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"Discovery" in Bacon's "Novum Organon"

"The understanding must not be supplied with wings, but rather hung with weights, to keep it from leaping and flying." (No. 1,104)

David Dykes

ベーコンの「新機関」に於る「発見」

デイビッド・ダイクス

Sir Francis Bacon is often thought of as one of the founders of modernism in Western science. It is also possible, however, to see him as a continuer and developer of various traditions of non-Socratic science that existed alongside the dominant scholastic learning of the Mediaeval and Renaissance periods. Bacon claims to differ from many other non-Socratics in that he refuses to work in the framework of a pre-imagined cosmic system. In fact his scientific theory is less original, and his practice considerably more tradition-bound than he would have us believe. His true originality is in his picture of "progress", which sees an open-ended advance in knowledge producing a similarly open-ended increase in the wealth and power of scientifically developed nations.

1. New lights for old

In textbooks and histories, sir Francis Bacon (1561-1626) is generally portrayed as a pioneer figure. This reputation was established for him by his admirers among the founders of the Royal Society (1660). The leaders of the French Enlightenment were similarly enthusiastic about Bacon's calls for open-mindedness and independence from the past, while they chose to ignore his political authoritarianism. Later critics have attacked him for such things as clinging to Ptolemaic astronomy, for failing to base his hypotheses on mathematics and for believing too readily in various kinds of magic. But in the aims he set for the sciences, at least on the theoretical level, most commentators still see one of the great intellectual innovations of the age. Bacon's name is a by-word for modernity.[1)]

Bacon might have been moderately happy to hear posterity's verdict on him, since, in the years just before his death, the prospects of his works being widely read did not seem good. Many years of searching for sponsors to implement his reforms had met with no success. The 1620's saw him feverishly publishing fragments and outlines of his "Great Instauration" of science in the realisation that what he did not accomplish himself would most likely never get done. His haste can be appreciated from the fact that so many of his major works were written simultaneously and finally left unfinished.

Bacon's writings are voluminous and varied. Here and there they include passages of palpable nonsense. Anthony Quinton cites the example from the posthumous "Sylva Sylvarum" that : "the heart of an ape, worn near the heart, comforteth the heart, and increaseth audacity."[2)] Sometimes, it seems, Bacon had more ideas in his head than time to sift them. But he is always aware that the true value of his work is not in the information he has to impart, but in the guidelines he is setting for future inquiry by others. His other, and better posthumous book, "The New Atlantis", purveys no information at all, but a vision of what might be done in science if only men would heed Bacon's suggestions. It describes a Utopia where continuous collective research into the laws of nature is promoted by an enlightened government. It is briskly to the point as well as imaginative : a Brave New World portrayed without a trace of irony. Not a trace, that is, with respect to the Atlantans themselves. For with respect to James I's England "The New Atlantis" is far from gentle. If the traveller is so amazed to find scientific work progressing smoothly under officials who place the public good above the

interests of bribe-paying individuals, it is because he is not accustomed to such blessings in his homeland.

All Utopias are fragile, of course, just as mirrors are. Their images are an inverted reflection of reality, and will never become true because men do not invert so easily. Even if a whole rising generation could share a single concept of "the common good" and then agree to work towards it, there would still remain the problem of what to do with those of the older generation who had devoted their lives to completely different ideals. Social conflict would be inevitable. And in the 1620's, with the 30 Years War raging on the Continent, conflict was the last thing any politically responsible person wanted to wish on religiously divided England.

But if fear of anarchy precluded the setting up of New Atlantises, it also worked against general approval of Bacon's scientific and educational ideas even among intellectuals. At times Bacon claims that the advance towards new kinds of knowledge can coexist peacefully with a respect for the old. But his very words as he makes the claim are intolerant and insulting :

> "There is no reason why the arts which are now in fashion should not continue to supply matter for disputation and ornaments for discourse, to be employed for the convenience of professors and men of business. . ."
>
> (NO, 1,128)

The professors in question might find it less than amusing that a life's work of serious disputation should serve no better end than providing witty anecdotes for use at business negotiations.

Rather than for an immediate large-scale implementation of his ideas, Bacon was really arguing for the minds of scholars and administrators of the future. He was thus justified in using all his rhetorical skill to make his own proposed reforms seem attractive, and the ways of the past seem inefficient and stultifying. Accordingly, we cannot expect to find exact proportion in his presentation of one or the other. The principle of objectivity often associated with Bacon's name applies to descriptions of natural phenomena and experiments, not to arguments of policy.

2. A Reformation of science

Innovators are often thought of as people who are brave enough to cast aside centuries of superstition and prejudice. Bacon is happy to be seen in this kind of way. The frontispiece of the "Instauratio Magna" shows a ship of discovery boldly sailing out between the Pillars of Hercules, symbolising the

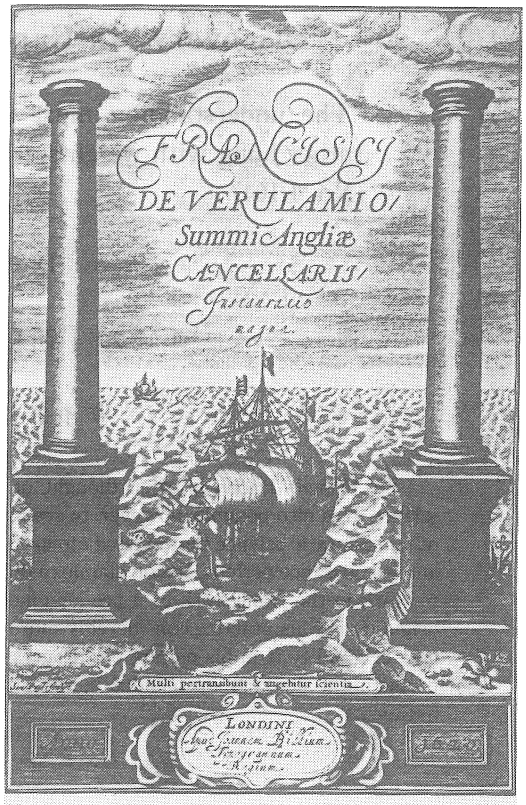

FIGURE 1.
FRANCIS BACON, *Instauratio Magna*, title page (1620).

geographical and intellectual limits of the classical world.[3]

Again, among Bacon's favourite quotations we find the following, which occurs prominently in both "The Advancement of Learning" and the "Novum Organon". It is Livy's description of Alexander undertaking the conquest of Asia :

> "Nil aliud quam bene ausus vana contemnere."
> ("All he did was dare to despise empty fears")
>
> (AL, 1,5,2. NO, 1,97)

This image of the scientist as an opener of new worlds is an inspiring one, but also an insidious one. It implies that the scientific past has been static and unenterprising.

In fact, scholasticism and its derivatives since Aquinas had had a very fertile history.[4] The adoption of Aristotelian physics by scholars of the 13th century, and the ingenious application of its principles to the Christian faith was a refreshing challenge to the transcendentalism of the earlier Middle Ages. Henceforth, the forms and causes of things were to be studied in conjunction with their material properties. No sooner had Aquinas achieved this delicate balance between the two traditions, but Scotus and then

Ockham upset it and started questioning whether "natural theology" could ever arrive at absolute conclusions unaided by revealed religion. This is precisely what Bacon asks, and denies, in "The Advancement of Learning", 2,6,1. This left the way open for natural philosophy to break free of its attachment to religion, and by the mid 14th century thinkers like Autrecourt were using logical arguments to prove that absolute certainty, even in physics, is unattainable if defined in the strictest sense. Two of the chief characteristics of Renaissance thought can be largely traced back to this kind of scholastic debate : firstly, increasing scepticism towards theories that explain too much on insufficient proof ; and secondly, the growth of interest in the immediate rather than the ultimate causes of things. These two characteristics are both strongly present in Bacon's attitude to science, as we shall see later. We may perhaps sympathise with his criticism of the Schoolmen's "small variety of reading" (AL, 1,4,5) which limited the scope of everything they said. But his sweeping assertions that Scholastic Aristotelianism failed to develop and bear fruit, and that from its start it steadily grew more and more divorced from the real facts of life (NO, 1,74), do not stand up to serious examination.

Bacon entirely, and no doubt deliberately, ignores the continuities in the history of Western thought. He prefers the theory of a kind of "triple leap" comprising Greece, Rome and the Renaissance as "hop", "step" and "jump" respectively, and expressly denies either the Arabs or the Schoolmen any significant part in the enterprise. (NO, 1,78)

This dubious line of argument is made easier for him by the Mediaevals themselves. Ibn Rushd (Averroes), the 12th century commentator through whom the Europeans came to rediscover Aristotelian physics, wrote in a famous preface that Aristotle had not only been the first to establish physics, logic and metaphysics as serious sciences, but that "when his works appeared, men turned away from earlier investigations and no one in fifteen hundred years (had) been able to add anything to them that (was) worthy of notice."[5] This claim is alluded to by Bacon in the "Novum Organon", 1,77, where he speaks of it as being "the general opinion".

One major ground that Bacon asserts for his own historical importance is that before him few men thought of rejecting the past. He compares himself in this to Alexander and Columbus (NO, 1,97/92), whom we remember not for having done things others were incapable of, but for having taken initiatives that others had never thought of. But we must not forget that this is rhetoric. Even if we agree to accept Bacon's opinion about scholasticism's lack of variety, and follow him in regarding it as an intellectual monolith badly in need of replacement, we cannot seriously believe that Bacon developed his reforming ideas in a cultural vacuum.

Though Bacon claims that scholastic Aristotelianism had few opponents and that even fewer of these displayed either stamina or system (NO, 1,81/82), the facts plainly contradict him. The rebel spirits may have been a minority, but they had enjoyed wide publicity, and still did. Far from lacking stamina, a few, like Bruno Giordano, endured martyrdom (1600) for their scientific beliefs. Others, like Campanella and Galileo, refused to remain silent even after being imprisoned (Campanella, 1594～) or restricted in their right to teach (Galileo, 1616～).

Nor was there any lack of system.[6] On the contrary, systems propounded in opposition to Aristotelianism were confusingly numerous. The spread of Greek and Hebrew scholarship in the 16th century led to a revival of the ancient non-Socratic philosophies and then to the birth of several new ones. The theory of a sun-centred universe was once again taken seriously, after centuries of near-oblivion. Pythagorean number mysticism inspired Kepler and Fludd in their mathematical schemes of astronomy. Archimedes deeply influenced Galileo. Various Greek beliefs about states of eternal flux between opposite forces reappeared in the hot-sun / cold-earth system of Telesio. Democritus' doctrine of atoms, vacuums and the play of chance was making a timid comeback, and was soon to find a strong defender in Gassendi. Jewish Cabala mysticism introduced new forms of Neoplatonism. There were also attempts to integrate widely differing religious and secular traditions into comprehensive schemes of natural knowledge or magic. Campanella's astrologically directed world, and Paracelsus' system of natural sympathies linking stars, minerals, plants, animals and men are two representative examples.

Bacon is aware of most of these traditions, and in one place claims to prefer the pre-Socratic Greek philosophers to Plato and Aristotle on the grounds that they never sought to open schools for self-glorification, but worked away at their investigations "more silently and severely and simply" (NO, 1,71).

But Bacon differs from most of the best known anti-scholastic philosophers of his day in his refusal to embrace any particular rival scheme of cosmology. His main criticism of Aristotle is not so much that his principles are the wrong ones, as that he has no business at all to be drawing up the first principles of science before he has collated individual data :

"There are and can be only two ways of search-

ing into and discovering truth. The one flies from the senses and particulars to the most general axioms, and from these principles, the truth of which it takes for settled and immovable, proceeds to judgement and to the discovery of middle axioms. And this way is now in fashion. The other derives axioms from the senses and particulars, rising by a gradual and unbroken ascent, so that it arrives at the most general axioms last of all. This is the true way, but as yet untried."

(NO, 1,19. Cf 1,63/64 and AL 1,5,8.)

This attack clearly goes beyond the bounds of any particular school. Apart from Aristotle, we find Bacon criticising the same kind of overhasty systematisation in Plato (NO, 1,65 etc), Gilbert (NO, 1,64) and Paracelsus (AL, 2,11,3). We should also note his condemnation of the opposite extreme : he criticises Democritus' overhasty denial that any systematic order exists (NO, 1,62) and the New Academy's denial that any can be knowable (NO, 1,75).

Bacon's own starting position, which he never properly discusses, seems to be a rather unself-critical empiricism. The evidence of the natural world is clear enough to persuade us that a principle of order exists, but too obscure for us to understand by immediate intuition what that order might be. (AL, 2,6,1)[7]

Bacon's mother was an unusually devout Calvinist, and it is sometimes suggested that Bacon's rejection of scientific authorities is partly Calvinist in inspiration.[8] Just as Calvin's theology placed little stress on the role of the Church as a historical Establishment and took as its starting point the plight of the individual man, lost and requiring grace, so Bacon's scientific methodology consciously shuns existing theory and starts from the assumption that men are ignorant of everything unless guided by nature :

"Man being the servant and interpreter of Nature, can do and understand so much and so much only as he has observed in fact or in thought of the course of nature. Beyond this he neither knows nor can do anything."

(NO, 1,1)

What Bacon was aiming at, then, was not a mere replacement of one brand of wisdom for another, but rather a conscious curbing of human wit, and especially imagination, as a creative agent in the search for truth, for :

"the strength and excellence of the wit has but little to do in the matter." (Instauratio Magna, Preface)

3. "The understanding hung with weights"

Here again, we must be cautious about judging Bacon's claims to originality, to be found in the Novum Organon 1,122 and elsewhere. Men of most schools of thought had long recognised the folly of adhering rigidly to too small a set of principles. However, before pursuing this objection, it would be as well to summarise the main points of Bacon's programme for the discovery of nature's laws.

In the "Instauratio Magna", Bacon speaks of the total reform of science being accomplished in six, partly simultaneous stages :

1. a new division of the sciences
2. the "Novum Organon" (directions for the interpretation of Nature)
3. the Phenomena of the Universe (natural and experimental histories)
4. the Ladder of the Intellect (practical detailed examples of stage 2)
5. "Forerunners" (provisional findings awaiting confirmation)
6. the "New Philosophy" or "Active Science".

Part one of this unfinished enterprise is represented by "The Advancement of Learning" (1605) and its Latin enlargement "De Augmentis" (1623). Though ultimately modelled on the existing scholastic classifications of knowledge, Bacon's division differs in several ways. It rigorously separates theological and worldly sciences. It places much more importance on natural history and rather less on moral history. It insists that the same natural laws should be sought behind phenomena in different sciences. But perhaps its two most challenging assumptions are, firstly, that science should constantly be expanding into new and unexplored areas and, secondly, that it should exist as a basis for action, not just contemplation. Bacon urges the example of the alchemists (though not their lack of system !), who call on scholars to "sell their books, and to build furnaces". (AL, 2,10)

Parts 3 and 5 of the programme never progressed far for lack of helpers and, especially, patronage. In the last years of his life Bacon did produce a handful of natural histories on topics such as "Life and Death" and "The Winds", but these were as nothing compared with the list of 130 he suggests in his "Preparative Toward a Natural and Experimental History". Together with this list he provides several pages of practical directives. Natural history should be as vast in scope as the universe itself, omitting nothing on account of its uncleanness or pettiness. Accounts should be first-hand where possible. Where not, the source of information should be precisely given. Measurements are to be preferred to estimates. Experiments should be exactly described so as to be repeatable. Doubts and unanticipated findings should be highlighted, never concealed. The way to resolve such problems is by more refined experimenting, not

by dispute or appeal to famous authorities. The best way to see all these precepts actually being applied in a cooperative undertaking that expands knowledge and yields considerable technical benefits is to read through "The New Atlantis".

The part of the Great Instauration for which Bacon is especially remembered is Part 2, represented by the "Novum Organon". Just as Aristotle's logical works, traditionally called the "Organon", were supposed by scholars to supply basic arguing techniques which could be applied over the whole scope of his scientific treatises, so Bacon's New Organon presented basic guidelines, though not for demonstrating so much as for discovering.

The difference between demonstrating and discovering is important. Aristotle's books of Analytics appear to be designed to help debaters argue convincingly the truth of previously established doctrines.[9] If so, the old and new Organons have different purposes and cannot directly be compared. Notice how we can rob Bacon's previously quoted words of much of their force simply by replacing his word "discovery" with "demonstration":

> "The one (way) flies from the senses and particulars to the most general axioms, and from these principles. . . proceeds to judgement and to the *demonstration*(*) of middle axioms."

In teaching (which is what Aristotle is doing) and in persuading (which is what readers of the Analytics are supposed to be studying), this kind of deductive approach to a subject is perfectly defensible. Bacon uses it himself in "The Advancement of Learning".

The charge against Aristotle, then, is essentially one of omission. He "demonstrates" what he has never properly discovered. Bacon's six-stage programme, on the other hand, clearly divides science up into areas of discovery (Parts 2 and 3) for the acquisition of knowledge, and of demonstration (Parts 4 and 5) for its dissemination and application. Whether this division is really absent in Aristotelian science is a question that will be touched upon presently.

Bacon's method of discovering scientific truth is simple, though very laborious. In modern parlance, it boils down to information-gathering and information-processing. He sees natural laws as the logical apexes of vast piles of data. The slow but sure way to reach them is to:

> "rise from particulars to lesser axioms; and then to middle axioms, . . . the true and solid and living axioms, on which depend the affairs and fortunes of men; and above them again, last of all, those which are indeed the most general; such, I mean, as are not abstract, but of which those intermediate axioms are really limitations."
>
> (NO, 1,104)

In another, very famous image, we are told that the true scientist resembles neither the ant that merely gathers, nor the spider that spins flimsy cobwebs out of its own substance, but the bee that "gathers its material from the flowers of the garden and of the field, but transforms and digests it by a power of its own." (NO, 1,95)

The "digesting", we would say "processing", of data involves examining a given phenomenon in as many different occurrences, and under as many sets of conditions as possible, and then analysing the tabulated findings so as to pin-point significant similarities and differences, which will be made the object of further research. Bacon's inductive researcher will thus be in a position to "analyse nature by proper rejections and exclusions; and then, after a sufficient number of negatives, come to a conclusion on the affirmative instances." (NO, 1,105) In other words, research is a matter of eliminating false hypotheses until only the empirical truth remains.

To reduce the gap between empirical truth and absolute certainty, research conditions have to be made as near-perfect as possible. Wide-ranging and detailed natural histories are a necessity. So are reliable accounts of previous investigations: these should be complete enough to allow other scientists to repeat and verify them. Refined experimental skills also have to be developed, since "the secrets of nature reveal themselves more readily under the vexations of art than when they go their own way." (NO, 1,98)

The Second Part of the "Novum Organon" consists mainly of an extended example of Baconian research (NO, 2,11-20), followed by numerous suggestions of the kinds of techniques that might most readily vex nature into revealing her secrets. The example, the closest Bacon ever came to executing Part 4 of his programme, is an enquiry into the nature of heat. Although his "data" strike us today as unregenerately Aristotelian in certain places (as when heat and cold are regarded throughout as separate phenomena: NO, 2,13,36 etc.), he does finally come out with a definition different from Aristotle's and surprisingly close to ours: heat is a kind of expansive motion. Perhaps Bacon was lucky in the choice of his example. If he had taken it from biology or astronomy, his reputation as a practising scientist might have collapsed as quickly as Descartes', who "proved" in defence of his Method that blood circulation was not caused by the pumping of the heart.[10]

The catalogue of useful experimental techniques, with examples of their application, (NO, 2,21-51) is also a mixed bag. It includes much that is wise and subtle, for example the suggestions for investigating

the nature of tides (NO, 2,36). But it also abounds in the kind of imaginative leaps that Bacon warns others about. Very occasionally, such a leap may bring him very close to an undreamt of truth. One example is when he notices correspondences in the shapes of the continents on either side of the Atlantic. (NO, 2,27) But more often it lands him in futilities such as this one: ". . . the hairs of animals are not generally so beautiful and of so vivid a colour as the feathers of birds, viz., because the juices do not filter so finely through skin as through quills." (NO, 2,27)

To be fair, we should remember that Bacon lays no claim to infallibility. In any case, as he points out, the value of his programme of discovery does not depend on the truth of particular data. His method, in the long run, is self-correcting:

> "There will be found, no doubt, when my history and tables are read, some things in the experiments that are not quite certain, or perhaps that are quite false. . . . But this is of no consequence, for such things must needs happen at first. . . . they will presently, by the discovery of causes and axioms, be easily expunged and rejected."
>
> (NO, 1,118)

What is to be judged is not Bacon's observations, but the principles behind his method, which he summarises for us (NO, 1,130) in two maxims:

1. "to lay aside received opinions and notions"
2. "to refrain the mind for a time from the highest generalisations, and those next to them."

4. "Altogether a pioneer"(?)

One reason why Bacon is irritating to 20th century readers is that he is lacking in "author's modesty". We have already seen him compare himself with Alexander and Columbus. Even his occasional outbursts of "humility" have a way of becoming self-praise:

> "If there be any that despond, let them look at me, that being of all men of my time the most busied in affairs of state, and a man of health not very strong (whereby much time is lost), and in this course altogether a pioneer, following in no man's track nor sharing these counsels with anyone, have nevertheless by resolutely entering on the true road, and submitting my mind to Things, advanced these matters, as I suppose, some little way."
>
> (NO, 1,113)

Perhaps a man like Bacon, who achieved so many things in so many areas of life, has a real right to speak this way. Our purpose is only to point out that many of his writings, in particular the First Part of the "Novum Organon", routinely magnify Bacon's own achievements while distorting and belittling those of others.

With this in mind, we may question the originality of both of the two maxims quoted above as being the core of Bacon's method. We may also question whether Bacon always remains true to them himself.

The maxim of "laying aside received opinions", as has already been said in section two, is a commonplace of the age. Let us also note in passing that one of the characteristic ways Aristotle has of introducing a discussion is to mention what previous philosophers have said on a topic, and then refute it by appealing to experience or intuition.[11] This is not quite the same as what Bacon means, but nor is it entirely different.

In practice, Bacon himself often fails to discard the preconceptions of earlier thinkers. And some of his attacks on new alternative theories, especially those of Copernicus and Gilbert, place him in the reactionary camp. Admittedly, it is only hindsight that tells us this.

Taking the second, and more important maxim, that of refraining from premature generalisations, we must certainly allow that most of Bacon's predecessors had transgressed against it. Nevertheless, it is possible to find cases before Bacon of meticulous observation leading to unprejudiced findings. Mathematically based research (of which Bacon is suspicious, however: NO, 1,80) provides the clearest examples. The dispute about the perfect sphericality of the moon, which followed the appearance of Galileo's "Sidereus Nuncius" in 1610, was essentially a debate on whether observation should have precedence over traditional truths. Galileo's investigations into acceleration of balls on an inclined plane, and his father's work in correlating musical pitch with string length and tension are further examples.[12]

But once again, let us note that the germ of Bacon's idea can easily enough be found in Aristotle, in spite of Bacon's loud claim to the contrary in the "Novum Organon", 1,63:

> ". . . he did not consult experience, as he should have done, for the purpose of framing his decisions and axioms, but having first determined the question according to his will, he then resorts to experience . . ."

Now Aristotle does undeniably have this inclination, as we see in the "Generatio Animalium" where the "hot", "noble" and "formative" male principle is superior to the "cold", "base" and "inert" female one.[13] But the "Historia Animalium", compiled by Aristotle's school if not necessarily by himself, is an example of comparative objectivity. It opens with a

sweeping review of various types of animals : runners, creepers, swimmers, fliers ; social, gregarious, solitary ; day animals, night animals ; blooded, bloodless ; egg-laying, viviparous. The aim of this opening is not to argue for some preconceived classification scheme, but to illustrate the fact that all the more obvious categories overlap. In face of such confusion, the editor resorts to proto-Baconianism. His aim will be :

> "to determine first of all the differences that exist and the actual facts in the case of all of them. Having done this, we must attempt to discover the causes. And, after all, this is the natural method of procedure — to do this only after we have before us the ascertained facts about each item, for this will give us a clear indication of the subjects with which our exposition is to be concerned and the principles upon which it must be based."[14]

These are mere words of course, and it is possible to maintain, with Bacon, that Aristotle "determined the question"beforehand. But it could equally well be argued that Bacon determined in advance the result of his own investigation of heat in the "Novum Organon", Part 2. It is even quite likely that he did.

The "Historia Animalium" is not an isolated case. The "Meteorologica", dealing with atmospheric phenomena, is clearly based on systematic observations of nature, and the psychological treatises appeal frequently to common experience. If we contrast Aristotle with the more transcendental Plato, it is even possible, with a little licence, to place him at the head of an empirical tendency in philosophy, of which Bacon is the heir.

Thus, if we penetrate the surface of Bacon's rhetoric, we find that his methodological principles in themselves are far from new.

5. The fruits of tradition

One final claim of Bacon's must be qualified before we pass to a conclusion. Bacon promises mankind a new science characterised by light and fruit. By "light" he means pure knowledge and by "fruit" useful technical applications. (NO, 1,121 etc.) The "New Atlantis" shows an ideal world whose main organising principle is the gaining of this light and fruit. In contrast, scholastic Aristotelianism brings darkness and sterility :

> ". . . when the rational and dogmatic sciences began, the discovery of useful works came to an end."
>
> (NO, 1,85)

It is true, no doubt, that the dominance of Aristotelianism held up the advance of practical science in many respects. But it is not true that it had no useful contributions of its own to make. Aristotle's great strength as a practical scientist was in biology, a field Bacon is not at home in. Aristotle's analysis of anatomical and behavioural phenomena in terms of their assumed purpose helped shape much later concepts of evolution, organic growth and education. But the same kind of approach to scientific investigation in Bacon's time was as productive in physiology as the methods of experimentation and measurement were in physics and astronomy. Let us take the example of William Harvey.[15] Besides being the most successful English researcher of the age (in terms of results), he was also Bacon's personal medical consultant. His discovery of the circulation of blood was announced in 1616. In the "Novum Organon" (1620) Harvey's name is conspicuously absent.

Harvey once told John Aubrey that for a sound education he should "go to the Fountain-head, and read Aristotle, Cicero, Avicenna, and did call the Neoteriques shit-breeches". Therefore, we need not be surprised to hear that his philosophy differed from Bacon's :

> "He had been physician to the Lord Chancellor Bacon, whom he esteemed much for his wit and style, but would not allow to be a Philosopher."[16]

Harvey did not see the Aristotelian sciences, as Bacon put it, "thriving most under their first founder, and then declining." (NO, 1,74) For him, Aristotelianism was a valuable base to build upon, though he accepted that it required modifications in the light of recent anatomical findings. Harvey himself was continually engaged in dissection experiments. Among other research, he repeated Aristotle's studies of chick embryos.[17]

It was essentially the Aristotelian scientific method that led Harvey to envisage the possibility of blood circulation.[18] Starting from Italian discoveries of the imporosity of the inner walls of the heart and the presence of valves in the veins, he simply asked : what are these things for ? Bacon specifically condemns this kind of explanation by "final causes" : it "rather corrupts than advances the sciences, except such as have to do with human action." (NO, 2,2) But it is frankly difficult to see Bacon's data-correlation method working in this instance, since the principle datum of all, the flow direction of the blood in a living body, could not be independently ascertained in the 17th century. An imaginative leap was necessary.

It would be nonsense to suggest that Harvey was a typical Aristotelian of his day. He was an original thinker who dissociated himself from received teachings when persuaded to by powerful evidence. He was up to date with the most modern advances in anatomy. But if he was far from being one of the carica-

ture Aristotelians that Bacon loves to write about, he was also a very long way from being a self-sure Baconian. Aubrey hints as much :

> "Why, had he been stiff, starched, and retired, as other formal doctors are, he had known no more than they. From the meanest person, in some way, or other, the learnedst man may learn something. Pride has been one of the greatest stoppers of *the Advancement of Learning*."[19]

6. The rhetoric of discovery

It may seem that this essay has attempted to strip Bacon rather too bare of his reputation as an innovator. This is because we have been considering him purely as a theoriser, whereas in fact he was also a propagandist. Harvey had some justification in not allowing him to be a great Philosopher. He is too erratic and uneven. He starts many books and finishes few. In some areas he is overcredulous, in others needlessly negative. Despite his calls for scientific cooperation, he works alone, and does not acknowledge other people's efforts in the way Galileo does. He criticises the natural histories of the past for not presenting their contents "duly investigated, verified, counted, weighed or measured" (NO, 1,98), yet never publishes quantified accounts of his own experiments. Even his model investigation of heat relies entirely on such vague terms as "hotter", "colder", "become hot" and "become cold". Contrast this not just with Galileo, but with Aristotle's careful diagrams of rainbows in the "Meteorologica".[20]

But Harvey was also right to esteem Bacon for his "wit and style". Oddly, these are accomplishments that Bacon claims not to rate highly : "The strength and excellence of the wit has but little to do in the matter." (Instauratio Magna, Preface) "Here, therefore, is the first distemper of learning, when men study words and not matter. . ." (AL, 1,4,3) But in fact, wit and words are of great practical importance, as Bacon, the life-long professional lawyer and parliamentarian, is well aware.

Rhetoric, in the classical tradition, was a means for producing or preventing change in public life. This was still held to be its purpose in Bacon's day. Mark Antony's "Friends, Romans, Countrymen" speech was written in his lifetime. Bacon was a man of enormous eloquence, who applied his skill with words to the hard task of changing attitudes. His audience were not so much the full-time academics, but the wealthy and ruling class in general, and political office-holders in particular. That is why, in the "New Atlantis", he is at pains to make his model state not just wise, but wealthy, peaceful and prosperous.

Intricate tables of data leading to precise conclusions do not necessarily make the best rhetoric. This is perhaps one reason why Bacon avoids them. Instead, he conveys the main ideas of his method in subtly intoxicating imagery. The images often succeed precisely because they go unrecognised. Scholasticism "flies" from the senses and particulars to the most general axioms: this is the myth of Icarus, which recurs repeatedly in the "Novum Organon", though never by name. I have chosen it for the title of this essay. A contrasting image is the mountain of knowledge, and the true path "rising by a gradual and unbroken ascent, so that it arrives at the most general axioms last of all". Though explicitly describing data-processing, Bacon is also using language that evokes moral excellence and civic achievement.

The theme that comes across most strongly to the reader of Bacon's scientific works is that of progress, especially social progress. In Aristotle's works, physics and metaphysics help us to understand our place in the world, far removed from either the highest or the lowest classes of being, and to find peace from contemplating the great whole of which we are part. But in Bacon, the ends of the scale are unknown. Or, if we know them, we know them as words only, not as experienced realities. Contemplation is impossible except to visionaries. Life is a matter of advancing in search.

As men find new realms to discover — across the ocean, in space, or simply hidden by the roadside — they also accumulate new powers, riches and comforts. Another great attraction of Bacon's rhetoric is that it promises "fruit-bearing" discoveries to follow the "light-bearing" ones. Indeed, the "first-fruits" are promised long before perfect light is attained.

From Bacon's prose we feel a sense that Knowledge and Power are the same (NO, 1,3), just as the 16th century voyages of discovery had simultaneously been voyages of treasure-seeking.

Images of moral and social improvement were familiar to the people of the Renaissance age. They were the legacy of Greece and Rome. But for these old images to be associated with ideas of money and power was less conventional. Machiavelli, whom Bacon admired, was still something of a forbidden author. Bacon's "Essays" were among the earliest respectable books in England to show his clear influence.

The great surge in Bacon's popularity after the 1660 Restoration doubtless had something to do with the fact of an English king trying to create, on the French model, a national ideology that combined ostentatious wealth, centralised power and state-protected culture, as symbolised in institutions like the Royal Society.

Bacon's vision of firmly directed progress was embraced by the governing classes of this reborn but fragile monarchy. Ideas that encouraged unity and prosperity were in demand after twenty years of civil strife. Unfortunately, Bacon could offer no very precise method for discovering how this new concentration of power and science was to be controlled for the general good of nations. Instead, he leaves us his optimism :

> "Only let the human race recover that right over nature which belongs to it by divine bequest, and let power be given it ; the true exercise thereof will be governed by sound reason and true religion."
>
> (NO, 1,129)

—Charles II and Louis XIV would no doubt agree.

Notes

1. For a very recent discussion of Bacon's alleged "modernity", see Charles Whitney, "Francis Bacon and Modernity", Yale U. P., 1986.
2. Anthony Quinton, "Francis Bacon", Oxford U. P. (Past Masters Series), 1980, p.20.
3. Reproduced from Whitney, op. cit., p.34.
4. This paragraph draws on Julius R. Weinberg, "A Short History of Medieval Philosophy", Princeton U. P., 1964, chaps. 8-12.
5. Weinberg, op. cit., p.129.
6. This paragraph draws mainly on C. A. Patrides and Raymond B. Waddington, "The Age of Milton", Manchester U. P., 1980, pp.202-233. Also Tommaso Campanella, "La Cittã del Sole", tr. Daniel J. Donno, University of California Press, Berkeley, 1981, pp.1-21.
7. This relative complacency is matched by a similarly complacent assumption that our senses, though often misled, do not lie. (NO, 1,67) Most modern scientists make these same assumptions, of course.
8. Quinton, op. cit., pp.10-11.
9. According to D. J. Allan, "The Philosophy of Aristotle", Oxford U. P., 1970, p.99.
10. René Descartes, "Discours de la méthode", Librairie Générale Francaise ("Le Livre de Poche"), Paris, 1973, pp.145-154.
11. Allan, op. cit. p.25, p.37, etc..
12. Stillman Drake, "Galileo", Oxford U. P. (Past Masters Series), 1980, pp.23, 33. Note that observational studies of musical tone have an ancient history: Plato makes fun of them in "The Republic", 531 b (Penguin Classics, Harmondsworth, second edition, 1974, p.340).
13. Aristotle, "Generatio Animalium", Loeb Classical Library, Harvard U. P., 767,a.
14. Aristotle, "Historia Animalium", Loeb Classical Library, Harvard U. P., 491,a.
15. For Harvey, see Patrides and Waddington, op. cit., pp.219-223.
16. John Aubrey, "Aubrey's Brief Lives", ed. Oliver Lawson Dick, Penguin English Library, Harmondsworth, 1972, p.288.
17. Aubrey, op. cit., pp.286-287.
18. Patrides and Waddington, op. cit., p.223.
19. Aubrey, op. cit., p.288. (My italics)
20. Aristotle, "Meteorologica", Loeb Classical Library, Harvard U. P., 3, 4-5.

Bibliography

sir Francis Bacon :

"The New Organon",
ed. Fulton H. Anderson, Bobbs-Merrill, Indianapolis, 1960. (Reprint of the standard Spedding translation, Vol.8. Contains "The Great Instauration", "The New Organon" and "Preparative Toward a Natural and Experimental History".)

sir Francis Bacon :

"The Advancement of Learning" and "New Atlantis", ed. Arthur Johnston, Oxford U. P., 1974.

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