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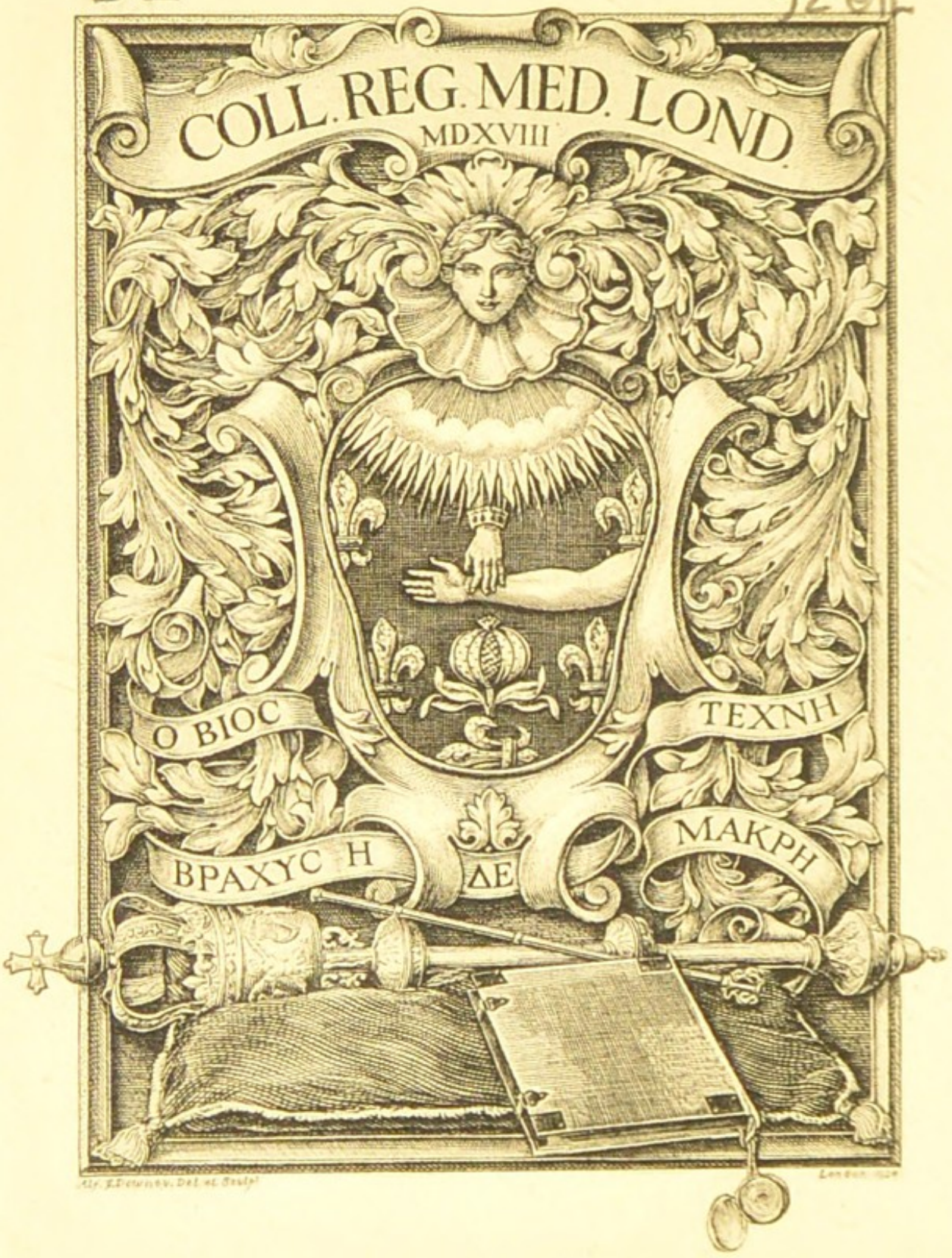


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Charles Le Penham.

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WILLIAM GILBERT OF COLCHESTER.

A SKETCH OF HIS MAGNETIC PHILOSOPHY.

BY

CHARLES E. BENHAM.

"Gilbert shall live till loadstones cease to draw,
Or British fleets the boundless ocean awe."

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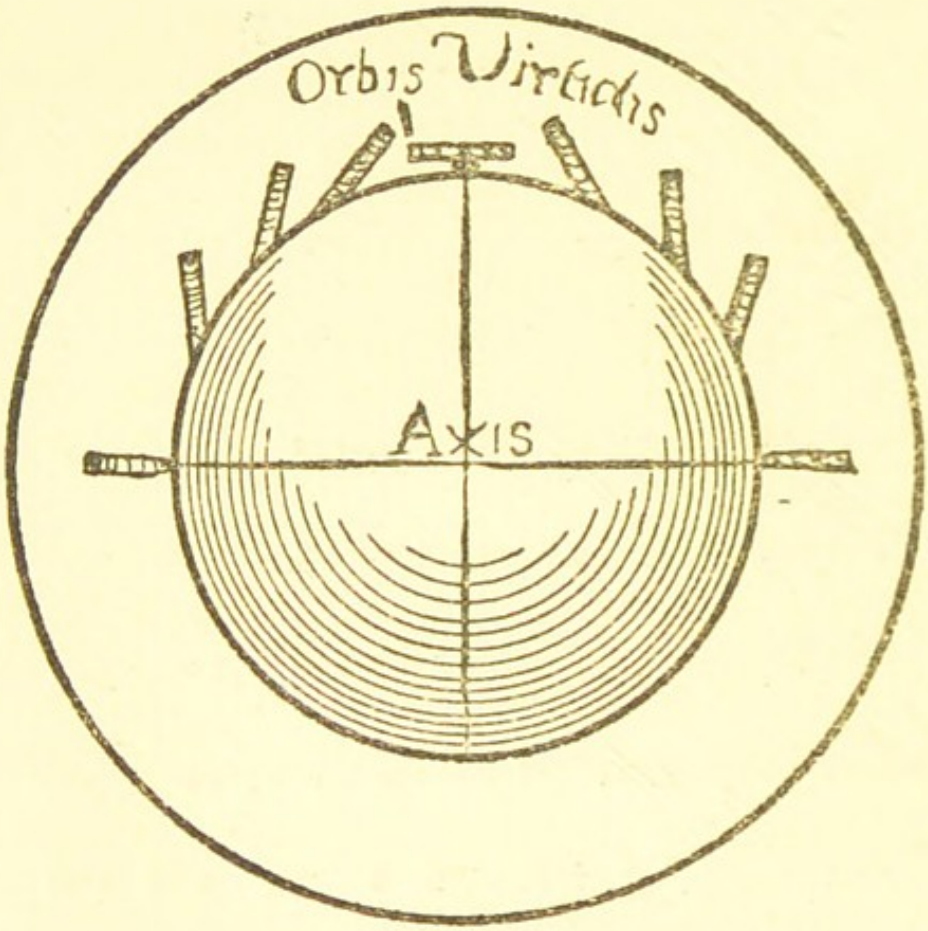

THE TERRELLA AND ITS "ORBE OF VIRTUE.

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WILLIAM GILBERT OF COLCHESTER.

CHAPTER I.—Introductory.

THE magnificent English translation of the De Magnete of Dr. William Gilbert of Colchester, which has been issued under the auspices of the Gilbert Club, will give to numbers of people who were unable to study the original an opportunity of making themselves acquainted with one of the most remarkable works in the whole library of historical science.

The translators and editors are to be warmly congratulated on having produced a version which can hardly be over-praised. The accuracy of the rendering and the tactful choice of an English not too antique yet just such as the author himself

might have used, are alike admirable. The conspicuous erudition of the notes leaves nothing to be desired, while the excellence of the facsimile illustrations and the typography and binding are all apiece with the pains, care, and skill evidenced throughout the enterprise.

The translation is indeed the very book itself. The Latin is of course eliminated ; otherwise it is, in outward form, to all intents and purposes GILBERT'S De Magnete exactly as it was given to the world 300 years ago, together with an extremely valuable and able commentary for the benefit of the more devout student.

While in outward form the monumental treatise has thus been revived and reproduced with a page-for-page fidelity which must ever be the admiration of scholars, it is the more inward character of GILBERT'S work that is of chief interest to the general public. The world would like to know what manner of man this GILBERT was, wherein lay his genius, what were his merits, and also his

faults and failings. It would like to comprehend the essential qualities of his work without a laborious following out of his innumerable experiments and arguments, to have a popular sketch of GILBERT and his philosophy, in fact a reanimation of the spirit of the book as well as of the letter, and it is with a view to some such end that these few chapters are written, with a full consciousness of the difficulty of the undertaking and the inevitable imperfection of the attempt made to carry it out.

The greatness of a man of genius is promptly appreciated by a few, and gradually recognised by a widening circle, but as that circle extends still further, what was originally appreciated for its pure merits is apt to become less intelligently admired. The essential qualities which really marked the genius of the man are lost sight of and are replaced by fictitious excellences, while the true nature of his greatness is more and more misapprehended. Merely incidental matters are

mistaken for the essentials of the man's work, and are exalted into its special merits. His idiosyncrasies and mannerisms, even his very faults and failings, are assumed to constitute his distinguishing virtues, and the real worth and superiority of his art are passed by unperceived by casual minds, whose approbation is often bestowed for very little better reason than the fact that it is universally accorded.

No more striking illustration of this tendency could be instanced than the popular estimation of GILBERT'S mighty contemporary Shakespere. Few have the candour of a Darwin to admit that they are without perception of the charm of Shakespere's plays, but many, quite as blind as he to that subtle dramatic power, rather than own to non-perception attribute the genius of the great poet to what they think they do see in his work, VIZ., a sort of encyclopedic knowledge of facts. He is reverenced as being supposed to have had a wondrous acquaintance with natural history,

horsemanship, sport, law, history, art, and innumerable other subjects of which as a matter of fact he had but the most superficial knowledge, as is evident from his abundant errors and anomalies. Of course his real pre-eminence is not to be sought in any such sphere. It lies in a higher plane than that of mere material text-book knowledge. It is totally distinct from and independent of either accuracy or inaccuracy in these incidentals. It is not diminished by the circumstance that he took plots from Holinshed or Boccaccio, that he made the cannon roar in the days of King John, or allowed Hector to quote from Aristotle, or refused the nightingale permission to sing in the daytime. It is not increased by the supposed knowledge of field botany and sport with which some people accredit him. The subject matter, with its accuracies, and inaccuracies, was but the paint and canvas; the genius of the writer consisted in the art with which he used these materials—the

magical way in which he held the mirror up to human nature.

In considering the work of Dr. WILLIAM GILBERT we are confronted with a not dissimilar tendency to misapprehend the essential qualities of his genius, to misunderstand the way in which he may be truly said to have been the pioneer and founder of physical research in England. He is often regarded as having risen to fame by discoveries of electric and magnetic phenomena unknown before his day, yet a perusal of his volume will show that he discovered comparatively few new phenomena of special importance in either province. The attractive power of the loadstone, the variation of the compass and its "dip" from the horizontal, were things known to the world before his time, while as to electricity—a term he never used—his only references to its manifestations are confined to one small portion of the De Magnete, in which he distinguishes between magnetic attraction and that of amber, jet, and other substances, which or

convenience he groups together as "electrics." He was the first, it is true, to use this term, and to call those substances which appeared to have no such attractive power "non electrics." He corrected undoubtedly a few glaring cases of "bad observation" on the part of other investigators of these attractive properties, but his own experiments in this particular field of research were extremely crude, and he was not always specially accurate, denying for example the existence of electric repulsion, and never suspecting that there was any connection between this form of energy and his magnetic force. Indeed, his whole purpose in introducing "electrics" is to emphatically contradict the notion that any such relationship exists.

But we must not look for GILBERT'S distinguishing genius in the discovery of facts and phenomena. Discovery is indeed often a mere accident, which may fall to the lot of either a genius or a commonplace man.

And yet GILBERT stands high above all his

contemporaries in England in the field of physical science, and to see in what respect this is true his methods rather than his actual results must be considered. What he laid the foundation of was not so much magnetism or electricity as the way in which magnetics and electrics ought to be studied. He was not the builder of sciences, but the architect of a truly scientific spirit, and his lifework consisted in the doctrine, new to England, that all scientific knowledge must be founded on practical experiment and observation alone, instead of upon speculations and theories evolved out of inner consciousness. Here lay the greatness of the man. Here lay the distinction between him and his predecessors—a greatness and a distinction that must ever be recognised by those who appreciate the enormous importance of this guiding principle in the search into the secrets of nature, a principle which GILBERT, anticipating Lord Bacon, the reputed founder of "inductive philosophy," taught and exemplified (with

occasional lapses) throughout his writings and researches.

It is this aspect of GILBERT, as the discoverer of true methods of investigation rather than of unknown facts and phenomena, that will be insisted on throughout these chapters.

That he did bring new facts to light too is of course undeniable, but they were not the important part of his work. It was impossible in that age that any experimenter could enter the then unexplored territory of research without continually coming upon something new. "Daily during our experimenting," says GILBERT, "new and unexpected properties came to light," and the modern student can scarcely help envying the pioneers of science, who, as if to compensate them for the arduous work that they had to accomplish, enjoyed at least the privilege of experiencing almost constantly the fascinating glamour of first glimpses into Nature's mysteries. They trod as it were, the forest primeval of science, and for all the entanglements

that beset their path they enjoyed the glory and the triumph of being the first to find what now are reckoned but familiar weeds of the field, so common, so everyday, that we hardly trouble to stop and gather them.

How different it all is nowadays. No matter what field of research the student enters now, innumerable specialists have been there before him, culling, naming, examining, dissecting, analysing down to its very elements, every leaf and blade. Hardly in a lifetime does the patient toiler now find one exception to the leaden rule that nothing is new beneath the sun. Glorious indeed must have been those truly "spacious" Elizabethan times when "daily during our experimenting new and unexpected properties came to light." Yet these minor discoveries, full of enticing delight as they must have been to GILBERT in all the freshness of their novelty, were but incidental features of his work. There have been many investigators more competent perhaps than he, but he taught them all

how to set about their work, and thus was enabled to taste the first-fruits of the new tree of knowledge which he planted in the Eden of Science, and of which no man is forbidden to eat. Thus he was first in a position to guess aright the signification of these "new properties," which except for his system of investigation would ever have remained for man fragments of the inscrutable magic of nature.

The chief of these "guesses at truth" which followed consequent on his experimental system of philosophy was of course that expressed in his enunciation of the great cardinal doctrine of the whole of his teaching—the hypothesis that the earth is a Magnet. On that grand conception more will have to be said presently. "I do not know," remarked Lord Rayleigh a few years ago, "that we know much more about it now." Might he not have said that perhaps we do not now know quite so much ?

CHAPTER II.

The Old Magnetic Philosophy.

THE great volume on the Magnet was not issued until its author had patiently repeated again and again the numberless experiments on which his conclusions were based. For nearly eighteen years he worked at these experiments before venturing to publish his Opus Magnum. His apparatus was of the simplest, homeliest character. First and foremost there were his terrellæ—(miniature worlds)—globular magnets, so shaped to enable him to trace the concordance between their behaviour and that of terra, the great earth itself, of which he held them to be magnetic counterparts. Then there were his versoria, delicately poised iron needles, to show the attractive, repulsive, and directive influences

of magnetism, so as to illustrate and elucidate the mysterious pointing of the compass northward, but not due north, nor yet in a horizontal line, but dipping for some reason downward below the horizon level. Besides these he utilised a great array of corks and little wooden boats floated on water and freighted with loadstones and iron needles to reveal the finer adjustments of magnetic movement. He had also such things as iron and steel bars, iron filings, lengths of iron wire, fragments of jet and amber, and pieces of glass, resin, and other "electrics," as he named them. With nothing but odds and ends of this kind—no elaborate instruments—he worked on for nearly 18 years, resolved to confirm every observation by repeated trials, and to set down nothing but what he had positively proved by indubitable evidence. At the same time throughout these long years he was collating, in connection with his experiments, observations as to the variations of the compass made by navigators in all parts of the world.

It was almost the first time that anyone in this country had set to work investigating in this experimental fashion in any department of science. It was quite the first time that anyone, either at home or abroad, had sought to solve the mysteries of the loadstone in this way.

Not that the philosophers had ignored the virtues of the wondrous "stone," nor that they had remained silent about them, for GILBERT declares that "with their labours the shops of the booksellers are crammed." And these prolific writers by no means under-estimated the wonderful properties of the loadstone. On the contrary they certainly gave it credit for a very great deal more than was necessary. One after another they scribbled on, some inventing, others merely copying, others again enlarging and embellishing the most astounding stories of the loadstone's virtues. They told of islands in the far seas where the loadstone rocks drew out all the iron nails from the ships that came near, so that wooden pegs had

to be substituted in the naval architecture of the region. They wrote of Mahomet's coffin, hanging in mid air beneath the roof of a shrine vaulted with loadstones. They talked learnedly of magnetic stars, notably the one in the tip of the tail of the Great Bear, which they solemnly declared directed the compass to its fixed position. They described how the loadstone, pickled in the salt of a sucking fish, had power to draw forth gold which had fallen into the deepest wells; how the super-eminent virtue of the diamond annulled the power of the gross stone, as did garlic too, though the loss was made good by the simple expedient of bathing the loadstone in the blood of a goat. Further, this most wonderful stone removed sorcery from women, put devils to flight, reconciled husbands to wives and wives to husbands, while in disease it was no less efficacious and invaluable, so that pounded loadstones were an essential ingredient of the "divine plaster" of Nicolaus, and were

equally approved by the master physician Paracelsus himself.

Such are a few samples of the magnetic philosophy current when GILBERT wrote, and the philosophizers were still going on, inventing, and copying, and embellishing, and generally vying with each other in the arts of lying and plagiarising, so that with their books the shops of the booksellers were crammed.

No wonder that GILBERT flashes scorn upon such balderdash parading as wisdom and backed up by the authority of men of high sounding titles, reputed to be the very cream of the philosophers. Here was he in a position to prove positively by 18 years of experiment what the magnet will do and what it will not do, and yet these "raw smatterers and copyists," who had perhaps never handled a loadstone in their lives, "troubled and fatigued the studious with a vast ocean of books" on subjects they knew nothing of by actual experience.

No doubt he had realised only too painfully what the "trouble and fatigue" were. One can fancy him poring over these fantastic tomes one by one—Cardan, Marbodæus Gallus ("that chorus leader of vanities," as he calls him), Avicenna, Paracelsus, Albertus Magnus, and the rest—and testing their "old wives' fables" one after another by experiment, only to find that the breath of the garlic had no more effect than the pure air of heaven, that the diamond, and the goat's blood, and the sucking fish were all so much waste material in his laboratory, that the tales of the coffin, and the stars, and the rocks that drew nails out of the ships were contradicted by the most elementary acquaintance with the phenomena of magnetic force. What a waste of time and money and toil to have secured these precious books, and spent days and nights wading through such inane ravings! No wonder that he grows angry, and that he starts by christening the whole babbling crew "corrupters of good arts, learned idiots,

grammatists, sophists, wranglers, and perverse little folk."

" To you alone," he says, " true philosophizers, honest men, who seek knowledge not from books only, but from things themselves, have I addressed these magnetical principles in this new sort of philosophizing."

If we lose sight of the ample justification that existed for his contempt and wrath, his bitter satire and fierce invective throughout this work against " the crowd of common philosophizers," as he calls them a hundred times, we might be tempted to accuse him of self-conceit and arrogance. But there is no reason to charge him with either of these faults. He was amply justified in all his sarcasm and banter. He wrote of what he knew, and he knew that he knew. They wrote of what they did not know, and—darkest phase of ignorance—they did not even know that they did not know.

His method of basing theory on experiment

seems to us nowadays merely a preliminary and obvious essential of all scientific work, but in his day the principle was as he says a "new sort of philosophizing." Lord Bacon, as has been already stated, was supposed to be the originator of the "inductive method," but WILLIAM GILBERT was really the pioneer, from whom perhaps the great Earl of Verulam, "the wisest, brightest, meanest of mankind," derived a good many more ideas and suggestions than he openly acknowledged.

There is always a fascinating interest in the contest of the single-handed champion of any new philosophy founded on true and sound principles against a host of the mighty whose teaching is founded on error and superstition. The episode turns up again and again in the history of the world. It is the old, old story of David and Goliath. Though armed only with the simple sling of truth and the five small stones of fact, the merest stripling may be confident of success against the Philistine giants, notwithstanding

their elaborate weapons and their high-sounding titles. It was so when Copernicus propounded his system of the Universe, and defied the fulminations of the Goliath of Rome. It was so when Galileo muttered his indignant "Yet it moves." So, too, when Harvey, careless of the ridicule of the ignorant, announced the circulation of the blood; when Thomas Young, regardless of the forthcoming anathemas of Lord Brougham and the "Edinburgh Review," boldly put forth his theory of light; when the authors of the famous "Essays and Reviews" challenged the clamorous Philistines of a later day; and later still, when Darwin and Spencer elaborated a truer conception of some of the higher problems of man's descent and origin. So, too, was it with WILLIAM GILBERT, of Colchester, whose infallible weapons of practical experiment and observation of the facts of Nature were bound to overthrow the armies of the Philistines.

But so long is the drama of History, and so short the parts played by each individual actor,

that not every David lives to see his Goliath slain and buried, and though now, these 300 years after the contest, all the world acclaims the victor, he in his own brief lifetime did not know of his triumph from the plaudits of the multitude, but only from the certain assurance within him that the truth is great and must prevail.

Yet we need not waste sympathy on geniuses on that account. That inward conviction is to them as full of satisfaction as the praise of the world, and, perhaps, had they their choice, they would far prefer the commendation of that still, small voice, to all the compliments which a Royal Society or a British Association could confer.

On the other hand, we may reasonably enough extend a little sympathy to the poor Goliaths, whose downfall is indeed a most pitiable thing. It is always the wrong and the false that are in need of pity, even though they are on the throne; never the right and true, even though they are on the scaffold.

One cannot help half regretting that the advance of knowledge should necessarily involve the destruction of so much that was charming enough artistically, just as it seems to have been impossible for the reformers of religion in this land to sweep away superstitions and abuses without demolishing abbeys and monasteries, statues and shrines—depriving the Church's temples of so large a portion of their former beauty. And can we help wishing that GILBERT might have been able to spare a few—if only a few—of these wondrous bits of fairy lore which he so ruthlessly demolishes and proves to be without a shadow of foundation? If he could only have found some germ of underlying truth in such pretty stories, such charming flights of fancy, instead of compelling us to admit that we must let them all go—every one of them, altogether! Take for example that star with the yearning for the loadstone, away and away through space in the tip of the tail of the Great Bear. The story had been told and re-told over

and over again, gathering little by little as it went on, till it grew to almost a romance. And GILBERT at a stroke relentlessly sweeps it all away. He sets up his rigid versorium, his row of terrellæ, his cork rafts with their magnetic crew, and with one consenting voice they tell us uncompromisingly and unequivocally that the loves of the Bear's tail star are not for them, and that they too care no more for that shining orb than for the man in the moon. Then too the rocks that drew the iron nails out of the ships—down they must go, back into the ocean depths of superstition out of which they arose. It is sad—so much less fairy-land in the world! And the garlic legend, is there not some shadow of foundation for that? Who that has been in the Louvre on a Sunday afternoon, and really tested the strength of the sphere of that objectionable herb-food of the Parisian working man, can fail to have had a lingering doubt as to whether the strength of a magnet could remain unimpaired in such an atmosphere? But no, this foolish fancy

must go too, together with the story of the diamond's anti-magnetic virtues.

As to this last, however, it will surprise many to learn that the belief still has its votaries, even amongst men of some distinction in science. Dr. Encausse, of Paris, describes and illustrates an experiment, in which he says he has proved that a diamond placed between a natural loadstone and a particle of soft iron stops the magnetic influence, or at any rate diminishes it considerably. He adds that while the experiment is of his own devising, the property it demonstrates has long been known to diamond merchants.

But only to think how in the dim past the highest imagination of long-cloaked doctors and sages must have been strained to devise these and many other magical tales of the loadstone, how generation after generation and century after century men laboured in the footsteps of these philosophizers, inventing, embellishing, fabulising, and plagiarising, or simply copying and copying and

copying in child-like faith and innocence, and all this labour was in vain, for now comes this upstart doctor, and poises his silly rods on needle ends, and floats his ugly terrellæ in a basin, and all the great magicians must bow down in deference to the stern wand of the versorium, and proud philosophy must humble herself to the pilotage of that iron cargoed cork, while all these delightful fictions of the past, wrought with such consummate skill by past masters in the art of lying, must sink for ever into the limbo of exploded vanities and superstitions.


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CHAPTER III.

The First Book of De Magnete.

WITH what delight Gilbert must have penned that opening chapter of the First Book of his treatise, in which he recapitulates the history of magnetic knowledge from earliest times down to his own day, and avenges himself on the impostors and fabulists who had so long sat unworthily in high places. With cynical solemnity and no small genuine classical erudition he quotes one after another the wild dreams of the ancients dealt with in the previous chapters of this sketch, and instances the bland acquiescence in these fictions exhibited by his contemporaries, whose only standard of truth seemed to be, "Have any of the rulers believed in it?" and who had no notion of ever appealing to the only rational and

authoritative tribunal, the court of practical experiment. "O that mine adversary had written a book!" cried Job, at the end of his long and bitter lamentation. GILBERT'S adversaries had, happily for him, written books many and massive, till "the shops of the booksellers were crammed with them," and lest their follies and vanities should escape unpunished to oblivion's secure haven of refuge, he seizes the opportunity of permanently pillorying them and holding up their ravings for the whole world to laugh at thenceforth and for ever.

Not one of them will he allow to escape. The whole "crowd of vain philosophizers" shall be brought to his bar and arraigned one by one. Regardless of the weariness which must have overtaken him as he painfully laboured through the musty tomes, he forces the babblers one by one to plead guilty to the extravagant and wilful falsities which they had so wantonly put forth as utterances of wisdom and divine philosophy.

Plato and Aristotle, Theophrastus and Discorides, with one or two others, he recommends to mercy. They knew nothing except that the loadstone attracted iron, and they had the prudence to say no more about it than they knew.

But after them arose those who, as though it were better to profess false knowledge than to admit ignorance, must needs invent "figments and falsehoods" which "these raw smatterers and copyists put forth to be swallowed by men." Such were Pliny the Younger, Ptolemy and the founders of the garlic heresy, Galen with his rubbish as to the medicinal virtues of the stone, Matthiolus with his Arabian Night story of the floating coffin of Mahomet, Cardan, Avicenna, Marbodeus Gallus (the "chorus leader of vanities"), and a whole host more whose names are all set forth in fullest style. These he condemns to the severe castigation which they justly deserved, and which he was fully entitled to administer, considering how their prolix lucubrations must have

wearied him and wasted his precious time in the perusal.

Paracelsus himself, despite his august repute, is not spared, and Acosta is reminded with scathing sarcasm, that while he is "quite ignorant about the loadstone, nevertheless he pours forth vapid talk upon it."

Dream after dream of all these sleepy quasi-sages is revived and retold by our scornful doctor, who indulges in playful banter for some of the philosophizers, and something very like a good solid British kick for others.

Such passages of De Magnete as these are assurances that the one only portrait of GILBERT extant has at least preserved something of his outward likeness. The keen straightforward searching glance, the twinkling play of good-humoured sarcasm, ready to vent itself on all "old wives' gossip" and "foolish vanities," the frank, fearless, open countenance, intolerant only of shams and frauds—all these characteristic traits

of the man are not untraceable in the portrait and are equally conspicuous in these tirades of his against imposture and deceit.

A few there are whom GILBERT, in his historical review, dismisses from his assize as not guilty. The "angelic doctor," Thomas Aquinas, is discharged with a caution that he ought to have experimented more, and trusted his "divine and clear intellect" less, while one or two—"all Englishmen" as GILBERT observes in a patriotic parenthesis—are given full credit for having faithfully observed the phenomena of magnetic "variation" in voyages in different seas. Among these are Abraham Kendall—a very Colcestrian name, and perhaps that of a member of the family of the benefactor so well known locally—and Edward Wright, evidently a firm friend, as he it is who writes the preface to De Magnete, from which glowing eulogy of the author it is evident that he was one of the few who had a full perception of the epoch-making nature of these

investigations into magnetics and of the "new sort of philosophizing."

Even the pioneer of a new age cannot altogether free himself of the zeit-geist, the spirit of the times in which he lives. Even our GILBERT, thundering anathemas on the prevalent custom of founding theory on conjecture instead of on observation, is not himself guiltless of some occasional tendency of a similar character. It is always so. The iconoclast unconsciously has an idol somewhere in his breast, even if it be but iconoclasm that he worships. The Puritan, inveighing against robes and stoles, has his own "vestments" too—his plain, dreary, sober attire, his solemn hat, and his ritual of sanctimonious attitude and manner.

Many are the passages in GILBERT'S work that now, in the clearer light of the twentieth century, the man of science cannot read without a smile, noting how the reformer "loses the touch he talked of," lapses, only momentarily perhaps, into the

very faults that he condemns in such just and forcible terms.

Mighty are hereditary tendencies and the influences of the age we live in, and mightily do they assert themselves in human nature. As long as WILLIAM GILBERT holds fast to his "new sort of philosophizing," his admirable principle of establishing all by actual experiment, he is on safe ground, and his work holds its own to the present day, but as soon as he temporarily forgets his own excellent precepts, and imagining, as those of his time always did, that it is incumbent on the philosopher to explain everything, and never to admit that he does not know, then his wings flap like those of the others, and, Icarus-like, he is in imminent risk of melting the wax by too near an approach to the dazzling sun of human imagination.

In the second chapter he has hardly ceased laughing over Nicander's fabled herdsman, whose shoe nails and the tip of whose staff stuck fast in a

magnetic field while he pastured his flocks—he has hardly recovered from his amusement over this pretty story before he almost sticks fast himself in the quagmire of conjecture, floundering sadly over the merest suppositions, which he sets forth just as if they were ascertained facts, whereas, however plausible some of them may have seemed, they were far from proved, and some at least have since been altogether disproved.

The loadstone, he dogmatically declares, is everywhere, and when it is not found it is only that men have not dug deeply enough. Ah, but he should first have dug everywhere deeply enough himself before he ventured upon making quite so confident a generalisation.

A little further on he shocks the Weller seniors of modern science by "werging on the poetical," when he explains in almost cabbalistic terms that "although the terrestrial globe, owing to the varied humours and natures of the soil arising from the continual succession of growth and decay, is in

the lapse of time efflorescing through all its ambit deeper into its surface, and is girt about with a varied and perishable covering, as it were with a veil, yet out of her womb ariseth in many places an offspring nigher to the more perfect body, and makes its way to the light of day. But the weak and less vigorous loadstones, enfeebled by the flow of humours, are visible in every region, in every strath." This may be all charming enough poetically, but it is not quite scientific. It is not at all in accord with his own "new sort of philosophizing." It is sadly at variance with his self-imposed initial resolve " to set down nothing in these books which hath not been explored and many times performed and repeated amongst us."

Such lapses occur from time to time throughout his treatise. One could not wish them expunged. Rather, they are specially interesting features of the work, noteworthy as showing the imperious power of a man's time and surroundings, and they take no more from the lustre of a GILBERT'S genius

than the spots on the sun take from the brightness of a summer day.

The next chapter leaves all this historical and critical survey of the theme, and goes straight to practical experimental work. The terrella, or micro-gē, is introduced—a globular loadstone, a model of terra herself as far as magnetism is concerned. Mapped out with chalk on the terrella are the poles, the equator, the meridians of this miniature world, and at once its correspondence is made manifest by the simple experiments he describes. The versorium, or compass, when within the terrella's "orb" (or sphere of magnetic influence) turns to the toy world's north, stands upright at the pole, lies horizontally at the equator, dips diagonally at intermediate latitudes, all just as it does on the great globe we inhabit.

The demonstration is a striking one. In a moment, as it were, the veil is half drawn aside that hid the mystery of the loadstone. The conclusion seems irresistible—evidently there must be

a correspondence between terra and terrella; the earth must be a globular magnet. That was GILBERT'S cardinal doctrine, his clue to the whole domain of magnetic philosophy, the foundation of his whole theory of magnetism, and well and amply does he illustrate and demonstrate the reasonableness of his contention by innumerable experiments with his terrella. In this First Book, however, he reserves the actual announcement that the Earth is a Magnet until the last chapter, where indeed it comes as a fitting climax to his able series of experimental demonstrations, all working up to corroborate this fundamental principle.

It will not be necessary to recapitulate all GILBERT'S experiments. They are many of them now familiar to every school boy. Nor will it be needful to dwell long on the argument with which he disposes of the erroneous common idea that the north pole of a loadstone is the end that turns northwards. Strictly speaking, it would be more proper to term the end that points to the north the

south pole of the loadstone, for opposite poles attract. All this is abundantly and admirably explained for the first time by GILBERT, and it is all thoroughly well understood nowadays, though after all it is not much more than a matter of arbitrary terms, and it is curious that the terminology he so stoutly opposes is still almost universally retained in this country, though in France, oddly enough, GILBERT'S proposed reform has been accepted. In modern times, when any confusion might arise from applying the word "north" or "south" to the pole of a magnet, the simple expedient is generally adopted of calling the end which points northward the "north-seeking" pole, thus preventing all possibility of misunderstanding.

The remainder of this First Book, some dozen more chapters, tells of the properties most obvious in loadstone and iron, their behaviour mutually and relatively, their action when suspended, when cut into halves, and so forth, all these branches of the subject being treated with a view to illustrate

an orderly connected argument, which is admirably relieved by a scathingly sarcastic chapter on the alleged medicinal virtues of the loadstone, in which he twits the smattering Galens and Avicennas with their internecine wranglings. "Whether iron is hot or cold," he drily remarks, "each settles according to his own sentiment," and he facetiously recommends that they be left to do so, only pointing out to them and their followers the extreme dangers of their drug, and the absolute impossibility that their loadstone powder, rendered perfectly unmagnetic as it is by heating and pulverisation, can either attract or repel anything in the body or out of the body.

The First Book also contains a somewhat unfortunate chapter on what iron is. Here GILBERT once more puts on those Icarus wings which lead him to such dangerous flights of conjecture, and he comes sadly to grief in his argument that as soil dug out of a deep well produces herbage and weeds which spring (as he thinks) from no

seed but spontaneously from the soil, so iron, by mysterious "efflorescences," and "deformations," and "precipitations," and "generations," is evolved from its "hidden primordial elements," and so forth.

Wiser would he have been to have admitted frankly what no one, be he philosopher or not, need be ashamed to admit, that as to what iron is, apart from its properties, we do not know, nor whence its origin in this universe. But it was not an age in which even a GILBERT had courage to say that.

CHAPTER IV.

Magnetic Motions and Electric Force.

AN orderly style is of the highest importance in all good work, and especially in all scientific work. More properly speaking, order is equally necessary in all good work, while in scientific work it should be manifest. In literature and in provinces that appeal more to the art side of the human mind, it is an advantage if the method of arrangement and composition is not tiresomely obtrusive. To conceal it and yet retain it throughout is the art of arts. There must be nothing at random, nothing unpurposed, though the old tedious custom of "Firstly, secondly, thirdly, finally, and one word more, my brethren," is happily no longer tolerated. The architect must use ruler and compasses, and the builder must erect

a scaffolding and work by the plummet, but when their finished labours are presented to the public these accessories are removed from view, and the building, if it is a true work of art, should suggest no thoughts of such things.

But in science, where the intellectual rather than the æsthetic faculties are appealed to, an orderly arrangement is not only necessary, but should be obvious throughout to the reader, if he is to follow his author intelligently, step by step.

In physical science in this country GILBERT was apparently the first to recognise this essential principle. His bugbears, Cardan, Paracelsus, and the rest of the "crowd of philosophizers," had no notion of the importance of orderliness. On the contrary, they had the best reasons for carefully eschewing it, taking advantage of chaotic confusion of style and treatment of a subject to hide their own ignorance under a veil of wild, whirling words.

Experimental work begets orderly treatment of a

subject almost as a matter of course, and it was because GILBERT'S foundation was on the rock of experience that the superstructure was so methodically wrought. He who makes good use of one talent has others committed to him, and so GILBERT, as a consequence of making the true experimental attitude of science his starting-point, became also the pioneer in further essentials of the scientific spirit, and was instinctively endowed with the power to handle his theme in orderly style. The First Book had laid the general foundations of his teaching in a resumé of the principal properties of the loadstone, and the Second Book follows on quite connectedly to consider matters for which the way has now been prepared—namely, magnetic motions, a branch of the subject which is dealt with by classifying those motions under five all-embracing heads, namely:—(1) Attraction, or movement bodily; (2) Direction, as when the compass is not moved bodily northwards, but merely points in that direction; (3) Variation, or

the change of goal to which it directs its point in different quarters of the globe; (4) Inclination, or the dip of the compass below the horizon line, also varying in different regions; and (5) Revolution, or circular motion, which, had the learned doctor been acquainted with modern dynamics, he would probably have omitted from his list as redundant.

It is in the course of discussing these various kinds of magnetic motion that GILBERT incidentally compares and contrasts the attraction of the loadstone with that of amber and other substances, giving rise to a common idea that he founded the science of electricity. The attractive properties of at least five other substances besides amber and jet were known to the world before GILBERT'S time, and what he really did was to add still further to the list, and to group such bodies together as "electrics."

He made a few interesting, though, apparently, rather hasty experiments with these "electrics," in order to see how far their properties agreed

with those of the loadstone. He came to a few correct conclusions, but to more that were incorrect, for alas in these particular experiments he was himself a sad victim to the "bad observation" that he rebukes so severely in others with regard to the loadstone. Worse still, he committed himself to some utterly untenable hypotheses with regard to the nature of electric force, temporarily forgetting entirely the splendid resolve with which he started his investigations, to set down nothing that he had not established by observation. But for his coinage of the potent words "electrics" and "non-electrics," and for his description of a few interesting experiments with these substances, one could almost wish that for his own sake he had blotted out this unfortunate chapter, so full is it of wild dreams and fanciful conjectures. Probably he himself thought it all apiece with his sounder philosophy, for even Homer nods occasionally while thinking himself wide-awake.

Students of the history of science will remember

abundant parallel instances. "Newton's Optics," for example, though marred by false premises, is generally faultless as a piece of close deductive reasoning, except here and there, where the slip-shod unscientific instincts of Newton's day occasionally assert themselves, and run riot with his intellect, as for example where he attempts to explain the highly refractive power of sulphur by the extraordinary argument that, as the sun's rays condensed by a lens most readily set in flame sulphureous bodies, so it is only natural, action and re-action being mutual, that sulphur should re-act more strongly on light!

And even a GILBERT may lapse into the foolish style of his contemporaries if for the nonce he loses grip of the rein with which, as he himself first taught, the man of science must ever hold his imagination in check.

"It is plain," he gravely assures his readers, in a passage worthy of Paracelsus, "that the earth is composed of things wet and things dry." Those

whose origin is from the humid principle, "such as lucid gems, which are made of water, and crystal, which has been concreted from clear water by hard frost"—save the mark!—"attract electrically, while those that are made out of the dry earth substance, such as the metals, are not electrics." And this is but a sample of much more equally sorry stuff, which it is not worth while to traverse now, though, in order to show how crudely he observed his rubbed amber, it must be mentioned that he goes so far as to positively deny the existence of electric repulsion. "All electrics attract all things," he declares, "they never repel anything at all." And from this sad blunder of "bad observation" he draws naturally enough, equally erroneous inferences as to the absence of any relationship between electric and magnetic force, and perhaps worst of all, he calmly lays down, with as much assurance as if it were an ascertained fact, the gratuitous dogma that the cohesion of the earth's particles

is electric, while rotation and direction are magnetic.

Ne sutor ultra crepidam. How wisely had he remarked just above that "this attraction of amber and of electrical substances must be further investigated." Alas, then, why could he not have awaited the results of such investigation before committing himself to such definite blunders in the very mode and manner of the foolish "crowd of philosophizers ?"

Quite otherwise is it throughout nearly the whole of the remainder of this Second Book, which consists of brief chapters describing experiments innumerable, the outcome of which is a clear, consecutive, and convincing argument supporting the theory he held as to the underlying principles of magnetic movements, and their relationship with the directive influence of the earth on the compass. One by one GILBERT roots out the weeds of error and deceit so diligently planted by "the herd of philosophizers and plagiarists" of old, foolish

dreams of perpetual motion, groundless stories of diamonds that snatched the iron from the magnet, and of sulphur flames seeking iron and stones, and of mysterious and rare magnets that attract flesh, water, fishes, gold, and what you will. With his faithful terrella and his geographical globe, he tracks down the mystic force to the earth's hidden centre, and with marvellous imagination—not of the Paracelsian order, but imagination of that kind which Tyndall so strongly insists on as essential to the truly scientific mind—he establishes a fundamental philosophy of magnetic motions, which as a general whole stands firm to this very day.

CHAPTER V.

The Magnet's Directive Virtue.

THE Third Book of De Magnete deals exhaustively with the "directive" as opposed to the "attractive" power of the loadstone, an important distinction previously never properly understood. By attractive is meant, of course, the actual translatory movement of iron to magnet, while directive virtue is the power which one magnet has of inducing on another a fixed verticity, as when the great Earth-Magnet, without drawing the compass to its north pole, merely forces it to point in that direction.

Gilbert fights hard against the word "attraction," as being the source of the whole prevailing misunderstanding as to the relationship of these two very different phenomena. He classes the term among the slipshod names of the ignorant

ancients, and he proposes "co-ition" as a more suitable word, using it himself throughout the volume in place of "attraction."

It is a hard task, however, to subvert established phraseology, reasonable as the suggested reform may be, and the old term "attraction" has clung, though the great doctrine, clearly perceived and enforced by GILBERT, that action and reaction are mutual and equal, which was really the essential at issue in his suggested alteration of terms, has become so thoroughly well realised that no misunderstanding is likely to arise now from the use of a word which in GILBERT's day involved considerable danger of misconception. As has already been pointed out a similar failure attended his attempt to re-christen the magnetic poles, yet there again the main point concerned in the suggested reform of terms (namely, that the earth's north pole and the magnet's north-seeking pole are really opposite poles) has not been lost upon the scientific world.

Into the hidden cause of the direction of the compass on this and the other side of the equator, a problem altogether unsolved up to his time, GILBERT spared no pains to penetrate. He investigated the mystery with the help of his miniature-earth load-stone, and compared the results of his experiments with observations as to the directive influences exercised on the larger scale on the compass by the Earth itself, taking his information as to this from reliable circum-navigators of the globe, including no less a worthy than "our most illustrious Sea-god, Francis Drake." What a triumph for him to realise, as he did, in the observations recorded by these seamen, the fulfilment of the anticipations which he had formed at home by the mere study of his faithful terrella, silencing for ever the random declarations of the opinionated philosophizers, whose silly tales as to the behaviour of the compass in the Southern Ocean had seemed to threaten the overthrow of his whole hypothesis of the magnetic nature of the earth itself.

Surely we may pardon him if from this further correspondence and accord of terra and terrella he was led to speculate a little further than the facts quite warranted, and even attributed the inclination of the earth's poles from the poles of the ecliptic to the world's "virtue magnetical." It may indeed be just possible that his conjecture is not altogether erroneous, though it cannot be said that 300 years of extending knowledge have demonstrated it, and even should further advances of science ever chance to support his ex cathedrâ statement on this matter, it must be admitted that he would only be entitled to the credit of having made a lucky guess, for certainly he did not adduce any rational grounds for his supposition. But probably no man yet ever hit upon a great and epoch-making discovery without a tendency to make his new yard wand sole measure of the universe, his cherished clue the magic key fitting all Nature's myriad locks.

On the other hand his deductions in general as to the relationship between directive virtue and

what he calls magnetic co-ition are grandly reasoned out, and his contentions are convincingly established, in a way that was new to the whole world, by his terellæ and versoria.

He is equally sound on the principles of the magnetisation of iron by the touch of loadstones, and by the induction of the earth when a rod of iron has lain long pointing to the poles of the globe. How far these magnetisation processes were discoveries by GILBERT it is not easy to say. His discoveries of facts and phenomena, as has already been stated, were not his great forte. His genius lay rather in observation, and still more in tracing out to bottom principles what the ordinary worker would have regarded as only isolated facts. Nor does he claim any originality as to the processes of magnetisation which he describes. The learned editors of the translation are also silent on this point, and perhaps it is not possible to decide it.

A remarkable circumstance is, however, incidentally brought to light in the editorial

comments on this part of the treatise. A quaint woodcut in the text of the volume depicts the blacksmith hammering an iron rod on the anvil, the rod being so directed that by the earth's inductive power it will be magnetised in the process. It seems that illustrations of human figures were few and far between in works of the 16th Century, and GILBERT, who doubtless was draughtsman enough to delineate a versorium or a terrella, was hard put to it to illustrate the village blacksmith. He found what he wanted, however, in Foxe's "Acts and Monuments" of all books in the world. It had been copied into the famous "Book of Martyrs," perhaps in a similar exigency, from an equally unlikely source, an illustrated German book of fables, where it did duty to point a moral to the improving story of the lazy dog who slept all day beneath the bellows shelf, while his industrious master hammered away "week in week out, from morn till night." Apparently GILBERT traced the drawing for his engravers,

omitting the unnecessary dog and an elaborate and well spun spider's web in the corner, which also possibly had a meaning in the original fable book. The print appears reversed in GILBERT'S volume, as though the tracing had been turned over and transferred to save retracing. The famous drawing seems to have been quite in demand, for besides appearing in these three very different illustrative capacities it turns up again in 1665, to embellish the "Emblems" of Jacob Cats, the Dutch poet.

Yet one more point of interest in this Third Book must not be passed over, namely an incidental and somewhat surprising allusion to astrology.

It certainly seems at first sight not a little remarkable to find that GILBERT, whose whole soul cried out against the follies of the sooth-sayers, and who was a Copernican of the Copernicans, a castigator hip and thigh of those who believed that the sun, moon, and stars were attendant satellites around a central earth, should

in an incidental passage show that he apparently neither doubted nor regarded with the least suspicion the superstitious doctrines of "nativities" and "planetary influences." As the babe, he says, has its qualities instilled at birth by the configuration of the planets and celestial bodies, and their peculiar influences, so the iron, born from its molten origin on the blacksmith's anvil, is imbued with its verticity in accordance with its position in relation to this planet, the earth.

It must be noted, however, that he uses this popular idea of the potency of nativities and astral influences merely as an apt illustration, and in no way as an argument. Astrology in those times was so universally acknowledged as a true science that probably not even GILBERT would have ventured entirely to deny its validity. Both of his contemporaries, Bacon and Shakespeare, were equally infused with credence in astrology, nor would the theologians of that time have dared for a moment to repudiate the inspired record that the

stars in their courses fought against Sisera, or to deny the irresistibly sweet influences of the Pleiades or the insoluble hands of Orion spoken of in Holy Writ. Astrology was the accepted belief of the times, much like the "set fair" and "very dry" on the barometer nowadays, in which even many of the intelligent still firmly believe; and affording, as the illustration did, so apt an analogy of the terrestrial influences that he was discussing it is not after all so much to be wondered at that GILBERT seized upon a simile so suggestive and so graphic. It is scarcely to be looked upon as an assent to astrology or even an approval of it, hardly more so perhaps than would be the casual use by a modern writer of such terms as "dis-astrous," "con-sider," or the ejaculation, "Thank your stars," expressions which all testify to the clinging hold which the belief in planetary influences exercised, a belief which even though now long since abandoned has yet rooted itself ineradicably in our very language.

CHAPTER VI.

The "Variation" of the Compass.

THE Fourth Book is on what GILBERT termed the "Variation" of the Compass—"Declination" it is now more generally called, for, in common with other terminology adopted by GILBERT, this has had to undergo change with increasing knowledge of the subject. It is now known that the compass not only deviates from the true north, which is what GILBERT meant by its "variation," but it also varies in the actual amount of deviation from the north day by day, and year by year, and age by age, facts which GILBERT did not know, and which he emphatically denied. Now the term "variation" has, in consequence of this extended knowledge, been naturally applied rather to these daily and secular changes of

deviation than to the deviation itself, for which the word "declination" has therefore been generally substituted.

It is strange that GILBERT should have been so confident that there were no daily or secular variations, and that they were impossible. Unless, he urges, somewhat too dogmatically, Plato's fabled Atlantis story were actually realised, and a whole continent sank beneath the ocean, the amount of variation at any given spot must remain immutable. But Dame Nature delights in her vagaries, and often seems to take a special pleasure in showing that what the learned philosopher declares her laws forbid her to perform she mischievously does, as if to mock the narrow scope of our puny human efforts to wrest her secrets from her.

It is not unnatural that with the crude means of investigation at his disposal GILBERT was unable to detect the minute variations of the compass from day to day, or from year to year, but

unquestionably he was a little precipitate in classing the notion of such a possible phenomenon with the dreams of his oft-quoted "crowd of philosophizers." Yet there is some excuse for his hasty and erroneous conclusion. So utterly chaotic were the prevailing notions about the whole theme of the deviation of the magnet from the true north, that in clearing the tares away it is not unnatural that he should have rooted up a little wheat with them. For the chapter begins with his usual lamentation over the wild and groundless speculations of "those who have before us written." No sooner did the pre-Gilbertian philosophers come upon any phenomenon that was new than they deliberately created a cause for it out of the airy fabric of their imagination, and worse still, they recorded in favour of their hypothesis alleged facts which were equally the children of their own wanton fancy. How then, in such a maze of falsity and deceit, often ingeniously interwoven with fragments of true experience and observation,

was it possible for even a GILBERT not to fail occasionally to distinguish between a true path and a false track? So perhaps there is excuse for GILBERT that with only his unchanging terrella poles as guide, he characterised as an idle dream the supposition of variations in the directive influences of the corresponding poles of terra. If those who before him had written came some of them nearer the mark than he on this point, it was but an accidental accuracy on their part, and by no means an evidence of their better observation. For what manner of statements as to "variation" did GILBERT find in those ponderous works of the philosophers with which "the shops of the book-sellers were crammed?" One told of magnetic rocks and islands which had never been seen save by philosophic intuition, but which were calmly assumed to lie above or below the level of the distant oceans as fancy dictated, and to modify the well-intentioned efforts of the pole star to keep the little needle in the straight path. Then there was

Cardan again, with his incessant chatter about a star of wondrous virtues slightly removed from the central Polaris, and then there were mountains conveniently located in inaccessible regions which were brought to judgment for leading the compass astray. Even Plutarch, writing more than 1,500 years previously, ridiculed the dishonesty of geographers who "crowd into the edges of their maps parts of the world which they do not know about."

All this sort of rubbish GILBERT has to sweep away ere he can lay before his readers his new sort of philosophizing, He has to do more than merely disprove these random statements. He has to show that the supposed rocks, mountains, islands, stars, and all the other castles in the air, even if they existed, could have no special directive influence on the compass, nor would they in the least account for the varying deviations that occur in different parts of the earth. All this he demonstrates with convincing experimental evidence.

Then, with infinite pains, he gathers from navigators true accounts of the actual amount of the deviation of the compass from the true north, here, there, everywhere on the Globe—in mid-ocean, along all the coasts of Europe and America, up north in Nova Zembla, away south in Morocco, in Virginia, Brazil, Cape Verde, the Azores and many other places. Like a true investigator of "philosophy," or as we call it nowadays "science," he collates his facts first, and then looks for the common principle connecting them and affording the clue to their mystery. He shapes a terrella to mimic earth's continents, by corroding its surface here and there with acid. He lays his barleycorn lengths of wire on this quaint iron world and notes how they vary in their directive tendencies in consequence of the altered configuration of his miniature globe. Then he traces the harmony and concordance between these variations and the successive variations along the coasts of the world's continents. The argument

is most ingenious, and imperfect as his conclusions may be in the fuller knowledge of to-day, the method which he adopted for solving the problem affords ample proof of the surpassing genius of the man. Taken as a whole, his general inference is irresistible, and once more it is a triumph for his fundamental hypothesis that the earth herself is the directive magnet which the compass obeys, and, moreover, that the earth is a magnet not at her poles alone, as many might assume, but through and through, the poles being but the foci that manifest her virtues, just as his terrella too is a magnet through and through also provided with polar points. It is a magnificent piece of inductive reasoning, and the demonstration is so ingenious that, in spite of its imperfections and incompleteness in the light of modern science, the fact remains that the foolish fancies of the Cardans, Fracastorios, Scaligers, and the rest of that chorus of the supposed sages of olden time, are at a breath scattered like chaff before the wind,

notwithstanding the glamour lent them by the reputation of their long-titled inventors.

Allowing for errors inevitable from lack of sufficient data and of sufficiently delicate means of measurement and observation, this Fourth Book on "Variation" is in itself a monument to the genius of GILBERT and to his truly scientific mode of investigating and theorising. Even if he did not quite arrive at the full truth, he at least went to work in the only way by which the full truth allows itself to be ultimately arrived at.

The latter part of the Book, which deals with instruments and computations, affords a striking illustration of the intensely practical nature of his mind, and his fixed ideal of turning all his discoveries of the principle underlying magnetic movements to real material uses for the benefit of mankind.

Possibly there were many in his day, ignorant as men then were of the methods by which Nature's problems can alone be solved, who smiled

contemptuously at this dry-as-dust doctor, with his new-fangled method of philosophising, with his tiresome and apparently useless scientific toys—his loadstones, and terrellæ, and versoria, and floating corks, and barleycorn lengths of wire—and with his wearisome crotchet about the earth being a magnet. Many may have thought him a crank with odd ideas, for his great volume was by no means enthusiastically received, and even Lord Bacon was guilty of a sneer at "the man who made a whole philosophy out of a loadstone," though he owned to the painstaking and valuable nature of GILBERT'S experimental work, and, more than that, as has already been hinted, he showed his appreciation still more unmistakably by appropriating a good deal as his own which he ought really to have credited to WILLIAM GILBERT, of Colchester.

The pioneer in science has often to incur the penalty of temporary ridicule. Draper was accounted a harmless lunatic as he sat blowing

soap bubbles and watching their colours, and Franklin was asked somewhat cynically as to what after all was the use of his electricity, with its snapping sparks and sudden jerky shocks. "What is the use of a baby?" was his well-known significant reply.

Of course the worker himself always knows that experiments which seem so trivial and almost childish to outsiders, may be really of vast importance if they are directed towards a solution of the problems of Nature, and GILBERT could not have been unaware that his rough experiments were unlocking doors that were destined to lead to a vista of knowledge in which the whole world would rejoice with acclamation in years to come, though probably he would have been astounded could he have looked forward 300 years, and seen how mighty and how marvellous would be the palace in the vestibule of which he then stood alone. Of the future value of his work, however, he cannot have been in any doubt, but as though to

justify even in his own day these apparently trivial experiments, and as if to illustrate and enforce then and there the direct practical importance of his work, he applied himself, as we find in this Fourth Book, to the actual construction of apparatus, and the working out of tables of the stars' ascensions, for the practical use of navigators, not omitting to warn the observers who should adopt his method to make due allowance for the refraction of light—a striking testimony to his high ideal of exact accuracy. In this way he proudly draws from his experiments, trifling and useless as they might have thus far seemed, direct practical applications, and he attempts to show that his new philosophy will enable the sailor to comprehend the indications of the compass more correctly and to interpret aright the meaning of its deflections, though he regretfully admits that the fiction often advanced that actual longitude may be computed from the variation of the needle must

give place to the stern logic of facts, which enforces the abandoning of any such charmingly simply aid to navigation. But GILBERT'S claims as to the direct material value of his discoveries must be dealt with more fully in the next chapter.

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CHAPTER VII.

THE "DIP," "ORBES OF VIRTUE," AND THE "LIFE OF THE UNIVERSE."

THE "dip" of the magnetic needle—its "declination" as GILBERT called it, its "inclination" as it is now usually termed—is dealt with in the Fifth Book of the treatise. The dip, or downward tilt of the north-seeking end of a poised magnetic needle, was known before GILBERT's time. It was noticed and described by a Nuremberg ecclesiastic, the Vicar of St. Sebaldus, one Georg Hartmann, who died in 1564. It was also commented upon by Robert Norman, one of the few non-visionary scientific investigators in this country in Elizabethan times. It remained for GILBERT to interpret the mysterious phenomenon, and once more with no small pride

he triumphs in the "unity, concordance, and mutual agreement" maintained between his terrella and the earth in regard to this particular phenomenon. With elaborate exactness he describes the method of demonstrating this "unity, concordance, and mutual agreement," warning his readers emphatically that they must make the experiment with minutest attention to his instructions, for "unless you contrive everything very skilfully and cleverly, you will secure no result," he says. With diagrams and lucid directions, he sets forth explicitly how the dip may be made manifest, and how its measurement at given points on the earth's surface may be computed, all exactly in accord with similar measurements accomplished in miniature on his terrella with its dipping barleycorn lengths of wire. The proportions of dip and latitude, as shown by the directive influence of his terrella on the fragments of wire, are ingeniously worked out in a geometric figure in accordance with rigid mathematical law, and such is his

confidence that earth herself must be subservient to identical law, that he is at the pains to work out on the same plan a fine scheme of geometrical construction which forms quite a complex piece of curve tracery, filling a sheet larger than his folio page, so that it has to be folded into the book. This diagram must have cost him infinite care and patience to elaborate correctly, but no doubt he felt it worth any amount of labour spent upon it, purporting, as it did, to enable the navigator to ascertain his latitude at any part of the globe by the simple position of a suspended versorium.

His delight in this practical application of his new teaching is unbounded. He dwells almost ecstatically on the boon he is conferring upon the world. Henceforth, he triumphantly declares, the sailor tossed about on the waves, with nothing to aid him but this chart of curves and the poised needle, "with dark clouds above and around, and no celestial luminaries visible to guide his way," is to be comforted by the faithful finger of the tiny

instrument, pointing out with unerring precision the exact latitude of the storm-tost barque. "How agreeable, how helpful, how divine!" he exclaims.

Alas, as a matter of fact, while as a general principle his contentions were theoretically sound as far as his terrella was concerned, the application of them with a view to accurately ascertain the latitude on terra would be practically impossible, and the versorium, to the sailor who relied upon it, in conjunction with the chart, in the way proposed, would be a veritable siren, leading him to almost certain destruction.

The "concordance, unity, and mutual agreement" of terra and terrella are not anything like as complete as GILBERT, not unnaturally, imagined. A scientific generalisation is almost always too large at first. Nature is so much more complex, the powers in her vast domain of the universe are so incalculably more numerous and intricate than the pioneer of science at first has any idea of, that he

is sure to leave out of his reckoning a hundred interfering influences which modify, and may even reverse, his expectations in a way which completely upsets his calculations. It is a long time before the first workers in any branch of discovery fully realise how many more things there are in heaven and earth than are dreamed of in their philosophy.

As everyone knows now, the magnetic latitudes, though roughly agreeing with geographical latitudes, vary from them far too widely to enable any such practical uses as GILBERT here proposes to be really available. His assumption that terra and terrella must agree in every respect, left out of consideration the fact that the earth is but part of a vast system of worlds, and is interlinked with innumerable influences of sun, moon, planets, and so forth, which have no counterparts in the case of the terrella, to say nothing of the circumstance that after all terra is not a mere lump of loadstone, however much the terrella may mimic many

terrrestial characteristics. Unmindful of such considerations as these, GILBERT too rashly concluded that all along the equatorial line of the earth, as on that of his terrella, the needle must lie horizontally, and that the two must show an exact concordance of dip at all other latitudes, or, to put it technically, that the magnetic poles of the earth must coincide with its geographical poles, the magnetic with the geographic equator, and each magnetic latitude with a corresponding geographic latitude. Plausible seems the theory, after following his experimental demonstrations, but Nature laughs at all absolute decrees. So far is GILBERT'S expectation from being fulfilled, that in reality the magnetic equator only touches the geographical equator in two places, and while London and Labrador are on one and the same parallel of latitude geographically, the line of equal dip with that at London travels in a sinuous curve across the Atlantic, and brings us to the shores of North Carolina. Luckless sailor would he be indeed,

who, bound for Labrador, with GILBERT's terrella and chart for guide, should strike the rocky coasts of the Bermudas!

Imperishable was GILBERT's underlying conception of the earth as a magnet, and its general consequent accord with his toy earth, but too hasty was his attempt to apply so general a principle to purposes requiring such rigid accuracy, and involving such disastrous results if any modification of the theoretical truth of the law lurked undiscovered, as was surely not improbable when as yet nothing of the nature of a thorough magnetic survey of the globe had been possible. The incident is a significant warning to the pioneer against presuming too much upon the universality of any generalisation before it has been practically tested, a pitfall into which in the enthusiasm of discovery even a man like GILBERT, whom Poggendorf calls the Galileo of Magnetism, evidently may be easily led.

Not that GILBERT in the least neglected the importance of exact measurement — that

hand-maiden to modern science—as he shows by a resource which has since found many uses and adaptations. It was a simple thing enough—merely the slinging of a versorium in a single thread of unspun silk, to avoid as far as possible all friction, yet this apparently trivial device was a foreshadowing of many an invaluable instrument for delicate measurement. Of course such a commonplace expedient would most likely have suggested itself in any case to workers in after-times, but it is interesting all the same to think of GILBERT'S homely iron rod, swung in a loop of slender silken cord, which it appears he drew, bachelor-like, from the window curtain, as the archetype of the delicate galvanometer and the torsion balance, in which the needle is poised in the very same way.

It is to be regretted that none of GILBERT'S actual apparatus is now in existence. The temporary oblivion of his fame has even been attributed in part to the fact that all those

interesting relics, his magnets, his maps, manuscripts, letters, minerals, and so forth, bequeathed to the Royal College of Physicians, perished in the Great Fire of 1666. In February, 1902, however, several pieces of his handwriting, undoubtedly genuine, came to light. Until then only one specimen was known to be in existence.

The topic of the dip leads GILBERT into a theme full of wonder and mystery—the theme of "orbes of virtue," or, as we should now say, the "spheres" or "fields of energy" surrounding the loadstone or its counterpart, the earth. He had, indeed, touched earlier upon this topic, to which he now recurs, dwelling delightedly upon the revelation which this new conception of a surrounding sphere of magnetic activity opened out to him, especially in connection with the hidden causes of the dip. As to these causes, he says, he "laboured long and hard to arrive at them by various and complicated devices." In the midst of these seemingly fruitless efforts the "orbe of virtue" idea suddenly

flashes upon him, and he raises his joyous "Eureka," claiming to have hit upon "a new and admirable science of the orbes themselves—beyond the marvels of all virtues magnetical." He illustrates by diagram the influences of a magnet on a versorium at a greater or less distance, and shows that, imagining concentric spheres of magnetic virtue to surround the central magnet, endowed with similar polarity to that of the actual loadstone which they enclose, all the phenomena observable under such conditions tally exactly with expectations, demonstrating in fact that such orbes really do exist. This is scientific hypothesis as it should be—originating in imagination, but not adopted until it has been tested and confirmed by experiment. No matter that the "orbe" is but an imaginary thing, invisible, intangible, its reality is nevertheless as certainly proved in this way as it would be, could we feel it with our hands or gaze upon it with our eyes.

But what might be called the climax of this

Fifth Book, and indeed of the whole magnetic philosophy of GILBERT, is not so scientific. It is a rhapsodical flight of imagination, not exactly unscientific, but rather one outside the province of science.

With his mind more and more elated by the wondrous suggestiveness of his newly found orbes —"beyond the marvels of all virtues magnetical" —he soars to transcendental conceptions of the essence of the inscrutable orbes themselves, and declares it to be no mere sphere of dead force, but Life, very Life itself. The universe is alive, he suddenly proclaims, and its vitality consists of this wondrous magnetism, with its spirit-like spheres of radiating energy, emanating from the very inmost centres of material things, and effusing themselves in orbes of potent virtue. Suns, stars, planets, "and also the noble earth," are conscious beings, positively choosing their orbits and directing themselves to the course that their own inclination favours, turning and moving themselves to satisfy

their own longings and aspirations—"governed," says he, "by their own appointed souls."

He drops for the time his terrellæ and his versoria, he forgets his prosaic iron rods, cork rafts, and silken threads, and all his experimental methods. He conjures forth Hermes, Zoroaster, Orpheus, the great ones of the Golden Age, who told of "universal life." He glories in their ennobling intuitions, enlarges on their bare dogma, and claims that not only are the worlds of space alive, sentient, spiritual, but organic also. They have their actual organs, he declares, "though not of flesh and blood," yet veritable organs, perfectly suited to their special activities. He contrasts this elevating doctrine of the vitality of the universe, as taught by the very ancients, with the dismal and degrading Aristotelian teaching of the later ancients, according to whom all in the universe was alive save the earth alone, which "unhappy portion" was condemned to senselessness, lifelessness, and reckoned "paltry, imperfect, dead, inanimate,

and decadent." "Miserable were the condition of the stars, abject the lot of earth," he cries, "if that wonderful dignity of life be denied to them which is conceded to worms, ants, moths, plants, and toadstools, for thus worms, moths, grubs would be bodies more honoured and perfect in nature, for without life no body is excellent, valuable, or distinguished."

Into this metaphysical discussion we need not now follow the doctor further. It is a typical schoolmen's problem, and much depends upon what definition we agree upon at the outset as to such terms as life, sensation, consciousness, senselessness, and the other words involved. More properly, perhaps, such themes are for the poet and the artist to dwell on rather than for GILBERT'S followers, working in prosaic laboratories of scientific research. But at any rate, if we cannot assert the vitality of the universe with the thrice great Hermes, the Persian sage Zoroaster, and Orpheus the Thracian minstrel, our crucibles and

retorts, our testpapers and our spectroscopes are but silent to this riddle of the Sphinx. They do not deny, they simply have no answer to offer, and if a Gilbert styles the mystic virtue Life that an Edison declares is "only magnetism," fair Science merely shrugs her shoulders and murmurs, "Call it what you will; I do no not quarrel as to names."

CHAPTER VIII.

The Copernican Theory.

THOUGH the last Book of Gilbert's treatise deals less with the magnet and its properties than any of the others it must ever be reckoned the masterpiece of the series, the one which above all testifies to his unwavering confidence in the certain ultimate triumph of true conceptions of the universe, and the inevitable abandonment of an irrational system which yet had practically the unanimous support of all who were reputed to be learned. With absolute disregard of the storm of abuse, if not of actual persecution, which was the probable consequence of so daring a pronouncement, he boldly stands up single-handed to champion the then new and detested Copernican heresy. De Magnete, it must be remembered, was

actually published 33 years before Galileo muttered his indignant "Yet it moves!" GILBERT was the very first man of repute in England to openly propound the heretical teaching of a diurnal earth-motion.

His own friends were aghast. Archdeacon William Barlowe, his co-worker and firm disciple, was so shocked at the impiety of this Sixth Book, that he was at pains to declare publicly his entire disapproval of GILBERT'S Copernican tendencies, though he commended all the rest of his work. Mark Ridley, another devout sympathizer with the "new sort of philosophizing," also cleared himself in a similar way of any imputations of sharing in such obnoxious doctrines, so say the learned editors of the new translation. In Italy, of course, the Sixth Book was violently execrated. Many mutilated copies of De Magnete are still to be found in that country, bearing witness to the superstition that hampered the advance of knowledge there, and the copy in the College Library at

Rome has the Sixth Book completely torn out to avoid all possible risk of corrupting public morals. The Jesuit students of science, of whom there were many who respected GILBERT'S magnetic teaching, were unanimous in disclaiming all sympathy with this terrible Sixth Book.

Galileo himself only came into possession of the publication, which must have filled him with intense delight, through having a copy given to him by a certain "Peripatetick philosopher of great fame," who desired to "free his library of contagion."

It speaks well for the respect for liberty maintained in Elizabethan England that the author was, in such an age, free to publish the work in this land without inquisition terrors, and not only to publish it unmolested, but within a year to be honoured with the high distinction of being appointed Chief Physician in personal attendance on the Queen.

His brief for Copernicus is no trembling apology,

no equivocating or half-hearted approval of the dire heresy of a revolving earth. On the contrary, it is a sustained, fearless hammering indictment of what he indignantly calls "a fiction accepted by weak-minded folk," "a fable now only to be believed by idiots," though hitherto "accepted even by mathematicians under pressure of an importunate mob of philosophizers." He can hardly find words strong enough to condemn the monstrous invention of imaginary spheres of adamantine nothingness, assumed to be whirling round the earth and carrying the myriads of celestial globes through the whole orbit of heaven every 24 hours. With a masterly command of language and of historical science, and with arguments that are as sound to-day as they were 300 years ago, and will be 300 years hence, he simply demolishes the "time-honoured opinion" of the "primum mobile." He mocks at the sophistical subtleties of the ancients, who set afloat the foolish fiction, and going back still further to the very-ancients—

Heraclides of Pontus, and Pythagoras with his followers—commends the clearer insight which gave them the true conception of a world revolving on its axis. He glories in Copernicus as the modern restorer of this pristine wisdom, and then he opens the vials of his wrath on the inveterate prejudice that was blinding the quasi-philosophers of his day to the plain clear truth.

What evidence, he asks at the outset, is there that any such unthinkable and yet adamantine spheres enwrap the planets and stars, and whirl with them round the earth? With consummate skill he sets forth one by one the absurdities involved in such a wild theory. The inconceivable speed with which the distant faintly-visible stars, incalculable leagues away, would have to be swirled through space to make such extraordinary, such impossible diurnal orbits; the preposterous supposition that each star's pace varied so that the varying circles of orbit are each achieved in precisely the same 24 hours; the amazing improbability

that the spheres turn with an opposite rotation to that of all else in the universe; the paradox of supposing a motion of infinite space ; all these anomalies, and others like them, he mercilessly drives home to the "importunate mob of philosophizers," and appeals to common sense to make choice between this tissue of impossibilities on the one hand, kept alive only by superstition and prejudice, and on the other hand the perfectly conceivable and reasonable alternative of a revolving earth, a hypothesis which immediately accounts for the whole of the apparent celestial movements, and obviates all the gratuitous inconsistencies and absurdities of the spheres " with cycle and epicycle scribbled o'er."

The whole argument is so unanswerable, so convincing throughout, that one can only marvel at the tremendous power of prejudice which for so long hindered its acceptance.

What moves your imaginary primum mobile, he scornfully asks the philosophers, and if the diurnal

motion of our earth seemed incredible to them how could they put faith in a theory, "worse than insane," of a primum mobile whose rate of revolution must be past all understanding? Such questions they could not have replied to, and yet the obvious force of his criticisms had but little influence for a long time in shaking the orthodox belief. Reason does not count in the case of those for whom it is enough that their belief is orthodox, and that the other is heretical; and in spite of Galileo and GILBERT, the learned world generally remained obdurate,

> "Concluding all were desperate sots and fools
> Who durst depart from Aristotle's rules."

The doctrine of the spheres GILBERT proved to demonstration to be an utter impossibility, yet so far from being convinced, like Tertullian, the bigoted philosophizers then believed apparently only because it was impossible. But, however much a false orthodoxy may trust to the maxim that Might is Right, however long it may console

itself with the delusion that what is the accepted faith of the vast majority must outweigh the beliefs of the solitary reformer, sooner or later Truth and Logic come along under their banner with the counter motto that Right is Might, and in the end they win the day. Barlowe, publicly disclaiming the Gilbertian heresy of a revolving earth, gained no doubt the approval that he sought of Church prelates and men of influence around him. He had his reward. GILBERT, on the other hand, called down upon himself the anathemas of these distinguished ecclesiastics and influential men when he boldly declared, "Let theologians discard and wipe out with sponges those old women's tales of so rapid a spinning round of the heavens." But he had his reward too, not merely in the praises of posterity, but then and there, a reward worth far more to him than that sought by the Archdeacon.

The objections to the Copernican system of a revolving earth are then disposed of with equally cogent reasoning. One by one he pitilessly

demolishes them, and had the world no other refutation of the flat-earth theory than this Sixth Book of the "De Magnete," the modern "Zetetic astronomers" would find it very hard indeed to prove their case.

As to the causes of the earth's revolution and the inclination of its poles, GILBERT is perhaps not quite so sound in the light of later knowledge. He wrote more than 60 years before Sir Isaac Newton first propounded the laws of gravitation, and his devotion to his magnetic investigations undoubtedly led him into somewhat unwarrantable conclusions as to the all-embracing character of the force that he took to be supreme.

He returns to his conception of a living world, whose vitality is magnetic force, and whose inner soul yearns for appropriate relation to the generating sun, so that she "seeks and re-seeks him by her magnetic virtue," revolving day by day that every continent and island may rejoice in basking in his beams, and may be replenished by

his fertilising power. She turns her poles of her own free will to just that amount of deviation from the poles of the ecliptic that pleases this inner soul of hers, that satisfies her desire to get all the beneficent solar influence that she needs for her comfort and well-being. Even the precession of the equinoxes is but the swaying of her soul's desire towards a secular change of relation with the sun. So the allurement of the sunshine, and the magnetic response to the invitation on the part of Terra herself, are assigned as the dual causes jointly operating to keep this world in her true course and save her from straying heedlessly into "perpetual shades and eternal night," where "all things would verily be frightful and stark with extreme cold." "Since the Earth herself would not choose to endure this so miserable and horrid appearance on both her faces, she, by her magnetic astral genius, revolves in an orbit that, by a perpetual change of light, there may be a perpetual alternation, heat and cold, risings and settings, day

and night, morn and eve, noon and midnight. Thus the Earth seeks and re-seeks the Sun, turns away from him and pursues him, by her own wondrous magnetic virtue."

All this may not be exact science, yet it has the charm of beauty, and who can deny that at least it is true poetry, while perhaps "the high priests of science" cannot altogether disprove that it may be true in a stricter sense also.

GILBERT left behind him the manuscript of another work dealing with the system of the world. It was his intention, expressed in a letter to Archdeacon Barlowe, to re-publish De Magnete, with an appendix of new experiments, to which he invited contributions from Barlowe's own observations, but death cut short the project, and on November the Thirtieth, 1603, not three years after the publication of this memorable treatise "Concerning the Magnet," the author died—a victim, it is said, to that terrible scourge the Plague, which in 1603-4 carried off no less than

30,000 persons in London alone. He died at the age of 63, and was buried, says Morant, in the chancel of Holy Trinity Church, Colchester, where a monument on one of the Church walls was placed in memory of him by his brothers Ambrose and William.

His work was but faintly appreciated in his day, except by those few Elishas who are always appointed to take up the mantle of the great prophets. He was in advance of his time, and for a long while the scientific world felt, rather than perceived, the superiority of his "new sort of philosophizing." It was the unseen leaven which worked gradually but surely, and influenced methods of research throughout this country. The contagion of his example took effect long before the importance of its reforming power had been realised. And at last in the publication of this superb translation by the Gilbert Club, it is fully revealed. He cast his bread upon the waters, and after many days it has been

found. The postponed recognition of his genius and influence is well illustrated, as in an allegory in another and more outward foundation which he laid for the benefit of times to come. Quietly and unassumingly he gathered round him at his house in Peter's Hill, Knightrider Street, London, his scientific friends once a month to discuss philosophical subjects. The meetings developed into the formation of a little science club. At his death this club fell temporarily into abeyance, but later on it was revived by Sir Christopher Wren and others, and received the patronage of King Charles II. That Society, with an origin so humble that its first beginnings are almost forgotten, is now known as the Royal Society.

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