated by the assumption that the "form," that is, the general law and cause of the property which is the subject of investigation, is to be looked for directly in the instances; which, as we have seen in his inquiry concerning heat, is a fundamental error.

19. Yet his phraseology in some cases, as in the *instantia crucis*, serves well to mark the place which certain experiments hold in our reasonings: and many of the special examples which he gives are full of acuteness and sagacity. Thus he suggests swinging a pendulum in a mine, in order to determine whether

the attraction of the earth arises from the attraction of its parts; and observing the tide at the same moment in different parts of the world, in order to ascertain whether the motion of the water is expansive or progressive; with other ingenious proposals. These marks of genius may serve to counterbalance the unfavourable judgment of Bacon's aptitude for physical science which we are sometimes tempted to form, in consequence of his false views on other points; as his rejection of the Copernican system, and his undervaluing Gilbert's magnetical speculations. Most of these errors arose from a too ambitious habit of intellect, which would not be contented with any except very wide and general truths; and from an indistinctness of mechanical, and perhaps, in general, of mathematical ideas:—defects which Bacon's own philosophy was directed to remedy, and which, in the progress of time, it has remedied in others.

(VIII.) 20. *His Idols.*—Having thus freely given our judgment concerning the most exact and definite portion of Bacon's precepts, it cannot be necessary for us to discuss at any length the value of those more vague and general *Warnings* against prejudice and partiality, against intellectual indolence and presumption, with which his works abound. His advice and exhortations of this kind are always expressed with energy and point, often clothed in the happiest forms of imagery; and hence it has come to pass, that such passages are perhaps more familiar to the general reader than any other part of his writings. Nor are Bacon's counsels without their importance, when we

have to do with those subjects in which prejudice and partiality exercise their peculiar sway. Questions of politics and morals, of manners, taste, or history, cannot be subjected to a scheme of rigorous induction; and though on such matters we venture to assert general principles, these are commonly obtained with some degree of insecurity, and depend upon special habits of thought, not upon mere logical connexion. Here, therefore, the intellect may be perverted, by mixing, with the pure reason, our gregarious affections, or our individual propensities; the false suggestions involved in language, or the imposing delusions of received theories. In these dim and complex labyrinths of human thought, *the Idol of the Tribe*, or *of the Den*, *of the Forum*, or *of the Theatre*, may occupy men's minds with delusive shapes, and may obscure or pervert their vision of truth. But in that Natural Philosophy with which we are here concerned, there is little opportunity for such influences. As far as a physical theory is completed through all the steps of a just induction, there is a clear daylight diffused over it which leaves no lurking-place for prejudice. Each part can be examined separately and repeatedly; and the theory is not to be deemed perfect till it will bear the scrutiny of all sound minds alike. Although, therefore, Bacon, by warning men against the idols of fallacious images above spoken of, may have guarded them from dangerous error, his precepts have little to do with Natural Philosophy: and we cannot agree with him when he says[184], that the doctrine concerning these

[184] *Nov. Org.* lib. i. Aph. 40.

idols bears the same relation to the interpretation of nature as the doctrine concerning sophistical paralogisms bears to common logic.

(IX.) 21. *His Aim, Utility.*—There is one very prominent feature in Bacon's speculations which we must not omit to notice; it is a leading and constant object with him to apply his knowledge to *Use*. The insight which he obtains into nature, he would employ in commanding nature for the service of man. He wishes to have not only principles but works. The phrase which best describes the aim of his philosophy is his own[185], "Ascendendo ad *axiomata*, descendendo ad *opera*." This disposition appears in the first aphorism of the *Novum Organon*, and runs through the work. "Man, the *minister* and interpreter of nature, *does* and understands, so far as he has, in fact or in thought, observed the course of nature; and he cannot know or *do* more than this." It is not necessary for us to dwell much upon this turn of mind; for the whole of our present inquiry goes upon the supposition that an acquaintance with the laws of nature is worth our having for its own sake. It may be universally true, that Knowledge is Power; but we have to do with it not as Power, but as Knowledge. It is the formation of Science, not of Art, with which we are here concerned. It may give a peculiar interest to the history of science, to show how it constantly tends to provide better and better for the wants and comforts of the body; but *that* is not the interest which engages us in our present inquiry into the

[185] *Nov. Org.* lib. i. Ax. 103.

nature and course of philosophy. The consideration of the means which promote man's material well-being often appears to be invested with a kind of dignity, by the discovery of general laws which it involves; and the satisfaction which rises in our minds at the contemplation of such cases, men sometimes ascribe, with a false ingenuity, to the love of mere bodily enjoyment. But it is never difficult to see that this baser and coarser element is not the real source of our admiration. Those who hold that it is the main business of science to construct instruments for the uses of life, appear sometimes to be willing to accept the consequence which follows from such a doctrine, that the first shoemaker was a philosopher worthy of the highest admiration[186]. But those who maintain such paradoxes, often, by a happy inconsistency, make it their own aim, not to devise some improved covering for the feet, but to delight the mind with acute speculations, exhibited in all the graces of wit and fancy.

It has been said[187] that the key of the Baconian doctrine consists in two words, Utility and Progress. With regard to the latter point, we have already seen that the hope and prospect of a boundless progress in human knowledge had sprung up in men's minds, even in the early times of imperial Rome; and were most emphatically expressed by that very Seneca who disdained to reckon the worth of knowledge by its value in food and clothing. And when we say that Utility was the great business

[186] *Edinb. Rev.* No. cxxxii. p. 65.

[187] *Ib.*

of Bacon's philosophy, we forget one-half of his characteristic phrase: "Ascendendo ad aximomata," no less than "descendendo ad opera," was, he repeatedly declared, the scheme of his path. He constantly spoke, we are told by his secretary[188], of two kinds of experiments, *experimenta fructifera*, and *experimenta lucifera*.

Again; when we are told by modern writers that Bacon merely recommended such induction as all men instinctively practise, we ought to recollect his own earnest and incessant declarations to the contrary. The induction hitherto practised is, he says, of no use for obtaining solid science. There are two ways[189], "hæc via in usu est," "altera vera, sed intentata." Men have constantly been employed in *anticipation*; in illicit induction. The intellect left to itself rushes on in this road[190]; the conclusions so obtained are persuasive[191]; far more persuasive than inductions made with due caution[192]. But still this method must be rejected if we would obtain true knowledge. We shall then at length have ground of good hope for science when we proceed in another manner[193]. We must rise, not by a leap, but by small steps, by successive advances, by a gradation of ascents, trying our facts, and clearing

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[188] Pref. to the *Nat. Hist.* i. 243.

[189] *Nov. Org.* lib. i. Aph. 19.

[190] *Ibid.* lib. i. Aph. 20.

[191] Aph. 27.

[192] *Ib.* 28.

[193] Aph. 104. So Aph. 105. "In constituendo axiomate forma *inductionis* alia quam adhuc in usu fuit excogitanda est," &c.

our notions at every interval. The scheme of true philosophy, according to Bacon, is not obvious and simple, but long and technical, requiring constant care and self-denial to follow it. And we have seen that, in this opinion, his judgment is confirmed by the past history and present condition of science.

Конец ознакомительного фрагмента.