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THE PHILOSOPHY  
OF  
FRANCIS BACON

By  
C. D. BROAD



CAMBRIDGE  
UNIVERSITY PRESS

1926

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# THE PHILOSOPHY OF FRANCIS BACON

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BY

C. D. BROAD, Litt.D., F.B.A.

*Fellow and Lecturer in the Moral  
Sciences, Trinity College,  
Cambridge*

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TO  
C·E·M·

*Ad extremum autem visum est ei, si quid in his quae dicta sunt aut dicentur boni inveniatur, id tanquam adipem sacrificii Deo dicare, et hominibus, ad Dei similitudinem, sano affectu et charitate hominum bonum procurantibus.*

BACON, *Cogitata et Visa.*

The  
PHILOSOPHY  
OF FRANCIS BACON

THE great man whose memory we are honouring today was so universal a genius, his speculative and practical activities were so various, that we must be content either with a superficial glance at his achievements as a whole or with the contemplation, at the risk of onesidedness, of a single aspect of his work. Faced with these unsatisfactory alternatives I choose the second. Others, better fitted than I, must appraise Bacon's merits as lawyer, statesman, and stylist; I shall consider only his claims to be the Father of Inductive Philosophy. It is fitting that Bacon should be viewed in that light in this country and this University. Inductive Logic is almost wholly the work of Englishmen; and in the short list of great Englishmen who have contributed to this branch of philosophy Cambridge

is proud to number Bacon, Whewell, and Venn in the past, and Mr Johnson and Mr Keynes in the present. Even the restricted subject which I have chosen is of vast extent, so without further preface I will enter on it.

Bacon's grounds for dissatisfaction with the past and present state of human knowledge and his hopes for the future were stated in many forms; but they reduce in essence to the following. Our present Natural Philosophy amounts to very little. It consists of portions of Greek philosophy tricked out in various ways, so that the apparent plenty is like a number of dishes made of the same meat disguised with different sauces. Nor does it include the whole even of Greek philosophy; for Aristotle, like the Turk, would brook no rivals near his throne, and the Barbarian invasions extinguished what he and his followers had failed to suppress. The current philosophy, derived from Aristotle, is difficult to criticise; partly because its



technical terms and fundamental concepts have passed into theology, law, and common discourse; and partly because its premises and modes of reasoning are questionable, so that there is no common basis for argument. But we can at least point out certain facts which are very ill omens of its truth or usefulness. The Greeks were the Peter Pans of the ancient world, and their philosophy has the boyish characteristics of being "apt to chatter and unable to generate." It started at a time when there was little knowledge of geography or history compared with that which we now possess. Plato and Aristotle, though men of the highest intellectual power, could not make bricks without straw; their method of teaching, which involved a school, an audience, and a sect, was singularly unfavourable to disinterested observation of Nature or free speculation on observed facts. The triumph of Aristotle's philosophy over its rivals is not to be ascribed to

its intrinsic superiority. In philosophical matters general consent is of ill omen, for a popular philosophy is usually one which indulges human laziness by using loose superficial notions and by substituting an appeal to a few high-sounding generalities for the patient investigation of details. Two of the worst signs of the current philosophy are that it does not progress and that it does not lead to practical results. It stands still and wrangles about old questions instead of settling them and passing on to new ones. And in practical affairs we owe more to the sagacity of animals and the blind instincts of ignorant men than to all the theories of Natural Philosophy. The mechanical arts do slowly progress through the growth of technical skill and the co-operation of many hands. But Philosophy is like the statues of the gods "which are worshipped and celebrated but cannot move." The very perfection of systematic form which the traditional philo-

sophy has acquired is a defect, for it diverts men's minds from the narrowness of its foundations and the flimsiness of its superstructure. Indeed the exponents of this philosophy admit its barrenness by their constant complaints about the obscurity and subtlety of Nature and the weakness of the human mind. This appearance of modesty cloaks the pride which assumes that what cannot be known by their methods cannot be known at all. And so progress is hampered equally by an unwarranted satisfaction with what has been done and by an unwarranted despair of accomplishing what remains to do.

If we now consider the empiricists, e.g., the alchemists and the magicians, we find the opposite defects. Each has laboriously tilled a very narrow field of phenomena, using no scientific method of culture, and snatching greedily at immediate practical results. Although they have by chance discovered some useful facts, they have failed both as

theorists and as practitioners. Their philosophical theories are crazy attempts to interpret the whole of Nature in terms of the small fragment of it with which each happens to be familiar. Nature can never be controlled except on the basis of a wide and deep knowledge of its inner structure and fundamental laws, and this can be won only by disinterested scientific investigation. Though no one has asserted more strongly than Bacon that ability to produce practical results is the ultimate test of scientific theories and the ultimate end of scientific research, no one has protested more vigorously against a narrow and short-sighted pragmatism. He compares it to the golden apple of Atalanta which diverted the runners from their course. And he compares those who are obsessed by it to harvesters who cannot wait till the crop has grown up, but trample on the young shoots in order to mow down moss.

If the old methods are still to be used

the prospect is dark indeed. Our intellectual powers are no greater than those of the ancients; our only advantage over them is in the additional experience which has accumulated in two thousand years. And we cannot be more diligent than the alchemists and magicians who devoted their lives to the furnace and the crucible. Our only hope is to devise a new method which shall be to the mind as rulers and compasses are to the hand. The mere rationalists are like spiders who spin wonderful but flimsy webs out of their own bodies; the mere empiricists are like ants who collect raw materials without selection and store them up without modification. True and fruitful science must combine rationalism with empiricism, and be like the bee who gathers materials from every flower and then works them up by her own activities into honey. This marriage between rationalism and empiricism, and this discovery of a new method, are the tasks which Bacon set

before himself. The times are peculiarly favourable, and he feels that he has the necessary qualifications. He will bring about the Great Instauration and will show men how to win back that dominion over Nature which was lost at the Fall.

Bacon has left us a detailed plan of the Great Instauration as he conceived it. It was to consist of six parts. The first was to be a complete encyclopaedia of the existing sciences, classified according to general principles which would make the gaps obvious. These gaps were not merely to be indicated. In each case suggestions were to be made as to the nature of the missing science and the best way of building it up. This portion of the plan is adequately fulfilled by the *De Augmentis*. The second part was to contain the principles of the new Art of Interpreting Nature, which is to put all human minds on a level and to provide them with an infallible mechanism for the discovery

and invention, not of new arguments, but of new arts and sciences. Bacon's latest exposition of this is found in the *Novum Organum*. But it is admittedly incomplete in vitally important respects. This incompleteness it shares with the treatises on scientific method of Descartes, Spinoza, and Leibniz, all of which start with the same magnificent pretensions and end like noble rivers which never reach the sea but lose themselves in the sands of the desert. Bacon constantly said that he would return to the subject and that he knew how to complete it; but, in view of the failure of all similar attempts and the intractable nature of the problem, we may venture to believe that he was mistaken. The third part was to consist of a collection of particular data of experiment and observation specially chosen and arranged in accordance with principles laid down in Part II so as to form the empirical basis of Natural Philosophy. It is extremely fragmentary,

consisting of three natural histories, prefaces to three others, a general preface, and the curious rag-bag of facts and fables called *Sylva Sylvarum*. Part IV, called the *Ladder of the Intellect*, was to consist of a number of fully worked-out examples of the application of the method. They were to be so chosen that the subject-matter of each should be intrinsically important, and that between them they should illustrate the use of the method in very varied media. Of this nothing is extant but a short preface. It is important to remember that we have no complete example of Bacon's method. The fifth part was to be called the *Forerunners, or Anticipations of the New Philosophy*. It was to contain interesting generalisations which Bacon had reached from his Natural History without using his special method of interpretation. These results are not guaranteed, and their importance is only temporary. The preface to this part exists; and it may reasonably be held



that the admittedly imperfect investigation of the nature of heat which occupies so large a space in the Second Book of the *Novum Organum* is a sample of what Bacon meant to include in Part V. The sixth part was to be called *The New Philosophy or Active Science*. It was to consist of the complete science of Nature, theoretical and practical, firmly built on the facts of Part III by the methods of Part II. The preface is extant, but the work is naturally left to posterity.

Taking the Great Instauration as a whole, we may compare Part II to a factory full of ingenious machinery, Part III to a storehouse of selected materials for this machinery to work upon, Part IV to a show-room in which typical samples of the finished products are exposed to public view, and Part VI to a warehouse in which all the finished products are to be stored. Part V is a collection of goods made by inferior methods or only half finished, but useful enough for many purposes. Part I is a

list in which the directors have noted what goods the public already have and what further needs remain as yet unrecognised or unsatisfied. Unfortunately the machinery is incomplete; and the engineer, instead of drawing the plans for completing it, has to spend his time in collecting raw materials and in penning eloquent prospectuses.

We will now consider Bacon's classification of actual and possible human knowledge. The first division is made by reference to the source from which the materials of knowledge flow into the mind. They may come either from the direct action of the Creator on his creatures, or from the action of the created world including ourselves. Thus human knowledge is first dichotomised into that which is acquired supernaturally and that which is acquired naturally. Each of these great divisions is then trichotomised on a psychological principle, viz., with reference to the cognitive faculty which the mind mainly uses in

the work of knowing. Bacon recognises three such faculties, viz., Memory (which for the present purpose includes Sense-perception), Imagination, and Reason. Memory and Imagination are concerned with particular things, events, and facts; Reason with general concepts, facts, and laws. Memory deals with real particulars and Imagination with feigned particulars. Thus human knowledge, whether of natural or of supernatural origin, is divided into History, Poesy, and Philosophy (or Science).

Before considering further subdivisions we must explain Bacon's views about supernaturally acquired knowledge; we shall then be able to confine ourselves to the knowledge which originates naturally. According to Bacon there are three subjects which need for their complete treatment data that spring from a supernatural source. These are Theology, Ethics, and Psychology. Each of these sciences can, how-

ever, be carried to a certain length without appeal to revelation. Each of them therefore divides into a natural and a revealed part. Theology is the most fundamental of the three, since the parts of Ethics and of Psychology which depend on revelation are branches of Revealed Theology.

Bacon holds that the existence of teleology in Nature is an obvious fact, and that the investigation of final causes is a perfectly legitimate branch of Natural Philosophy. It has, however, been misplaced; for it belongs to the division of Natural Philosophy which Bacon calls *Metaphysics* and not to that which he calls *Physics*. Bacon's epigram that "the research into Final Causes, like a virgin dedicated to God, is barren and produces nothing" has been taken by careless or biased readers to be a condemnation of such research. It is nothing of the kind. It is simply a statement of the obvious fact that there is no art of Applied Teleology as there is an art of

Applied Physics. Now Bacon holds that the existence and some of the attributes of God can be established conclusively by reflexion on the teleology of Nature. But this does not give determinate enough information about God to form an adequate basis for religion. The further details must be supplied by God himself in revelation. God, says Bacon, did not need to work miracles to convince atheists but to convert heathens.

His view about Ethics is very similar. We have a partial and inadequate knowledge of right and wrong by the light of Nature. But it does little more than show us that certain types of action are wrong; it gives no very determinate information about our positive duties. Divine revelation is needed to provide an adequate basis for a detailed morality.

The division of Psychology into a natural and a revealed part follows a different principle. There are not two

Gods, one of whom is the subject of Natural and the other of Revealed Theology. But in man there are two souls, the rational and the animal. The former is immaterial, peculiar to man, and directly created by God at the moment of conception. The latter is shared with animals; it is material, and due to one's parents. It is described as "a corporeal substance, attenuated and made invisible by heat," which resides mainly in the head, runs along the nerves, and is refreshed by the arterial blood. It is in fact our old friend "the animal spirits" which are as material as methylated spirits. In man the rational soul uses the animal soul as its immediate instrument. Now the science of the rational soul, its origin, nature, and destiny, must "be drawn from the same divine inspiration from which that substance first proceeded." The science of the animal soul belongs to Natural Philosophy. Bacon's theory of the animal soul owes much to Telesius,

while his sharp distinction between it and the rational soul is closely analogous to the theory which Descartes worked out in greater detail a little later.

It remains to consider Bacon's views as to the relations of reason and revelation. It is legitimate to exercise our reason on the data of revelation in two ways. In the first place we may try to understand them. But we have no more ground for expecting God's revealed nature to be agreeable to our reason than for expecting his revealed commands to be agreeable to our wishes. On the whole Bacon thinks that there is a strong presumption that the contents of divine revelation will be repugnant to our reason; and that, the more preposterous God's revealed nature and commands appear to be, the greater is our merit in believing in the former and obeying the latter. The position which Bacon here adopts has been most forcibly stated by Hobbes: "The doctrines of religion are like the pills

prescribed by physicians, which if swallowed whole do us good, but if chewed up make us sick." The second legitimate use of reason in matters of revelation is the following. We may take the revealed nature and commands of God as fixed, and to us arbitrary, premises like the rules of chess. We may then use reasoning to deduce remote consequences from them, just as we may use it in solving a chess-problem. Each use of reason has its characteristic dangers. In trying to understand the contents of divine revelation we may distort them by forcing them into the mould of the human intellect. And in drawing consequences from revealed truths we may ascribe to the conclusions of our fallible reasoning that certainty which the premises derive from their Divine Author.

It is evident then that religion and morality have little to hope and nothing to fear from the advance of Natural Philosophy. Bacon has been acclaimed



by the French Encyclopaedists, and abused by Joseph de Maistre, as an *esprit fort* who concealed his real atheism and materialism under a thin disguise of orthodoxy which sufficed to deceive the Wisest Fool in Christendom. Neither acclamation nor abuse is justified. It is evident that he was a sincere if unenthusiastic Christian of that sensible school which regards the Church of England as a branch of the Civil Service, and the Archbishop of Canterbury as the British Minister for Divine Affairs. Having seen fanatical superstition in action, and knowing of atheism only as a rare speculative doctrine, he naturally preferred the latter to the former. Actively fanatical atheism was not yet a practical possibility. It was reserved for a later age, which had reaped the fruits of the Great Instauration in poison-gas and high-explosive shells, to witness the Barbarians of the East persecuting Christians in the name of Darwin, whilst the Barbarians of the

West persecuted Darwinians in the name of Christ.

We can now deal with History, Poesy, and Philosophy, regarded henceforth as of purely natural origin. History is divided into Natural and Civil, according to whether it treats the particular facts of non-human Nature or the actions of men. As we have seen, a complete and properly chosen Natural History was to form the third part of the Great Instauration. The best account of what Bacon meant by such a History is contained in the tract called *Parasceve*, which he published along with the *Novum Organum*. He feels that some excuse is needed for publishing something which is mainly concerned with Part III when Part II is admittedly incomplete. His explanation is as follows. A complete Natural History will be an immense work, needing the co-operation of many men for long periods. It will be expensive, needing the help of royal, noble, and wealthy

benefactors. It can, however, be carried on by men without special training or eminent intellectual qualifications, provided they are told what to look for, whereas Bacon himself and he only can complete the second part of the Great Instauration. He can provide others with the necessary methodological instructions without which the works of would-be Natural Historians will be as futile as those of their predecessors. Finally, Bacon says that the most perfect method of interpretation can accomplish nothing without an adequate and accurate Natural History to work upon, whilst even the existing methods of interpretation (bad as he believes them to be) could accomplish a great deal were such a Natural History provided. So the *Parasceve* is published to inspire the great to give their money and lend their authority, and to instruct plain men who are willing to offer their services how to collect that complete Natural History which is to restore to

humanity its lost dominion over the material world. In the meanwhile Bacon is to be left in peace to his proper task of completing the method of Interpretation. Unfortunately the British Solomon, in partial resemblance to his Jewish namesake, was too easily diverted from the austere beauties of science by others of a less ideal kind. And the plain men cared more for the eternal war of Church and Chapel than for winning the kingdom of Nature for humanity. Like the deaf adder they stopped their ears; and the architect of the Great Instauration was forced to dig his own clay and bake his own bricks.

The gist of Bacon's directions for forming a complete Natural History is as follows. Nature may act either freely and normally, or freely but abnormally, or under the deliberate constraint of man. Corresponding to these three possibilities there will be a History of the Normal, a History of Abnormalities, and a History of Experimental Results

and Processes. Bacon rightly attaches very great importance to abnormal variations from the ordinary course of Nature, though he recognises that all reports about them must be severely scrutinised before being accepted. The importance of abnormalities is twofold. They overthrow prejudices in favour of received theories, and they suggest practical means of making new artificial products. Bacon insists, and in this he is much ahead of his age, that there is no essential difference between the natural and the artificial. Again, he continually stresses the extreme importance of deliberate experiment as contrasted with mere passive observation. Experiment "takes off the mask and veil from natural objects," and "the vexations of art are . . . as the bonds of Proteus which betray the ultimate struggles and efforts of matter." In the History of the Normal we need not enter into extremely minute varieties of species, as botanists and zoologists

are wont to do; but we must not be too proud to include what is homely and familiar or too fastidious to record what is filthy and disgusting. The rays of the sun, says Bacon, illuminate the sewer as well as the palace and take no corruption; and "if the money obtained from Vespasian's tax smelled well, much more do light and information from whatever source derived."

So much for the contents of the Natural History. The principle of selection is that facts are to be chosen and recorded, not for their immediate use or intrinsic interest, but simply for their aptness to give rise to important inductions. Bacon gives some indication of the kind of facts which are likely to have this property in the account of Prerogative Instances at the end of the *Novum Organum*.

Finally, Bacon gives the following directions for recording the data. There are to be no controversies with other authors and no graces of style. The

History is a storehouse to be entered only as occasion requires, and not a dwelling-house or an art-gallery. If the facts to be recorded are certain they are simply to be stated without evidence. If they are doubtful and not very important the authority should be mentioned for reference but no arguments should be given. If they are both doubtful and important all information should be given about the authority which bears on his value as a witness. Commonly accepted fictions should not be passed over in silence. They should be explicitly mentioned and denied, and, if possible, the causes of the illusion should be stated. All data that are capable of accurate measurement should be measured, and where exact measures are impossible upper and lower limits should be stated. All difficult experiments must be fully and accurately described so that others may be able to criticise and repeat them. We cannot expect that all the alleged facts which

will at first be included in the Natural History will be genuine. But so long as most of the observations are sound the presence of a small number of mistakes will not be disastrous. For the large mass of genuine facts will suffice to establish the general laws and structure of Nature, and in their light the few mistakes will stand out clearly and can be corrected at leisure. To sum up in Bacon's words: When we have this comprehensive Natural History, and not till then, we shall "no longer be kept dancing in rings, like persons bewitched, but our range and circuit will be as wide as the compass of the world."

I now leave History and pass to Philosophy, stopping for a moment by the way at Poesy in order to indicate a curious crotchet of Bacon's. He held that the stories of Greek mythology were deliberately composed to conceal from the vulgar and reveal to the elect profound philosophical truths; and he wasted much time and ingenuity in



showing that some mute inglorious Newton has hidden the true principles of Natural Philosophy in the story of *Pan*, and that some pre-historic Clausewitz has embedded the rules of military strategy in that of *Perseus and Medusa*.

Bacon divides Philosophy according to its subject-matter into Natural Theology, the Science of Non-human Nature, and the Science of Man. But he holds that philosophy begins as an undivided stem which rises to some height before these branches emerge. The undivided stem he calls *First Philosophy* or *Wisdom*. First Philosophy consists of two parts, between which there seems to be very little connexion. The first consists of those general principles which are common to several different sciences. Bacon gives a number of examples, and among them the principle that the quantum of Nature is neither increased nor diminished by any natural process. He says that these common principles are not mere analogies but are the com-

mon impress of the Creator on diverse materials, so that this part of Philosophy displays the essential unity of Nature. It must be confessed, however, that some of his examples rest on mere metaphors and that his collection of common principles seems arbitrary and internally incoherent. The second part of First Philosophy treats of what he calls the *Adventitious Conditions of Essences*. From his examples it is clear that it was to ask and answer such questions as: "Why does the world contain so much of some substances and so little of others?" "Why is the arrangement of the stars and planets such as it is?" "Why is pentadic symmetry so common among flowers and unknown among crystals?" Bacon fully recognises that there is a point at which we reach ultimate principles and brute facts, and he insists that a philosopher may show as great folly in professing to explain the simple and the ultimate as in stopping short in his

analysis of what is complex and causally explicable. Nevertheless the kind of question which he relegates to the second part of First Philosophy is obviously legitimate, though we must eventually come to proportions and configurations which have simply to be accepted as ultimate facts about the constitution of Nature.

Having already said what is necessary about Natural Theology we can now consider the two remaining branches which spring from the common stem of First Philosophy. The Science of Non-human Nature or Natural Philosophy is divided into a theoretical part which seeks to explain given facts by discovering their causes, and a correlated practical part which seeks to produce desired effects by applying this knowledge of causes. Theoretical Natural Philosophy is subdivided into Metaphysics and Physics. Metaphysics, in Bacon's sense, has two parts: the study of Final Causes and that of

Formal Causes. Physics is concerned with Material and Efficient Causes. We have already seen that Bacon regards the study of Final Causes as a legitimate enquiry which is the basis of Natural Theology but gives rise to no practical art. The art which corresponds, not to Metaphysics as a whole, but to the Metaphysics of Forms, is called by Bacon *Natural Magic*. The art which corresponds to Physics is called *Mechanics*.

With the Metaphysics of Forms we have reached the inner sanctuary of Bacon's philosophy, and we must pause awhile and make a careful inspection. Let us begin by stating two propositions, one of which would be metaphysical and the other physical. That heat consists of violent irregular molecular movement is a proposition of Metaphysics. That mixing sulphuric acid with water generates heat is a proposition of Physics. The particular substances, water and sulphuric acid,

are the material causes; the process of mixing them is the efficient cause. The notions of material and efficient cause, as used by Bacon, are thus perfectly clear. But what does he mean by a formal cause? When we ask: "What is the formal cause of heat?" we are asking, not directly how to *produce* heat, but what heat *really is* in Nature apart from man and his sensations. "Heat itself," says Bacon, "its essence and its quiddity, *is* Motion and nothing else, limited however by certain specific differences." By the last phrase he means, e.g., that it is irregular and not periodic motion, motion of molecules and not of electrons or of molar masses, and so on. "Sensible heat," he says, "is a relative notion and has relation to man not to the Universe. It is correctly defined as merely the *effect* of heat on the animal spirits."

In order to make Bacon's view quite clear and self-consistent we must draw a threefold distinction which was cer-

tainly present to his mind but is never explicitly stated by him. This is the distinction between sensible qualities, physical properties, and metaphysical forms. The sensible quality of hotness is the characteristic quality which is revealed to a human being in sensation when he touches a hot body or is exposed to radiant heat. The metaphysical form of heat is violent and irregular molecular movement. But when a plain man says that a certain body is hot he does not necessarily mean that he or anyone else is receiving a sensibly hot feeling from it, and he certainly is not thinking of molecular movements. He means roughly that the body has the *power* to produce such a feeling in anyone who should touch it, that it has the *power* of expanding the mercury in a thermometer, and so on. This power, or faculty, or disposition is what I mean by the physical property of hotness. Now Bacon asserts that the "form" of any

“nature,” such as hotness, is always present when this nature is present and always absent when this nature is absent. It is evident that this would be a tautology if he identified the nature called *hotness* with the metaphysical form; and it would be a glaring falsehood if he identified the nature called *hotness* with the sensible quality. For the kind of movement which is the form of heat might be present in a body and yet the sensible quality of hotness might be absent because no sensitive organism was near enough to this body. I conclude then that, by a “nature” such as heat, weight, colour, etc., Bacon must mean a physical property, i.e., a power of producing certain kinds of effect under certain assignable circumstances, and among these effects sensations with a certain characteristic sensible quality in presence of a sensitive organism.

We come now to another important assertion which Bacon makes about

forms. The form of a given simple nature is not merely something which is always present when the nature is present and absent when it is absent. The form must in addition be "a limitation of some more general nature, as of a true and real genus." The form of heat, e.g., is one species of motion, viz., the violent irregular motion of molecules. The form of colour would be another species of motion, e.g., the periodic variation of electro-magnetic forces. And the form of redness would be a still more specific kind of motion, e.g., a periodic variation of such forces with its frequency confined within a certain narrow range. This is a vitally important point, for it marks the division between mediaeval and modern Natural Philosophy. A mediaeval physicist would recognise a large number of different powers in bodies, just as we do. But each of these powers would be for him a distinct and ultimate faculty. In this respect modern psychology, with all its



boasting, is in much the same position as mediaeval physics. For us these various powers of matter reduce to so many specific kinds of minute structure and movement. The whole progress of modern physics depends on the clear recognition of this fundamental fact; and the absence of any similar progress in psychology is due to our inability up to the present to conceive the faculties of the mind in similar terms.

Closely connected with the point which we have just been discussing is the principle which Mr Keynes calls that of *Limited Variety*. Mr Keynes rightly holds that this was recognised by Bacon and that it is essential for the vindication of inductive reasoning. Bacon is not indeed perfectly clear on this point. But there is no doubt that he asserts at least two different forms of this principle. In the first place, he definitely asserts that the same simple nature, e.g., heat, cannot be reduced in some cases (e.g., in fires) to one form,

and in other cases (e.g., in the heavenly bodies or in dunghills) to another form. He thus definitely denies that there can be a plurality of forms for a given simple nature. Secondly, Bacon says that "the forms of simple natures, though few in number, yet in their communications and co-ordinations make all this variety." It is clear that this is a different sense of the Principle of Limited Variety from that which we have just noticed. It needs, however, some further elucidation. Bacon has said that there is a one-to-one correlation between simple natures and their forms; it follows directly that there must be as many forms as there are simple natures. The explanation is, I think, as follows. By "simple natures" Bacon evidently means *generic* physical properties, such as colour, temperature, density, etc., in general. He does not include their specific determinations or particular values, such as brick-red, a temperature of 59° C., or a density of 2.73. Now the

number of unanalysable generic physical properties with which we are acquainted is quite small, though the number of specific modifications of each is very great, if not infinite. We describe any particular kind of substance, such as gold, and distinguish it from substances of all other kinds, such as silver, by mentioning its generic physical properties and stating the specific modification or value of each which is characteristic of the kind of substance in question.

This being premised, the rather vague statement of Bacon which I have quoted covers four distinct and vitally important cases of Limited Variety within the material world. (1) That the material world is composed of various kinds of substance, such that each kind can be distinguished from all the others by enumerating a comparatively small number of specific properties characteristic of it. This small selection carries with it all the rest of the properties of

the kind. E.g., gold can be completely distinguished from all other kinds of substance by mentioning that it is yellow in white light, that its density is 19.26, and that its melting point is 1062° C. Anything that has these few specific properties will have all the other specific properties of gold. (2) That the number of different kinds of material substance is comparatively small, and that the apparent multiplicity of kinds arises from the various proportions in which these few are mixed and compounded. (3) The various specific modifications of a single generic property, such as colour, often differ from each other in such a way that we can immediately recognise the differences but cannot reduce them to any one principle. E.g., we can immediately recognise the differences between red, blue, green, and yellow; but each of these differences is ultimate and incomparable with the others. Now, if the form of colour be a certain kind of periodic change, these

ultimate and incomparable differences between the specific colours reduce in the form to the single numerical difference of frequency. (4) The various generic physical properties, such as colour, temperature, etc., are wholly incomparable with each other and cannot be regarded as species of any one genus. But, if the form of colour be periodic motion of particles of a certain order of magnitude, and the form of heat be violent irregular motion of particles of a certain other order of magnitude, it is evident that there is a generic unity among the forms which is lacking among the simple natures themselves.

I do not suggest that Bacon clearly recognised and distinguished these four cases of the second form of the Principle of Limited Variety. But I have little doubt that he meant to assert them all. It is possible to adduce explicit statements for the second and the fourth. In the fragment called *Abecedarium Naturae* he says: "The nature of things

is rich . . . in quantity of matter and variety of individuals; but so limited in . . . species as even to appear scanty and destitute." And he constantly asserts that the doctrine of forms introduces a hierarchical unity into Nature which is otherwise lacking. He compares Nature to a pyramid, at the apex of which is something which he calls the *Summary Law of Nature*, though he doubts whether this is knowable to man. What is this but an expression of Bacon's personal conviction that the forms of all simple natures are specific modifications of a single generic form?

We now understand what Bacon meant by the Metaphysics of Forms. As he recognises, it is something very different from what has ordinarily been called Metaphysics. It is an empirical science, and is in fact what we should call the Theoretical Physics of the Microscopic World. The contents of Metaphysics in the traditional sense are distributed by Bacon between First

Philosophy and Natural Theology. Let us now consider the art of Natural Magic, which corresponds to the Metaphysics of Forms. Any physical process which induces a certain nature on a body must in fact do so by inducing the form of that nature. But so long as the form is unknown any practical method of inducing this nature can be discovered only by chance. It remains a mere isolated *recipe* which cannot be employed unless certain very special materials and conditions be available. If a man knew merely the rule that heat is produced by mixing sulphuric acid with water he could never produce heat except on the rare occasions when he had these materials to hand. But if he knew that violent molecular motion is the form of heat he would know that *any* way of generating such motion will produce heat, and that nothing else will do so. Thus a knowledge of forms enormously increases our practical control over Nature; it frees us from the

contingency and redundancy of rule-of-thumb methods. When we understand exactly what is essential to our purpose we can devise the simplest and most direct means and can avoid all that is irrelevant. In this way, and in this way only, Bacon thought that we might eventually solve the problem of the alchemists, viz., to transmute substances of one kind into substances of another kind. The characteristic properties of mercury depend on a certain complex form; those of gold on a certain other complex form. Now, if these two different forms be different specific modifications of a single generic form or be different mixtures of specific modifications of a few generic forms, we may hope eventually to convert the form of mercury into that of gold and so to transmute the one metal into the other.

The objects of the alchemists, says Bacon, are not absurd; what is absurd is their theories and the means by which they hope to reach their ends. Now



transmutation would be the *opus magnum* of Natural Magic; but any case in which we produce profound modifications in the properties of matter by deliberately using our knowledge of the forms of simple natures would be an instance of Natural Magic. Thus the Master of Trinity and the Cavendish Professor are profound Metaphysicians in Bacon's sense, whilst the Mendelians who produce new strains of wheat with desired qualities are eminent Natural Magicians. It must be remarked, however, that Bacon sometimes confines the name "magical" to certain types of physical process in which the material and efficient causes seem very trivial compared with the effect. Examples would be the use of catalysts or enzymes in quickening and improving the yield of chemical reactions, the breaking of great masses by repeated small blows of suitable periodicity, and the propagation of explosive waves in air which is full of inflammable dust.

Now Bacon holds that there is a branch of Physics which is very closely connected with the Metaphysics of Forms and with Natural Magic. This he calls the investigation of the *Latent Processes* and the *Latent Structure* of bodies. No body is ever at rest both as a whole and in its parts; what appears as rest is merely a balance of motions. The efficient and material causes which we recognise in daily life are merely the outstanding and easily perceptible phases in processes which are perfectly continuous and for the most part escape the senses. Every natural result depends on factors which are too small to be perceived by the naked eye, and no one need hope to govern Nature if he confines his attention to macroscopic phenomena. Bacon holds that our present knowledge of Latent Structure is very imperfect, but that our knowledge of Latent Process is far more so. Until we consider Nature in its dynamical as well as its

statical aspect we shall neither understand it theoretically nor control it practically. Bacon indeed refuses to call himself an Atomist. But this is partly because he takes the word "atom" in a very strict philosophical sense, and partly because he takes Atomism to include the doctrine that the spaces between finite bodies are empty of all matter. But it is clear that he accepted a molecular view of matter. Even in the curious tract *Temporis Partus Masculus*, where he deliberately lashes himself into a passion against all other philosophers, calls Plato a crack-brained theologian, and addresses Galen as "*O pestis, o canicula!*" he consents to praise Democritus with faint damns. In many other places he speaks very highly of Democritus, who of course enjoys the double advantage over Aristotle that we know much less about him and that his admirers never succeeded in making him a public nuisance.

The relation of the *Metaphysics* of

Forms and Natural Magic, on the one hand, to the research into Latent Structure and Latent Process, on the other, is as follows. Even if we have an adequate knowledge of the form of a simple nature we shall not be able to devise means of inducing it at will on a given body unless we know the Latent Structure of this body and the Latent Processes involved. On the other hand, a knowledge of Latent Structure and Latent Process will often extend our power of inducing a required simple nature on a body even though we are ignorant of the form of this nature.

I pass now to the third and last division of Philosophy, viz., the Science of Human Nature. This is first divided according as it is concerned with Man as an Individual or with Human Communities. Now the individual man is a composite of soul and body. Hence the Science of Individual Man splits into three parts, one concerned with Man as a composite whole, another with the

Human Body, and a third with the Human Soul. Now we can consider either the substance and faculties of the human soul or the right uses and objects of these faculties. The science of the former is Psychology; the latter constitute the subject of Logic, which deals with the right use of our cognitive faculties, and of Ethics, which deals with that of our conative faculties. Logic, in this wide sense, is the subject of Part II of the Great Instauration.

Logic falls into three great divisions. The human mind has both positive faults and negative deficiencies. The first business of Logic is to correct the former, and the second is to supplement the latter. When this is accomplished it can proceed to its main task of supplying the mind with a positive method of discovery. Thus Logic may be divided into a destructive, an auxiliary, and a constructive part. We will now consider these in turn.

There are certain innate sources of

error common to the human race. Bacon calls these *Idols of the Tribe*. The most important of them are the following. Men tend to impose certain human ideas of order, fitness, and simplicity on external Nature. They tend to notice facts which support their existing beliefs and to ignore or pervert those which conflict with them. The last thing that they think of doing is deliberately to seek for exceptions so as to try their beliefs as by fire. The human intellect is at once lazy and restless. It still tries to explain and analyse when it has reached what is ultimate and simple, and yet it is content to couch its explanations in terms of what is gross enough for the unaided senses to perceive. It is "no dry light," but is constantly affected by the will and the emotions. And, finally, it is given to reifying abstractions and to substantialising mere occurrents. Very closely connected in their effects with *Idols of the Tribe* are those of the *Market-Place*. These are the associations

of current words and phrases which have crept insensibly into the mind from infancy through our intercourse with our fellows. Words and phrases represent the analyses of facts which were made by our remote ancestors. Some of them are names for non-existent things or for inappropriate concepts based on bad observations and false theories. They are thus crystallised errors, all the more dangerous because we do not recognise that they embody theories at all. *Idols of the Cave* are innate or acquired sources of error or bias peculiar to individuals. It was, e.g., an Idol of the late Lord Kelvin's Cave to want all physical theories to be capable of representation by mechanical models. Naturally such Idols are too various to be classified. Bacon sums them up by saying that "whatever one's mind seizes and dwells upon with peculiar satisfaction is to be held in suspicion."

Bacon admits that the three kinds

of Idol just mentioned cannot be altogether eliminated. The best that Logic can do is to point them out to us and thus put us on our guard against them. But there is a fourth kind of Idol which is set up in the mind deliberately and wittingly after we have reached what are ironically termed "years of discretion." This kind is called *Idols of the Theatre*. They consist of false systems of Natural Philosophy, and arise through applying faulty methods of reasoning to inadequate or badly selected and arranged data. Such Idols can be eliminated, not by refuting the various false systems one by one, but by pointing out the many signs which are unfavourable to the claims of all of them, by giving directions for collecting and arranging an adequate Natural History, and by substituting correct methods of reasoning for those now in use. We have already seen how Bacon deals with the first and second of these tasks. The third leads us from the purely destruc-



tive to the auxiliary and constructive parts of Logic. Bacon sums up the destructive part by saying that a man can enter the Kingdom of Nature, like the Kingdom of Heaven, only by becoming as a little child. By a "little child" he means the ideal infant of Locke and Condillac, not the actual *polymorphe pervers* of the Psychoanalysts. His "little child," as he well knows, is not born but made by an elaborate process of mental polishing. Even when the first three Idols have been smoothed away from the mind as far as may be, the writings of False Philosophy remain on its surface. And here Bacon says definitely that the analogy to a waxen tablet breaks down. In a tablet we should shave the old writing off the surface before beginning to write anything new. But in the mind the traces of False Philosophy can be erased only by deeply engraving the letters of True Philosophy.

The auxiliary part of Logic consists

of three *Ministrations*, one to the Senses, another to the Memory, and a third to the Reason. The senses have two defects, one positive and the other negative. The positive defect is that there is always a subjective element in sensations; they represent things as they affect a particular organism in a particular place and not simply as they are in Nature. The negative defect is that the senses respond delicately only to a very narrow range of stimuli. They overlook what is very small or distant or swift or slow or weak or intense. Bacon holds that these negative defects can be largely overcome by the use of instruments and by other devices which he discusses very acutely in the *Novum Organum* under the name of *Instances of the Lamp*. The subjective element again can be eliminated by judicious comparisons between one sense and another and one percipient and another. The deliveries of the senses, when thus supplemented and neutralised, are the

solid and indispensable foundation of all scientific knowledge. But Bacon adds the extremely important remark that in a well-devised experiment the office of sensation is reduced to a minimum. "The senses," he says, "decide touching the experiment only, and the experiment touching the point in Nature and the thing itself."

The Ministration to the Memory consists of methods of recording observations and tabulating them so that they shall be available when wanted. For this purpose they must be classified from the very first. It is true that our first classifications will be very largely erroneous. But "truth will emerge more quickly from error than from confusion, and reason will more easily correct a false division than penetrate a confused mass." We must continually return to our tables and correct and re-classify our results as knowledge grows.

It is difficult to draw a sharp line between the Ministration to Reason and

the constructive part of Logic, so I will take them together. Reason may be used either for discovering plausible arguments to persuade others or justify oneself, or in order to understand and master Nature. For the former purpose the existing method of establishing wide generalisations from superficial and unanalysed facts by simple enumeration and then deducing consequences from them by syllogistic reasoning is admirably adapted. We may therefore leave barristers, politicians, preachers, and newspaper-editors in happy possession of so useful an instrument. But these methods are perfectly useless for a serious study of Nature which aims at practical control. For this purpose three fundamental changes are needed. (1) The data must be collected, arranged, and analysed according to the rules laid down in the *Parasceve* by men whose minds have been purged of the Idols and whose senses and memories have been corrected and sup-

plemented by the Ministrations already mentioned. (2) The order of procedure must be altered. We must not jump from particular facts to sweeping generalities and then deduce propositions of medium generality from these. The right process is a very gradual ascent from particulars through middle principles to the highest laws and a very gradual descent from these to new middle principles and finally to new particulars. At every stage of the upward process the generalisation is to cover the then known facts and to extend a very little way beyond them, and this small extension is to be tested by a fresh appeal to experience. Thus the ascending and the descending process, like the movements of the angels on Jacob's ladder, take place side by side; and the latter is the means of testing the validity of the former. Bacon does, however, allow to the weaker brethren an inferior method, viz., a direct passage from one experiment to

another partly analogous experiment. This he calls *Instructed Experience*. He enumerates eight general methods of Instructed Experience, such as applying the old process to new materials or, conversely, applying the same process a second time to the products of its first application (as in redistillation), inverting one of the agents (e.g., substituting cold for heat), and so on. And he makes extremely judicious observations on the fallacies to be avoided. He evidently holds that Instructed Experience is a useful preparation for the true method, which he calls the *Formula of Interpretation*, but that only the latter will lead to far-reaching discoveries and inventions.

(3) We must substitute for induction by simple enumeration a method which makes use of negative instances and arrives at truth by successive elimination of false alternatives. Our ultimate aim is to discover the forms of simple natures. But only God, and perhaps

the angels, can have a direct positive knowledge of forms; men must proceed by rejection and exclusion. Now the form of a simple nature will always be present when the nature is present, absent when it is absent, and varying when it varies. We must therefore draw up comparative tables of cases in which the given nature is present, of cases in which it is absent, and of cases in which its degree varies. We shall then know that the form cannot be anything that is absent in the first list or present in the second list or constant in the third list. By this means we may gradually eliminate all other natures and be left with the form which we are seeking.

It is evident that this is equivalent to Mill's Joint Method of Agreement and Difference, supplemented by his Method of Concomitant Variations. Bacon, like Mill, thought that results which are certain and not merely probable could be reached in this way. But he was far more alive to the difficulties than Mill.

We cannot be sure that the natures which we take to be simple really are so. And we have not at present any list of the simple natures in the Universe which is known to be exhaustive. Until these defects have been rectified no certain results can be reached, as Bacon clearly sees. Again, unless some means can be found for abridging our Tables the work will be endless; for the Table of Absence will be a mere hotch-potch of heterogeneous items. Bacon therefore enumerates nine "more powerful aids for the use of the understanding," which he promises to supply. But the promise is very imperfectly fulfilled. Only two of them are treated explicitly, viz., the *Theory of Prerogative Instances* and the *Rules for Preparing a Natural History*. The Theory of Prerogative Instances is designed to abridge our enquiries by teaching us how to choose such instances that a few of them will suffice to eliminate a very large number of suggested forms for the nature under



investigation. Bacon has lavished immense care and acuteness on this part of his work, which is full of admirable detail. But we miss the promised *Theory of Prerogative Natures*, which was to abridge enquiry still further by teaching us which subjects to investigate first because they "hand on a torch to those that come after" on account of their greater generality or certainty or use in practice. And most of all we miss the promised *Synopsis of all the Natures in the Universe*, without which it is evident that no method of successive elimination could ever lead to results that are both positive and certain. It remains only to notice that Bacon held that his method would need modification in detail according to the subject-matter to which it was to be applied, that it would itself develop as more things were discovered by its means, and that we may hope some day to apply it to Psychology and Politics as well as to inanimate nature.

I have now outlined to the best of my ability the Baconian philosophy. To those who know the state of scientific thought in Bacon's time and are capable of estimating philosophical achievement this bare account of his doctrines will be better praise than any studied panegyric. But we are here to bury Bacon as well as to praise him; so I will end with a very brief estimate of what he did and what he did not accomplish.

In the first place, we may set aside as of purely historical interest the attacks on Aristotle and the attempted delimitation of the spheres of reason and faith. We can afford to be fair to Aristotle, for his Natural Philosophy has ceased to be a nuisance and has become a museum-specimen embalmed in the rich spices of Oxonian erudition. It was no more possible for Bacon to be meticulously just to him than for an Englishman in 1812 to appreciate the finer shades of character of the Corsican Ogre. And, on the question

of reason and faith, those of us who have not personally been favoured with divine revelations have to estimate by ordinary human reason the revelations which are alleged to have been vouchsafed to others. The one test that Bacon suggests, viz., that the contents of a divine revelation may be expected to be shocking to reason, is obviously insufficient in a world so replete as ours with every form of fantastic lunacy.

Setting these points aside, let us ask and try to answer the following questions. (1) Was Bacon a great scientist who discovered new facts and established physical theories which form the basis of modern science? Most certainly not. As regards experiment and observation he "never said a foolish thing and never did a wise one." He seems to have been an incompetent but pertinacious experimenter; and in his *Natural Histories* he breaks all his own rules, copying quite uncritically a jumble of facts and fables from other writers. His

incapacity in mathematics prevented him from understanding the best work of his contemporaries, and *a fortiori* made it impossible for him to state or work out far-reaching physical theories himself.

(2) Granted that modern science does not owe any important facts or special theories to Bacon, does it derive its general methods and its general outlook on the world from him? This is a question of historical causation which must be answered with a decided negative. So far as I can see, the actual course which science has taken, even if it has been in accord with Bacon's principles and has led to the results which he desired and anticipated, has been influenced little if at all by his writings. I suspect that the popularity of the opposite view is due to the magnificent advertisement which Bacon received from D'Alembert and the French Encyclopaedists, who found it convenient to march into battle under

his ensign. If then Bacon be the father of the method and outlook of modern science he is so by spiritual affinity rather than by natural generation.

(3) Granted that Bacon's actual influence has been over-rated, did he in fact discover and state explicitly those methods and principles of scientific research and inductive proof which scientists implicitly use with so much success? It seems to me that the honours of stating these methods and principles are pretty evenly divided between Bacon and Descartes. Up to a point they cover much the same ground. There is considerable analogy between the destructive part of Bacon's method and Descartes' systematic doubt. Here Bacon can be praised without reserve; he discusses in far greater detail than Descartes the causes of human error and the remedies for it, and his treatment is exhaustive, profound, and illuminating. Again, Descartes, in the *Regulae*, agrees with Bacon in recognising the

importance of the Principle of Limited Variety. After this point the two methodologies diverge, and the truth is divided between them. Each is strong where the other is weak. Bacon is paralysed whenever he touches mathematics, pure or applied. He has no theory of mathematical reasoning and was ignorant of the swift advances that pure mathematics was making. He verbally recognises the importance of applied mathematics; but he failed to see how predominant a part mathematical statement and deduction must play in physics if anything like his theory of forms is to work. Here Descartes is strong with the strength of a man who has himself invented a method which in his own hands has revolutionised geometry and mechanics. On the other hand, Descartes is as helpless over induction as Bacon is over mathematical deduction. In his analysis of inductive arguments Bacon was, so far as I know, breaking new ground, and all later discussion has

followed on his lines. That the constructive side of his method is incomplete is admitted by himself. We can see that its main defects are the following. Under the most favourable circumstances possible Bacon's method of exclusions would not suffice to discover the form of a simple nature, but at most empirical laws connecting one simple nature with another. A form is not one among the physical properties which can be perceived to be present or absent in a thing; it is the hypothetical structural and motional basis of a perceptible property. It follows that forms can be established only by hypothesis, mathematical deduction of observable consequences, and subsequent verification of these by actual observation. Closely connected with this fact is Bacon's other great defect. He never clearly distinguished between approaching facts with a prejudice and approaching them with a working hypothesis. He is so anxious to avoid the

former that he fails to see that no progress can be made without the latter. Whewell's great contribution to the theory of induction was to point out the importance of the appropriate colligating concept and the fruitful working hypothesis. And these are just the points at which rules and methods fail us and the insight of individual genius comes into its own, though that genius must be trained in the methods and soaked with the facts of science.

(4) Lastly, did Bacon provide any logical justification for the principles and methods which he elicited and which scientists assume and use? He did not, and he never saw that it was necessary to do so. There is a skeleton in the cupboard of Inductive Logic, which Bacon never suspected and Hume first exposed to view. Kant conducted the most elaborate funeral in history, and called Heaven and Earth and the Noumena under the Earth to witness that the skeleton was finally disposed



of. But, when the dust of the funeral procession had subsided and the last strains of the Transcendental Organ had died away, the coffin was found to be empty and the skeleton in its old place. Mill discretely closed the door of the cupboard, and with infinite tact turned the conversation into more cheerful channels. Mr Johnson and Mr Keynes may fairly be said to have reduced the skeleton to the dimensions of a mere skull. But that obstinate *caput mortuum* still awaits the undertaker who will give it Christian burial. May we venture to hope that when Bacon's next centenary is celebrated the great work which he set going will be completed; and that Inductive Reasoning, which has long been the glory of Science, will have ceased to be the scandal of Philosophy?

( 67 )

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