Bacon's last egg?—the Exploratory

Francis Bacon (1561–1626) is still remembered in Popes's words as the "wisest, brightest, meanest of mankind". But, when one thinks of Bacon's achievements in his lifetime and how much he left to us, this seems a mean appraisal. His chief crime seems to have been that his judgements, as Queen Elizabeth's Keeper of the Great Seal and Lord Chancellor, were not affected by bribes. The distinction between bribes and fees was probably less clear-cut than now. In any case he died in debt. Quite apart from his formidable legal and political careers Francis Bacon was a considerable literary figure, as he perfected the Essay form; and as a philosopher he virtually invented modern Scientific Method, which he saw as essentially based on Inductive procedures for generating knowledge from many exploratory and some carefully chosen critical observations. He stressed the importance of tests, at 'crossroads' of possibilities, hence 'crucial', or cross-like experiments. He urged the importance of making effective use of discoveries and devising processes and machines for the general good of mankind. Perhaps his greatest contribution was to invent the concept of cooperative research for generating knowledge, as an alternative to, or at least an essential extension of, individual intuitions. This was a fundamental break from Plato's notion, which permeated the Middle Ages, that we are born with all knowledge but lose it more or less at birth; and to become wise we have to retrieve the lost knowledge as intuitions to be found only through philosophy and artistic training. For Plato truth and wisdom are intuitions available only to a very few specially trained individuals of an elite. By contrast, Bacon thought of science as knowledge built up cumulatively, piece by piece, and generally by many small contributions based not so much on special intuitions as on planned experiments, that in his words, "will level men's wits". He made no sharp distinction between science and technology, and he was a martyr to both, as he died from a cold following freezing a chicken for experimental purposes on Hampstead Heath.

It is generally thought that Bacon underestimated the importance of mathematics and that this tarnished his reputation, as the powerful Platonic tradition of his time, as well as almost all scientists of the highest standing since, revere mathematics as 'The Queen of the Sciences'. There are, however, such truly notable exceptions as the greatest laboratory experimentalist, Michael Faraday, and the greatest observer and theoretical biologist, Charles Darwin, for whom mathematics was not important.

Mathematics has, however, always been very generally accepted as the golden justification of individual intuition and the purest source of knowledge. Practical successes, perhaps especially of geometry, were for two thousand years accepted as justifying mathematical intuitions, unsullied by observation or experiment, as not only beautiful in their own right, but also as sometimes applying with precision and generality beyond any possible measurements to the world we perceive but imperfectly with our senses. Newtonian science substantiated powers of mathematics entirely undreamed of by Bacon; but it did, fairly clearly, depend on observations and measurements. This was not evident in geometry, which seemed to be pure intuitions—right up to the invention of alternative non-Euclidian geometries which revealed that there are hidden empirical assumptions in the Euclidian axioms. This, at a stroke, destroyed the long-standing claim that intuition provides pure knowledge, without a basis of perception, of measurement, or of experiment. Indeed non-Euclidian
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geometries challenged not only the claims of mathematical intuition, but very generally the basis of metaphysics, as geometry had been the prime example of intuition which seemed to justify claims of metaphysical thinking as providing knowledge without observations or experiments. So non-Euclidian geometries destroyed the heart of Platonism, and justified Bacon. They also raised the status of working hypotheses from mere speculative guesses to what science, and also perhaps perception, is about. This allowed science to be as Bacon saw it, an exciting activity for very many people to extend knowledge far beyond the understanding of any one individual’s learning and intuitions. It allowed technology to develop, until now knowledge is stored more in our possessions than in mind. This makes it possible to drive a car without understanding what makes it go, or stop. It is amazing how little we understand as knowledge has become embodied in tools, devices, engines, and now computers which can only be designed by other computers. Surely though, it is fun and it can be useful to understand and see how things work! It is more difficult now than it used to be, as modern mechanisms are hidden from sight and electronics works by invisible processes. So knowledge available only to a few elite individuals, which Bacon so rightly disliked, is coming back now—paradoxically through the success of the programme of shared research which Bacon hoped would “level men’s wits”. In some ways of course it has; but will this continue, now that most of technology is out of sight, if we don’t make an effort to help people to see for themselves how things work?

Our perceptual and imaginative limitations, as well as something of the relations between them which are still largely mysterious, were recognised by Bacon. He says of the senses (in the Novum Organum, 1620, Book 1 Section vi):

“By far the greatest hindrance and aberration of the human understanding proceeds from the dullness, incompetency, and deception of the senses .... Hence it is that speculation commonly ceases where sight ceases; insomuch that of things invisible there is little or no observation”.

Somewhat curiously the newly invented optical instruments were not for Bacon much help, except (as we might put it following Thomas Kuhn) when used for testing possibilities within conceptual paradigms. Bacon may well have been right. He said of this, more elaborately (in a following passage in the Novum Organum):

“For the sense by itself is a thing infirm and erring; neither can instruments for enlarging or sharpening the senses do much; but all the truer kind of interpretation of nature is effected by instances and experiments fit and apposite; wherein the sense decides touching the experiment only, and the experiment touching the point in nature and the thing itself”.

The classical Greek philosophers were attacked by Bacon as mere logic-choppers, who made no real progress and so left us in the dark. But surely he was less than fair to Aristotle, who extolled observation and also (though less widely appreciated) gave considerable weight to Inductive generalisations as well as the syllogistic forms of Deductive argument he invented. Nevertheless, Bacon criticised Aristotle (Aphorisms, 1620, Book 1, 98) for: “corrupting natural philosophy by his logic; fashioning the world out of categories”; even though Aristotle did say of Inductive generalisations that (Analytica Posterioria, Book A, 87b): “The universal is valuable because it shows the cause, and therefore universal knowledge is more valuable than perception or intuitive knowledge”. This is remarkably close to Bacon’s own philosophy, while it is equally distant from Plato’s, though Bacon criticises them equally.

Aristotle had a stranglehold in Bacon’s time, so possibly his unfairness here was justified. However this may be, Bacon rejected, surely too cavalierly, both in The Advancement of Learning of 1605 and in the Novum Organum of 1620, the manner of enquiry of the Greeks as too static, and so ineffective that according to Bacon
(in the preface to De Interpretatione Naturae): "The knowledge that we now possess will not teach a man even what to wish". Can this be justified? Bacon was reacting against his too simple view of Greek philosophers when he urged—and surely the pioneering Greeks would have agreed—that discovery and learning should be by active exploration, as in ship's voyages. He accepted the dangers as well as the benefits to be gained by active exploration. In the 'Essay on Boldness' he passes on Demosthenes's advice for learning and teaching:

"Question was asked of Demosthenes, what was the chief part of an orator? He answered, action; what next? action; what next again? action".

Bacon had bad luck in his own lifetime, and he is still sadly misrepresented though he wrote with admirable clarity. Thus, it is commonly said that he espoused Induction by Simple Enumeration of instances as the sole way of gaining knowledge; but this does not at all match Bacon's ideas as expressed very clearly in his major work the Novum Organum, meaning the 'New Instrument' for generating knowledge. Here he proposes: 'Tables of Invention' to derive 'minor generalisations' for suggesting general or universal Laws whose validity and range should be tested by experiments. He described 'crucial' experiments, as like crossroads, requiring choices of which road to take, and these crucial decisions were clearly more important for him than building inductions by enumeration of instances; though Bacon did criticise his contemporaries—with the notable exception of William Gilbert whose De Magnete of 1600 set experimental standards which Bacon recognised—for not repeating observations, or experiments, adequately for gaining reliability. Though he stressed many times the vital importance of crucial experiments and observations this is, amazingly, ignored in recent highly influential accounts of Bacon's methods of cooperative discovery by people of limited understanding for generating knowledge and inventions.

Not nearly so well known as the Novum Organum of 1620, is Bacon's New Atlantis which appeared unfinished in 1627, the year after his death. The New Atlantis is an imaginary country, based on America, where he describes a civilization of pre-Socratic origin which avoided what he saw as the stultifying effects of Greek thinking. It is, however, a Christian civilisation. Most important is its House of Salomon. Established as he imagines before Greek philosophy, it presents the wonders of science and technology to the people so that they can learn by exploring for themselves. No doubt Bacon hoped that such an interactive Science Centre would be founded in his time.

Bacon's House of Exploration is his last Golden Egg. Could it be laid in England today? He describes many houses, some being caves, and towers miles high, in which are presented for individual exploration technologies and knowledge of all kinds. Perception is included:

"We have also perspective-houses, where we make demonstrations of all lights and radiations; and of all colours; and out of things uncoloured and transparent, we can represent unto you all several colours; not in rain-bows, as it is in gems and prisms, but of themselves single. We represent all multiplications of light, which we carry to great distance, and make so sharp as to discern small points and lines; also all colorations of light: all delusions and deceits of the sight, in figures, magnitudes, motions, colours: all demonstrations of shadows. We find also divers means, yet unknown to you, of producing of light originally from diverse bodies. We procure means for seeing objects afar off; as in the heaven and remoter places; and represent things near as afar off, and things afar off as near; making feigned distances. We have also helps for sight, far above spectacles and glasses in use ... . We make artificial rainbows, haloes, and circles about light. We represent all manner of reflexions, refractions, and multiplications of visual beams of objects ...."

"We have also sound-houses, where we practise and demonstrate all sounds and their generation. We have harmonies which you have not, of quarter-sounds, and lesser slides of sounds ... . We represent and imitate all articulate sounds and letters, and the voices of and notes
of beasts and birds. We have certain helps which set to the ear do further the hearing greatly. We have also means to convey sounds in trunks and pipes, in strange lines and distances."

"We have also perfume-houses; wherewith we join also practices of taste. We multiply smells, which may seem strange. We imitate smells, making all smells to breathe out of other mixtures than those that give them. We make divers imitations of taste likewise, so that they will deceive any man's taste."

"We have also engine houses. Also fire works for pleasure and use. We imitate also flights of birds; we have some degrees of flying in the air; we have ships and boats for going under water, and brooking of seas; also swimming-girdles and supporters. We have divers curious clocks, and other like motions of return, and some perpetual motions. We imitate also motions of living creatures, by images of men, beasts, birds, fishes, and serpents."

"We have also a mathematical house, where are represented all instruments, as well of geometry as astronomy, exquisitely made."

"We have also houses of deceits of the senses; where we represent all manner of feats of juggling, false apparitions, impostures, and illusions; and their fallacies. And surely you will easily believe that we have so many things truly natural which induce admiration, could in a world of particulars deceive the senses, if we would disguise those things and labour to make them seem more miraculous."

The House of Salomon has a structured staff of researchers and demonstrators, including Merchants of Light who traffic in knowledge. Then there are "three that collect the experiments of all mechanical arts; and also of liberal sciences; and also of practices which are not brought into art. These we call Mystery-men." Then there are experimenters, called Pioneers or Miners; and three that draw the experiments into "titles and tables, to give the better light for the drawing of observations and axioms out of them. These we call Compilers." Then there are Dowry-men or Benefactors, who "cast about how to draw out of them things of use and practice for man's life and knowledge as well for works as for plain and demonstration of causes."

Bacon is sometimes criticized for not giving adequate weight to individual initiative or inspiration, and for underestimating the importance of hypotheses. But there are those who are Lamps—"then after divers meetings and consults of our whole number, to consider the former labours and collections, we have three that take care, out of them, to direct new experiments, of a higher life, more penetrating into nature than the former. These we call Lamps." The ideas of the Lamps are executed by the Inoculators; and "lastly we have three that raise the former discoveries by experiments into greater observations, actions, and aphorisms. These we call Interpreters of Nature."

There is indeed a House of Salomon in New Atlantis—the Exploratorium in San Francisco which was founded, some twenty years ago, by Dr Frank Oppenheimer (cf Perception 1977 6 611-613). It is an enchanted palace where all with initiative can discover and see for themselves the world of science and how things work.

The importance of active exploration and also the inhibiting effect of glass cases in museums were impressed upon me twenty years ago—before I had read Francis Bacon's New Atlantis or met with Frank Oppenheimer's ideas. This was when Jean Wallace, who was then my Research Assistant, and I studied the case of SB. SB regained his sight by corneal graft in middle life, having been effectively blind since a baby of ten months. After the successful operations to his eyes when he was fifty-two, we found that he was immediately able to see things he already knew from his explorations of the world while blind, and especially by touch, though for many months and even years he remained blind to things he did not already understand. Thus, he could immediately tell the time by sight, from a clock on the wall of the hospital ward, as years before he had learned to read time from his pocket watch by touching its hands; and he could read upper case though not lower case letters, as he had learned upper case though not lower case letters by touch as a boy at the
Blind School. Most dramatic was his response to first seeing a lathe (which he had ardently wished he could use when blind), which we showed him in a glass case at the Science Museum in South Kensington shortly after he left hospital. As we reported (Gregory and Wallace 1963, page 33):

We led him to the glass case, which was closed, and asked him to tell us what was in it. He was quite unable to say anything about it, except that he thought the nearest part was a handle. (He pointed to the handle of the transverse feed.) He complained that he could not see the cutting edge, or the metal being worked, or anything else about it, and appeared rather agitated. We then asked a Museum Attendant for the case to be opened, and SB was allowed to touch the lathe. The result was startling: he ran his hands deftly over the machine, touching first the transverse feed handle and confidently naming it as a ‘handle’, and then on to the saddle, the bed and the head-stock of the lathe. He ran his hands eagerly over the lathe, with his eyes shut. Then he stood back a little and opened his eyes and said: “Now I’ve felt it I can see”.

From these background ideas and experiences, we are setting out to start what we propose to call the Exploratory. This is to be in, what in Bacon’s time was the second town of England, the City of Bristol. The Exploratory will follow the lead of Francis Bacon and Frank Oppenheimer: presenting science and technology without the impediment of glass cases so that one may learn to see by actively exploring.

Time travelling will be by re-enacting experiments with the technology then available. For example, one will be able to carry out Galileo’s experiments with weights falling down inclined planes, with only the methods for observing and timing their fall that Galileo had early in his and Bacon’s Seventeenth Century. We should measure the speed of light, and of nerve impulses, with increasing accuracy as technology advances.

Conceptually the Exploratory will start from the individual’s power and limitations of perception, judging, thinking, predicting, and so on—to move out to the world of physical understanding and technology we have created. Technology’s inventions may be presented both as embodying and as inspiring science; and, almost paradoxically, as providing the conceptual models by which we try to understand ourselves. So what is ‘objective’ and what ‘subjective’ may be explored.

It is remarkable, though perhaps seldom noticed, that very few people have a clue how the things around them work. There will be examples and models for playing and interacting with physical principles and how they are embodied in devices and gadgets, and instruments and engines of technology very much as Bacon described. The Exploratory should also be a centre for developing better ways of presenting knowledge and ideas: by fun and games, by computer and perhaps video disc technologies—to avoid King John’s cry of pain, we too often echo: “Zounds, I am bethumped by words!”

Plans are quite far advanced. Suggestions and contributions—material or perceptual—will be most welcome, for hatching the Bristol Exploratory.

References
Bacon Francis, 1627 New Atlantis Quoted by kind permission of the Oxford University Press from Francis Bacon: The Advancement of Learning and New Atlantis Ed. Arthur Johnston (Oxford: Oxford University Press, 1974) pp 243-246
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Richard L Gregory
Readers comments on Editorials

Your Editorials on Cognition (Perception 1981 10 603, 1982 11 1) while addressing other issues, prompt me to question your usage of the concept cognition. Are we not possibly in danger of repeating the mistake we made with concepts such as Mind and Learning?

We now know that Mind is composed of perceptions, memories, thoughts, feelings, and so forth. Similarly, Learning can now be usefully re-specified as habituation, imprinting, conditioning, motor learning, verbal learning, or even into subdivisions of these broad categories. Within a period of two months I have come across widely different usages of the concept Cognition:

(i) at a meeting on ‘Animal Cognition’ in June 1982 to describe the achievements of, for example, pigeons (eg by H S Terrace) in respect of serial learning;
(ii) in reading an important paper by E K Warrington and L Weiskrantz (Neuropsychologia 1982 20 233–248) on human amnesia to describe memory processes in man;
(iii) at a meeting on ‘Cognition and Motor Processes’ in July 1982 to describe the antecedents to human motor performance (eg by W Prinz).

Moreover, it would not be difficult to find examples of yet other usages of Cognition (eg in respect to representation, thought, and language).

It seems unlikely that Cognition will remain a unitary concept for long. When you argue on behalf of cognitive explanations are you intending to imply a commonality of processing across the spectrum currently labelled ‘cognitive’? If not, is there not a borderland, where some particular cognitive explanations of today may be expected to merge into the mechanistic explanations of tomorrow?

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The Editor replies

Professor Ettlinger presents a useful warning, but as the tortoise said: "I can’t take a step forward without sticking my neck out". As Russell and many others have pointed out, there are two very different kinds of definitions—by iteration of instances, or by description of supposed intrinsic characteristics—and both have their uses. I feel that to give intrinsic definitions in terms of concepts of knowledge is useful for discussing cognitive processes. All the examples that Professor Ettlinger gives do involve knowledge-handling, which confirms my view that definition along these lines is sufficiently broad while at the same time being conceptually suggestive. Perhaps other readers would like to comment?

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