

JOY IN DISCOVERY

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ONE of the popular conceptions of the man of science is that he is cold and unemotional. The common belief is that he is one who makes records of a large number of facts, from which later he may or may not deduce certain laws. His sympathies, if he has any, are regarded as far removed from the concerns of every-day life, and he is supposed to live in a colourless world of his own where emotion neither flushes his cheek nor brightens his eye. Science, it is imagined, demands this, for must not her worshippers sternly sink their predilections in the search for truth?

Now, it is of course quite rightly insisted that scientific men must make so impersonal a study of Nature's laws that their conclusions shall not be vitiated either by their own feelings or by those of their followers. But ever since Archimedes rushed naked through the streets of Syracuse shouting "Eureka", there has been proof that the man of science need not be a stranger to strong emotion. We have had in modern times quite as striking examples of the delight of the discoverer at his discovery, although the expressions of it were certainly more restrained, and more consonant with the police regulations for urban areas. Gaspar Aselli of Pavia also shouted "Eureka" when by accident he found the lacteal vessels or absorbents, structures of the utmost importance in the economy of the living body. Even he whom most would regard as the high priest of arid systematists, I mean the Swedish botanist, Linnaeus, confessed that he could not refrain from weeping when he beheld the golden gorse in its glory. This article will be concerned with recalling some supreme moments of scientific rapture.

The first is that of the dying Copernicus, when his feeble hands were just able to grasp a copy of his great work. It was in 1543, when he was on his deathbed in Frauenburg, that the *De Orbium Coelestium Revolutionibus* was at last actually published. The whole life of Copernicus may be said to have been devoted to its consummation in that hour. This father of modern astronomy had taken the degree of Doctor of Medicine at the University of Cracow, but, yielding to his very decided mathematical tastes, he studied mathematics in Rome, and for some years subsequently

occupied the professorial chair in that subject. Copernicus was one of those who used the leisure afforded by a sinecure in the Church to devote his energies to the prosecution of science, for his canonry in the cathedral at Warma did not in any way interfere with his astronomical observations. The attitude of the Church towards him is in striking contrast with the fate of his great follower Galileo ninety years later, for the bishops of Capua and Cologne urged the publication of his book thirteen years before he himself would consent to it. Copernicus had good reason to fear the disturbing of accepted beliefs, especially when these beliefs were supposed to be those of the author of *Genesis*. The Church, however, in this case seems to have been in sympathy with her scientifically minded canon, for Pope Paul III (Alexander Farnese) allowed the *De Orbium* to be dedicated to himself, and the expenses of its publication to be borne by the Cardinal-Archbishop of Capua.

Copernicus wrote with boldness, although some have hinted that he purposely delayed the appearance of his book until he knew that he had not much longer to live. But his actual words were bold enough:—

Should there be any babblers who, ignorant of all mathematics, presume to judge of these things on account of some passages of Scripture wrested to their own purpose, and dare to blame and cavil at my work, I will not scruple to hold their judgment in contempt.

It was an epoch-making treatise that his enfeebled hands held before his closing eyes on the 23rd day of May, 1543. Copernicus himself could never have dreamed of the magnitude of the intellectual revolution which his own work on revolutions inaugurated. When we consider the grandeur of the scale of those phenomena studied by astronomers, we ought not to be surprised at their feverent emotion for—as Young said—

An undevout astronomer is mad.

Kepler, Newton's most important forerunner, was certainly neither undevout nor devoid of emotion, for in 1619 he could write as follows:

What I prophesied two and twenty years ago that for which I devoted the best part of my life to astronomical contemplation, at length I have brought to light, and recognised its truth beyond my most sanguine expectations. . . . The die is cast, the book is written, to be read either now or by posterity, I care not which. It may wait a century for a reader, since God has waited six thousand years for an observer.

Kepler was no mere dry statistician; he had "most sanguine" expectations; he was so overjoyed at the verifying of his prophecy that he was perfectly content to let a remote future judge the value of his work.

From Kepler we are led at once to Galileo, "the starry Galileo and his woes", a man born as it were out of due time. There was little actual joy in his life, although he did derive immense satisfaction from his discovery of the satellites of Jupiter, the phases of Venus, and the details of the surface of the moon. He suffered much in body, and more at the hands of the representatives of that Church of which he always regarded himself as a true son. He had to struggle against the incubus of the errors in *a priori* Aristotelian physics, against tradition with the psychic momentum of nearly two thousand years behind it. He seemed to fail in a supreme moment,—when he put his signature below the words

At Rome in the convent of Minerva, 22nd June, 1633, I
Galileo Galilei, having abjured as above with mine own hand

That was one of the most painful moments in the history of science, for the clouds of obscurantist tradition seemed to roll up and shut out the new light. But it was only a seeming, for that light is unquenchable, and it was destined to burst forth afresh with increased splendour in the Englishman, Isaac Newton. One recalls the inscription on the stone in Westminster Abbey:—

Nature and Nature's Laws lay hid in night;
God said "Let Newton be", and all was light.

He had first thought of gravitation in 1666:—

In 1682 Newton returned to his attempt of sixteen years earlier to explain the moon's motion by means of the assumed influence of gravitation. . . . Newton's earlier data had led to a determination of the acceleration due to gravity at the distance of the moon as $13\frac{1}{2}$ feet per second. The new data changed this result to 15 in agreement with his hypothesis that the force varies inversely as the square of the distance. Stirred to the inmost depths of his usually calm nature by his realization that he was approaching a solution of the great problem, he had to beg a friend to complete his calculation.

You may well feel an agitating joy when you are on the verge of demonstrating that you have discovered the principle which orders the movements of the earth, the planets, the moon, the comets, the tides, as well as those of all falling bodies. He who could contemplate the intellectual grandeur of this without emotion must be more or must be less than human:

The very law that moulds a tear
 And bids it trickle from its source,
 Has also formed the earth a sphere,
 And guides the planet in its course.

My next case shall be from the life of Michael Faraday, who, alluding to the life of the man of science, asked, "Do not many fail because they look rather to the renown to be acquired than to the pure acquisition of knowledge and the *delight* which the contented mind has in acquiring it for its own sake?" Someone has described the scene in the laboratory when this investigator first saw a wire which was conducting an electric current begin to rotate under the influence of terrestrial magnetism. "All at once Faraday exclaimed 'Do you see, do you see?' as the wire began to revolve, and I shall never forget the enthusiasm expressed in his face and the sparkling in his eyes." Modern science owes to that modest, obscure-born Englishman more than can be easily expressed.

Again, recall the great William Harvey. He was indeed a discoverer, the Columbus of biology. Biologically speaking, we must pronounce the knowledge of the circulation of the blood to have divided the ancient from the modern world. Harvey himself wrote: "Truly in such pursuit it is sweet not merely to toil but even to grow weary, when the pains of discovery are amply compensated by the pleasures of discovery." The intellectual joy that arises from the reward of toil in searching for something unknown and perhaps entirely unsuspected is one of the purest forms of pleasure permitted to mortal men.

It was in 1628 that Harvey published the small, great work which contained the demonstration that the blood in a very large number of animal types flows continuously from the arteries into the veins. But the actual tubular communications now called capillaries, between the arterial and venous vessels, he could not see because they are invisible to the unaided eye. He could but infer their existence. Harvey died in 1657; three years afterwards the Italian naturalist, Marcello Malpighi, actually saw under the microscope the blood streaming through the capillary vessels in the lung of a living frog. His was the first eye to see this verification of the truth of Harvey's great inference,—one day in the year 1660 in the old-world city of Bologna. Malpighi announced his discovery after the manner of his time in a private letter to his friend, the mathematician and physiologist, G. A. Borelli, at Pisa. He wrote, of course in Latin, *magnum certum oculis video*, "I see with my own eyes a great certain thing." It has been carelessly translated "I see a certain great thing", but this does not give the real sense of

the original at all. In the letter the significant words are underlined. Malpighi is evidently excited over his discovery, which he describes as a great and sure fact, or phenomenon, as we should now call it. Not only was the phenomenon he had just observed important or great; but he was absolutely sure or certain of having observed it correctly. He writes as though fully aware that he of all men was the first to behold this wonder, and so the beautiful net-work of vessels in the lung is still called *rete mirabile Malpighii*. He devoted much time also to the elucidation of minute details of the structure and metamorphosis of insects, particularly the silk-worm. After years of this trying work, often interrupted by inflammation of the eyes, he could write:

Nevertheless in performing these researches so many marvels of Nature were spread before my eyes that I experienced an internal pleasure that my pen cannot describe.

And yet Malpighi has been considered as very unemotional!

For another case of scientific joyousness we pass north to Holland, to the little town of Delft, where one Anthony van Leeuwenhoek worked incessantly with his microscopes during a very long life, for he was born in 1632 and died in 1723. His life was placid and uneventful, if we except a visit he had in 1698 from the Tsar Peter I, commonly called Peter the Great, who was particularly delighted at the spectacle of the blood circulating under the microscope in the tail of a small eel.

Amongst the many things which Leeuwenhoek saw for the first time was the circulation of the blood in what are called "systemic" capillaries, that is capillaries other than pulmonary. The latter had been already observed by Malpighi in 1660, but systemic capillaries were not seen until 1688. Leeuwenhoek used the translucent tissues of certain aquatic animals, such as the web of the frog's foot, the tail of the tadpole, and the tail of the little fish called "stickleback". He has left an admirable description illustrated by figures of the manner in which arteries end in capillaries and capillaries become veins in the tail of the fish. Leeuwenhoek was the first to behold the blood passing unceasingly in the same direction through the capillaries from the arteries to the veins, and so he discovered the circulation for himself.

In a fuller way than that of Malpighi, he verified Harvey's induction that the blood moves always and only from arteries to veins. Harvey could not discern capillaries, not only because he had no microscope of nearly sufficient power, but also because the walls of these minute vessels are perfectly transparent in their

state of nature. To be quite accurate, we must say that neither Malpighi nor Leeuwenhoek saw capillaries in the sense in which we now see them in dead "fixed" preparations, or in "sections" of tissues beautifully stained and differentiated from the cells and fibres around them. But they both saw blood moving in minute tubes, whose transparent walls they very properly assumed to exist.

Leeuwenhoek evidently derived immense satisfaction from viewing this wonderful spectacle. To the secretary of the Royal Society of London he wrote:—

But now that I hear that more credit will be given to my words when I mention the names of those who have partly seen the aforesaid circulation of the blood about which I write to your honourable Society and which I have discovered, I have no objection to mentioning—instead of many—such as I trust will deserve most belief, as for example Mr. Cornelius Gravesande, M. D., and ordinary professor of anatomy and surgery, and also Councillor and late sheriff of this town, Mr. Cornelius Valensis also councillor and late sheriff, Mr. Antoni Heinsius, LL.D., councillor and *pensionaris* of this town, late Envoy Extraordinary to His Majesty, the King of France, and not long ago Ambassador of this State to the Court of His Royal Majesty of England. To these gentlemen . . . I have shown the true circulation of the blood as distinctly as we see with our naked eyes the current of the water in a running river.

Commenting on the circulation in the tail of the tadpole, he exclaimed: "A sight presented itself more delightful than any mine eyes had ever beheld."

Leeuwenhoek was willing to share his joy in discovery, for when he found the embryo of *Unio*, the fresh water mussel, he had to call in his daughter and his engraver to watch it swimming about "for three whole hours". It is recorded that he was particularly delighted with finding embryo eels in the body of the female, for he had been specially charged to show how eels are bred. There was more than the usual nonsense believed in his day about the reproduction of eels. Leeuwenhoek was the first microscopist to see a bacterium.

Another supreme moment in science belongs to the life of one of the greatest benefactors the human race has ever seen,—Edward Jenner, who was born in 1749 and died in 1823. Jenner's careful observations had shown him that certain persons, usually dairy-maids, who had contracted the mild disease of cows called cowpox or *Vaccinia*, were immune from the far more serious human disease called smallpox or *Variola*. He soon saw how a crucial experiment could be planned, namely, to inoculate someone with cowpox,

thereafter with smallpox, and demonstrate that in the latter case the disease would not develop. In the year 1796 a dairymaid, Sarah Nelmes, took cowpox, and on May 14th Jenner inoculated a healthy boy—James Phipps—eight years old, with some of the liquid from a sore on the woman's arm. The boy had that slight fever and reaction we should now call "the vaccination taking", and remained perfectly well for six weeks. Jenner then decided to put his theory to the test and actually inoculate the child with smallpox.

On July 1st this was done. Time passed, and the boy showed no sign whatever of the loathsome disease. Jenner, as one might well expect, was very much elated, and at once wrote the news to his friend, Mr. Gardner. He tells how James Phipps had been inoculated with cowpox, and how he looked exactly as though he had caught this complaint in the usual way through contagion. "But now listen", he continues, "to the most delightful part of the story. The boy has since been inoculated for the smallpox, which—as I ventured to predict—produced no effect. I shall now pursue my experiments with redoubled ardour". Joy in scientific discovery is ever an incentive to further enterprise. July 19th, 1796! A supreme moment in the development of the science of medicine and for the future happiness of the human race! No wonder that the German Government proclaimed the day of Phipps's inoculation as a public holiday. Shortly after this date Mr. Cline, the well known London surgeon, wrote to Jenner: "I think the substitution of cowpox poison for smallpox poison promises to be one of the greatest improvements that have ever been made in Medicine." But no contemporary of Jenner in his most sanguine moments could have foreseen the magnitude of the boon which the modest country practitioner was to confer on suffering mankind.

An example of joy aroused by a scientific triumph, and—not less—of grief at the limitations to the beneficent work of science, may be taken from the life of Pasteur. He ranks with Jenner as one of the greatest benefactors of mankind. Pasteur discovered the cause and cure of the souring of wine, of the silk-worm disease, of anthrax, of fowl cholera, and finally of hydrophobia. Using the method of inoculation of attenuated virus, in itself virtually an extension of the principle involved in vaccination, Pasteur after a masterly series of experiments felt justified in believing that he had found the natural or biological cure for hydrophobia or rabies,—one of the most awful diseases which man shares with the lower animal world. He had come to the conclusion that these anti-rabic inoculations cured the more effectively according as they

were given as soon as possible after the patient had been bitten by the rabid animal,—dog, wolf, or fox. The first case sent to Paris for treatment (July 6, 1885) was that of a little Alsatian boy, Joseph Meister, nine years old, who two days previously had been badly bitten in fourteen places by a mad dog. After days of deep thought Pasteur decided to inoculate the child with weakened anti-rabic virus on July 11th, and he performed the final injection on July 16th. He had been prepared to inoculate himself with rabies, and then give himself the anti-rabic material, but little Meister provided him with the test case. To his son-in-law and biographer, Valery-Radot, Pasteur wrote: "I think great things are coming to pass." And again: "I have an ardent desire to snatch little Meister from death". When the last inoculation had been given, the child went to bed to sleep peacefully, while Pasteur in an agony of anxiety spent a sleepless night. But as the child was perfectly well on August 3rd, he could write—"Very good news of the bitten lad". Pasteur had all the direct and sympathetic insight of the cultured Frenchman, all his keen delight in the victories of science,—always tempered for him by a vast human tenderness.

When, some time later, he knew that he could not save the life of Louise Pelletier, bitten on October 3rd, but not brought to him until the 9th of November, he stood holding her hand as spasm after spasm of the diabolical disease convulsed her, and then burst into tears,—a prince among scientists weeping, a man, a tender great man! His joy on demonstrating that sheep infected with the deadly anthrax would not die if subsequently inoculated with the weakened virus was very intense. When he received the telegram informing him that all the infected sheep were dead or dying, and that every one of the inoculated animals was alive and well, his delight was deep, and had at once to be shared with his children. "Joy reigns in the laboratory and in this house. Rejoice, my children" were the concluding words of a letter written at this time.

On one occasion Pasteur said, "Nothing is more agreeable to a man who has made science his career than to increase the number of discoveries, but his cup of joy is full when the result of his observations is put to immediate practical use." Monsieur Radot remarks, "The emotions of *savants* are all the deeper that they are not enfeebled, as in so many writers or speakers, by the constant use of words which end in wearing out the feelings."

One may recall, too, the great English surgeon, Joseph Lister. His discovery that wounds, whether of accidental origin or produced by the surgeon, "go bad" because infected by germs of putrefaction—that is, by ferments present practically everywhere—is of cardinal

value in the healing art. Lister's practice of employing chemicals or "anti-septics" to prevent or reduce this putrefaction in wounds has not only occasioned the re-birth of surgery, but along with the use of the anaesthetic powers of chloroform has been the means of banishing surgical pain and much pre-operational anxiety for the human race. These stupendous benefits were conferred upon mankind about 1867 by this gentle English Quaker, while Professor of Surgery in the University of Glasgow. One of the chief troubles before his time was the coming loose of the ligatures or cords used in tying arteries to prevent their bleeding. These insoluble tapes or strings frequently slipped off the blood-vessels as a result of the disintegrating agencies in the soft edges of the putrid wound, so that the patient might lose much blood in this so-called secondary haemorrhage. Much of Lister's early success was due to the introduction of the catgut ligature, a cord of animal and therefore absorbable material, so treated chemically (chromicised) as to resist putrefaction and yet not become an irritant to the living tissues of the healing wound.

Early in 1868 Mr. Lister had the opportunity to put these ideas into practice when he decided to perform the major operation of tying one of the great blood-vessels for iliac aneurysm in a patient, a lady of fifty-one years of age. It is in letters to his father that we find the best accounts of this case. In one dated February 2nd he wrote: "Six weeks after the operation I found the ligature still there, but surrounded on all sides by perfectly healthy, firm tissue, the thread (silk) having caused none of the irritation which it does when not managed antiseptically. . . . Hitherto the patient's progress has been all that can be desired. I imagine there never before was a patient in so good a state after this very serious operation." Ten days later he wrote again: "I send just a few lines to give what I know will be the welcome news that the case of the ligature of the external iliac continues to do as well as can be wished. . . . I think the case may now be considered a success. I don't think any case ever excited me so much."

We have to remember that to exhibit strong emotion is a thing forbidden to members of the Society of Friends, so that Lister's phrase "excited me so much" means considerably more than it would if used by one of a different religious school. Although he did not at any time in his life give way to boisterous expression of his feelings, it is perfectly clear from the admirable record by his nephew, Sir Rickman Godlee, that Lord Lister was a man of powerful emotion and of deep convictions. Godlee's remark on this correspondence is: "In Lister's letters to his father this case is re-

ferred to again and again; it evidently impressed him profoundly.' It impressed him profoundly because it was the first serious operation of its kind performed on principles that were at that time absolutely new and entirely untried. The surgeon's task is always responsible and anxious; but this occasion was one of peculiar import, for a pioneer was putting novel and extremely unpopular views to the test in a case where a human life was involved. By all, save a few "cranks" whom we shall always have with us, Lister's discovery has been acclaimed as one of the cardinal advances in scientific medicine, and as one of the most beneficent presentations that science has ever made to suffering humanity. The late Professor Rudolph Virchow, when he delivered the Huxley Memorial Lecture on a subject which involved constant references to Lister's work, turned round from the lecture desk and grasped the hand of the venerable master. "Equally touching it was when, at a small dinner given by Virchow on the occasion of Lister's eightieth birthday to his family and a few intimate friends, he did such eloquent homage to the greatness of Lord Lister's work that the latter could scarcely restrain his emotion." Not all men of science are the cold-blooded molluscs which in some quarters they are thought to be. When representatives of the world's learning were congratulating Pasteur on his seventieth birthday, Lister—as President of the Royal Society—advanced to the dais and fervently embraced the great Frenchman. This scene is commemorated in a fine painting. Speaking of it, Monsieur Vallery-Radot says: "The sight of these two men gave the impression of a brotherhood labouring to diminish the sorrows of humanity."

Keats surely struck the right note when he spoke of the ecstasy of "some watcher of the skies when a new planet swims into his ken". We know how Simpson rejoiced over the first child born to the exhausted mother painlessly through the influence of the soothing vapour of chloroform. We know the joy of Lister when, for the first time in the history of surgery, a compound fracture healed without inflammation and without giving rise to suffering under the antiseptic effect of carbolic acid. We know how delighted was Graham Bell when he first heard human speech conveyed over the wires of his telephone. We know how Edison was thrilled when, having spoken to his wax cylinder, he heard every word reproduced. Lord Kelvin, when he had perfected one more of those exquisitely delicate electrical instruments of which he was the inventor, would have it brought up and placed on the drawing-room mantelpiece so that he might exult at his leisure over the latest product of his genius. And the daughter of Sir David Brewster

wrote thus of her father at work in his physical laboratory: "After a while he would forget I was there; and I have often seen him suddenly throw himself back in his chair, lift up his hands and exclaim "Good God, Good God, how marvellous are Thy works!"

There is a holy joy in seeing Law extend her placid reign into the regions where Chaos rioted, in seeing scientific light steadily and majestically pushing back the circumambient darkness of ignorance. This joy of the creative intellect is probably one of the most exalted and altogether lovely of the human emotions. It comes as the reward only of undaunted effort, of that persistent search for causes which is of the very essence of science. The pleasures of scientific discovery are as worthy of poetic celebration as the pleasures of memory, the pleasures of imagination, or the pleasures of hope; inasmuch as they include all these and yet transcend them, the pleasures of discovery can but be awaiting their Milton. If it is true that "There's not a joy the world can give like that it takes away", then it is certainly as true that there is a joy in creative discovery with which science rewards her lovers, a joy which the world can not give, neither can it take away.