

## CHAPTER XII.

### *FROM MAGIC TO CHEMISTRY AND PHYSICS.*

#### I.

IN all the earliest developments of human thought we find a strong tendency to ascribe mysterious powers over Nature to men and women especially gifted or skilled. Survivals of this view are found to this day among savages and barbarians left behind in the evolution of civilization, and especially is this the case among the tribes of Australia, Africa, and the Pacific coast of America. Even in the most enlightened nations still appear popular beliefs, observances, or sayings, drawn from this earlier phase of thought.

Between the prehistoric savage developing this theory, and therefore endeavouring to deal with the powers of Nature by magic, and the modern man who has outgrown it, appears a long line of nations struggling upward through it. As the hieroglyphs, cuneiform inscriptions, and various other records of antiquity are read, the development of this belief can be studied in Egypt, India, Babylonia, Assyria, Persia, and Phœnicia. From these civilizations it came into the early thought of Greece and Rome, but especially into the Jewish and Christian sacred books. Both in the Old Testament and in the New we find magic, witchcraft, and soothsaying constantly referred to as realities.\*

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\* For magic in prehistoric times and survivals of it since, with abundant citation of authorities, see Tylor, *Primitive Culture*, chap. iv; also *The Early History of Mankind*, by the same author, third edition, pp. 115 *et seq.*, also p. 380; also Andrew Lang, *Myth, Ritual, and Religion*, vol. i, chap. iv. For magic in Egypt, see Lenormant, *Chaldean Magic*, chaps. vi-viii; also Maspero, *Histoire Ancienne des Peuples de l'Orient*; also Maspero and Sayce, *The Dawn of Civilization*, p. 282, and for the threat of the magicians to wreck heaven, see *ibid.*, p. 17, note, and especially the citations from Chabas, *Le Papyrus Magique Harris*, in chap.

The first distinct impulse toward a higher view of research into natural laws was given by the philosophers of Greece. It is true that philosophical opposition to physical research was at times strong, and that even a great thinker like Socrates considered certain physical investigations as an impious intrusion into the work of the gods. It is also true that Plato and Aristotle, while bringing their thoughts to bear upon the world with great beauty and force, did much to draw mankind away from those methods which in modern times have produced the best results.

Plato developed a world in which the physical sciences had little if any real reason for existing; Aristotle, a world in which the same sciences were developed largely indeed by observation of what is, but still more by speculation on what ought to be. From the former of these two great men came into Christian theology many germs of mediæval magic, and from the latter sundry modes of reasoning which aided in the evolution of these; yet the impulse to human thought given by these great masters was of inestimable value to our race, and one legacy from them was especially precious—the idea that a science of Nature is possible, and that the highest occupation of man is the discovery of its laws. Still another gift from them was greatest of all, for they gave scientific freedom. They laid no interdict upon new paths; they interposed no barriers to the extension of knowledge; they threatened no doom in this life or in the

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vii; also Maury, *La Magie et l'Astrologie dans l'Antiquité et au Moyen Age*. For magic in Chaldea, see Lenormant as above; also Maspero and Sayce, pp. 780 *et seq.* For examples of magical powers in India, see Max Müller's *Sacred Books of the East*, vol. xvii, pp. 121 *et seq.* For a legendary view of magic in Media, see the *Zend Avesta*, part i, p. 14, translated by Darmsteter; and for a more highly developed view, see the *Zend Avesta*, part iii, p. 239, translated by Mill. For magic in Greece and Rome, and especially in the Neoplatonic school, as well as in the Middle Ages, see especially Maury, *La Magie et l'Astrologie*, chaps. iii–v. For various sorts of magic recognised and condemned in our sacred books, see Deuteronomy xviii, 10, 11; and for the burning of magical books at Ephesus under the influence of St. Paul, see Acts xix, 14. See also Ewald, *History of Israel*, Martineau's translation, fourth edition, vol. ii, pp. 55–63; vol. iii, pp. 45–51. For a very elaborate summing up of the passages in our sacred books recognizing magic as a fact, see De Haen, *De Magia*, Leipsic, 1775, chaps. i, ii, and iii, of first part. For the general subject of magic, see Ennemoser, *History of Magic*, translated by Howitt, which, however, constantly mixes sorcery with magic proper.

next against investigators on new lines; they left the world free to seek any new methods and to follow any new paths which thinking men could find.

This legacy of belief in science, of respect for scientific pursuits, and of freedom in scientific research, was especially received by the school of Alexandria, and above all by Archimedes, who began, just before the Christian era, to open new paths through the great field of the inductive sciences by observation, comparison, and experiment.\*

The establishment of Christianity, beginning a new evolution of theology, arrested the normal development of the physical sciences for over fifteen hundred years. The cause of this arrest was twofold: First, there was created an atmosphere in which the germs of physical science could hardly grow—an atmosphere in which all seeking in Nature for truth as truth was regarded as futile. The general belief derived from the New Testament Scriptures was, that the end of the world was at hand; that the last judgment was approaching; that all existing physical nature was soon to be destroyed: hence, the greatest thinkers in the Church generally poured contempt upon all investigators into a science of Nature, and insisted that everything except the saving of souls was folly.

This belief appears frequently through the entire period of the Middle Ages; but during the first thousand years it is clearly dominant. From Lactantius and Eusebius, in the third century, pouring contempt, as we have seen, over studies in astronomy, to Peter Damian, the noted chancellor of Pope Gregory VII, in the eleventh century, declaring all worldly sciences to be "absurdities" and "fooleries," it

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\* As to the beginnings of physical science in Greece, and of the theological opposition to physical science, also Socrates's view regarding certain branches as interdicted to human study, see Grote's *History of Greece*, vol. i, pp. 495 and 504, 505; also Jowett's introduction to his translation of the *Timæus*, and Whewell's *History of the Inductive Sciences*. For examples showing the incompatibility of Plato's methods in physical science with that pursued in modern times, see Zeller, *Plato and the Older Academy*, English translation by Alleyne and Goodwin, pp. 375 *et seq.* The supposed opposition to freedom of opinion in the *Laws* of Plato, toward the end of his life, can hardly make against the whole spirit of Greek thought.

becomes a very important element in the atmosphere of thought.\*

Then, too, there was established a standard to which all science which did struggle up through this atmosphere must be made to conform—a standard which favoured magic rather than science, for it was a standard of rigid dogmatism obtained from literal readings in the Jewish and Christian Scriptures. The most careful inductions from ascertained facts were regarded as wretchedly fallible when compared with any view of nature whatever given or even hinted at in any poem, chronicle, code, apologue, myth, legend, allegory, letter, or discourse of any sort which had happened to be preserved in the literature which had come to be held as sacred.

For twelve centuries, then, the physical sciences were thus discouraged or perverted by the dominant orthodoxy. Whoever studied nature studied it either openly to find illustrations of the sacred text, useful in the "saving of souls," or secretly to gain the aid of occult powers, useful in securing personal advantage. Great men like Bede, Isidore of Seville, and Rabanus Maurus, accepted the scriptural standard of science and used it as a means of Christian edification. The views of Bede and Isidore on kindred subjects have been shown in former chapters; and typical of the view taken by Rabanus is the fact that in his great work on the *Universe* there are only two chapters which seem directly or indirectly to recognise even the beginnings of a real philosophy of nature. A multitude of less-known men found warrant in Scripture for magic applied to less worthy purposes.†

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\* For the view of Peter Damian and others through the Middle Ages as to the futility of scientific investigation, see citations in Eicken, *Geschichte und System der mittelalterlichen Weltanschauung*, chap. vi.

† As typical examples, see the utterances of Eusebius and Lactantius regarding astronomers given in the chapter on Astronomy. For a summary of Rabanus Maurus's doctrine of physics, see Heller, *Geschichte der Physik*, vol. i, pp. 172 *et seq.* For Bede and Isidore, see the earlier chapters of this work. For an excellent statement regarding the application of scriptural standards to scientific research in the Middle Ages, see Kretschmer, *Die physische Erdkunde im christlichen Mittelalter*, pp. 5 *et seq.* For the distinctions in magic recognised in the mediæval Church, see the long catalogue of various sorts given in the Abbé Migne's *Encyclopædie Théologique*, third series, article *Magie*.

But after the thousand years had passed to which various thinkers in the Church, upon supposed scriptural warrant, had lengthened out the term of the earth's existence, "the end of all things" seemed further off than ever; and in the twelfth and thirteenth centuries, owing to causes which need not be dwelt upon here, came a great revival of thought, so that the forces of theology and of science seemed arrayed for a contest. On one side came a revival of religious fervour, and to this day the works of the cathedral builders mark its depth and strength; on the other side came a new spirit of inquiry incarnate in a line of powerful thinkers.

First among these was Albert of Bollstadt, better known as Albert the Great, the most renowned scholar of his time. Fettered though he was by the methods sanctioned in the Church, dark as was all about him, he had conceived better methods and aims; his eye pierced the mists of scholasticism; he saw the light, and sought to draw the world toward it. He stands among the great pioneers of physical and natural science; he aided in giving foundations to botany and chemistry; he rose above his time, and struck a heavy blow at those who opposed the possibility of human life on opposite sides of the earth; he noted the influence of mountains, seas, and forests upon races and products, so that Humboldt justly finds in his works the germs of physical geography as a comprehensive science.

But the old system of deducing scientific truth from scriptural texts was renewed in the development of scholastic theology; and ecclesiastical power, acting through thousands of subtle channels, was made to aid this development. The old idea of the futility of physical science and of the vast superiority of theology was revived. Though Albert's main effort was to Christianize science, he was dealt with by the authorities of the Dominican order, subjected to suspicion and indignity, and only escaped persecution for sorcery by yielding to the ecclesiastical spirit of the time, and working finally in theological channels by scholastic methods.

It was a vast loss to the earth; and certainly, of all organizations that have reason to lament the pressure of ecclesiasticism which turned Albert the Great from natural phi-

losophy to theology, foremost of all in regret should be the Christian Church, and especially the Roman branch of it. Had there been evolved in the Church during the thirteenth century a faith strong enough to accept the truths in natural science which Albert and his compeers could have given, and to have encouraged their growth, this faith and this encouragement would to this day have formed the greatest argument for proving the Church directly under Divine guidance; they would have been among the brightest jewels in her crown. The loss to the Church by this want of faith and courage has proved in the long run even greater than the loss to science.\*

The next great man of that age whom the theological and ecclesiastical forces of the time turned from the right path was Vincent of Beauvais. During the first half of the twelfth century he devoted himself to the study of Nature in several of her most interesting fields. To astronomy, botany, and zoölogy he gave special attention, but in a larger way he made a general study of the universe, and in a series of treatises undertook to reveal the whole field of science. But his work simply became a vast commentary on the account of creation given in the book of Genesis. Beginning with the work of the Trinity at the creation, he goes on to detail the work of angels in all their fields, and makes excursions into every part of creation, visible and invisible, but always with the most complete subordination of his thought to the literal statements of Scripture. Could he have taken

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\* For a very careful discussion of Albert's strength in investigation and weakness in yielding to scholastic authority, see Kopp, *Ansichten über die Aufgabe der Chemie von Geber bis Stahl*, Braunschweig, 1875, pp. 64 *et seq.* For a very extended and enthusiastic biographical sketch, see Pouchet. For comparison of his work with that of Thomas Aquinas, see Milman, *History of Latin Christianity*, vol. vi, p. 461. "Il était aussi très-habile dans les arts mécaniques, ce que le fit soupçonner d'être sorcier" (Sprengel, *Histoire de la Médecine*, vol. ii, p. 389). For Albert's biography treated strictly in accordance with ecclesiastical methods, see *Albert the Great*, by Joachim Sighart, translated by the Rev. T. A. Dickson, of the Order of Preachers, published under the sanction of the Dominican censor and of the Cardinal Archbishop of Westminster, London, 1876. How an Englishman like Cardinal Manning could tolerate among Englishmen such an unctuous glossing over of historical truth is one of the wonders of contemporary history. For choice specimens, see chapters ii and iv. For one of the best and most recent summaries, see Heller, *Geschichte der Physik*, Stuttgart, 1882, vol. i, pp. 179 *et seq.*

the path of experimental research, the world would have been enriched with most precious discoveries; but the force which had given wrong direction to Albert of Bollstadt, backed as it was by the whole ecclesiastical power of his time, was too strong, and in all the life labour of Vincent nothing appears of any permanent value. He reared a structure which the adaptation of facts to literal interpretations of Scripture and the application of theological subtleties to nature combine to make one of the most striking monuments of human error.\*

But the theological spirit of the thirteenth century gained its greatest victory in the work of St. Thomas Aquinas. In him was the theological spirit of his age incarnate. Although he yielded somewhat at one period to love of natural science, it was he who finally made that great treaty or compromise which for ages subjected science entirely to theology. He it was who reared the most enduring barrier against those who in that age and in succeeding ages laboured to open for science the path by its own methods toward its own ends.

He had been the pupil of Albert the Great, and had gained much from him. Through the earlier systems of philosophy, as they were then known, and through the earlier theologic thought, he had gone with great labour and vigour; and all his mighty powers, thus disciplined and cultured, he brought to bear in making a truce which was to give theology permanent supremacy over science.

The experimental method had already been practically initiated: Albert of Bollstadt and Roger Bacon had begun their work in accordance with its methods; but St. Thomas gave all his thoughts to bringing science again under the sway of theological methods and ecclesiastical control. In his commentary on Aristotle's treatise upon *Heaven and Earth* he gave to the world a striking example of what his method could produce, illustrating all the evils which arise in combining theological reasoning and literal interpretation of Scripture with scientific facts; and this work remains to

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\* For Vincent de Beauvais, see *Études sur Vincent de Beauvais*, par l'Abbé Bourgeat, chaps. xii, xiii, and xiv; also Pouchet, *Histoire des Sciences Naturelles au Moyen Age*, Paris, 1853, pp. 470 *et seq.*; also other histories cited hereafter.

this day a monument of scientific genius perverted by theology.\*

The ecclesiastical power of the time hailed him as a deliverer; it was claimed that miracles were vouchsafed, proving that the blessing of Heaven rested upon his labours, and among the legends embodying this claim is that given by the Bollandists and immortalized by a renowned painter. The great philosopher and saint is represented in the habit of his order, with book and pen in hand, kneeling before the image of Christ crucified, and as he kneels the image thus addresses him: "Thomas, thou hast written well concerning me; what price wilt thou receive for thy labour?" The myth-making faculty of the people at large was also brought into play. According to a widespread and circumstantial legend, Albert, by magical means, created an android—an artificial man, living, speaking, and answering all questions with such subtlety that St. Thomas, unable to answer its reasoning, broke it to pieces with his staff.

Historians of the Roman Church like Rohrbacher, and historians of science like Pouchet, have found it convenient to propitiate the Church by dilating upon the glories of St. Thomas Aquinas in thus making an alliance between religious and scientific thought, and laying the foundations for a "sanctified science"; but the unprejudiced historian can not indulge in this enthusiastic view: the results both for the Church and for science have been most unfortunate. It was a wretched delay in the evolution of fruitful thought, for the first result of this great man's great compromise was to close for ages that path in science which above all others leads to discoveries of value—the experimental method—and to reopen that old path of mixed theology and science which, as Hallam declares, "after three or four hundred years had not untied a single knot or added one unequivocal truth to the domain of philosophy"—the path which, as all modern history proves, has ever since led only to delusion and evil.†

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\* For citations showing this subordination of science to theology, see Eicken, chap. vi.

† For the work of Aquinas, see his *Liber de Caelo et Mundo*, section xx; also, *Life and Labours of St. Thomas of Aquin*, by Archbishop Vaughan, pp. 459 *et seq.*



The theological path thus opened by these strong men became the main path for science during ages, and it led the world ever further and further from any fruitful fact or useful method. Roger Bacon's investigations already begun were discredited: worthless mixtures of scriptural legends with imperfectly authenticated physical facts took their place. Thus it was that for twelve hundred years the minds in control of Europe regarded all real science as *futile*, and diverted the great current of earnest thought into theology.

The next stage in this evolution was the development of an idea which acted with great force throughout the Middle Ages—the idea that science is *dangerous*. This belief was also of very ancient origin. From the time when the Egyptian magicians made their tremendous threat that unless their demands were granted they would reach out to the four corners of the earth, pull down the pillars of heaven, wreck the abodes of the gods above and crush those of men below, fear of these representatives of science is evident in the ancient world.

But differences in the character of magic were recognised, some sorts being considered useful and some baleful. Of the former was magic used in curing diseases, in deter-

For his labours in natural science, see Hoefler, *Histoire de la Chimie*, Paris, 1843, vol. i, p. 381. For theological views of science in the Middle Ages, and rejoicing thereat, see Pouchet, *Hist. des Sci. Nat. au Moyen Age, ubi supra*. Pouchet says: "En général au milieu du moyen âge les sciences sont essentiellement chrétiennes, leur but est tout-à-fait religieux, et elles semblent beaucoup moins s'inquiéter de l'avancement intellectuel de l'homme que de son salut éternel." Pouchet calls this "conciliation" into a "harmonieux ensemble" "la plus glorieuse des conquêtes intellectuelles du moyen âge." Pouchet belongs to Rouen, and the shadow of Rouen Cathedral seems thrown over all his history. See, also, l'Abbé Rohrbacher, *Hist. de l'Église Catholique*, Paris, 1858, vol. xviii, pp. 421 *et seq.* The abbé dilates upon the fact that "the Church organizes the agreement of all the sciences by the labours of St. Thomas of Aquin and his contemporaries." For the complete subordination of science to theology by St. Thomas, see Eicken, chap. vi. For the theological character of science in the Middle Ages, recognised by a Protestant philosophic historian, see the well-known passage in Guizot, *History of Civilization in Europe*; and by a noted Protestant ecclesiastic, see Bishop Hampden's *Life of Thomas Aquinas*, chaps. xxxvi, xxxvii; see also Hallam, *Middle Ages*, chap. ix. For dealings of Pope John XXII, of the Kings of France and England, and of the Republic of Venice, see Figuier, *L'Alchimie et les Alchimistes*, pp. 140, 141, where, in a note, the text of the bull *Spondet pariter* is given. For popular legends regarding Albert and St. Thomas, see Éliphas Lévi, *Hist. de la Magie*, liv. iv, chap. iv.

minating times auspicious for enterprises, and even in contributing to amusement; of the latter was magic used to bring disease and death on men and animals or tempests upon the growing crops. Hence gradually arose a general distinction between white magic, which dealt openly with the more beneficent means of nature, and black magic, which dealt secretly with occult, malignant powers.

Down to the Christian era the fear of magic rarely led to any persecution very systematic or very cruel. While in Greece and Rome laws were at times enacted against magicians, they were only occasionally enforced with rigour, and finally, toward the end of the pagan empire, the feeling against them seemed dying out altogether. As to its more kindly phases, men like Marcus Aurelius and Julian did not hesitate to consult those who claimed to foretell the future. As to black magic, it seemed hardly worth while to enact severe laws, when charms, amulets, and even gestures could thwart its worst machinations.

Moreover, under the old empire a real science was coming in, and thought was progressing. Both the theory and practice of magic were more and more held up to ridicule. Even as early a writer as Ennius ridiculed the idea that magicians, who were generally poor and hungry themselves, could bestow wealth on others; Pliny, in his *Natural Philosophy*, showed at great length their absurdities and cheaterly; others followed in the same line of thought, and the whole theory, except among the very lowest classes, seemed dying out.

But with the development of Christian theology came a change. The idea of the active interference of Satan in magic, which had come into the Hebrew mind with especial force from Persia during the captivity of Israel, had passed from the Hebrew Scriptures into Christianity, and had been made still stronger by various statements in the New Testament. Theologians laid stress especially upon the famous utterances of the Psalmist that "all the gods of the heathen are devils," and of St. Paul that "the things which the Gentiles sacrifice, they sacrifice to devils"; and it was widely held that these devils were naturally indignant at their dethronement and anxious to wreak vengeance upon Chris-

**tianity.** Magicians were held to be active agents of these dethroned gods, and this persuasion was strengthened by sundry old practitioners in the art of magic—impostors who pretended to supernatural powers, and who made use of old rites and phrases inherited from paganism.

Hence it was that as soon as Christianity came into power it more than renewed the old severities against the forbidden art, and one of the first acts of the Emperor Constantine after his conversion was to enact a most severe law against magic and magicians, under which the main offender might be burned alive. But here, too, it should be noted that a distinction between the two sorts of magic was recognised, for Constantine shortly afterward found it necessary to issue a proclamation stating that his intention was only to prohibit deadly and malignant magic; that he had no intention of prohibiting magic used to cure diseases and to protect the crops from hail and tempests. But as new emperors came to the throne who had not in them that old leaven of paganism which to the last influenced Constantine, and as theology obtained a firmer hold, severity against magic increased. Toleration of it, even in its milder forms, was more and more denied. Black magic and white were classed together.

This severity went on increasing and threatened the simplest efforts in physics and chemistry; even the science of mathematics was looked upon with dread. By the twelfth and thirteenth centuries, the older theology having arrived at the climax of its development in Europe, terror of magic and witchcraft took complete possession of the popular mind. In sculpture, painting, and literature it appeared in forms ever more and more striking. The lives of saints were filled with it. The cathedral sculpture embodied it in every part. The storied windows made it all the more impressive. The missal painters wrought it not only into prayer books, but, despite the fact that hardly a trace of the belief appears in the Psalms, they illustrated it in the great illuminated psalters from which the noblest part of the service was sung before the high altar. The service books showed every form of agonizing petition for delivery from this dire influence, and every form of exorcism for thwarting it.

All the great theologians of the Church entered into this belief and aided to develop it. The fathers of the early Church were full and explicit, and the mediæval doctors became more and more minute in describing the operations of the black art and in denouncing them. It was argued that, as the devil afflicted Job, so he and his minions continue to cause diseases; that, as Satan is the Prince of the power of the air, he and his minions cause tempests; that the cases of Nebuchadnezzar and Lot's wife prove that sorcerers can transform human beings into animals or even lifeless matter; that, as the devils of Gadara were cast into swine, all animals could be afflicted in the same manner; and that, as Christ himself had been transported through the air by the power of Satan, so any human being might be thus transported to "an exceeding high mountain."

Thus the horror of magic and witchcraft increased on every hand, and in 1317 Pope John XXII issued his bull *Spondent pariter*, levelled at the alchemists, but really dealing a terrible blow at the beginnings of chemical science. That many alchemists were knavish is no doubt true, but no infallibility in separating the evil from the good was shown by the papacy in this matter. In this and in sundry other bulls and briefs we find Pope John, by virtue of his infallibility as the world's instructor in all that pertains to faith and morals, condemning real science and pseudo-science alike. In two of these documents, supposed to be inspired by wisdom from on high, he complains that both he and his flock are in danger of their lives by the arts of the sorcerers; he declares that such sorcerers can send devils into mirrors and finger rings, and kill men and women by a magic word; that they had tried to kill him by piercing a waxen image of him with needles in the name of the devil. He therefore called on all rulers, secular and ecclesiastical, to hunt down the miscreants who thus afflicted the faithful, and he especially increased the powers of inquisitors in various parts of Europe for this purpose.

The impulse thus given to childish fear and hatred against the investigation of nature was felt for centuries; more and more chemistry came to be known as one of the "seven devilish arts."

Thus began a long series of demonstrations against magic from the centre of Christendom. In 1437, and again in 1445, Pope Eugene IV issued bulls exhorting inquisitors to be more diligent in searching out and delivering over to punishment magicians and witches who produced bad weather, the result being that persecution received a fearful impulse. But the worst came forty years later still, when, in 1484, there came the yet more terrible bull of Pope Innocent VIII, known as *Summis Desiderantes*, which let inquisitors loose upon Germany, with Sprenger at their head, armed with the *Witch-Hammer*, the fearful manual *Malleus Maleficarum*, to torture and destroy men and women by tens of thousands for sorcery and magic. Similar bulls were issued in 1504 by Julius II, and in 1523 by Adrian VI.

The system of repression thus begun lasted for hundreds of years. The Reformation did little to change it, and in Germany, where Catholics and Protestants vied with each other in proving their orthodoxy, it was at its worst. On German soil more than one hundred thousand victims are believed to have been sacrificed to it between the middle of the fifteenth and the middle of the sixteenth centuries.

Thus it was that from St. Augustine to St. Thomas Aquinas, from Aquinas to Luther, and from Luther to Wesley, theologians of both branches of the Church, with hardly an exception, enforced the belief in magic and witchcraft, and, as far as they had power, carried out the injunction, "Thou shalt not suffer a witch to live."

How this was ended by the progress of scientific modes of thought I shall endeavour to show elsewhere: here we are only concerned with the effect of this widespread terrorism on the germs and early growth of the physical sciences.

Of course, the atmosphere created by this persecution of magicians was deadly to any open beginnings of experimental science. The conscience of the time, acting in obedience to the highest authorities of the Church, and, as was supposed, in defence of religion, now brought out a missile which it hurled against scientific investigators with deadly effect. The mediæval battlefields of thought were strewn with various forms of it. This missile was the charge of unlawful compact with Satan, and it was most effective. We

find it used against every great investigator of nature in those times and for ages after. The list of great men in those centuries charged with magic, as given by Naudé, is astounding; it includes every man of real mark, and in the midst of them stands one of the most thoughtful popes, Sylvester II (Gerbert), and the foremost of mediæval thinkers on natural science, Albert the Great. It came to be the accepted idea that, as soon as a man conceived a wish to study the works of God, his first step must be a league with the devil.

It was entirely natural, then, that in 1163 Pope Alexander III, in connection with the Council of Tours, forbade the study of physics to all ecclesiastics, which, of course, in that age meant prohibition of all such scientific studies to the only persons likely to make them. What the Pope then expressly forbade was, in the words of the papal bull, "the study of physics or the laws of the world," and it was added that any person violating this rule "shall be avoided by all and excommunicated."\*

The first great thinker who, in spite of some stumbling into theologic pitfalls, persevered in a truly scientific path, was Roger Bacon. His life and works seem until recently to have been generally misunderstood: he was formerly ranked as a superstitious alchemist who happened upon some inventions, but more recent investigation has shown him to be one of the great masters in the evolution of human thought. The advance of sound historical judgment seems likely to bring the fame of the two who bear the name of Bacon nearly to equality. Bacon of the chancellorship and of the *Novum Organum* may not wane, but Bacon of the prison cell and the *Opus Majus* steadily approaches him in brightness.

More than three centuries before Francis Bacon advocated the experimental method, Roger Bacon practised it, and the results as now revealed are wonderful. He wrought

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\* For the charge of magic against scholars and others, see Naudé, *Apologie pour les Grands Hommes soupçonnés de Magie, passim*; also Maury, *Hist. de la Magie*, troisième édition, pp. 214, 215; also Cuvier, *Hist. des Sciences Naturelles*, vol. i, p. 396. For the prohibition by the Council of Tours and Alexander III, see the *Acta Conciliorum* (ed. Harduin), tom. vi, pars ii, p. 1598, Canon viii.

with power in many sciences, and his knowledge was sound and exact. By him, more than by any other man of the Middle Ages, was the world brought into the more fruitful paths of scientific thought—the paths which have led to the most precious inventions; and among these are clocks, lenses, and burning specula, which were given by him to the world, directly or indirectly. In his writings are found formulæ for extracting phosphorus, manganese, and bismuth. It is even claimed, with much appearance of justice, that he investigated the power of steam, and he seems to have very nearly reached some of the principal doctrines of modern chemistry. But it should be borne in mind that his *method* of investigation was even greater than its *results*. In an age when theological subtilizing was alone thought to give the title of scholar, he insisted on *real* reasoning and the aid of natural science by mathematics; in an age when experimenting was sure to cost a man his reputation, and was likely to cost him his life, he insisted on experimenting, and braved all its risks. Few greater men have lived. As we follow Bacon's process of reasoning regarding the refraction of light, we see that he was divinely inspired.

On this man came the brunt of the battle. The most conscientious men of his time thought it their duty to fight him, and they fought him steadily and bitterly. His sin was not disbelief in Christianity, not want of fidelity to the Church, not even dissent from the main lines of orthodoxy; on the contrary, he showed in all his writings a desire to strengthen Christianity, to build up the Church, and to develop orthodoxy. He was attacked and condemned mainly because he did not believe that philosophy had become complete, and that nothing more was to be learned; he was condemned, as his opponents expressly declared, "on account of certain suspicious novelties"—"*propter quasdam novitates suspectas.*"

Upon his return to Oxford, about 1250, the forces of unreason beset him on all sides. Greatest of all his enemies was Bonaventura. This enemy was the theologic idol of the period: the learned world knew him as the "seraphic Doctor"; Dante gave him an honoured place in the great poem of the Middle Ages; the Church finally enrolled him among the

saints. By force of great ability in theology he had become, in the middle of the thirteenth century, general of the Franciscan order: thus, as Bacon's master, his hands were laid heavily on the new teaching, so that in 1257 the troublesome monk was forbidden to lecture; all men were solemnly warned not to listen to his teaching, and he was ordered to Paris, to be kept under surveillance by the monastic authorities. Herein was exhibited another of the myriad examples showing the care exercised over scientific teaching by the Church. The reasons for thus dealing with Bacon were evident: First, he had dared attempt scientific explanations of natural phenomena, which under the mystic theology of the Middle Ages had been referred simply to supernatural causes. Typical was his explanation of the causes and character of the rainbow. It was clear, cogent, a great step in the right direction as regards physical science: but there, in the book of Genesis, stood the legend regarding the origin of the rainbow, supposed to have been dictated immediately by the Holy Spirit; and, according to that, the "bow in the cloud" was not the result of natural laws, but a "sign" arbitrarily placed in the heavens for the simple purpose of assuring mankind that there was not to be another universal deluge.

But this was not the worst: another theological idea was arrayed against him—the idea of Satanic intervention in science; hence he was attacked with that goodly missile which with the epithets "infidel" and "atheist" has decided the fate of so many battles—the charge of magic and compact with Satan.

He defended himself with a most unfortunate weapon—a weapon which exploded in his hands and injured him more than the enemy; for he argued against the idea of compacts with Satan, and showed that much which is ascribed to demons results from natural means. This added fuel to the flame. To limit the power of Satan was deemed hardly less impious than to limit the power of God.

The most powerful protectors availed him little. His friend Guy of Foulques, having in 1265 been made Pope under the name of Clement IV, shielded him for a time; but the fury of the enemy was too strong, and when he made ready



to perform a few experiments before a small audience, we are told that all Oxford was in an uproar. It was believed that Satan was about to be let loose. Everywhere priests, monks, fellows, and students rushed about, their garments streaming in the wind, and everywhere rose the cry, "Down with the magician!" and this cry, "Down with the magician!" resounded from cell to cell and from hall to hall.

Another weapon was also used upon the battlefields of science in that time with much effect. The Arabs had made many noble discoveries in science, and Averroes had, in the opinion of many, divided the honours with St. Thomas Aquinas; these facts gave the new missile—it was the epithet "Mohammedan"; this, too, was flung with effect at Bacon.

The attack now began to take its final shape. The two great religious orders, Franciscan and Dominican, then in all the vigour of their youth, vied with each other in fighting the new thought in chemistry and physics. St. Dominic solemnly condemned research by experiment and observation; the general of the Franciscan order took similar ground. In 1243 the Dominicans interdicted every member of their order from the study of medicine and natural philosophy, and in 1287 this interdiction was extended to the study of chemistry.

In 1278 the authorities of the Franciscan order assembled at Paris, solemnly condemned Bacon's teaching, and the general of the Franciscans, Jerome of Ascoli, afterward Pope, threw him into prison, where he remained for fourteen years. Though Pope Clement IV had protected him, Popes Nicholas III and IV, by virtue of their infallibility, decided that he was too dangerous to be at large, and he was only released at the age of eighty—but a year or two before death placed him beyond the reach of his enemies. How deeply the struggle had racked his mind may be gathered from that last affecting declaration of his, "Would that I had not given myself so much trouble for the love of science!"

The attempt has been made by sundry champions of the Church to show that some of Bacon's utterances against ecclesiastical and other corruptions in his time were the

main cause of the severity which the Church authorities exercised against him. This helps the Church but little, even if it be well based; but it is not well based. That some of his utterances of this sort made him enemies is doubtless true, but the charges on which St. Bonaventura silenced him, and Jerome of Ascoli imprisoned him, and successive popes kept him in prison for fourteen years, were "dangerous novelties" and suspected sorcery.

Sad is it to think of what this great man might have given to the world had ecclesiasticism allowed the gift. He held the key of treasures which would have freed mankind from ages of error and misery. With his discoveries as a basis, with his method as a guide, what might not the world have gained! Nor was the wrong done to that age alone; it was done to this age also. The nineteenth century was robbed at the same time with the thirteenth. But for that interference with science the nineteenth century would be enjoying discoveries which will not be reached before the twentieth century, and even later. Thousands of precious lives shall be lost, tens of thousands shall suffer discomfort, privation, sickness, poverty, ignorance, for lack of discoveries and methods which, but for this mistaken dealing with Roger Bacon and his compeers, would now be blessing the earth.

In two recent years sixty thousand children died in England and in Wales of scarlet fever; probably quite as many died in the United States. Had not Bacon been hindered, we should have had in our hands, by this time, the means to save two thirds of these victims; and the same is true of typhoid, typhus, cholera, and that great class of diseases of whose physical causes science is just beginning to get an inkling. Put together all the efforts of all the atheists who have ever lived, and they have not done so much harm to Christianity and the world as has been done by the narrow-minded, conscientious men who persecuted Roger Bacon, and closed the path which he gave his life to open.

But despite the persecution of Bacon and the defection of those who ought to have followed him, champions of the experimental method rose from time to time during the succeeding centuries. We know little of them personally; our

main knowledge of their efforts is derived from the endeavours of their persecutors.

Under such guidance the secular rulers were naturally vigorous. In France Charles V forbade, in 1380, the possession of furnaces and apparatus necessary for chemical processes; under this law the chemist John Barrillon was thrown into prison, and it was only by the greatest effort that his life was saved. In England Henry IV, in 1404, issued a similar decree. In Italy the Republic of Venice, in 1418, followed these examples. The judicial torture and murder of Antonio de Dominis were not simply for heresy; his investigations in the phenomena of light were an additional crime. In Spain everything like scientific research was crushed out among Christians. Some earnest efforts were afterward made by Jews and Moors, but these were finally ended by persecution; and to this hour the Spanish race, in some respects the most gifted in Europe, which began its career with everything in its favour and with every form of noble achievement, remains in intellectual development behind every other in Christendom.

To question the theological view of physical science was, even long after the close of the Middle Ages, exceedingly perilous. We have seen how one of Roger Bacon's unpardonable offences was his argument against the efficacy of magic, and how, centuries afterward, Cornelius Agrippa, Weyer, Flade, Loos, Bekker, and a multitude of other investigators and thinkers, suffered confiscation of property, loss of position, and even torture and death, for similar views.\*

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\* For an account of Bacon's treatise, *De Nullitate Magiæ*, see Hoefler. For the uproar caused by Bacon's teaching at Oxford, see Kopp, *Geschichte der Chemie*, Braunschweig, 1869, vol. i, p. 63; and for a somewhat reactionary discussion of Bacon's relation to the progress of chemistry, see a recent work by the same author, *Ansichten über die Aufgabe der Chemie*, Braunschweig, 1874, pp. 85 *et seq.*; also, for an excellent summary, see Hoefler, *Hist. de la Chimie*, vol. i, pp. 368 *et seq.* For probably the most thorough study of Bacon's general works in science, and for his views of the universe, see Prof. Werner, *Die Kosmologie und allgemeine Naturlehre des Roger Baco*, Wien, 1879. For summaries of his work in other fields, see Whewell, vol. i, pp. 367, 368; Draper, p. 438; Saisset, *Descartes et ses Précurseurs*, deuxième édition, pp. 397 *et seq.*; Nourrisson, *Progrès de la Pensée humaine*, pp. 271, 272; Sprengel, *Histoire de la Médecine*, Paris, 1865, vol. ii, p. 397; Cuvier, *Histoire des Sciences Naturelles*, vol. i, p. 417. As to Bacon's orthodoxy, see Saisset, pp. 53, 55. For special examination of causes of Bacon's condemnation, see

The theological atmosphere, which in consequence settled down about the great universities and colleges, seemed likely to stifle all scientific effort in every part of Europe, and it is one of the great wonders in human history that in spite of this deadly atmosphere a considerable body of thinking men, under such protection as they could secure, still persisted in devoting themselves to the physical sciences.

In Italy, in the latter half of the sixteenth century, came a striking example of the difficulties which science still encountered even after the Renaissance had undermined the old beliefs. At that time John Baptist Porta was conducting his investigations, and, despite a considerable mixture of pseudo-science, they were fruitful. His was not "black magic," claiming the aid of Satan, but "white magic," bringing into service the laws of nature—the precursor of applied

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Waddington, cited by Saisset, p. 14. For a brief but admirable statement of Roger Bacon's relation to the world in his time, and of what he might have done had he not been thwarted by theology, see Döllinger, *Studies in European History*, English translation, London, 1890, pp. 178, 179. For a good example of the danger of denying the full power of Satan, even in much more recent times and in a Protestant country, see account of treatment of Bekker's *Monde Enchanté* by the theologians of Holland, in Nisard, *Histoire des Livres Populaires*, vol. i, pp. 172, 173. Kopp, in his *Ansichten*, pushes criticism even to some scepticism as to Roger Bacon being the discoverer of many of the things generally attributed to him; but, after all deductions are carefully made, enough remains to make Bacon the greatest benefactor to humanity during the Middle Ages. For Roger Bacon's deep devotion to religion and the Church, see citation and remarks in Schneider, *Roger Bacon*, Augsburg, 1873, p. 112; also, citation from the *Opus Majus* in Eicken, chap. vi. On Bacon as a "Mohammedan," see Saisset, p. 17. For the interdiction of studies in physical science by the Dominicans and Franciscans, see Henri Martin, *Histoire de France*, vol. iv, p. 283. For the suppression of chemical teaching by the Parliament of Paris, see *ibid.*, vol. xii, pp. 14, 15. For proofs that the world is steadily working toward great discoveries as to the cause and prevention of zymotic diseases and of their propagation, see Beale's *Disease Germs*, Baldwin Latham's *Sanitary Engineering*, Michel Lévy's *Traité d'Hygiène Publique et Privée*. For a summary of the bull *Spondent pariter*, and for an example of injury done by it, see Schneider, *Geschichte der Alchemie*, p. 160; and for a studiously moderate statement, Milman, *Latin Christianity*, book xii, chap. vi. For character and general efforts of John XXII, see Lea, *Inquisition*, vol. iii, p. 436, also pp. 452 *et seq.* For the character of the two papal briefs, see Rydberg, p. 177. For the bull *Summis Desiderantes*, see previous chapters of this work. For Antonio de Dominis, see Montucla, *Hist. des Mathématiques*, vol. i, p. 705; Humboldt, *Cosmos*; Libri, vol. iv, pp. 145 *et seq.* For Weyer, Flade, Bekker, Loos, and others, see the chapters of this work on Meteorology, Demoniacal Possession and Insanity, and Diabolism and Hysteria.

science. His book on meteorology was the first in which sound ideas were broached on this subject; his researches in optics gave the world the camera obscura, and possibly the telescope; in chemistry he seems to have been the first to show how to reduce the metallic oxides, and thus to have laid the foundation of several important industries. He did much to change natural philosophy from a black art to a vigorous open science. He encountered the old ecclesiastical policy. The society founded by him for physical research, "I Secreti," was broken up, and he was summoned to Rome by Pope Paul III and forbidden to continue his investigations.

So, too, in France. In 1624, some young chemists at Paris having taught the experimental method and cut loose from Aristotle, the faculty of theology beset the Parliament of Paris, and the Parliament prohibited these new chemical researches under the severest penalties.

The same war continued in Italy. Even after the belief in magic had been seriously weakened, the old theological fear and dislike of physical science continued. In 1657 occurred the first sitting of the Accademia del Cimento at Florence, under the presidency of Prince Leopold de' Medici. This academy promised great things for science; it was open to all talent; its only fundamental law was "the repudiation of any favourite system or sect of philosophy, and the obligation to investigate Nature by the pure light of experiment"; it entered into scientific investigations with energy. Borelli in mathematics, Redi in natural history, and many others, enlarged the boundaries of knowledge. Heat, light, magnetism, electricity, projectiles, digestion, and the incompressibility of water were studied by the right method and with results that enriched the world.

The academy was a fortress of science, and siege was soon laid to it. The votaries of scholastic learning denounced it as irreligious, quarrels were fomented, Leopold was bribed with a cardinal's hat and drawn away to Rome, and, after ten years of beleaguering, the fortress fell: Borelli was left a beggar; Oliva killed himself in despair.

So, too, the noted Academy of the Lincei at times incurred the ill will of the papacy by the very fact that it

included thoughtful investigators. It was "patronized" by Pope Urban VIII in such manner as to paralyze it, and it was afterward vexed by Pope Gregory XVI. Even in our own time sessions of scientific associations were discouraged and thwarted by as kindly a pontiff as Pius IX.\*

A hostility similar in kind, though less in degree, was shown in Protestant countries.

Even after Thomasius in Germany and Voltaire in France and Beccaria in Italy had given final blows to the belief in magic and witchcraft throughout Christendom, the traditional orthodox distrust of the physical sciences continued for a long time.

In England a marked dislike was shown among various leading ecclesiastics and theologians towards the Royal Society, and later toward the Association for the Advancement of Science; and this dislike, as will hereafter be seen, sometimes took shape in serious opposition.

As a rule, both in Protestant and Catholic countries instruction in chemistry and physics was for a long time discouraged by Church authorities; and, when its suppression was no longer possible, great pains were taken to subordinate it to instruction supposed to be more fully in accordance with the older methods of theological reasoning.

\* For Porta, see the English translation of his main summary, *Natural Magick*, London, 1658. The first chapters are especially interesting, as showing what the word "magic" had come to mean in the mind of a man in whom mediæval and modern ideas were curiously mixed; see also Hoefler, *Histoire de la Chimie*, vol. ii, pp. 102-106; also Kopp; also Sprengel, *Histoire de la Médecine*, vol. iii, p. 239; also Musset-Pathay. For the Accademia del Cimento, see Napier, *Florentine History*, vol. v, p. 485; Tiraboschi, *Storia della Letteratura*; Henri Martin, *Histoire de France*; Jevons, *Principles of Science*, vol. ii, pp. 36-40. For value attached to Borelli's investigations by Newton and Huygens, see Brewster's *Life of Sir Isaac Newton*, London, 1875, pp. 128, 129. Libri, in his *Essai sur Galilée*, p. 37, says that Oliva was summoned to Rome and so tortured by the Inquisition that, to escape further cruelty, he ended his life by throwing himself from a window. For interference by Pope Gregory XVI with the Academy of the Lincei, and with public instruction generally, see Carutti, *Storia della Accademia dei Lincei*, p. 126. Pius IX, with all his geniality, seems to have allowed his hostility to voluntary associations to carry him very far at times. For his answer to an application made through Lord Odo Russell regarding a society for the prevention of cruelty to animals and his answer that "such an association could not be sanctioned by the Holy See, being founded on a theological error, to wit, that Christians owed any duties to animals," see Francis Power Cobbe, *Hopes of the Human Race*, p. 207.

I have now presented in outline the more direct and open struggle of the physical sciences with theology, mainly as an exterior foe. We will next consider their warfare with the same foe in its more subtle form, mainly as a vitiating and sterilizing principle in science itself.

We have seen thus far, first, how such men as Eusebius, Lactantius, and their compeers, opposed scientific investigation as futile; next, how such men as Albert the Great, St. Thomas Aquinas, and the multitude who followed them, turned the main current of mediæval thought from science to theology; and, finally, how a long line of Church authorities from Popes John XXII and Innocent VIII, and the heads of the great religious orders, down to various theologians and ecclesiastics, Catholic and Protestant, of a very recent period, endeavoured first to crush and afterward to discourage scientific research as dangerous.

Yet, injurious as all this was to the evolution of science, there was developed something in many respects more destructive; and this was the influence of mystic theology, penetrating, permeating, vitiating, sterilizing nearly every branch of science for hundreds of years. Among the forms taken by this development in the earlier Middle Ages we find a mixture of physical science with a pseudo-science obtained from texts of Scripture. In compounding this mixture, Jews and Christians vied with each other. In this process the sacred books were used as a fetich; every word, every letter, being considered to have a divine and hidden meaning. By combining various scriptural letters in various abstruse ways, new words of prodigious significance in magic were obtained, and among them the great word embracing the seventy-two mystical names of God—the mighty word "*Schemhamphoras*." Why should men seek knowledge by observation and experiment in the book of Nature, when the book of Revelation, interpreted by the Kabbalah, opened such treasures to the ingenious believer?

So, too, we have ancient mystical theories of number which the theological spirit had made Christian, usurping an enormous place in mediæval science. The sacred power of the number three was seen in the Trinity; in the three main divisions of the universe—the empyrean, the heavens,

and the earth ; in the three angelic hierarchies ; in the three choirs of seraphim, cherubim, and thrones ; in the three of dominions, virtues, and powers ; in the three of principalities, archangels, and angels ; in the three orders in the Church—bishops, priests, and deacons ; in the three classes—the baptized, the communicants, and the monks ; in the three degrees of attainment—light, purity, and knowledge ; in the three theological virtues—faith, hope, and charity—and in much else. All this was brought into a theologico-scientific relation, then and afterward, with the three dimensions of space ; with the three divisions of time—past, present, and future ; with the three realms of the visible world—sky, earth, and sea ; with the three constituents of man—body, soul, and spirit ; with the threefold enemies of man—the world, the flesh, and the devil ; with the three kingdoms in nature—mineral, vegetable, and animal ; with “the three colours”—red, yellow, and blue ; with “the three eyes of the honey-bee”—and with a multitude of other analogues equally precious. The sacred power of the number seven was seen in the seven golden candlesticks and the seven churches in the Apocalypse ; in the seven cardinal virtues and the seven deadly sins ; in the seven liberal arts and the seven devilish arts, and, above all, in the seven sacraments. And as this proved in astrology that there could be only seven planets, so it proved in alchemy that there must be exactly seven metals. The twelve apostles were connected with the twelve signs in the zodiac, and with much in physical science. The seventy-two disciples, the seventy-two interpreters of the Old Testament, the seventy-two mystical names of God, were connected with the alleged fact in anatomy that there were seventy-two joints in the human frame.

Then, also, there were revived such theologic and metaphysical substitutes for scientific thought as the declaration that the perfect line is a circle, and hence that the planets must move in absolute circles—a statement which led astronomy astray even when the great truths of the Copernican theory were well in sight ; also, the declaration that nature abhors a vacuum—a statement which led physics astray until Torricelli made his experiments ; also, the declaration



that we see the lightning before we hear the thunder because "sight is nobler than hearing."

In chemistry we have the same theologic tendency to magic, and, as a result, a muddle of science and theology, which from one point of view seems blasphemous and from another idiotic, but which none the less sterilized physical investigation for ages. That debased Platonism which had been such an important factor in the evolution of Christian theology from the earliest days of the Church continued its work. As everything in inorganic nature was supposed to have spiritual significance, the doctrines of the Trinity and Incarnation were turned into an argument in behalf of the philosopher's stone; arguments for the scheme of redemption and for transubstantiation suggested others of similar construction to prove the transmutation of metals; the doctrine of the resurrection of the human body was by similar mystic jugglery connected with the processes of distillation and sublimation. Even after the Middle Ages were past, strong men seemed unable to break away from such reasoning as this—among them such leaders as Basil Valentine in the fifteenth century, Agricola in the sixteenth, and Van Helmont in the seventeenth.

The greatest theologians contributed to the welter of unreason from which this pseudo-science was developed. One question largely discussed was, whether at the Redemption it was necessary for God to take the human form. Thomas Aquinas answered that it was necessary, but William Occam and Duns Scotus answered that it was not; that God might have taken the form of a stone, or of a log, or of a beast. The possibilities opened to wild substitutes for science by this sort of reasoning were infinite. Men have often asked how it was that the Arabians accomplished so much in scientific discovery as compared with Christian investigators; but the answer is easy: the Arabians were comparatively free from these theologic allurements which in Christian Europe flickered in the air on all sides, luring men into paths which led no-whither.

Strong investigators, like Arnold of Villanova, Raymond Lully, Basil Valentine, Paracelsus, and their compeers, were thus drawn far out of the only paths which led to fruitful

truths. In a work generally ascribed to the first of these, the student is told that in mixing his chemicals he must repeat the psalm *Exsurge Domine*, and that on certain chemical vessels must be placed the last words of Jesus on the cross. Vincent of Beauvais insisted that, as the Bible declares that Noah, when five hundred years old, had children born to him, he must have possessed alchemical means of preserving life; and much later Dickinson insisted that the patriarchs generally must have owed their long lives to such means. It was loudly declared that the reality of the philosopher's stone was proved by the words of St. John in the Revelation, "To him that overcometh I will give a white stone." The reasonableness of seeking to develop gold out of the baser metals was for many generations based upon the doctrine of the resurrection of the physical body, which, though explicitly denied by St. Paul, had become a part of the creed of the Church. Martin Luther was especially drawn to believe in the alchemistic doctrine of transmutation by this analogy. The Bible was everywhere used, both among Protestants and Catholics, in support of these mystic adulterations of science, and one writer, as late as 1751, based his alchemistic arguments on more than a hundred passages of Scripture. As an example of this sort of reasoning, we have a proof that the elect will preserve the philosopher's stone until the last judgment, drawn from a passage in St. Paul's Epistle to the Corinthians, "We have this treasure in earthen vessels."

The greatest thinkers devoted themselves to adding new ingredients to this strange mixture of scientific and theologic thought. The Catholic philosophy of Thomas Aquinas, the Protestant mysticism of Jacob Boehme, and the alchemistic reveries of Basil Valentine were all cast into this seething mass.

And when alchemy in its old form had been discredited, we find scriptural arguments no less perverse, and even comical, used on the other side. As an example of this, just before the great discoveries by Stahl, we find the valuable scientific efforts of Becher opposed with the following syllogism: "King Solomon, according to the Scriptures, possessed the united wisdom of heaven and earth; but King

Solomon knew nothing about alchemy [or chemistry in the form it then took], and sent his vessels to Ophir to seek gold, and levied taxes upon his subjects; *ergo* alchemy [or chemistry] has no reality or truth." And we find that Becher is absolutely turned away from his labours, and obliged to devote himself to proving that Solomon used more money than he possibly could have obtained from Ophir or his subjects, and therefore that he must have possessed a knowledge of chemical methods and the philosopher's stone as the result of them.\*

Of the general reasoning enforced by theology regarding physical science, every age has shown examples; yet out of them all I will select but two, and these are given because

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\* For an extract from Agrippa's *Occulta Philosophia* giving examples of the way in which mystical names were obtained from the Bible, see Rydberg, *Magic of the Middle Ages*, pp. 143 *et seq.* For the germs of many mystic beliefs regarding number and the like, which were incorporated into mediæval theology, see Zeller, *Plato and the Older Academy*, English translation, pp. 254 and 572, and elsewhere. As to the connection of spiritual things with inorganic nature in relation to chemistry, see Eicken, p. 634. On the injury to science wrought by Platonism acting through mediæval theology, see Hoefer, *Histoire de la Chimie*, vol. i, p. 90. As to the influence of mysticism upon strong men in science, see Hoefer; also Kopp, *Geschichte der Alchemie*, vol. i, p. 211. For a very curious Catholic treatise on sacred numbers, see the Abbé Auber, *Symbolisme Religieux*, Paris, 1870; also Detzel, *Christliche Ikonographie*, pp. 44 *et seq.*; and for an equally important Protestant work, see Samuell, *Seven the Sacred Number*, London, 1887. It is interesting to note that the latter writer, having been forced to give up the seven planets, consoles himself with the statement that "the earth is the seventh planet, counting from Neptune and calling the asteroids one" (see p. 426). For the *electrum magicum*, the seven metals composing it, and its wonderful qualities, see extracts from Paracelsus's writings in Hartmann's *Life of Paracelsus*, London, 1887, pp. 169 *et seq.* As to the more rapid transmission of light than sound, the following expresses the scholastic method well: "What is the cause why we see sooner the lightning than we hear the thunder clappe? That is because our sight is both nobler and sooner perceptive of its object than our ear; as being the more active part, and prior to our hearing: besides, the visible species are more subtle and less corporeal than the audible species."—Person's *Varieties*, *Meteors*, p. 82. For Basil Valentine's view, see Hoefer, vol. i, pp. 453–465; Schmieder, *Geschichte der Alchemie*, pp. 197–209; *Allgemeine deutsche Biographie*, article *Basilius*. For the discussions referred to on possibilities of God assuming forms of stone, or log, or beast, see Lippert, *Christenthum, Volksglaube, und Volksbrauch*, pp. 372, 373, where citations are given, etc. For the syllogism regarding Solomon, see Figuier, *L'Alchimie et les Alchimistes*, pp. 106, 107. For careful appreciation of Becher's position in the history of chemistry, see Kopp, *Ansichten über die Aufgabe der Chemie*, etc., *von Geber bis Stahl*, Braunschweig, 1875, pp. 201 *et seq.* For the text proving the existence of the philosopher's stone from the book of Revelation, see Figuier, p. 22.

they show how this mixture of theological with scientific ideas took hold upon the strongest supporters of better reasoning even after the power of mediæval theology seemed broken.

The first of these examples is Melanchthon. He was the scholar of the Reformation, and justly won the title "Preceptor of Germany." His mind was singularly open, his sympathies broad, and his usual freedom from bigotry drew down upon him that wrath of Protestant heresy-hunters which embittered the last years of his life and tortured him upon his deathbed. During his career at the University of Wittenberg he gave a course of lectures on physics, and in these he dwelt upon scriptural texts as affording scientific proofs, accepted the interference of the devil in physical phenomena as in other things, and applied the mediæval method throughout his whole work.\*

Yet far more remarkable was the example, a century later, of the man who more than any other led the world out of the path opened by Aquinas, and into that through which modern thought has advanced to its greatest conquests. Strange as it may at first seem, Francis Bacon, whose keenness of sight revealed the delusions of the old path and the promises of the new, and whose boldness did so much to turn the world from the old path into the new, presents in his own writings one of the most striking examples of the evil he did so much to destroy.

The *Novum Organon*, considering the time when it came from his pen, is doubtless one of the greatest exhibitions of genius in the history of human thought. It showed the modern world the way out of the scholastic method and reverence for dogma into the experimental method and reverence for fact. In it occur many passages which show that the great philosopher was fully alive to the danger both to religion and to science arising from their mixture. He declares that the "corruption of philosophy from superstition and theology introduced the greatest amount of evil both into whole systems of philosophy and into their parts." He denounces those who "have endeavoured to found a

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\* For Melanchthon's ideas on physics, see his *Initia Doctrina Physica*, Wittenberg, 1557, especially pp. 243 and 274; also in vol. xiii of Bretschneider's edition of the collected works, and especially pp. 339-343.

natural philosophy on the books of Genesis and Job and other sacred Scriptures, so 'seeking the dead among the living.' He speaks of the result as "an unwholesome mixture of things human and divine; not merely fantastic philosophy, but heretical religion." He refers to the opposition of the fathers to the doctrine of the rotundity of the earth, and says that, "thanks to some of them, you may find the approach to any kind of philosophy, however improved, entirely closed up." He charges that some of these divines are "afraid lest perhaps a deeper inquiry into nature should penetrate beyond the allowed limits of sobriety"; and finally speaks of theologians as sometimes craftily conjecturing that, if science be little understood, "each single thing can be referred more easily to the hand and rod of God," and says, "*This is nothing more or less than wishing to please God by a lie.*"

No man who has reflected much upon the annals of his race can, without a feeling of awe, come into the presence of such clearness of insight and boldness of utterance, and the first thought of the reader is that, of all men, Francis Bacon is the most free from the unfortunate bias he condemns; that he, certainly, can not be deluded into the old path. But as we go on through his main work we are surprised to find that the strong arm of Aquinas has been stretched over the intervening ages, and has laid hold upon this master-thinker of the seventeenth century; for only a few chapters beyond those containing the citations already made we find Bacon alluding to the recent voyage of Columbus, and speaking of the prophecy of Daniel regarding the latter days, that "many shall run to and fro, and knowledge be increased," as clearly signifying "that . . . the circumnavigation of the world and the increase of science should happen in the same age." \*

In his great work on the *Advancement of Learning* the firm grasp which the methods he condemned held upon him is shown yet more clearly. In the first book of it he asserts that "that excellent book of Job, if it be revolved with dili-

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\* See the *Novum Organon*, translated by the Rev. G. W. Kitchin, Oxford, 1855, chaps. lxxv and lxxxix.

gence, will be found pregnant and swelling with natural philosophy," and he endeavours to show that in it the "roundness of the earth," the "fixing of the stars, ever standing at equal distances," the "depression of the southern pole," the "matter of generation," and "matter of minerals" are "with great elegancy noted." But, curiously enough, he uses to support some of these truths the very texts which the fathers of the Church used to destroy them, and those for which he finds Scripture warrant most clearly are such as science has since disproved. So, too, he says that Solomon was enabled in his Proverbs, "by donation of God, to compile a natural history of all verdure."\*

Such was the struggle of the physical sciences in general. Let us now look briefly at one special example out of many, which reveals, as well as any, one of the main theories which prompted theological interference with them.

It will doubtless seem amazing to many that for ages the weight of theological thought in Christendom was thrown against the idea of the suffocating properties of certain gases, and especially of carbonic acid. Although in antiquity we see men forming a right theory of gases in mines, we find that, early in the history of the Church, St. Clement of Alexandria put forth the theory that these gases are manifestations of diabolic action, and that, throughout Christendom, suffocation in caverns, wells, and cellars was attributed to the direct action of evil spirits. Evidences of this view abound through the mediæval period, and during the Reformation period a great authority, Agricola, one of the most earnest and truthful of investigators, still adhered to the belief that these gases in mines were manifestations of devils, and he specified two classes—one of malignant imps, who blow out the miners' lamps, and the other of friendly imps, who

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\* See Bacon, *Advancement of Learning*, edited by W. Aldis Wright, London, 1873, pp. 47, 48. Certainly no more striking examples of the strength of the evil which he had all along been denouncing could be exhibited than these in his own writings. Nothing better illustrates the sway of the mediæval theology, or better explains his blindness to the discoveries of Copernicus and to the experiments of Gilbert. For a very contemptuous statement of Lord Bacon's claim to his position as a philosopher, see Lange, *Geschichte des Materialismus*, Leipsic, 1874, vol. i, p. 219. For a more just statement, see Brewster, *Life of Sir Isaac Newton*. See also Jevons, *Principles of Science*, London, 1874, vol. ii, p. 298.

simply tease the workmen in various ways. He went so far as to say that one of these spirits in the Saxon mine of Annaberg destroyed twelve workmen at once by the power of his breath.

At the end of the sixteenth century we find a writer on mineralogy complaining that the mines in France and Germany had been in large part abandoned on account of the "evil spirits of metals which had taken possession of them."

Even as late as the seventeenth century, Van Helmont, after he had broken away from alchemy and opened one of the great paths to chemistry—even after he had announced to the world the existence of various gases and the mode of their generation—was not strong enough to free himself from theologic bias; he still inclined to believe that the gases he had discovered, were in some sense living spirits, beneficent or diabolical.

But at various periods glimpses of the truth had been gained. The ancient view had not been entirely forgotten; and as far back as the first part of the thirteenth century Albert the Great suggested a natural cause in the possibility of exhalations from minerals causing a "corruption of the air"; but he, as we have seen, was driven or dragged off into theological studies, and the world relapsed into the theological view.

Toward the end of the fifteenth century there had come a great genius laden with important truths in chemistry, but for whom the world was not ready—Basil Valentine. His discoveries anticipated much that has brought fame and fortune to chemists since, yet so fearful of danger was he that his work was carefully concealed. Not until after his death was his treatise on alchemy found, and even then it was for a long time not known where and when he lived. The papal bull, *Spondent pariter*, and the various prohibitions it bred, forcing other alchemists to conceal their laboratories, led him to let himself be known during his life at Erfurt simply as an apothecary, and to wait until after his death to make a revelation of truth which during his lifetime might have cost him dear. Among the legacies of this greatest of the alchemists was the doctrine that the air which asphyxiates

workers in mines is similar to that which is produced by fermentation of malt, and a recommendation that, in order to drive away the evil and to prevent serious accidents, fires be lighted and jets of steam used to ventilate the mines—stress being especially laid upon the idea that the danger in the mines is produced by “exhalations of metals.”

Thanks to men like Valentine, this idea of the interference of Satan and his minions with the mining industry was gradually weakened, and the working of the deserted mines was resumed; yet even at a comparatively recent period we find it still lingering, and among leading divines in the very heart of Protestant Germany. In 1715 a cellar-digger having been stifled at Jena, the medical faculty of the university decided that the cause was not the direct action of the devil, but a deadly gas. Thereupon Prof. Loescher, of the University of Wittenberg, entered a solemn protest, declaring that the decision of the medical faculty was “only a proof of the lamentable license which has so taken possession of us, and which, if we are not earnestly on our guard, will finally turn away from us the blessing of God.”\* But denunciations of this kind could not hold back the little army of science; in spite of adverse influences, the evolution of physics and chemistry went on. More and more there rose men bold enough to break away from theological methods and strong enough to resist ecclesiastical bribes and threats. As alchemy in its first form, seeking for the philosopher’s stone and the transmutation of metals, had given way to alchemy in its second form, seeking for the elixir of life and remedies more or less magical for disease, so now the latter yielded to the search for truth as truth. More and more the “solemnly constituted impostors” were resisted in every field. A great line of physicists and chemists began to appear.†

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\* For Loescher’s protest, see Julian Schmidt, *Geschichte des geistigen Lebens*, etc., vol. i, p. 319.

† For the general view of noxious gases as imps of Satan, see Hoefler, *Histoire de la Chimie*, vol. i, p. 350; vol. ii, p. 48. For the work of Black, Priestley, Bergmann, and others, see main authorities already cited, and especially the admirable paper of Dr. R. G. Eccles on *The Evolution of Chemistry*, New York, D. Appleton & Co., 1891. For the treatment of Priestley, see Spence’s *Essays*, London, 1892; also Rutt, *Life and Correspondence of Priestley*, vol. ii, pp. 115 et seq.



## II.

Just at the middle of the seventeenth century, and at the very centre of opposition to physical science, Robert Boyle began the new epoch in chemistry. Strongly influenced by the writings of Bacon and the discoveries of Galileo, he devoted himself to scientific research, establishing at Oxford a laboratory and putting into it a chemist from Strasburg. For this he was at once bitterly attacked. In spite of his high position, his blameless life, his liberal gifts to charity and learning, the Oxford pulpit was especially severe against him, declaring that his researches were destroying religion and his experiments undermining the university. Public orators denounced him, the wits ridiculed him, and his associates in the peerage were indignant that he should condescend to pursuits so unworthy. But Boyle pressed on. His discoveries opened new paths in various directions and gave an impulse to a succession of vigorous investigators. Thus began the long series of discoveries culminating in those of Black, Bergmann, Cavendish, Priestley, and Lavoisier, who ushered in the chemical science of the nineteenth century.

Yet not even then without a sore struggle against unreason. And it must here be noticed that this unreason was not all theological. The unreasoning heterodox when intrusted with irresponsible power can be as short-sighted and cruel as the unreasoning orthodox. Lavoisier, one of the best of our race, not only a great chemist but a true man, was sent to the scaffold by the Parisian mob, led by bigoted "liberals" and atheists, with the sneer that the republic had no need of *savants*. As to Priestley, who had devoted his life to science and to every good work among his fellow-men, the Birmingham mob, favoured by the Anglican clergymen who harangued them as "fellow-churchmen," wrecked his house, destroyed his library, philosophical instruments, and papers containing the results of long years of scientific research, drove him into exile, and would have murdered him if they could have laid their hands upon him.

Nor was it entirely his devotion to rational liberty, nor

even his disbelief in the doctrine of the Trinity, which brought on this catastrophe. That there was a deep distrust of his scientific pursuits, was evident when the leaders of the mob took pains to use his electrical apparatus to set fire to his papers.

Still, though theological modes of thought continued to sterilize much effort in chemistry, the old influence was more and more thrown off, and truth sought more and more for truth's sake. "Black magic" with its Satanic machinery vanished, only reappearing occasionally among marvel-mongers and belated theologians. "White magic" became legerdemain.

In the early years of the nineteenth century, physical research, though it went on with ever-increasing vigour, felt in various ways the reaction which followed the French Revolution. It was not merely under the Bourbons and Hapsburgs that resistance was offered; even in England the old spirit lingered long. As late as 1832, when the British Association for the Advancement of Science first visited Oxford, no less amiable a man than John Keble—at that time a power in the university—condemned indignantly the conferring of honorary degrees upon the leading men thus brought together. In a letter of that date to Dr. Pusey he complained bitterly, to use his own words, that "the Oxford doctors have truckled sadly to the spirit of the times in receiving the hotchpotch of philosophers as they did." It is interesting to know that among the men thus contemptuously characterized were Brewster, Faraday, and Dalton.

Nor was this a mere isolated exhibition of feeling; it lasted many years, and was especially shown on both sides of the Atlantic in all higher institutions of learning where theology was dominant. Down to a period within the memory of men still in active life, students in the sciences, not only at Oxford and Cambridge but at Harvard and Yale, were considered a doubtful if not a distinctly inferior class, intellectually and socially—to be relegated to different instructors and buildings, and to receive their degrees on a different occasion and with different ceremonies from those appointed for students in literature. To the State University of Michigan, among the greater American institutions

of learning which have never possessed or been possessed by a theological seminary, belongs the honour of first breaking down this wall of separation.

But from the middle years of the century chemical science progressed with ever-accelerating force, and the work of Bunsen, Kirchhoff, Dalton, and Faraday has, in the last years of the century, led up to the establishment of Mendeleef's law, by which chemistry has become predictive, as astronomy had become predictive by the calculations of Newton, and biology by the discoveries of Darwin.

While one succession of strong men were thus developing chemistry out of one form of magic, another succession were developing physics out of another form.

First in this latter succession may be mentioned that line of thinkers who divined and reasoned out great physical laws—a line extending from Galileo and Kepler and Newton to Ohm and Faraday and Joule and Helmholtz. These, by revealing more and more clearly the reign of law, steadily undermined the older theological view of arbitrary influence in nature. Next should be mentioned the line of profound observers, from Galileo and Torricelli to Kelvin. These have as thoroughly undermined the old theologic substitution of phrases for facts. When Galileo dropped the differing weights from the Leaning Tower of Pisa, he began the end of Aristotelian authority in physics. When Torricelli balanced a column of mercury against a column of water and each of these against a column of air, he ended the theologic phrase that "nature abhors a vacuum." When Newton approximately determined the velocity of sound, he ended the theologic argument that we see the flash before we hear the roar because "sight is nobler than hearing." When Franklin showed that lightning is caused by electricity, and Ohm and Faraday proved that electricity obeys ascertained laws, they ended the theological idea of a divinity seated above the clouds and casting thunderbolts.

Resulting from the labour of both these branches of physical science, we have the establishment of the great laws of the indestructibility of matter, the correlation of forces, and chemical affinity. Thereby is ended, with various other sacred traditions, the theological theory of a visible uni-

verse created out of nothing, so firmly imbedded in the theological thought of the Middle Ages and in the Westminster Catechism.\*

In our own time some attempt has been made to renew this war against the physical sciences. Joseph de Maistre, uttering his hatred of them, declaring that mankind has paid too dearly for them, asserting that they must be subjected to theology, likening them to fire—good when confined and dangerous when scattered about—has been one of the main leaders among those who can not relinquish the idea that our body of sacred literature should be kept a controlling text-book of science. The only effect of such teachings has been to weaken the legitimate hold of religion upon men.

In Catholic countries exertion has of late years been mainly confined to excluding science or diluting it in university teachings. Early in the present century a great effort was made by Ferdinand VII of Spain. He simply dismissed the scientific professors from the University of Salamanca, and until a recent period there has been general exclusion from Spanish universities of professors holding to the Newtonian physics. So, too, the contemporary Emperor of Austria attempted indirectly something of the same sort; and at a still later period Popes Gregory XVI and Pius IX discouraged, if they did not forbid, the meetings of scientific associations in Italy. In France, war between theology and science, which had long been smouldering, came in the years 1867 and 1868 to an outbreak. Toward the end of the last century, after the Church had held possession of advanced instruction for more than a thousand years, and had, so far as it was able, kept experimental science in servitude—after

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\* For a reappearance of the fundamental doctrines of black magic among theologians, see Rev. Dr. Jewett, Professor of Pastoral Theology in the Prot. Episc. Gen. Theolog. Seminary of New York, *Diabology: The Person and Kingdom of Satan*, New York, 1889. For their reappearance among theosophists, see Éliphas Lévi, *Histoire de la Magie*, especially the final chapters. For opposition to Boyle and chemical studies at Oxford in the latter half of the seventeenth century, see the address of Prof. Dixon, F. R. S., before the British Association, 1894. For the recent progress of chemistry, and opposition to its earlier development at Oxford, see Lord Salisbury's address as President of the British Association, in 1894. For the Protestant survival of the mediæval assertion that the universe was created out of nothing, see the Westminster Catechism, question 15.

it had humiliated Buffon in natural science, thrown its weight against Newton in the physical sciences, and wrecked Turgot's noble plans for a system of public instruction—the French nation decreed the establishment of the most thorough and complete system of higher instruction in science ever known. It was kept under lay control and became one of the glories of France; but, emboldened by the restoration of the Bourbons in 1815, the Church began to undermine this hated system, and in 1868 had made such progress that all was ready for the final assault.

Foremost among the leaders of the besieging party was the Bishop of Orleans, Dupanloup, a man of many winning characteristics and of great oratorical power. In various ways, and especially in an open letter, he had fought the "materialism" of science at Paris, and especially were his attacks levelled at Profs. Vulpian and Sée and the Minister of Public Instruction, Duruy, a man of great merit, whose only crime was devotion to the improvement of education and to the promotion of the highest research in science.\*

The main attack was made rather upon biological science than upon physics and chemistry, yet it was clear that all were involved together.

The first onslaught was made in the French Senate, and the storming party in that body was led by a venerable and conscientious prelate, Cardinal de Bonnechose, Archbishop of Rouen. It was charged by him and his party that the tendencies of the higher scientific teaching at Paris were fatal to religion and morality. Heavy missiles were hurled—such phrases as "sapping' the foundations," "breaking down the bulwarks," and the like; and, withal, a new missile was used with much effect—the epithet "materialist."

The results can be easily guessed: crowds came to the lecture-rooms of the attacked professors, and the lecture-room of Prof. Sée, the chief offender, was crowded to suffocation.

A siege was begun in due form. A young physician was

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\* For the exertions of the restored Bourbons to crush the universities of Spain, see Hubbard, *Hist. Contemporaine de l'Espagne*, Paris, 1878, chaps. i and iii. For Dupanloup, *Lettre à un Cardinal*, see the *Revue de Thérapeutique* of 1868, p. 221

sent by the cardinal's party into the heterodox camp as a spy. Having heard one lecture of Prof. Sée, he returned with information that seemed to promise easy victory to the besieging party: he brought a terrible statement—one that seemed enough to overwhelm Sée, Vulpian, Duruy, and the whole hated system of public instruction in France—the statement that Sée had denied the existence of the human soul.

Cardinal Bonnechose seized the tremendous weapon at once. Rising in his place in the Senate, he launched a most eloquent invective against the Minister of State who could protect such a fortress of impiety as the College of Medicine; and, as a climax, he asserted, on the evidence of his spy fresh from Prof. Sée's lecture-room, that the professor had declared, in his lecture of the day before, that so long as he had the honour to hold his professorship he would combat the false idea of the existence of the soul. The weapon seemed resistless and the wound fatal, but M. Duruy rose and asked to be heard.

His statement was simply that he held in his hand documentary proofs that Prof. Sée never made such a declaration. He held the notes used by Prof. Sée in his lecture. Prof. Sée, it appeared, belonged to a school in medical science which combated certain ideas regarding medicine as an *art*. The inflamed imagination of the cardinal's heresy-hunting emissary had, as the lecture-notes proved, led him to mistake the word "*art*" for "*âme*," and to exhibit Prof. Sée as treating a theological when he was discussing a purely scientific question. Of the existence of the soul the professor had said nothing.

The forces of the enemy were immediately turned; they retreated in confusion, amid the laughter of all France; and a quiet, dignified statement as to the rights of scientific instructors by Wurtz, dean of the faculty, completed their discomfiture. Thus a well-meant attempt to check science simply ended in bringing ridicule on religion, and in thrusting still deeper into the minds of thousands of men that most mistaken of all mistaken ideas: the conviction that religion and science are enemies.\*

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\* For a general account of the Vulpian and Sée matter, see *Revue des Deux Mondes*, 31 mai, 1868, "Chronique de la Quinzaine," pp. 763-765. As to the result

But justice forbids raising an outcry against Roman Catholicism for this. In 1864 a number of excellent men in England drew up a declaration to be signed by students in the natural sciences, expressing "sincere regret that researches into scientific truth are perverted by some in our time into occasion for casting doubt upon the truth and authenticity of the Holy Scriptures." Nine tenths of the leading scientific men of England refused to sign it; nor was this all: Sir John Herschel, Sir John Bowring, and Sir W. R. Hamilton administered, through the press, castigations which roused general indignation against the proposers of the circular, and Prof. De Morgan, by a parody, covered memorial and memorialists with ridicule. It was the old mistake, and the old result followed in the minds of multitudes of thoughtful young men.\*

And in yet another Protestant country this same mistake was made. In 1868 several excellent churchmen in Prussia thought it their duty to meet for the denunciation of "science falsely so called." Two results followed: upon the great majority of these really self-sacrificing men—whose first utterances showed complete ignorance of the theories they attacked—there came quiet and widespread contempt; upon Pastor Knak, who stood forth and proclaimed views of the universe which he thought scriptural, but which most schoolboys knew to be childish, came a burst of good-natured derision from every quarter of the German nation.†

But in all the greater modern nations warfare of this kind, after the first quarter of the nineteenth century, became more and more futile. While conscientious Roman bishops, and no less conscientious Protestant clergymen in Europe and America continued to insist that advanced education, not only in literature but in science, should be kept under careful control in their own sectarian universities and colleges, wretchedly one-sided in organization and inadequate

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on popular thought, may be noted the following comment on the affair by the *Revue*, which is as free as possible from anything like rabid anti-ecclesiastical ideas: "Elle a été vraiment curieuse, instructive, assez triste et même un peu amusante." For Wurtz's statement, see *Revue de Thérapeutique* for 1868, p. 303.

\* De Morgan, *Paradoxes*, pp. 421-428; also Daubeny's *Essays*.

† See the Berlin newspapers for the summer of 1868, especially *Kladderadatsch*.

in equipment ; while Catholic clerical authorities in Spain were rejecting all professors holding the Newtonian theory, and in Austria and Italy all holding unsafe views regarding the Immaculate Conception, and while Protestant clerical authorities in Great Britain and America were keeping out of professorships men holding unsatisfactory views regarding the Incarnation, or Infant Baptism, or the Apostolic Succession, or Ordination by Elders, or the Perseverance of the Saints ; and while both Catholic and Protestant ecclesiastics were openly or secretly weeding out of university faculties all who showed willingness to consider fairly the ideas of Darwin, a movement was quietly in progress destined to take instruction, and especially instruction in the physical and natural sciences, out of its old subordination to theology and ecclesiasticism.\*

The most striking beginnings of this movement had been seen when, in the darkest period of the French Revolution, there was founded at Paris the great Conservatory of Arts and Trades, and when, in the early years of the nineteenth century, scientific and technical education spread quietly upon the Continent. By the middle of the century France and Germany were dotted with well-equipped technical and scientific schools, each having chemical and physical laboratories.

The English-speaking lands lagged behind. In England, Oxford and Cambridge showed few if any signs of this movement, and in the United States, down to 1850, evidences of it were few and feeble. Very significant is it that, at that period, while Yale College had in its faculty Silliman and Olmsted—the professor of chemistry and the professor of physics most widely known in the United States—it had no physical or chemical laboratory in the modern sense, and

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\* Whatever may be thought of the system of philosophy advocated by President McCosh at Princeton, every thinking man must honour him for the large way in which he, at least, broke away from the traditions of that centre of thought ; prevented, so far as he was able, persecution of scholars for holding to the Darwinian view ; and paved the way for the highest researches in physical science in that university. For a most eloquent statement of the opposition of modern physical science to mediæval theological views, as shown in the case of Sir Isaac Newton, see Dr. Thomas Chalmers, cited in Gore, *Art of Scientific Discovery*, London, 1878, p. 247.



confined its instruction in these subjects to examinations upon a text-book and the presentation of a few lectures. At the State University of Michigan, which had even then taken a foremost place in the higher education west of the Great Lakes, there was very meagre instruction in chemistry and virtually none in physics. This being the state of things in the middle of the century in institutions remarkably free from clerical control, it can be imagined what was the position of scientific instruction in smaller colleges and universities where theological considerations were entirely dominant.

But in 1851, with the International Exhibition at London, began in Great Britain and America a movement in favour of scientific education; men of wealth and public spirit began making contributions to them, and thus came the growth of a new system of instruction in which Chemistry and Physics took just rank.

By far the most marked feature in this movement was seen in America, when, in 1857, Justin S. Morrill, a young member of Congress from Vermont, presented the project of a law endowing from the public lands a broad national system of colleges in which scientific and technical studies should be placed on an equality with studies in classical literature, one such college to be established in every State of the Union. The bill, though opposed mainly by representatives from the Southern States, where doctrinaire politics and orthodox theology were in strong alliance with negro slavery, was passed by both Houses of Congress, but vetoed by President Buchanan, in whom the doctrinaire and orthodox spirit was incarnate. But Morrill persisted and again presented his bill, which was again carried in spite of the opposition of the Southern members, and again vetoed in 1859 by President Buchanan. Then came the civil war; but Morrill and his associates did not despair of the republic. In the midst of all the measures for putting vast armies into the field and for saving the Union from foreign interference as well as from domestic anarchy, they again passed the bill, and in 1862, in the darkest hour of the struggle for national existence, it became a law by the signature of President Lincoln.

And here it should not be unrecorded, that, while the vast majority of the supporters of the measure were laymen, most efficient service was rendered by a clergyman, the Rev. Dr. Amos Brown, born in New Hampshire, but at that time an instructor in a little village of New York. His ideas were embodied in the bill, and his efforts did much for its passage.

Thus was established, in every State of the American Union, at least one institution in which scientific and technical studies were given equal rank with classical, and promoted by laboratories for research in physical and natural science. Of these institutions there are now nearly fifty: all have proved valuable, and some of them, by the addition of splendid gifts from individuals and from the States in which they are situated, have been developed into great universities.

Nor was this all. Many of the older universities and colleges thus received a powerful stimulus in the new direction. The great physical and chemical laboratories founded by gifts from public-spirited individuals, as at Harvard, Yale, and Chicago, or by enlightened State legislators, as in Michigan, Wisconsin, Minnesota, California, Kansas, and Nebraska, have also become centres from which radiate influences favouring the unfettered search for truth as truth.

This system has been long enough in operation to enable us to note in some degree its effects on religion, and these are certainly such as to relieve those who have feared that religion was necessarily bound up with the older instruction controlled by theology. While in Europe, by a natural reaction, the colleges under strict ecclesiastical control have sent forth the most powerful foes the Christian Church has ever known, of whom Voltaire and Diderot and Volney and Sainte-Beuve and Renan are types, no such effects have been noted in these newer institutions. While the theological way of looking at the universe has steadily yielded, there has been no sign of any tendency toward irreligion. On the contrary, it is the testimony of those best acquainted with the American colleges and universities during the last forty-five years that there has been in them a great gain, not only as regards morals, but as regards religion in its highest and best sense. The reason is not far to seek. Under the old

American system the whole body of students at a university were confined to a single course, for which the majority cared little and very many cared nothing, and, as a result, widespread idleness and dissipation were inevitable. Under the new system, presenting various courses, and especially courses in various sciences, appealing to different tastes and aims, the great majority of students are interested, and consequently indolence and dissipation have steadily diminished. Moreover, in the majority of American institutions of learning down to the middle of the century, the main reliance for the religious culture of students was in the perfunctory presentation of sectarian theology, and the occasional stirring up of what were called "revivals," which, after a period of unhealthy stimulus, inevitably left the main body of students in a state of religious and moral reaction and collapse. This method is now discredited, and in the more important American universities it has become impossible. Religious truth, to secure the attention of the modern race of students in the better American institutions, is presented, not by "sensation preachers," but by thoughtful, sober-minded scholars. Less and less avail sectarian arguments; more and more impressive becomes the presentation of fundamental religious truths. The result is, that while young men care less and less for the great mass of petty, cut-and-dried sectarian formulas, they approach the deeper questions of religion with increasing reverence.

While striking differences exist between the European universities and those of the United States, this at least may be said, that on both sides of the Atlantic the great majority of the leading institutions of learning are under the sway of enlightened public opinion as voiced mainly by laymen, and that, this being the case, the physical and natural sciences are henceforth likely to be developed normally, and without fear of being sterilized by theology or oppressed by ecclesiasticism.





