

## ROBERT BOYLE.

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ALL modern thought, so far as it is scientific, is largely dependent upon the labors of three men—Isaac Newton, Robert Boyle and John Locke. Newton was born in 1642 (December 25), Locke 1632 (August 29), and Boyle 1626 (January 25), the same year that Francis Bacon died. It is true that Bacon preceded them all, and is justly referred to as the father of inductive philosophy; but in order to understand the relation of Bacon's labors to modern science it is necessary to recall Whewell's observation,<sup>1</sup> That to the formation of science two things are requisite, Facts and Ideas; or, in other words, Sense and Reason. The impressions of sense, unconnected by some rational and speculative principle, can only end in a practical acquaintance with individual objects; the operations of the rational faculties, on the other hand, if allowed to go on without a constant reference to external things, can lead only to empty abstraction and barren ingenuity. Real speculative knowledge demands the combination of two ingredients:—right reason, and facts to reason upon.

Aristotle's immense accumulation of facts lay, as loose stones in a quarry, more than two thousand years; though *philosophy* gained from his labor the idea of a final cause. The fundamental facts of astronomy were as well known to the Chaldæans as to Newton; but, though logic, metaphysics and geometry were highly developed, no science of astronomy arose before him.

In the fact of the lack of trained perception, reason instructed to deal with the results of observation and conscience, obedient to the teaching of nature, united in one man, must be sought the explanation of the slow progress of the knowledge of the external world during the period which preceded the seventeenth century.

The era of progress in science begins with Lord Bacon; but the *Instauratio Magna* was a method; and had not Locke and Boyle worked it out and given it practical efficiency—one in the science of mind, the other in the sciences of matter—it might have lain neglected; there would have been great admiration of it as an intellectual achievement, but no science of chemistry. To borrow and extend a Scripture image, Bacon ploughed, Boyle tilled, Locke watered, Newton harvested.

Of the three founders of modern science, Newton and Locke have received their full meed of praise; but a certain obscurity has settled

<sup>1</sup> *Hist. Induc. Sci.*, 1, 43.

over the merits of Boyle. There are two reasons for this undeserved misfortune :

I. It is certain that every great discoverer reflects the brilliancy of his discovery and that his personal worthiness must be estimated by a knowledge of his actual contribution to the wealth of the world through achievement of courage, knowledge and faith. Columbus is great because he got over, and his greatness would be secure had San Salvador been an isolated island with no America beyond; but his greatness is the opaque planet upon which a new world casts a great light. It is no disparagement of the "incomparable Newton" to admit that the effect upon the imagination of the unique splendor of his discovery of the law of gravitation has produced a certain exaggeration in the popular estimate of the man. Boyle's discoveries were not of the kind that appeal to the imagination or strike the eye of the ordinary observer; his work was of the fundamental sort upon which subsequent generations of scholars have built imposing structures of learning. Newton worked mathematically, Boyle experimentally; hence one did not, in any sense, furnish tools for the other. Newton established a body of philosophy, Boyle a method of research; Newton wrenched one reluctant but momentous secret from the hand of nature which undoubtedly has in it the solution of the whole economy of forces, but he did not see its scope; Boyle ascertained by independent experiment a great number of laws of less magnitude; Newton studied force—Boyle matter. In brief any attempts to form comparative estimates of Newton and Boyle are rendered abortive by the fact that their characteristic merits and achievements are incommensurable. One thing is certain, that the two were intimates, and that Newton's estimate of Boyle is shown by his submitting to him for criticism a manuscript of his speculations on the nature of gravity which he carefully concealed from every one else.

Hume says, without sufficient reason:—Boyle was apparently a great partisan of the mechanical philosophy, which led him to the discovery of so many secrets of nature and led others to imagine the rest. Newton showed the imperfections of this philosophy, and relegated the intricate secrets of nature to the obscurity where they have ever since remained.<sup>1</sup>

There is another view of this: Boyle never disputed the imperfections of the mechanical philosophy; no one saw them more clearly or admitted them more frankly; but he did not choose to abandon this philosophy till he had exhausted its possibilities of good. A study of Boyle's face and of the whole of his work in Ethics as well as in Natural Science, shows that he had that deep spiritual insight into things unseen, which led him at once to great confidence in the methods and results of experimental demonstration, when it laid hold of a determinate problem, and not less to hesitation and scrupulous care when he

<sup>1</sup> Hume, *Hist. Eng.*, 1, 374.

attempted the solution of a problem whose elements included ideas outside the realm of matter.

II. Another reason for Boyle's obscurity, is his misfortune in being called an Alchemist, though, as we shall see he was no more entitled to this epithet than either one of his great contemporaries.

In Notes and Queries, 3d series, 10, 103, General Index of Subjects, Boyle's name appears under Alchemists, on the ground of his paper, An Historical Account of a Degradation of Gold made by an Anti-Elixir; a strange chemical narrative. No greater act of injustice has been committed against the fame of a great man.

Robert Boyle was not an alchemist, though he was deeply interested in alchemy. The Historical Account is an accurate description of the behavior of gold in the presence of mercury. The story of the man who called on Boyle with a magic powder which he projected into a crucible, in Boyle's presence, with the effect of leaving in it a button of gold is told by Mangetus, and obscurely referred to by Boyle. There is an impression that Boyle gave to Locke the first part of a recipe for the transmutation of base metals into gold, and to Newton the second and third parts; and Newton wished Locke as one of Boyle's executors, to insert these recipes in his memoirs. Boyle is responsible in all this for nothing more than speculations upon possible explanations of the fact which he discovered, but which is familiarly known to metallurgists now, that mercury grows hot when mixed with gold. This discovery drew out a long letter from Newton to Oldenberg.<sup>1</sup> In urging his view of the origin of the differences in bodies he adduces in evidence the fact that by a certain treatment silver can be educed from gold; of course this was the resolution of an alloy, and obtaining silver from gold is very bad alchemy.

These are all the facts that go to show the truth of the allegation.

On the other hand, in a letter to Glanville,<sup>2</sup> Boyle alluding to a statement then current, that Friar Wencel had transmuted base metals into gold, hopes "to get one positive instance which will prove more than all the cheats and fictions."

And in *The Sceptical Chemist*, Sect. III., he says, "I would fain see that fixed and noble metal; gold, separated into salt, sulphur and mercury; and, if any man will submit to a competent forfeiture, in case of failing, I shall willingly, if he succeeds, pay for the materials and bear the charges of such an experiment. After what I have myself tried, I peremptorily deny, that there may out of gold be extracted a certain substance, which chymists call tincture or sulphur, and which deprives the remaining body of its usual color. (Nor am I sure that there *cannot* be drawn out of the same metal a real, quick and mining mercury), but for this salt of gold, I never could either see it, or be satisfied by the relation of any credible eye-witness that there was such

<sup>1</sup> Birch's Life of Boyle, p. 221.

<sup>2</sup> Boyle's Works, Birch, London, 1772, VI., 58.

a thing separated. That which most deters me from such trials is not that they are chargeable, but unsatisfactory, though they should succeed. For the extraction of this golden salt, being in chymical processes prescribed to be obtained only by corrosive menstrua, or the intervention of other saline bodies, it will remain doubtful whether the salt produced be that of the gold itself, or of the saline bodies or spirits employed to prepare it; for that such disguises of metals impose upon artists is no new thing in chymistry."<sup>1</sup>

It is a very hard fate that Boyle alone should have borne whatever stigma attaches to meddling with alchemy, for it is certain that Locke shared his curiosity in this matter, that Newton was quick to take up every new suggestion in regard to it, even writing to Locke about Boyle's "red powder," and that Leibnitz was Secretary to the Society of Rosicrucians at Nuremberg.<sup>2</sup> Newton, Boyle, Locke and Leibnitz were all alchemists, if either was. Sir David Brewster, *Memoirs of Newton*, II., chap. 25, speaks of Newton as an alchemist, but adds that Boyle, Locke and Newton studied alchemy as a science — all others, for fraudulent purposes. There is a letter from Newton to Ashton, given in Brewster's *Memoir* [1, 388], which shows that his mind was impressed with some belief in alchemy; he urges Ashton to inquire about the alleged transmutation of metals, and says, "such transmutations are above all others worth noting, being the most luciferous and many times luciferous experiments in philosophy."<sup>3</sup>

But that such men should ever meddle with such a subject is very strange, and Sir David justly remarks: <sup>4</sup> There is no problem of more difficult solution, than that which relates to the belief in alchemy and to the practice of its arts by men of high character and lofty attainments. In so far as Newton's inquiries were limited to the transmutation and multiplication of metals, and even to the discovery of the universal tincture, we may find some apology for his researches, but we cannot understand how a mind of such power \* \* could stoop to be even the copyist of the most contemptible alchemical poetry and the annotator of a work, the obvious production of a fool and a knave. Such, however, was the taste of the century in which Newton lived, and when we denounce the mental epidemics of a past age we may find some palliation of them in those of our own time.

In order to form a just critical estimate of Boyle, it is necessary to glance at the circumstances of his birth, education and friendships.

Robert Boyle, seventh son of Richard, Earl of Cork, was born at Lismore, County of Cork, Ireland, January 25, 1626. His mother was daughter of Sir Geoffrey Fenton, a lady of great beauty and strength of character.

It appears from Birch's *Life of Robert Boyle* that his ancestors were persons of importance among the titled landholders of Ireland. The

<sup>1</sup> Brewster, *Mem. Newton*, 2, 375. <sup>2</sup> *Ib.*, 2, 375.

<sup>3</sup> Brewster, 1, 35. <sup>4</sup> *Ibid.*, 2, 372.

name was originally Biuvile, and Humphrey de Biuvile was a lord in the times of Edward the Confessor. Lodovick Boyle, who lived in the reign of Henry III., was father of John Boyle and he of James and he of Lodovick whose son, probably of same name, was succeeded by his son James the father of Lodovick Boyle of Rodney and of the Friars in Hereford in the reign of Henry VI. His, Lodovick's, second son Roger was grandfather of Richard Boyle, Bishop of Cork and Ross, and afterwards Archbishop of Tuam, who died March 19, 1644. His second son Richard, Lord Boyle, Baron of Yonghall, Viscount Dungarvan, Earl of Cork, Lord High Treasurer of Ireland, one of his majesty's honorable privy council, and one of the two lords justices for the government of Ireland, was the father of Robert,—by far the greatest man who has borne the name, and with whom it becomes practically extinct. The only persons of the name mentioned in the *Biographie Universelle*, are Robert, his brother Roger, his nephew Charles, and John, Charles's son. Charles Boyle was one of the defenders of the genuineness of the epistles of Phalari's against Richard Bentley. In the *Biographie Générale*, Richard is mentioned only as the father of his sons; of these, Roger, Count d'Orrery, Baron of Broghill, an older brother, Charles a younger son of Roger and Charles's son John, are all that are mentioned. Charles became a peer, and to him George Graham dedicated his planetarium; John died in 1762, so that in seventy-one years from the death of Robert the name disappears from literature and from science.

The Earl of Cork conducted the education of his sons on principles radically unlike those that prevailed among the noble families of England in the seventeenth century. Truth, purity and a proper ambition for excellence, as well as a charitable regard for others, were inculcated and exemplified in the family, and it is recorded of Robert that an almost fanatical truthfulness was a marked trait of his boyhood. He says, in the *Life of Philaretus*, his own autobiography, "that he was born in a condition that was neither high enough to favor a temptation to laziness, nor low enough to discourage him from aspiring." These natural advantages were improved by assiduous study under the best tutors, supported by the fine physical training which is such a boon to English boys. From the age of ten, for four years he was at Eton under the care of Sir Henry Wotton, and to this admirable master Boyle was fond of acknowledging his indebtedness; for Wotton was to his age what Arnold is to ours, a teacher in whom the man was always superior to the pedagogue, and who without relaxing the strictness of discipline thought it a teacher's main duty to awaken in boys an unquenchable thirst for knowledge, with enthusiasm for righteousness, and "to fix the awful must of duty below the tides of feeling." R. Ackerman enters Boyle in his list of Etonians as an oppidan. Locke was at Westminster at the same time. After Eton, Philaretus travelled, lived awhile in Florence and learned Italian. He became familiar with the writings of Galileo, and records an exquisite anecdote of the great

astronomer: Before his death, being long grown blind, to certain friars (a tribe whom for their vices and impostures he long had hated), that reproached him with his blindness, as a just punishment of heaven incensed for being so narrowly pried into by him, he answered that he had "the satisfaction of not being blind till he had seen in heaven what never mortal eyes beheld before."<sup>1</sup>

And his fine susceptibility to the charms of natural scenery comes out in a bit of description, which has done valiant service in letters of travel since. Looking down from one of the peaks of the Alps, he says, "The hill was eight miles in ascent, and double that number downward. It was there free from snow; but all the neighboring hills where store of crystal is digged, like perpetual penitents do all the year wear white."<sup>2</sup>

In Italy he gave attention to philosophy and especially affected that of the Stoics.

Five years of travel kept him away from the excitements of politics. He returned to England in 1644, and only after waiting four months, such was the confusion consequent upon the battle of Marston Moor, reached the manor of Stalbridge, which had become his own by inheritance, where he resided for some time. He removed to Oxford in 1644, and to London in 1668, where he spent the remainder of his life.

The condition of England during Boyle's life was unfavorable to the quiet and repose of scholarship. Born under Charles I., he went through the Commonwealth and the reigns of Charles II. and James II., and died soon after the accession of William. In the turmoil of the Restoration, those who were by nature adverse to strife withdrew from politics and gave themselves to their chosen studies: and this age of agitation produced Newton, Boyle, Locke, Halley, Hooke, Dr. Burnet and others. These flowers of learning sprung from the filthy ooze of the last days of the Stuarts.

All his life long, in spite of the utmost care in infancy and youth, — his father having committed him to the care of a country nurse to bring him up as hardy as her own son, — he was a sufferer from acute pain. He had ague at Eton and endured the tortures of an organic disease most of his life. In 1669, he was partially paralyzed and was constantly apprehensive of the loss of his sight. But by simplicity in diet and regularity of life he maintained his powers to the end; "his sight began not to grow dim above four hours before he died," says his biographer; "and when death came upon him, he had not been above three hours in bed, before it made an end of him, with so little pain, that it was plain the light went out merely for want of oil to maintain the flame."<sup>3</sup>

He died in London, December 31, 1691, at the age of 65.<sup>4</sup> A week later his remains were laid in the Chancel of St. Martin's in the Fields,

<sup>1</sup> Birch, 44. <sup>2</sup> *Ib.*, 43. <sup>3</sup> *Ib.*, 289. <sup>4</sup> He expired at 12.45 midnight, so that the date is often erroneously given as December 30.

Westminster, without pomp or ceremony, according to his request; and, to an audience that included nearly all the people of station, influence or learning in the kingdom, Bishop Burnet preached his remarkable sermon from the text, For God giveth to a man that is good in His sight, wisdom, and knowledge, and joy.<sup>1</sup>

Boyle was never married, but he found great delight in the society of his beautiful and accomplished sister the Lady Ranelagh, upon whom he poured the wealth of his generous and affectionate nature. He survived her death but a single week, and was laid to rest by her side.

John Locke, Dr. Cox and Dr. Dickson were named by Boyle as his literary executors, but the coveted labor fell mainly to Locke, who formed an elaborate scheme for gathering up and securing to posterity the fruits of his friend's life-work, but his own death in 1704, frustrated the scheme; Locke did, however, edit an edition of Boyle's *History of the Air* in 1691. The work was done in 1744 by Dr. Thomas Birch, but the list of Boyle's works given by Birch is incomplete, and, indeed, no complete list of them has ever been published. It is an instance of the adverse fate that has attended Boyle, that in Johnson's *Cyclopædia*, this life of Boyle, which is by far the most considerable and the best performed of all Birch's biographies, is not mentioned at all in the list of his writings.

In person, Boyle was tall and slender, of a wan visage and serious aspect. His face showed a certain dignity and sweetness of expression that were very winning. He spoke slowly and hesitatingly, a habit resulting from his effort to overcome stammering.

He was plain in dress and unostentatious in all affairs. Aware of his physical weakness, and determined to apply to himself the dicta of physiology, he cultivated the most scrupulous abstemiousness in diet and regulated his dress by the thermometer.

He had himself perfectly in hand, disputed little; constantly employed the phrases "perhaps," "it seems," "it is not improbable" (for which indeed he apologizes in the *Proœmial Essay*); but, not losing sight of the truth to which he was devoted, persistently threw into the empirical debates of his time inevitable doubts and unanswerable difficulties. He compares the fate of all erroneous views to the disappearance of the camera-pictures upon the admission of full light; urging that the only way to banish darkness is to pour in light.

He urges as an illustration "that the bare making of trials with the loadstone and irons touched by it, hath produced inventions of greater use to mankind than were ever made by Leucippus or Epicurus or Aristotle." He was shy of theories, and, incredible as it seems, worked out with his own hands the results given in his voluminous papers.

His temper was open, generous and communicative; he held back nothing but those secrets of chemistry in the shape of medical recipes which he hoped to exchange with the chance visitors from the continent

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<sup>1</sup> Eccl. II., 26.

who brought him valuable information in return. But he refused even to transmit to the Royal Society his information concerning the possibility of counterfeiting gold and erasing ink, lest they might be put to unlawful uses.

Boyle knew men as well as things. The only instance in which he was deceived in his man, was that of Greatrakes, and that was because he suspected that this fellow might open a door to some new knowledge. In his total freedom from credulity, he had the advantage of Lord Bacon, whose weakness it was to put faith in stories and prodigies.

Sir Edward Creasy says of Boyle: <sup>1</sup>

"He was happily as unlike Lord Bacon in moral principle as he was like him in intellectual grandeur, and Eton can point to Robert Boyle as one of the purest and the best as well as one of the most renowned of her sons."

His modesty was almost fanatical. He was fond of saying that he saw nothing but the first dawning of science, so far beyond what he could prove, did his fine piercing instinct go. The Royal Society at first yielded to his urgent request not to be chosen president, but as time went on, his preëminent fitness for the office, as shown by his personal qualities, vast attainments in learning and great celebrity, led them on St. Andrew's Day, November 30, 1680, to choose him president and add reasons for the act. This unique testimonial Boyle declined in a letter, as remarkable for its delicacy of feeling, as for its well-reasoned judgments. <sup>2</sup> The letter is addressed to Mr. Robert Hooke.

His habit of close and careful analysis, and study of his own mind is interesting. He regrets the ill-considered zeal of his sister, who, lest an illness should overmuch depress his spirits, procured for him the reading of some light stories, which set his thoughts to "go a gadding to objects then unseasonable and unpertinent;" and says, "Philaretus did in a considerable measure fix his volatile fancy and reclaim his thoughts, by the use of all those expedients he thought likeliest to fetter or at least to curb the roving wildness of his wandering thoughts. Amongst all which, the most effectual way he found to be, the extraction of the square and cube roots." <sup>3</sup>

It must be admitted that Boyle suffered from immaculateness. It is not so surprising that his total want of humor, his habitual seriousness and solemnity of manner drew upon him the ridicule of Swift, who perpetrated an act of cruelty and injustice in his Pious meditation upon a Broomstick in the style of the Hon. Mr. Boyle. This was a caricature upon Boyle's Reflections upon Several Subjects; and the wantonness of the act appear from the point made by an anonymous critic of Swift's that the complete idea and outline of Gulliver's Travels appear as a conceit of Boyle's in the paper which Swift ridiculed.

Boyle's knowledge was vast and accurate. He knew the whole com-

<sup>1</sup> Mem. Em. Etonians, 123. <sup>2</sup> Birch, 251. <sup>3</sup> Ib., 28.



pass of the mathematical sciences; geography, history, medicine and the sciences of nature, especially chemistry; he knew all contemporary literature, especially theological, and was not unfamiliar with the ancient. He mastered Latin, Greek, French, German and especially Hebrew. The latter language he learned late in life, and made a grammar of it, and he gives the reason for this in a passage found in an unfinished essay on the Scriptures:<sup>1</sup>

“Methinks those that learn other languages should not grudge those that God hath honored with speaking to us, and employed to bless us with that heavenly doctrine that comes from Him and leads to Him. When I have come into the Jewish schools and seen those children that were never bred up for more than tradesmen, bred up to speak what hath been peculiarly called God’s tongue, as soon as their mother’s, I have blushed to think how many grown men, that boast themselves to be the true Israelites, are perfect strangers to the language of Canaan, which I should learn were it but to be able to pay God the respect usual from civil inferiors to princes with whom they are wont to converse in their own languages.”

In order to master Hebrew he learned a grammar by rote, at the age of sixty, and took “not a few” private lessons of one of “their (Jewish) skillfullest doctors, that cost him,” he says, “twenty miles riding at a time,” though he was under medical treatment and his health “very unsettled.”

His supreme love of the truth and his habit of submitting all propositions in science to the test of rigid experimental demonstration, begot in him great prudence in judgment and devout charity and toleration towards the opinions of others. In a letter to John Dury, who was famous for his efforts to reconcile Lutherans and Calvinists, 3 May, 1647, he says:<sup>2</sup>

“It has been long as well my wonder as my grief to see such comparatively petty differences in judgment make such wide breaches and vast divisions in affection. It is strange that men should rather be quarrelling for a few trifling opinions wherein they dissent, than to embrace one another for those fundamental truths wherein they agree. For my own part, in some two or three and forty months that I spent in the very town of Geneva, as I never found that people discontented with their own church government, the gallingness of whose yoke is the grand scare-crow that frights us here; so could I never observe in it any such transcendent excellency as could oblige me either to bolt heaven against or open Newgate for all those that believe that they may be saved under another.”

And, in the Proömial Essay, he says:

“And, though for a man to change his opinions without seeing more reason to forsake them than he had to assent to them, be a considerable

<sup>1</sup> Birch, 96. <sup>2</sup> *Ib.*, 77 and 297.

levity and inconstancy of mind; yet to adhere to whatever he once took for truth, though by occasion of more light, he discover it to be erroneous, is but a proud obstinacy, very injurious to truth, and very ill-becoming the sense we ought to have of human frailties."

In his will he bequeathed an annual salary to be paid to some clergyman, for preaching eight sermons in a year, in order "to prove the truth of the Christian religion against Atheists, Deists, Pagans, Jews and Mohammedans, not descending to any controversies that are among Christians themselves." This is the Boyle Foundation, and in furthering Boyle's design more than sixty volumes have been published, beginning with Bentley's in 1691.

Buckle<sup>1</sup> calls attention to Boyle as illustrating in the finest way the transitory state of the seventeenth century mind, particularly upon the theological theory of the causes of disease, and cites two examples from Boyle's discourse on the air, wherein after observing "that it is the less likely that contagious maladies should always be sent for the punishment of impious men, because some plagues destroy beasts as well as men," he goes on to say: "Upon these and the like reasons I have sometimes suspected that in the controversy about the plague, namely, whether it be natural or supernatural, neither of the contending parties is altogether in the right." This was a great awakening from the credulity of the sixteenth century, and contrasts sharply with Lord Bacon's comments on the plague.

He had a habit of maintaining friendly relations with all sorts of people, even travelling jugglers, alchemists and adventurers, because he got from such people bits of information—the grains of gold-leaf—which he found useful. In this way he got hold of the uses of phosphorus long before Brande had published his experiments, and found out the secret of Peruvian Bark.

He was kind and delicate in his treatment of all. His house was open as freely to the destitute as to inquirers for knowledge. While the master received Newton, Halley and Bishop Burnet at one door, the butler was dispensing charity to crowds of the poor of London at another.

No man ever had a greater number of learned and accomplished friends. His life was never disturbed or embittered by personal controversy, so perfect was his subjugation of a naturally violent and choleric temper. Charles II., James II., and William III. were so charmed with his conversation that they often sought his society, admitted him to the palace with the slightest possible formality and discoursed with him with familiarity.

The new philosophy of Descartes set men to reading the older work of Bacon, and thus John Locke and Boyle were brought together in a friendship that ended only with Boyle's death, a friendship whose character and value is attested by a voluminous correspondence. New-

<sup>1</sup> Hist. Civ., 1, 128 n.

ton's regard for Boyle has been mentioned. Dr. Thomas Sydenham was so enamored of him and found such profit in his society that he got him, when he could, for a companion in his ordinary visits to his patients; this gave Boyle in his turn a rare chance to study pathology. Robert Hooke, Professor in Gresham College, seems to be sitting constantly at his feet. One of his most intimate friends was Dr. Thomas Barlow, keeper of the Bodleian Library and afterwards Bishop of Lincoln. Mr. Thomas Hyde of Queen's College, eminent for his skill in the languages of the East, was often consulted. John Evelyn of Wotton, says of his friend, "he is alone, a society of all that were desirable to a consummate felicity." Dr. John Wallis, Bishop Sanderson and Dr. Burnet also appear among his intimates, the former having addressed to Boyle an Hypothesis about the Flux and Reflux of the Sea. Dr. John Cudworth, 1684, urges him, in vain; to issue all his works in Latin. Halley, Dr. Stillingfleet, Dr. John Beale, Bishop Berkeley gather into the same brilliant company. I do not find why Prince Rupert never found his way to the inner circle of Boyle's friends, for he was active in the foundation of the Royal Society. Boyle maintained an active correspondence with all the prominent scholars on the continent, and was received by them with the same enthusiasm as was shown in England.

Boyle's profound reverence, and sense of satisfaction in the idea of God as the Creator, combined with his truthfulness and candor, made him always ardently philanthropic. Actively engaged in promoting the interests of the East India Company, which owed its new charter to his skilful intervention at court and its prosperity largely to his management,<sup>1</sup> he writes to Robert Thompson, 5 March, 1676, urging that the Company undertake the "propagation of the Gospel in those countries where their commerce gave them an opportunity." He says that Lord Berkeley and the Bishop of Oxford have called on him to urge this matter, and supports the reasonableness of his suggestion by referring to the wise behavior of the Dutch in Batavia, and the methods of the work in New England. "These methods are three: First, we have caused the holy scripture and some few choice practical books to be translated into the chiefest (language," to which this most courteous and reasonable Christian adds: To which you may add the publishing of a solid but civilly penned confutation of the authentic books wherein the Brahmin's religion is contained.<sup>2</sup>) Next, we have caused men of ours to learn their tongue. And then we breed some of their hopeful forward youths to that knowledge of the English tongue and European learning, that they may afterwards be able to confute idolatrous priests and convert and instruct their own countrymen.<sup>3</sup> In the year following he was at the expense of printing five hundred copies of the four Gospels and the Acts in the Malayan tongue, under the direction of Dr. Thomas Hyde, Keeper of the Bodleian Library. Dr. Hyde's dedication to

<sup>1</sup> Birch, 226. <sup>2</sup> *Ib.*, 229. <sup>3</sup> *Ib.*, 229.

Boyle is addressed to him as one of the Directors of the East India Company and Governor of the Corporation for the Propagation of the Gospel and the Conversion of the American Natives in New England. He gave a handsome douceur to Dr. Edward Pococke for translating Grotius's Truth of the Christian Religion into Arabic, paid the expense of printing it at Oxford in 1660, and then scattered it widely amongst Arabic-speaking people. He wished to do the same for the Turkish Empire, but was restrained by his associates in the East India Company who preferred to undertake this labor themselves. He paid £700 towards printing and circulating the Bible in the Irish dialect, by Dr. Wm. Bodell, Bishop of Kilmore, in Ireland, and contributed largely toward another edition to be circulated among the Welsh and in the Highlands of Scotland. He contributed very largely to the expense of publishing Dr. Burnet's History of the Reformation, an act handsomely acknowledged by the author in the preface to the second edition.

But his most important labor and the one which attracted him most strongly was his service as Governor of the Corporation for Propagating the Gospel in New England and the parts adjacent in America. It appears that in 1649 an ordinance was passed in Parliament for erecting a corporation to be called The President and Society for the Propagation of the Gospel in New England. This Society secured an income of about £600 a year. Upon the restoration of Charles II., the corporation being dead in law, a certain Col. Bedingfield, who had sold them an estate worth £322 per annum, seized the estate and refused to pay over the income. Boyle obtained from Clarendon an order which prevented this outrage; and he then obtained a fresh charter, February 7, 1661, from Charles II. substantially continuing the Puritan Society with enlarged powers, and an increase in the number of corporators. Most of the old members were retained. Boyle was named as Governor, in the Act.<sup>1</sup> This was the Society under whose auspices most of the missionary work among the Indians of New England was done prior to the Revolution. Among its missionaries appear the two Eliots, the two Mayhews, Abraham Pierson, John Cotton of Plymouth, son of John of Boston, Richard Bourne and Simon Poponet. "By the sole cost and care of this corporation it was that the whole Bible and some other books of piety were translated into the language of New England by the pains of the Rev<sup>d</sup> Mr. Eliot, who made a grammar never also in print for that language, and who daily labours in the work of the Gospel there, he having an honorary stipend continued to him by the above mentioned corporation."<sup>2</sup> It is certain that Eliot recognized Boyle as the source of the life and efficiency of the Society.

Boyle paid a large sum of money into the treasury of the corporation, and it is interesting to inquire into the reasons for the act. What

<sup>1</sup> Neal, Hist. N. E., 1, 280. Tracy, Hist. Am. Missions, says Boyle was most zealous and influential of all.

<sup>2</sup> Letter from Thomas Hyde to Boyle. Birch, 230.

portion of the expenses of doing missionary work among the Indians was borne by the corporation in England, and what portion by the churches in Massachusetts cannot easily be determined. The expenditure of all the money, from whatever source received, was entrusted to the Commissioners at Boston, who seem to have received all their money by way of annual drafts from the corporation,<sup>1</sup> and who rendered an annual account to the corporation; and it is noteworthy that Mr. Usher, the treasurer at Boston, always shows an unexpended balance. Nearly all Mr. Usher's accounts are given in Hazard, and no credits are made of cash sent to England or charges of any expended there; and in the matter of Bibles and Testaments no charges are made for type, though the expense of paper and printing is duly entered.<sup>2</sup> Mr. Usher charges himself in 1660, with a draft for £800 from the corporation; in 1661, the same. In 1662, the first draft drawn by Robert Boyle, Governor of the Corporation, appears — amount £500; in 1663, Boyle sends draft for £320, and with it a letter to the Commissioners, urging the strictest economy, “for,” he says, “our present revenue is not above £320 per annum.” He alludes to home expenses for salaries and for a suit-at-law, obviously the proceedings against Bedingfield. In 1664, the annual draft was for £500, and by this time the work on the Bible was done. The sudden shrinkage in the resources of the Society indicated by these facts, is explained by the cessation of the spasmodic offerings of the churches in England, there being no record of any considerable amount from this source after the Restoration, and the diminution in the contributions of the New England churches. The last general contribution in England, was in 1649, which was urged by Winthrop and others, and resulted in the establishment of a fund that yielded *not* £700 to £800 as Baxter says, but £500 to £600 a year, as Neale says.<sup>3</sup> The loss by Bedingfield's resistance was £322, as shown in Boyle's appeal to Clarendon for relief; and this added to the amount mentioned in his letter just quoted, shows that the entire income, after the recovery of the Bedingfield estate, did not exceed £622 per annum. It is only necessary to set the annual receipts from casual gifts at from £25 to £30 per annum to justify Neale's statement.

The amount of the annual draft compared with Boyle's statement about income and the known value of the Bedingfield estate renders it

<sup>1</sup> For accounts of receipts and expenditures at Boston, by the Commissioners for the corporation, see Hazard, *Hist. Collec.*, Vol. II., *passim*.

<sup>2</sup> In Hazard, II., 407, see that the old corporation paid £80 prior to September, 1659, “for letters to print the Bible,” and in 1660, £120 for paper. May, 1661, the old corporation in London wrote (p. 438), that they had paid to Mr. Usher's use £800, which together with the £347 balance in the hands of the New England Commissioners, they hoped would be sufficient to defray the charge of printing the Bible, &c. For this note, I am indebted to a letter from Dr. Trumbull.

<sup>3</sup> *Hist. New England*, 1, chap. VI.

certain that the amount acknowledged by Mr. Usher, included the contributions made in Massachusetts. The largest amount ever raised by the colonial churches was £500, so that a draft for £800 was as large as the treasury could sustain, at the time the printing was begun. The income from the Bedingfield estate did not become available till 1662, at the earliest, and there is no hint of any income from any other source but the fund. No debts were ever incurred by the Corporation of which we have any account, indeed, debts due from such a Corporation would be, in Boyle's eyes, little less than flagrant iniquity.

Boyle declares in his will,<sup>1</sup> "I have given and paid the sum of three hundred pounds towards that piety, i. e. The Corporation for Propagating the Gospel," and then gives £100 more.

There is no record of any unusual outlay of money by the Corporation, except that caused by the printing of Eliot's Bible and the other books which were taken from the same type, and the small outlay required to recover the Bedingfield property; the annual drafts sent to Boston seem to exhaust, in each case, the available annual income. Dr. Trumbull<sup>2</sup> points out the strange indifference of the Commissioners to the value of Eliot's work. They withheld from him a suitable salary, till they were twice compelled to raise it, by vote of the Corporation. It is not at all strange, then, that they, and the Corporation who acted largely under their advice, should have failed entirely to take in the importance of a font of Indian type, or to provide for buying one. It remains probable, therefore, that Boyle's contributions, stimulated by his intense interest in Eliot's Bible, began before the type were paid for, and were largely increased upon the issue of the second edition. This edition, published in 1685, was<sup>3</sup> dedicated to Boyle in terms which leave no doubt that the obligation to him was considered vital. Though Boyle resigned the presidency of the Corporation, May 30, 1689, his successor was not chosen till after his death in 1691; so that practically, his presidency was the period of the Society's effective existence.

He made large gifts to clergymen. He assumed sole charge of the orphan children of Oldenburg, first secretary of the Royal Society. Bishop Burnet, in his eulogy, says, that Boyle spent a thousand pounds a year in charity and benevolence; in his will he left five thousand four hundred pounds for the propagation of Christianity.

His early love for the study of ethics and theology leaves its traces in the shape of essays on Seraphic Love, Some motives and incentives to the Love of God, Some considerations touching the style of the Holy Scriptures, Some considerations about the reconcilableness of Reason and Religion, A discourse of things above reason, &c., which appear in the earlier volumes of his works mixing quaintly but not unpleasantly with Considerations touching the spring of the air, Of the mechanical

<sup>1</sup> Birch's Life, 339. <sup>2</sup> Proc. Am. Ant. Soc., 61, Oct., 1873.

<sup>3</sup> A point suggested by Dr. Charles Deane.

origin and production of fixedness, On a hydrostatical paradox, The sceptical chemist, A record of physical and mechanical experiments, and Of the intestine motions of the particles of quiescent solids.

In the troubles of the colony of Massachusetts Bay about the Commissioners, and in other matters, Boyle's influence at Court was always thrown heavily in favor of the colony. In Hutchinson's State Papers, 450, is a letter from Boyle to some person of consequence in New England, whose name is missing, in which he modestly claims a large share in influencing the mind of the Court in favor of the colony; and this view is supported by a letter from Endicott to Charles II., and Clarendon's reply.<sup>1</sup>

"We are all amazed," wrote Clarendon, who says Robert Boyle was no enemy to Massachusetts, "you demand a revocation of the Commission without charging the Commissioners with the least matter of crimes or exhorbitances." Boyle echoed the astonishment, "The commrs. are not accused of one harmful thing even in your private letters."<sup>2</sup> Boyle's eyes were holden here. He could not understand a principle of liberty which lay deeper than loyalty. But he felt the wrong without comprehending the impolicy of forcing the Commissioners upon a virtuous and law-abiding community.

In his will Boyle directed that his personal estate should be expended by the trustees for charitable and pious uses. They directed that £90 a year should go to Harvard College, and the rest to the College of William and Mary for the maintenance and education of Indian students. The latter institution received 650 pounds sterling annually from this source, and was until the Revolution the wealthiest college in the United States. The property set aside in England, by the trustees to support this payment, was Brafferton Manor, and the Brafferton House, built for Indians out of this fund, in the grounds of the College of William and Mary, to-day preserves this record of the indebtedness of the institution to Robert Boyle.<sup>3</sup>

William Penn, August 5, 1683,<sup>4</sup> writes him at length concerning the Indians of Pennsylvania, and submits to his rare judgment ores, plants and flowers which may add to the wealth of the new colony and the good of the world. A very unique letter from President Leonard Hoar is given in Birch's *Life*, VI., 652, accompanying a collection of plants, models, &c., sent to Boyle for information about Massachusetts. In this letter the President gratefully acknowledges Boyle's invaluable services in the affairs of the colony and then confides to him a plan for the enlargement of Harvard University, to include: "A large well-sheltered garden and orchard for students addicted to planting; an ergasterium for mechanic fancies; and a laboratory chemical for those philosophers that by their senses would cultivate their understandings;

<sup>1</sup> See also Winthrop's letter of 27 October, 1670. <sup>2</sup> Bancroft, I., 443.

<sup>3</sup> Prest. B. S. Ewell. <sup>4</sup> Birch, VI., 658.

for the students to spend their times of recreation in them; for readings or notions are but husky provender."

This is the earliest recorded conception of a technological school; and as the President refers to numerous prolonged and agreeable conferences with Boyle during his visit to England, it may be inferred that this idea was attributable to a suggestion of the philosopher. And that the Lawrence School was not anticipated by two centuries, is probably due to the want of funds and to some conservative views of Boyle in his letter of reply to the President, which is unfortunately lost.

The judgment of his contemporaries is very clearly in his favor. A Dublin newspaper of the day calls him "the father of chemistry and son of the Earl of Cork!" Dr. Cudworth, urging him to issue his complete works in Latin, says, The writers of hypotheses in Natural Philosophy will be confuting one another a long time before the world will ever agree if it ever do. But your pieces of Natural History are unconfutable and will afford the best grounds to build hypotheses upon. You have much outdone Sir Francis Bacon in your natural experiments.<sup>1</sup> Lord Clarendon, in his letter to Massachusetts Colony, 1664, alluding to their petition against the Commissioners, says, he has referred their letters to my Lord Chamberlain and Mr. Robert Boyle, and has had divers conferences with them on the subject.

Six letters from John Eliot are preserved in Birch's appendix, addressed to Boyle as "Right honorable, deep learned, charitable, indefatigable nursing father." For his powerful intervention at Court in behalf of the Massachusetts, a letter of thanks was ordered by the General Court, and written by John Endicott, October 19, 1664; and a remarkable letter, signed by John Leverett, Governor, Samuel Symonds, Dep. Gov., Daniel Gookins, Asst. and five others, dated Boston, May 10, 1673, recognizes the value of Boyle's services and argues with him the case of the colony against the Commissioners. Robert Hooke's correspondence with Boyle is voluminous, and submits to him that scholar's own researches. (How fortunate that the lack of easy travelling forced all these men to record their thoughts in letters!) Boerhaave calls him the ornament of his age and country, and the successor to the genius and inquiries of the great Chancellor Verulam.<sup>2</sup> Dr. Richard Bentley, in the fourth Boyle lecture, says, "The mechanical or corpuscular philosophy, though peradventure the oldest as well as the best in the world, had lain buried for many ages in contempt and oblivion, till it was happily restored and cultivated anew by some excellent wits of the present age. But it principally owes its reestablishment and lustre to Mr. Boyle."<sup>3</sup>

Mr. John Hughes, after noticing the coincidence of the death of Bacon and the birth of Boyle, observes: "The excellent Mr. Boyle was the person who seems to have been designed by nature to succeed

<sup>1</sup> Birch, 257. <sup>2</sup> *Ib.*, 306. <sup>3</sup> *Ib.*, 307.



to the labors and inquiries of the extraordinary genius I have just mentioned." He in great measure filled up those plans and outlines of science which his predecessors had sketched out. It would be impossible to name many persons who have extended their capacities as far as these two, in the studies they pursued; but my learned readers, on this occasion, will naturally turn their thoughts to a third who is yet living (Sir. I. Newton), and is likewise the glory of our own nation.<sup>1</sup>

Francesco Redi, in the edition of Boyle's Works published at Florence, 1724. expresses the highest esteem and veneration for him, and asserts that he was the greatest man that ever was, and, perhaps, ever will be, for the discovery of natural causes.

The justest and most appreciative judgment of him, is that of the learned Dr. Peter Shaw, who was born four years after the death of Boyle. He says of Boyle's Works:<sup>2</sup> "Those works have from their first appearing in public, done an honor to his country, and procured him a general esteem in the world. The novelty, the variety, the dignity and the usefulness of the several subjects he treats, with the easy and familiar manner wherein they are handled, recommend his performances to the whole body of mankind. He takes up his reader at the elements or fundamental principles of things; and, with exquisite judgment conducts him through all the regions of nature to furnish him with objects whereon to exercise his faculties; and being first solicitous to make him a general philosopher, leaves him prepared for any further inquiry he shall think fit to make into the works of nature or art. \* \* The men of wit and learning have, in all ages, busied themselves in explaining nature by words; but it is Mr. Boyle alone, who has wholly laid himself out in showing philosophy in action." Sir John Evelyn, one of Boyle's associates in founding the Royal Society, says, that he wished to have Boyle for a fellow-member, "who is alone, a society of all, that were desirable to consummate felicity."<sup>3</sup>

Clarendon pressed him to take holy orders, Charles II., James II. and William III. successively offered him a peerage, but all these honors were firmly declined. This was done with such unaffected modesty and obvious devotion to learning as to leave in the bestower rather than in the recipient of the honor the sense of loss. The Provostship of Eton was offered to Boyle, without his solicitation or request, by Charles II., on the death of Dr. Meredith, in 1665; but Boyle declined from a conscientious conviction that it ought to be filled by a person in holy orders.<sup>4</sup>

His tracts were received with great interest and eagerly read. The Sceptical Chemist, which made such havoc with old notions, went through ten editions in the author's life-time—an unusual occurrence,—

<sup>1</sup> Spectator, No. 554, Vol. VII.

<sup>2</sup> Shaw's Boyle, 2d ed., London, 1738, p. 1. <sup>3</sup> Birch, 117, 397.

<sup>4</sup> Creasy Memoirs of Eminent Etonians, 133.

and Buckle finds<sup>1</sup> that as early as 1696, his works were becoming scarce and there was talk of reprinting them.

Many books were dedicated to him, among which is: Dr. John Wallis's *Hypothesis about Flux and Reflux of the Sea*, 1666. Dr. Thomas Sydenham (1666), *Methodus curandi febres*, begins *Illustrissimo et Excellentissimo Domino Roberto-Boyle*, and sets his character in a most amiable light. The second edition of this work, in 1668, was also so dedicated to Boyle and elicited from him a letter of thanks. Dr. du Moulin, 1670, son of the celebrated Peter du Moulin, dedicated to him a volume of Latin poems, in which he praises Boyle's attainments in Latin verse; though Gunning cut out of it a stanza addressed to the Royal Society. In 1667, Dr. Walter Needham dedicated to him his *Anatomical Works*. In 1673, Anthony le Grand dedicated to him his *Historia Naturae*, and applies to Boyle what had been said of Aristotle, "that nature had formed him as an exemplar of the highest perfection to which mankind can attain."<sup>2</sup> Dr. Burnet acknowledges his deep obligation to Boyle, in the preface to vol. II. of his *History of the Reformation*; and Dr. Bentley in the fourth Boyle Lecture speaks of him in terms of unqualified admiration. Dr. Richard Bentley says Boyle reëstablished the corpuscular philosophy. "Which of his writings shall I recommend," exclaims Boerhaave,<sup>3</sup> better qualified perhaps than any one to judge correctly of Boyle, "All. We owe him the secrets of fire, air, water, animals, vegetables, fossils; so that from his works may be deduced the whole system of natural knowledge." Dr. Nathaniel Highmore dedicated to him his book on the *History of Generation*, 1651.

The judgment of his successors supports that of his contemporaries. Monk in his *Life of Bentley*, 1, 37, says Boyle's discoveries have placed his name in a rank second only to that of Newton, and Buckle quoting this, adds approvingly, 1, 367, "and this I believe is true, notwithstanding the immense superiority of Newton." Buckle further says, in the same place, "After the death of Bacon, one of the most distinguished Englishmen was certainly Boyle; who if compared with his contemporaries, may be said to rank immediately below Newton, though of course very inferior to him as an original thinker."

And it was Boyle who opened up those chemical inquiries, which went on accumulating until a century later they supplied the means by which Lavoisier and his contemporaries fixed the real basis of chemistry, and enabled it for the first time to take its proper stand among those sciences that deal with the external world.<sup>4</sup>

Cuvier<sup>5</sup> says "One of the creators of experimental physics, the

<sup>1</sup> *Hist. Civ.*, 1, 371. <sup>2</sup> *Birch*, 214. <sup>3</sup> *Ib.*, 306.

<sup>4</sup> As this gives the credit of the science to the English rather than the French, it is well to consult Whewell, *Bridge. Treat.*, p. 266. Thomson's *Hist. Royal Soc.*, p. 397 and his *Hist. of Chem.*, 1, 204.

<sup>5</sup> *Progrès des Sciences Naturelles*, Vol. I., p. 30.

illustrious Robert Boyle, ascertained in the middle of the seventeenth century a large part of the facts which serve to-day as the basis of this new chemistry." And some one justly says that Boyle had in his hand the key to the great discovery of Lavoisier. Boyle constantly insisted upon two fundamental principles: the importance of individual experiments, and the comparative unimportance of the facts, which on these subjects, antiquity has handed down. He says,<sup>1</sup> "For I am wont to judge of opinions as of coins: I consider much less in any one that I am to receive, whose inscription it bears than what metal it is made of. It is indifferent enough to me whether it was stamped many years or ages since, or came but yesterday from the mint."

But he calls attention himself,<sup>2</sup> to the frequent occurrence in the *Experimental Essays* of the phrases "perhaps," "it seems," "it is not improbable." His essay on crystals, a most remarkable production, is entitled, "Doubts and experiments touching the curious Figures of Salts."<sup>3</sup> And with good reason Humboldt calls him in *Cosmos*,<sup>4</sup> "The cautious and doubting Robert Boyle. First to doubt, then to inquire, then to discover, has been the process of all great explorers."

Francesco Redi<sup>5</sup> says he was the greatest man that ever was, or perhaps ever will be for the discovery of natural causes.

Dr. Monk, author of the *Life of Bentley*, ranks Boyle next to Newton. And Dr. Shaw dedicating his edition of Boyle to Lord Burlington, begins thus: "The original philosophical writings of the Hon. Mr. Boyle are a treatise worthy the cabinets of the princes; and perhaps the most valuable present of that kind the world ever received."

It is well known how much of our philosophy is derived from Boyle's discovery of the qualities of the air, yet of those who now adopt or enlarge his theory, very few have read the details of his experiments. His name is indeed revered; but his works are neglected; we are contented to know that he conquered his opponents, without inquiring what cavils were produced against him, or by what proofs they were impelled.<sup>6</sup>

<sup>1</sup> A large part of Boyle's work was recorded in papers originally read to the Royal Society, and then published in the *Philosophical transactions*; but he issued a considerable number of monographs on the topics which occupied his thoughts. The first tracts were issued in 1661 and 1663. In 1715, R. Boulton edited his complete *Theological Works*, published at London, in 3 vols., 8vo. Dr. Peter Shaw edited the *Philosophical Works*, abridged, methodized and disposed under general heads, published at London in 3 vols., 4to; first edition in 1725, second in 1738.

But the standard edition, and the only one approaching completeness, was carefully edited by Dr. Thomas Birch, Secretary Royal Society, and published at London in five superb folios, in 1744. A new edition

<sup>1</sup> Works, Birch ed., IV., 359. <sup>2</sup> *Ib.*, I., 197. <sup>3</sup> *Ib.*, II., 488.

<sup>4</sup> *Cosmos*, II., 730. <sup>5</sup> Birch, 306. <sup>6</sup> *Rambler*, March 23, 1751.

in 6 vols., 4to, was published in 1772. In this edition the only existing portrait of Boyle is given, and on the title-page appears a striking vignette, bearing the legend, "Ex rerum causis supremam noscere causam."

One Samuel Smith, in 1690, issued a catalogue of the Philosophical books and tracts written by the Hon. Robert Boyle, which was incomplete. A Latin edition of his works was published at Geneva, about 1700, in 4to, entitled, *Roberti Boyle nobilissimi Angli et Societatis Regiæ dignissimi socii opera varia*. Oldenburg denounces this edition as garbled and untrustworthy. Another Latin edition was issued at Geneva, in 5 vols., 4to, in 1714; another at Cologne, 3 vols., 4to, 1680; and still another at Venice, 4to, 1695. Selections from his papers were printed in French, in one vol., 8vo, 1679.

In the chronological annals of the year 1648, given in Green's Short History of the English People, the only event recorded in italics is—Royal Society founded at Oxford. Bancroft says<sup>1</sup> that John Winthrop was active and influential in founding the Royal Society—as he certainly was in the establishment of the Society for Propagating the Gospel. Sir John Evelyn had written his hopes of a philosophical college. But Boyle gives the true history of the origin of this remarkable Society: "About the year 1645, while I lived in London, I had the opportunity to be acquainted with divers worthy persons, inquisitive into natural philosophy and other parts of human learning, and particularly of what hath been called the new or experimental philosophy. We did by agreement, divers of us meet weekly, on a certain day, to treat and discourse of such affairs. \* \* About the year 1648, some of us being removed to Oxford, first Dr. Wilkins, then I, and soon after Dr. Goddard, our company divided." Those who remained in London kept up the meetings; those who remained at Oxford met usually at Boyle's lodgings. These assemblies were referred to in the letters of members as the Philosophical College or the invisible college, for obvious reasons. They were kept up with much spirit and regularity until the Restoration, when in 1661 Boyle obtained from Charles II. an act incorporating the intrepid scholars under the title of the Royal Society. The charter did not take effect till 1663. But the patent was all that the Society obtained from Charles. Hume<sup>2</sup> commenting on the contemporary rise and growth of the French Academy, founded 1666, under the liberal encouragement of Louis XIV., says, "But though the French Academy of Sciences was directed, encouraged and supported by the sovereign, there arose in England some men of superior genius, who were more than sufficient to cast the balance, and who drew on themselves and on their native country the regard and attention of Europe. Besides others there flourished during this period a Boyle and a Newton, men who trod with cautious and

<sup>1</sup> Hist. U. S., I., 422. <sup>2</sup> Hist. Eng., VI., 373.

therefore the more secure steps, the only road which leads to true philosophy."

That Boyle was the de facto founder of the Society appears from Glanville's defence of it against Crosse, wherein, answering the question "What have they done?" he gives an account of what has been done by "the illustrious Mr. Boyle for the promotion of useful knowledge."

The first volume of the *Philosophical Transactions* (March, 1665 — February, 1666), consists almost wholly of Boyle's contributions, and every volume till his death is enriched by his labors.

R. Watts<sup>1</sup> says he was one of the founders and chief promoters. Contemporary biographers and writers speak of Boyle as founder of the Royal Society. It was, beyond all question, stimulated and enlivened by his presence and labor. A. Chalmers says Boyle may be justly reckoned as one of the founders of the Royal Society; but his remarks are evidently based upon a hurried reading of Birch's Life.

The list of original members of the Invisible College, given by Boyle,<sup>2</sup> contains no name of special eminence, except, perhaps that of Dr. John Wilkins, afterwards Bishop of Chester, who certainly did not move in the matter; and Mr. Theodore Haak, a German, resident in London, who certainly could not.

But the Royal Society was founded for a purpose which was Boyle's purpose, and not that of any man before him, viz.: To increase knowledge by direct experiment. The charter declares that the object is the extension of natural knowledge as opposed to that which is supernatural.<sup>3</sup>

Boyle was also an influential member of the East India Company, and framed the second and permanent charter.

Boyle's merit in science at first was somewhat exaggerated, and afterwards, as I have before said, unfairly depreciated. There is force in the suggestion of a writer in Knight's *Cyclopedia*, that it is a fair method to take a foreign history of physics, and see what are the discoveries of the Briton of the seventeenth century which will be thought worthy of record by a Frenchman of the nineteenth.

In *Histoire Phil. du Progrès de la Physique*, Paris, 1810. M. Libres, is a chapter devoted to *Progrès de la Physique entre les mains de Boyle*, in which it is said, "That it is impossible to follow Boyle through his labors without being astonished at the immensity of his resources for tearing out the secrets of Nature." Boyle is credited with all the great additions to knowledge made by means of the air-pump, including the propagation of sound through the air — all the more creditable to him, because Guericke had been led astray as to the cause of this phenomenon, — and the author concludes with observing: "That it is impossible to say to what degree of obligation chemistry is to limit its acknowledgments to Boyle, and no one can say that his works, the eldest progeny

<sup>1</sup> Bib. Britt. <sup>2</sup> Birch, 83. <sup>3</sup> *Weld Hist. Roy. Soc.*, pass

of the *Novum Organum*, were anything but a credit to the source from whence they sprung."

Boyle says in the *Præfatorial Essay*, that he designed the narrative of what he had tried and observed as a continuation of Sir Francis Bacon's *Natural History*. It is certain that without Boyle, the Baconian philosophy would have remained one of the wanderings of cloisters and libraries. Boyle cast this philosophy into the waters of the seventeenth century, turbid with the fictions of the schoolmen and the reveries of the alchemists, and they grew quickly and transparently clear.

To enumerate his labors, is to epitomize the six ponderous quartos of Birch. In brief, in *Origin of Forms and Qualities*, and *Discourse of Subordinate Forms*, 1666, he insists that the mechanic motions and order of the parts of bodies are sufficient to yield an account of the differences of bodies and their affections, without recourse to the forms and qualities of the schools. It seems now, that no intelligent reader of this paper could keep moving along without interruption or hindrance to the fundamental conceptions of modern chemistry as involved in the hypothesis of Dalton.

At the annual meeting of the International Medical Congress, in London, 1881, the most distinguished person was Louis Pasteur, whose amazing experiments in the nature of disease-germs and the effect of successive inoculation are exciting the deepest interest among all thoughtful men. Dr. W. B. Carpenter describes this meeting with special reference to the labors of Pasteur,<sup>1</sup> and says, "The revival by Dr. Farr of the doctrine of Zymosis (fermentation), long ago, suggested by the sagacity of Robert Boyle, &c. Ferdinand Hofer" says, "He (Boyle) was persuaded that the study of ferments would some day clear up those pathological phenomena which up to this time remain inexplicable. A paper of Boyle's on fermentation is among the lost manuscripts which Birch declares he can get no trace of, except that they once existed; but his account of the fermentation of the blood;<sup>2</sup> of the air in reference to fermentation;<sup>3</sup> theory of effluvia; the behaviour of the juice of grapes;<sup>4</sup> the use of the knowledge of fermentation;<sup>5</sup> and the changes in animal substances by fermentation;<sup>6</sup> leave no doubt of his accurate solution of the problem of the changes that occur in vinic fermentation and made the way easy to the discovery of torula and the germ-theory. What Pasteur and his collaborators have done, is to explain and amplify the points experimentally established by Boyle. I quote a passage from *The use of the knowledge of fermentation*, to show how far his marvellous sagacity—the true philosophic instinct—outran his actual knowledge:—"I pretend not that vulgar chemistry will enable a physician to explicate all or most of

<sup>1</sup> In *Nineteenth Century*, October, 1881. *Hist. de la Chimie*, 411.

<sup>2</sup> Birch V., 97. <sup>3</sup> *Ib.*, V., 716. <sup>4</sup> *Ib.*, 216. <sup>5</sup> *Ib.*, I., 690. <sup>6</sup> *Ib.*, II., 83, 103. <sup>7</sup> *Ib.*, II., 119. <sup>8</sup> *Ib.*, II., 1183.

the pathological phenomena; but that true chemistry may assist him to explicate divers of them, which can scarce be solidly explicated without it. And let me add, that he, that thoroughly understands the nature of ferments and fermentation shall probably be much better able than he that ignores them, to give a fair account of divers phenomena of several diseases (as well fevers as others) which will perhaps be never thoroughly understood, without an insight into the doctrine of fermentation; in order to which, for that and other reasons, I designed my historical notes touching that subject."<sup>1</sup> So that the work of Pasteur, which is healing the wound of French agriculture, strikes its roots into the sagacious mind of the Englishman of the seventeenth century.

In the *Sceptical Chemist*, perhaps the most influential of all his works, Boyle reviews with irresistible clearness and conclusiveness the arguments of the school-men and points out the better way of induction as the only source of trustworthy knowledge of nature. The paper is skilfully cast into the form of doubts about the prevalent reasoning concerning natural phenomena, and leads the reader to see that it consisted largely of assumption, and that to learn of Nature one must become her pupil. I believe this book of Boyle's to be the first effective blow ever delivered at a priori, and the first really effective appeal to men to form their judgments of natural phenomena after rather than before a study of those phenomena.

He opposed Aristotle's system, not from any lack of recognition of his transcendent merit, but because he saw that the study of causes and the Final Cause had sublimed out of all contact with the facts of Nature, and that to bring men back to Nature, a new departure must be made. And with singular consistency and loyalty to his own convictions, for many years he refused to read Descartes—greatly to the astonishment of Locke—in order that he might leave his mind open and fresh to any truth that his own experiments might reveal to him. It is of course impossible that his long intimacy with Locke could have left him ignorant of Descartes, or wholly unimpressed by his system.

Boyle, in the *Sceptical Chemist*, was the first man to utter serious doubts as to the theory of the peripatetics and of the alchemists; he disputed the elementary character of fire, air, earth and water; said we must not be limited to three or four elements—that we shall some day find a larger number. He denounced the obscurity with which alchemists parade their alleged discoveries, and rebukes the alchemists for calling combinations of metals with acids, especially aqua fortis, the elements of those metals themselves. He says: "It is possible, that one body is composed of two elements, another of three, &c., and that one body may not have any of the same elements that another has; as we often see two words, whereof the one has not any of the letters to be met with in the other."

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<sup>1</sup> The lost paper.

He proposed trials to Dr. Lower based on experiments of his own concerning the transfusion of blood and the effect of new blood on the recipient animal. Many other speculations in Physiology originated with him. Boyle overthrew the alchemists at a touch, when he suggested in *The Sceptical Chemist* that in addition to visible and palpable elements there may be others more subtle and invisible that escape through the joints of the vessels.

Though Otto Guericke invented the air-pump, Boyle had no knowledge of it, and Birch says "that he, Boyle, invented that admirable engine." He ascertained and correctly stated all the essential properties of air; this he accomplished by means of an air-pump, constructed by Mr. Robert Hooke after original design by Boyle, including the glass-receiver on a metallic base,<sup>1</sup> and by this means established the science of pneumatics. His first publication on the subject was in 1660, at Oxford, under the title *New Experiments, physico-mechanical touching the spring of the air and its effects*, made for the most part in a new pneumatical engine. The work recorded in this paper included an experimental demonstration of the nature of a vacuum. He found or proved the pressure of air to be the cause of the Torricellian vacuum, showed the impossibility of a perfect vacuum, explained suction, loss of weight of bodies in vacuo, the necessity of air to combustion, and in short nearly every fact and principle in the behavior of the air.

Torricelli had made his tube and substantially fixed the fact of the materiality of the air. His theory of fluids drew Pascal from geometry to physics, and the result of the labors of this acute scholar was the dissertations on the *Equilibrium of Fluids and the Weight of the Atmosphere*, in which are given the first barometric measurements. (This work of Pascal brought on the controversy with Father Noël, an Aristotelian, which was the last real struggle of the old philosophy.) In these books Pascal extended the conception of fluid equilibrium to air as well as water, and also pointed out the compressibility of one and the incompressibility of the other. He reached the point of showing that air is compressible and there stopped. Boyle made, independently and almost simultaneously, the same discoveries, but did not stop; he asked the question, that has ever opened the door to real knowledge and marks the dividing line between knowledge and information, how *much* is air compressed for any given pressure? He also asked, how much does it expand or contract for any given change in temperature? And are the properties of air predicable of other gaseous bodies? In the year 1650, he found the law since known by his name (twenty-six years before Mariotte who has had the undeserved fortune to get his name associated with the discovery); and in the dim light of that early morning of science, a hundred years before Watt's steam engine, he worked out and established the law upon which unchanged foundation

<sup>1</sup> Guericke depended on water for his vacuum, and did not know the use of the glass receiver.



the whole modern science of steam-engineering securely rests.<sup>1</sup> This law has been empirically verified by the French Academy and found to be true to twenty-seven atmospheres.

He found that air once exposed to an excess of burning fuel will not again sustain combustion or life; that air which has been breathed sustains fire feebly; that distillation in a closed retort produces compounds totally unlike those of open combustion, the lack of which distinction vitiates nearly all the work of Van Helmont; that "an air" obtained by heating certain metallic salts intensifies combustion; found that fermentation and putrefaction are impossible in vacuo; spoke of a vital substance in air; in short he left nothing for Lavoisier but to pronounce the word Oxygen.

He discriminated carefully between air and ether, in that air refracts the rays of light, and comes very close to a statement of the possibility of Crooke's Radiant Matter.

Probably Boyle's tract *Fire and Flame*, gave George Ernst Stahl his idea of Phlogiston, though the acute German's claim to the origination of the idea is not affected by this fact.

Boyle clearly intimates his own belief in one ultimate, simple form of matter, precisely what Lockyer's spectroscopy is now leading us to. He published the first tables of specific gravities, which are as accurate as his apparatus could give.

Boyle showed<sup>2</sup> that the prevalent view of acid and alkaline parts in all bodies is undemonstrable and precarious, and that there is no criterion to which all acids can be brought. He noted the tastelessness of some undoubted acids, showed the convertibility of ternary compounds of nitrogen from an acid to an alkaline condition and vice versa, and having thus overturned much of the iatro-chemistry of the day, he paved the way to a rational theory of chemical attraction.

Whether Boyle or Pascal had the larger share in developing the laws of Hydrostatics may perhaps be questioned; Buckle<sup>3</sup> says we owe to Boyle the first exact experiments in the relation between color and heat; that he laid the foundation for the union of optics and thermics; and that he established hydrostatics as a science. It is doubtless true here as in pneumatics, that Pascal stopped with the demonstrated fact, but Boyle pushed on to the controlling principle.

He trod close to the truth under many strange disguises; for instance he says, air is composed of three kinds of molecules: 1st, From exhalations from waters (vapor), minerals, vegetables (oxygen), and animals (carbonic oxide), that exists on the earth's surface; 2d, much more subtle, consists of magnetic effluvia from the earth, and produces by attack upon innumerable atoms emanating from the stars, the sensation of light (terrestrial magnetism and aurora borealis); 3d,

<sup>1</sup> Whewell, *Hist.*, II., 557, 588. Thomson, *Hist. Chem.*, I., 215. Brande's *Chem.*, I., 363. <sup>2</sup> IV., 287.

<sup>3</sup> *Hist. Civ.*, I., 367.

the third is no other than the substance of air compressible and dilatable like the spring of a watch.

He made the first true statement of the nature of change in bodies,<sup>1</sup> showing the permanence of matter through all changes of form.

It is as difficult to analyze Boyle's influence on the best minds of his own and all succeeding centuries, as it is to find the effect upon the crop of the quality of the seed. It is the hidden secret of excellence; and I think so far as chemistry is concerned, it is certain that the *Instauratio Magna* would have shared the fate of other systems of abstract speculation, had not Robert Boyle given it practical efficiency through experimental demonstration.

The vastness and profundity of his learning coupled with his high social standing secured respect; the solidity of his judgments won confidence; the unusual spectacle of a man to whom all sensual indulgence was possible, renouncing all for learning's sake, and spending his powers for humanity's sake, begot enthusiastic admiration; the sweetness of his temper and the sensitiveness of his respect for other men, gave easy currency to his views; he was a "founder" in the largest sense; but I think his best and noblest service was the stimulus of his great example in obeying Lord Bacon's exhortation:

"If there be any man who has it at heart, not merely to take his stand on what has already been discovered, but to profit by that, and to go on to something beyond; — not to conquer an adversary by disputing but to conquer nature by working; — not to opine probably and prettily, but to know certainly and demonstrably; — let such as being true sons of nature (if they will consent to do so) join themselves to us; so that leaving the porch of nature, which endless multitudes have so long trod, we may at last open a way to the inner courts."<sup>2</sup>

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<sup>1</sup> Works, III., 37.

<sup>2</sup> Inst. Mag., Part II., Proef.

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