DISCOVERY

Or The Spirit and Service of Science

BY

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PREFACE

THE attention recently given to the position of science in the State, its relation to industry, and its relative neglect in education, suggests that the present is an appropriate time for putting into final shape a project contemplated for many years and practically completed before the outbreak of existing hostilities. This book represents the result; and its main purposes are to promote a more sympathetic attitude towards those who are engaged in the pursuit of scientific truth and to remove the widespread misconception which prevails as to the meaning and influence of science.

To the popular mind, a man of science is a callous necromancer who has cut himself off from communion with his fellows, and has thereby lost the throbbing and compassionate heart of a full life: he is a Faust who has not yet made a bargain with Mephistopheles, and is therefore without human interest. Scientific and humanistic studies are, indeed, supposed to be antipathetic, and to represent opposing qualities; so that it has become common to associate science with all that is cold and mechanistic in our being, and to believe that the development of the more spiritual parts of man's nature belongs essentially to other departments of intellectual activity.

When scientific work is instituted solely with the object of securing commercial gain, its correlative is

selfishness; when it is confined to the path of narrow specialisation, it leads to arrogance; and when its purpose is materialistic domination, without regard for the spiritual needs of humanity, it is a social danger and may become an excuse for learned barbarity. But scientific research is rarely inspired by these motives, and devotion to it does not necessarily inhibit response to other notes with which a well-balanced mind should be in symphony. Moreover, direct contact with Nature and inquiry into her laws produce a habit of mind which cannot be acquired in literary fields, and they are associated with a wide outlook on life more often than is usually supposed.

The relative influence of different studies on the formation of character need not be discussed here; yet the following pages will perhaps show that the spirit of scientific research has inspired the highest ethical thought and action, as well as increased the comforts of life, and added greatly to material welfare. We seek to justify the claim of science to be an ennobling influence as well as a creator of riches; and therefore as much importance is attached to motive and method as to discovery and industrial development, however marvellous or valuable these may be.

Wherever the purposeful inquiry is carried on in the field of Nature, there the spirit of science is manifest, and we learn that worthy intention defines its shape as much as brilliant achievement. For science is not to be measured by practical service alone, though it may contribute to material prosperity: it is an intellectual outlook, a standard of truth and a gospel of light.

Scientific investigation is not usually undertaken with personal profit in view, and the discoveries to

which it leads are not jealously kept within the precincts of the temple, but are offered freely to the world: self-help thus giving place to the higher attribute of help for others. This virtue, with the qualities of self-sacrifice, persistence, courage, duty, accuracy, humility, and hope may all be abundantly exemplified from the careers of men of science; yet such instances are rarely mentioned. From many countries and many times we have gathered incidents and allusions which display the nobility of scientific aims, and have accentuated them with words of wisdom from the biographies and writings of men who have devoted their lives to the extension of natural knowledge. In substance the book thus largely consists of selected testimony, while in intention it is a stimulus to high endeavour.

No attempt has been made to provide a complete record, in chronological or any other order, of natural philosophers and their triumphs, yet it is hoped that not many points of outstanding human interest have been overlooked. The aim has been eclectic rather than exhaustive; wherefore many scientific pioneers are not mentioned, while others find a place not so much on account of their distinguished eminence as because events in their careers, or results of their work, create a spirit of emulation in those who regard them. The whole is presented with a deep sense of humility before the extent and intricacy of scientific knowledge, and of dissatisfaction at the gap which persists between design and execution.

It remains only to be said that though none of the chapters have been published hitherto in their present form, a few parts have appeared in contributions to the *Cornhill*, *Fortnightly*, *Nature*, *School World*, *Sunday at Home*, and other magazines during a period extend-

ing over nearly a quarter of a century. The book as a whole owes little to these articles; nevertheless, grateful acknowledgment is offered for the further use now made of suitable material extracted from them.

R. A. Gregory.

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CHAPTER I

OUTLOOK AND ENDEAVOUR

No good work is ever lost. Max-Müller.

There is no darkness but Ignorance. Shakespeare.

All wish to know, but few the price will pay. Juvenal.

All science has one aim, namely, to find a theory of Nature. R. W. Emerson.

Tongues in trees, books in the running brooks. Sermons in stones, and good in everything. Shakespeare.

Nature alone is always true to herself; she alone through the ages never lies, never changes, never hesitates, ever presses onwards. Eden Phillpotts.

There are three voices of Nature. She joins hands with us and says Struggle, Endeavour. *She comes close to us, we can hear her heart beating, she says* Wonder, Enjoy, Revere. *She whispers secrets to us, we cannot always catch her words, she says* Search, Inquire. *These, then, are the three voices of Nature, appealing to Hand, and Heart, and Head, to the Trinity of our Being.* Prof. J. Arthur Thomson.

Since dawn the man had been seated on a stone at the bottom of a ravine. Three peasant women on their way to the vineyards exchanged "Good day" with him as they passed to their work. At sunset when they returned the watcher was still there, seated on the same stone, his eyes fixed on the same spot. "A poor innocent," one whispered to the others, "*pe'caïre!* a poor innocent," and all three made the sign of the cross. Fabre, the incomparable naturalist, patiently waiting to discover what is instinct and what is reason in insect-life is, to these vintagers, an object of supreme com-

miseration, an imbecile in God's keeping, wherefore they crossed themselves.

Members of the University of Pisa, and other onlookers, are assembled in the space at the foot of the wonderful leaning tower of white marble in that city one morning in the year 1591. A young professor climbs the spiral staircase until he reaches the gallery surmounting the seventh tier of arches. The people below watch him as he balances two balls on the edge of the gallery, one weighing a hundred times more than the other. The balls are released at the same instant and are seen to keep together as they fall through the air until they are heard to strike the ground at the same moment. Nature has spoken with no uncertain sound, and has given an immediate answer to a question debated for two thousand years.

"This meddlesome man Galileo must be suppressed," murmured the University fathers as they left the square. "Does he think that by showing us that a heavy and a light ball fall to the ground together he can shake our belief in the philosophy which teaches that a ball weighing one hundred pounds would fall one hundred times faster than one weighing a single pound? Such disregard of authority is dangerous, and we will see that it goes no further." So they returned to their books to explain away the evidence of their senses; and they hated the man who had disturbed their philosophic serenity. For putting belief to the test of experiment, and founding conclusions upon observation, Galileo's reward in his old age was imprisonment by the Inquisition, and a broken heart. That is how a new scientific method is regarded by guardians of traditional doctrine.

The most original experimenter the world has ever seen is lecturing before a distinguished audience at the

Royal Institution in London. He shows that when a magnet is brought suddenly near a coil of wire a slight current of electricity is produced in the wire. The experiment is not very impressive; and a lady probably voiced the feelings of most of the audience when she asked afterwards, "But, Professor Faraday, even if the effect you explained is obtained, what is the use of it?" The memorable reply was, "Madam, will you tell me the use of a new-born child?"

Lecky, in the Introduction to his *Democracy and Liberty,* says that the whole great field of modern scientific discovery seemed out of the range of even such a scholar and statesman as Mr. Gladstone, and that when Faraday was endeavouring to explain to Gladstone and several others an important new discovery in science, Gladstone's only commentary was, "But, after all, what use is it?" "Why, sir," replied Faraday, "there is every probability that you will soon be able to tax it!"

To cultured people, Faraday's discovery of a means of producing electricity by mechanical movement seemed trivial; to the schoolmen of the Middle Ages, Galileo's appeal to the court of Nature against the judgment of authority was impertinent; and to the peasant, Fabre's patient study of insects suggested imbecility.

Three typical scientific workers are here represented; and we see the attitude of three different classes of people towards them. There is first of all the naturalist who seeks knowledge purely for its own sake, and considers no vigil too long if at the end a corner of the veil behind which the mysteries of Nature are hidden has been lifted. He continually sees new beauties in the features of his mistress and new wonders in all her ways. Sufficient for him is the satisfaction he feels at each discovery, and he cares not whether his studies

have any value beyond that which he derives from them. In a world of hustle, such lovers of Nature are regarded as creatures to be pitied, if not held up to ridicule, by people who cannot understand why anyone should devote himself to a subject without expecting personal or public profit from it.

Of a different type is the iconoclast — the breaker of images—rebelling against authority, impetuous to prove that the old idols are false, impatient with the world because of its indifference to the new gospel he has to teach. This man is not content to see things for himself; he desires to convince others of the truth revealed to him, and single-handed he is prepared to storm the citadel of traditional belief. In all ages he is a disturber of the peace, and is as unwelcome in scientific circles to-day as he was to the contemplative philosophers of the Middle Ages or before. But be assured of this: you may crucify the body of such an apostle or you may visit him with the despair that follows upon neglect, but if his torch has been lighted from the divine flame of truth and righteousness it cannot be extinguished.

Most men of science are neither suppliants at the feet of Nature nor fiery advocates of truths wrested from her, but by critical inquiry into the origin of her strength and weakness they hope to discover the means of subduing her. She is cross-examined, tested, analysed, and every artifice or weapon which seems likely to induce her to reveal the secrets which she holds is brought into requisition. She is a Katharine to be tamed by the Petruchio of Science rather than a Juliet to be worshipped by a love-sick Romeo. Only those who consider her worthy of battle have the patience or the power to effect a conquest. From whatever side she is approached obstacles arise which prevent a clear

vision of her; and infinite labour as well as strong desire are necessary for every step of advance.

Pasteur carried on an unrelenting warfare against the forces of Nature hostile to man; it took him five years to discover the remedy for rabies. Above all, he was an indefatigable worker. He called the interval of night "hours of waiting," which always seemed to him slow to pass. C. G. J. Jacobi (1804-1851), the greatest mathematical teacher of his generation, likewise made the best use of time. "It must not be supposed," he said, "that it is to a gift of Nature that I owe such mathematical power as I possess. No, it has come by hard work, hard work. Not mere industry, but brain-splitting thinking—hard work; hard work that has often endangered my health."

Several years ago the leading astronomers in the United States were asked to set down in order of preference the names of living Americans who had contributed most to the progress of astronomy. The name which headed all the lists was that of Simon Newcomb, yet he made no discovery in astronomy to which the periodical press would give prominence. Far greater, however, than the observation of a new star, planet, or comet, was the exceedingly laborious computations made and directed by Newcomb to enable the positions of the sun, moon, planets and some of the fixed stars to be predicted with greater accuracy than had hitherto been the case. This was the work which gave him the first place in the esteem of men who were best able to judge its value to astronomical science.

When the French astronomer and mathematician, Lalande, was computing with Clairaut the disturbing influences to which Halley's comet had been subjected, he worked at the calculations during six months from morning to night, and often at meal times; and by his

devotion to this self-imposed task, contracted an illness which changed his constitution for the rest of his life. It was necessary to calculate the distance of each of the two planets Jupiter and Saturn from the comet separately for every degree over a period of one hundred and fifty years. There was no mercenary motive under this tremendous labour, but only the desire to define the movements of an object which at intervals of about seventy-six years had filled mankind with terror by its appearance in the sky.

Reward—as the world understands it—for work done or results obtained, is the last thought of a student of science. "I have no time to make money," was the reply of the naturalist, Louis Agassiz, to an offer to lend himself to a legitimate and tempting financial scheme. Napoleon the Third once expressed surprise to Pasteur that the great investigator did not endeavour to make his discoveries and their applications a source of profit. "In science," Pasteur replied, "men of science would consider that they lowered themselves by doing so." In a conversation with Lady Priestley, Pasteur remarked, "I could never work for money, but I would always work for science." If he had chosen to keep his discoveries to himself, he could have been one of the most wealthy men in the world, but he gave them to the human race, and was content to end his career as a professor of chemistry in receipt of a modest salary from the Government of his country.

Faraday on one occasion said to Tyndall that, at a certain stage of his career, he was forced definitely to ask himself, and finally to decide whether he would make wealth or science the pursuit of his life. He could not serve two masters, and he chose science. After the discovery of magneto-electricity, his fame was so well recognised that the commercial world would not

have considered any fees too high for the aid of abilities like his. Tyndall says he might with ease have realized an income of £10,000 a year during the last thirty years of his life, yet he earned almost nothing by professional services.

Taking the duration of his life into account, this son of a blacksmith, and apprentice to a bookbinder, had to decide between a fortune of £150,000 on one side, and his undowered science on the other. He chose the latter and died a poor man. But his was the glory of holding aloft among the nations the scientific name of England for a period of forty years. *Tyndall.*

The invention of the miner's safety-lamp by Sir Humphry Davy was based upon scientific researches described by him to the Royal Society between 1815 and 1817. The investigations were undertaken at the request of a "Society for Preventing Accidents in Mines," formed in 1813 in consequence of the increase of colliery explosions as pits of greater depth were worked. The Society looked to scientific men to provide "a cheap and effectual" remedy for these calamities, and Davy's assistance was secured in 1815, after a number of impracticable suggestions had been considered.

As the result of experiments, Davy discovered the principle upon which safety-lamps are constructed, namely, "that explosive mixtures of mine-damp will not pass through small apertures or tubes; and that if a lamp or lanthorn be made air-tight on the sides, and furnished with apertures to admit the air, it will not communicate flame to the outward atmosphere."

Davy might have made a fortune by his discovery, by taking out a patent for the invention of the safety-lamp, but he refused to do so. One of his friends, Mr. John Buddle, who urged him on one occasion to secure

this recompense for his investigations and their result, said: "I felt that he did not contemplate any pecuniary reward; and in a private conversation I remonstrated with him on the subject. I said 'You might as well have secured this invention by a patent, and received your five or ten thousand a year from it.' Davy's reply was, 'No, my good friend, I never thought of such a thing: my sole object was to serve the cause of humanity, and if I have succeeded, I am amply rewarded in the gratifying reflection of having done so.'"

When Dr. Roux, Director of the Pasteur Institute in Paris, was awarded the Osiris Prize of £4000 for the discovery of the "anti-diphtheria serum," which has been the means of saving the lives of many thousands of children, he made over the whole of the money to the institute of which he is the head, although he is relatively a poor man. The founder of the prize, M. Osiris, one day asked him why he had given the money to the institute. "All that I am," replied Dr. Roux, "I owe to the Pasteur Institute, for all my experiments and discoveries have been made there. Besides, the Institute is very poor, for we have no income except what we make by the sale of serums, and though that brings in enough to keep the establishment going, some fresh remedy may any day be discovered, in which case I fear the Institute would have to close its doors for want of funds." The millionaire said nothing at the time, but at his death, it was found that he had left the bulk of his wealth, amounting to nearly one and a quarter million pounds, to the Pasteur Institute, as a token of admiration for the scientific attainments and self-abnegation of its director.

A correspondent asked Newton's permission to publish in the *Philosophical Transactions of the Royal*

Society, the solutions, which Newton had sent him, of some mathematical problems. Newton was at a time of life—his age was about twenty-seven—when most men wish to obtain credit for their work, but he particularly asked that no mention should be made of his name in connection with this and like matters. "For I see not," he added, "what there is desirable in public esteem were I able to acquire and maintain it. It would perhaps increase my acquaintance, the things which I chiefly study to decline."

Newton was, indeed, never hasty in announcing his discoveries, and had little of the spirit of rushing into print to claim priority to which some investigators attach so much importance. After he had invented the reflecting telescope in 1668, he allowed the instrument to lie by him for several years before its existence became known to some of the fellows of the Royal Society who induced him to send it to the Society, where it is now carefully preserved. His important observations of the compound nature of sunlight, a beam of which he decomposed by passing it through a glass prism, were not communicated to the Society until 1672, though they were made before the invention of the reflecting telescope; and his discovery of the law of gravitation was completed several years before Halley knew of it and was able to make it known to the world.

What, then, are the motives of scientific work, if the praise and rewards of the world have no meaning? Chiefly love of knowledge and the joy of discovery; and possessing these things the man of science faces boldly all difficulties and is undaunted by danger. During an epidemic of cholera in Paris in 1865, Pasteur for a time undertook the study of the disease above the cholera ward of a hospital. Henri Saint

Claire Deville once said to him, "Studies of that sort require much courage." "What about duty?" said Pasteur simply. Danger is disregarded by the man of science as by the soldier when duty calls; and the spirit of both is reflected in the words of the battle-hymn:

> Grant that with zeal and skill this day I do
> What me to do behoves, what thou command'st me to;
> Grant that I do it sharp at moment fit,
> And, when I do it, grant me good success in it.

Huxley was a warrior of science throughout his life. When he was thirty-one years of age, while awaiting the birth of his first child, on December 31, 1856, he entered in his journal his ambitions for the future.

> To smite all humbugs, however big; to give a nobler tone to science; to set an example to abstinence from petty personal controversies, and of toleration for everything but lying; to be indifferent as to whether the work is recognised as mine or not, so long as it is done:—are these my aims? 1860 will show
>
> Wilt shape a noble life? Then cast
> No backward glances to the past.
> And what if something still be lost?
> Act as new-born in all thou dost.
> What each day wills, that shalt thou ask;
> Each day will tell its proper task;
> What others do, that shalt thou prize,
> In thine own work thy guerdon lies.
> This above all: hate none. The rest—
> Leave it to God. He knoweth best.

That such a prayer as this should be offered up at the most anxious moment of his life, by one who was thought to be the apostle of materialistic knowledge, shows how mistaken is the common impression that close devotion to science weakens the spiritual side of a man. The life consecrated to the study of Nature must by this purpose alone have aims and ideals as

high as any which stimulate human endeavour. No great work—whether in the natural or in the spiritual world—can be accomplished without noble aspiration. "Blessed is he," said Pasteur, "who carries with him a God, an ideal, and obeys it; ideal of art, ideal of science, ideal of the gospel virtues; therein lie the springs of great thoughts and great actions; they all reflect light from the Infinite."

All who labour to extend knowledge and establish truth are making for righteousness; though they sail in different seas they have the same guiding star, and it is set so far away in infinity that compared with its distance their paths are one. Let, then, the captain of each ship shape his own course and not concern himself with the tracks of other navigators; the new lands encountered may present very diverse characters, but each explorer is expected to describe only what comes within his own range of observation. He can know nothing of what pioneers in other directions have seen, but with hope at the helm and truth at the prow he strikes the course for which his ship was chartered, even when it seems to be crossing the tracks of other vessels or landing him upon the rocks. This is the spirit in which the scientific investigator sets out for unknown lands. "When I am in my laboratory," said Pasteur, "I begin by shutting the door on materialism and on spiritualism; I observe facts alone; I seek but the scientific conditions under which life manifests itself."

Facts which appear to be opposed to prevailing belief or theory are often reached in science, but if they stand unaltered after being subjected to rigorous and critical examination they must be adhered to and the belief or theory abandoned. In the world of natural knowledge, no authority is great enough to support a