

The Reformation and the Development of Modern Science

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SINCE the end of the Second World War the historians of science have tended to push the origins of the so-called 'scientific revolution' from the mid-seventeenth century into the sixteenth century. A. C. Crombie has even traced some of its roots as far back as Robert Grosseteste of the thirteenth century,¹ while Professor R. Hooykaas of the Free University, Amsterdam, has found in the writings of the medieval Nominalists, Jean Buridan and Nicole Oresme, evidence of a rejection of the authority of the great Greek thinker Aristotle.²

Yet, as Professor Crombie admits the historians of the origins of modern science are at a loss to provide a unified explanation for the fact that the modern scientific attitude towards nature seems to have had its beginnings in the latter half of the sixteenth century. In his great work *Augustine to Galileo*, Crombie suggests various reasons such as the new economic and social conditions that arose out of the break-up of medieval Christendom.³

In general, however, the historians of modern science have either ignored or specifically denied the influence of the Protestant Reformation upon the development of a new outlook upon the world. Thus H. Haydn in *The Counter-Renaissance* writes that Luther and Calvin both disliked the arts and sciences since they laid all their stress upon man's salvation in the next life.⁴ W. C. D. Dampier in his work *A History of Science* suggests that the only importance of the Reformation for science was that it unintentionally broke the medieval ecclesiastical control of European thought by undermining the papal monopoly over western scholarship.⁵ For Herbert Butterfield the scientific revolution of the late sixteenth and seventeenth centuries 'outshines everything since the rise of Christianity and reduces the Renaissance and Reformation to the rank of mere episodes, mere internal displacements, within the system of medieval Christendom.'⁶ At the same time Butterfield admits some connexion between the Reformation and the birth of modern science since the former religious movement attained its greatest influence in the very geographic areas, e.g., Holland and England where natural science later attained some of its greatest achievements. Thus he writes:

'Not only did England and Holland hold a leading position, but that part of France which was most active in promoting the new order was the Huguenot or ex-Huguenot section, especially the Huguenots in exile, the nomads, who played an important part in the intellectual exchange that was taking place.'

In this paper we shall seek to show that this geographical connection between Calvinism and the rise of modern science is not accidental. Both Professor W. Stanford Reid in Canada and Professor R. Hooykaas

in Holland have proved the formative influence played by Calvinism upon the development of modern science.

I (a) *The Classical Conception of Nature*

Our conception of natural science depends upon our view of the object of science, that is 'nature', nature including the whole of creation, even the human mind. Again, our conception of nature depends on what is believed about the cause of nature; whether this is ultimately Almighty God or the gods or purely materialistic forces.

The Classical conception of nature was thoroughly pagan. By immanent forces out of Chaos, the gods, men and animals sprang into being. As Virgil says 'All things are full of Jupiter'. Nature is a vast organism, self-supporting, self-generating and self-regenerating. Individuals may perish, but the species always remains. The Greeks in fact deified nature as an eternal self-generating rational god, and their view of nature is both organic as well as rationalistic.

The organic aspect implies the unchangeable character of nature; essentially there is no change; but an eternal repetitive cycle. Again the organic aspect excludes the possibility that man can artificially produce natural compounds; all things in nature are generated from similar things, of their own kind, and therefore man cannot make a natural compound in an artificial way.

The rationalistic view of nature implies that the mind of man can decide beforehand what is possible or what is impossible in nature, e.g., there cannot be any change in heavenly bodies (as these are thought to be divine, immortal, unalterable). There can only be circular and uniform movement in heavenly bodies. To all Aristotelian scientists it was *a priori* impossible that any change could occur in the heavens and therefore they concluded comets must belong to the sub-lunar sphere; further they believed it was impossible that there should be more than one planetary system or that heavenly bodies should have any motion except a perfectly circular one. Writing of this Greek view of nature, R. G. Collingwood says in his classic study of *The Idea of Nature*:

'Greek natural science was based on the principle that the world of nature is saturated or permeated by mind. Greek thinkers regarded the presence of mind in nature as the source of that regularity or orderliness in the natural world whose presence made a science of nature possible. The world of nature they regarded as a world of bodies in motion. The motions in themselves, according to Greek ideas, were due to vitality or "soul" . . .

Since the world of nature is a world not only of ceaseless motion and therefore alive, but also a world of orderly or regular motion, they accordingly said that the world of nature is not only alive but intelligent; not only a vast animal with a "soul" or life of its own, but a rational animal with a "mind" of its own. The life and intelligence of creature's inhabiting the earth's surface and regions adjacent to it, they argued, represent a specialised local organisation of this all pervading vitality and rationality, so that a plant or animal, according to their ideas participates in its own degree psychically in the life-processes of the world's "soul" and intellectually in the activity of

the world's "Mind" no less than it participates materially in the physical organisation of the world's "body".⁶

The essence of Greek wisdom concerning the origin of the world is summed up in the phrase *Ex nihilo nihil fit*; nothing comes out of nothing! For this reason Greek thought could accept the idea of a divine demiurge which gives form to pre-existing matter. The unformed matter itself, however, could not have its origin in the divine principle of form. Thus the Greek idea of the origin of the world is both dualistic and dialectical, since pagan immanence thought cannot fully grasp the intrinsic unity and coherence of reality which derives from God's creation of the world, but instead is bound to fall into a false dualism in which one aspect of reality is constantly played over against another aspect.

For this reason the Ionian philosophy of nature bestowed primacy upon the matter-motive by deifying the formless vital current as the divine origin of all things which have an individual form. The Eleatic School founded by Parmenides, on the other hand, denied the true reality of flowing matter and sought divine physis only in an eternal invariable being. Matter here becomes viewed as the principle of imperfection, and the Divine Mind is interpreted as pure form which is independent from all matter. After the controversy between the Heraclitian and Eleatic conceptions of divine physis, Greek thought abandoned every attempt at reducing form to matter or matter to form but conceived of physis or nature as a compound of both.

For both Plato and Aristotle, all true science is also teleological. It consists in interpreting phenomena in the light of the ends at which the Cosmic Mind, the Divine Demiurge, who strives to direct all things in accordance with the eternal forms, is presumed to aim. These ends are discovered not by observation and experiment, but by reason. Not by trying to act upon nature, but by argument about nature's final purposes, will the truth be discovered. In his book on *Greek Science* Benjamin Farrington suggests that the explanation for this teleological approach to science is due to Plato's and Aristotle's attempt to justify the institution of slavery. He writes:

'The master-slave relation provides the basic pattern for both Plato's and Aristotle's thought in every sphere. . . . Both men viewed the master-and-slave relation as a pattern that pervades all nature, and hence both regarded matter as being refractory, disorderly and disobedient. The Supreme Mind has as much difficulty in making matter do what he wants as does the master in making the slave do what he wants.'⁹

Such a teleological and qualitative approach to nature was bound to stultify all true scientific thinking about the universe, and Plato must therefore be held responsible, along with his pupil Aristotle for arresting the development of Greek science by separating the logic of science from its experimental practice. Until the Christian Church restored dignity to labour and abolished the universal cleavage of ancient society between freeman and slave there would be no advancement of natural science. Thanks to the great work done in the medieval monasteries of Western Europe men came to realize that they could worship God with their hands as well as with their minds.

I (b) *The Medieval Roman Catholic Conception of Nature*

With the revival of learning that took place first during the Carolingian and then during the great Twelfth Century Renaissance a new view of the world was born. Nature, conceived as form or design and matter in the Greek sense, became the autonomous basis of supernatural grace and Biblical revelation. By means of his doctrine of the eternal law, with its subjective counterpart in the natural law, the greatest medieval philosopher, Thomas Aquinas, sought to accommodate the Greek form-matter motive with the biblical ground motive of creation, fall into sin, and redemption in and through Jesus Christ in the communion of the Holy Spirit.

Through the natural law the creation in its essential nature, has a subjective part in the eternal law of God's world plan. Such a synthesis between the biblical and Greek religious ground motives implied a distinction between a natural and a supernatural sphere of thought and action. Within the sphere of nature a relative autonomy was ascribed by Thomas to the human reason, which he supposed to be capable by its own unaided light of discovering the natural truths about the universe and of man's place within it. As Professor David Knowles writes in his excellent work *The Evolution of Medieval Thought*:

'As a follower of Albert who outran his master Aquinas accepted human reason as an adequate and self-sufficient instrument for attaining truth within the realm of man's natural experience, and in so doing gave, not only to abstract thought but to all scientific knowledge, rights of citizenship in a Christian world. He accepted in its main outlines the system of Aristotle as a basis for his own interpretation of the visible universe' (p. 257).

In accordance with this synthesizing method Aquinas now understood the creation of the world by God as a natural truth which could be proved by the argument from motion. It could be proved in a purely theoretical way from the logical necessity of an unmoved Mover as the first Cause and final end of all movement in the universe. This had been the demonstration for God's existence furnished by Aristotle's metaphysics. The logical consequence of this argument is that God is opposed as pure form to matter which is a matter of imperfection, a doctrine which cannot be accepted from a truly biblical point of view.

To escape this contradiction Aquinas accommodated the Greek form-matter presupposition of all theoretical thought to the biblical motive of creation out of nothing by saying that God had created both form and matter. Yet this applied only to the form and matter of concrete creatures. The *principles* of form and matter could not be conceived of as results of creation, since Aquinas viewed God himself as pure form opposed to matter as a principle of imperfection. Thus Thomas agreed here with Aristotle in deifying the form and undeifying the matter.

In this scholastic way of synthesis required by the Roman Catholic ground-motives of nature and grace, the form-matter motive of Greek philosophy had lost its original religious sense. But at the same time the biblical creation motive was deprived of its original and radical character. As a result of this synthesis, creation was now proclaimed to be a natural truth which can be seen and proved by the

human reason independent of all divine revelation, thus eliminating the doctrine of creation understood in its biblical sense as the religious presupposition of all truly scientific thought about God's creation.

I (c) *The Reformed Conception of Nature*

At the Reformation Western men returned to the Word of God as their ultimate ordering principle for interpreting the world in which they lived. Both Luther and Calvin set themselves against the medieval synthesis which had taken place in Scholasticism between Classical and Biblical modes of thought about reality. They insisted that the Scriptures alone revealed God directly to men. In so doing they stressed the biblical teaching that the Triune God is sovereign over all things. In this great Reformation doctrine of God's sovereignty may be found the key to the Reformation.

Such a point of view meant first of all that the Reformers accepted without question the view that God is uncreated and completely independent of all else. The medieval philosophers had talked of 'the great chain of being', of which God formed the first link. They had in many ways tended to make God dependent upon, even subject to man, as for instance in their mariolatry, or in their doctrine concerning saints. In opposition to this the reformers held that God stands apart from and above the universe as one who is completely of a different order; 'infinite, eternal, unchangeable in His being'. Thus Calvin insisted that God is above time and space, having no defects and no rivals.

In Calvin's view of nature the Biblical doctrine of creation holds pride of place. The classical deification of nature now gives place to the biblical secularization of nature. According to Calvin the God Who has revealed Himself in the Bible is no immanent principle but a Personal Ruler, who creates the world out of nothing according to His own sovereign will. Matter as well as design or form are equally God's creatures; neither can exist for one moment apart from His will. Even in its ideal structure, creation has a qualitatively different essence from that of God.¹⁰ Neither are form or substance, universals nor particulars, co-eternal with God. Rather there exist two levels of reality, the Eternal and the temporal, the uncreated and the created, and though man made in the image of God spiritually and intellectually stands halfway between, he still forms part of the dependent, space-time condition of reality.¹¹

Yet with all his stress upon the difference between the Creator and the creature, Calvin never adopted a deistic interpretation of reality. God continually orders, upholds and governs creation by the secret power of His Holy Spirit who brought order out of original chaos and who keeps all things in existence even now. Calvin also insisted that all things operate usually according to the laws with which God has endowed nature and which the Holy Spirit continually maintains and activates.¹² Only upon special occasions, i.e., on occasions of special revelation or special redemptive action, does the Lord act directly; above or contrary to secondary causes. Thus, for Calvin, law established and continued by God's Spirit, binds the whole of creation together.

It should not surprise us therefore that Calvin insisted that temporal reality forms one vast system, not of substantial forms superimposed upon a recalcitrant matter as Plato supposed but of phenomena and laws. More than once Calvin devoted his attention to the magnificent order of the whole of the universe which operates without the slightest sign of confusion according to the laws which God sustains and governs all things at all times. The '*ordo naturae*' to Calvin forms one grand machine which manifests the wonderful divine wisdom, power and goodness. Contrary to what many historians seem to think, therefore, nature in his mind was something to be considered and enjoyed, for it radiates the glory of the sovereign God.¹³

Writing of the significance of this Reformed return to the biblical conception of nature as the creation of the Sovereign God, Professor Hooykaas says:

Modern science arose when the consequences of the biblical conception of reality were fully accepted. In the 16th and 17th centuries science was led out of the blind alley into which it had got through the philosophy of Antiquity and the Middle Ages. New horizons were opened. The picture of the world as an organism was replaced by that of the world as a mechanism. It is not generated but made; it is not self-supporting, but it needs maintenance.¹⁴

Such a secularization of nature was the essential prerequisite for the development of modern science. Max Weber called this freeing of nature from its religious overtones 'disenchantment'. Harvey Cox writes in *The Secular City*:

This disenchantment of the natural world provides an absolute precondition for the development of natural science. No real scientific breakthrough is possible until man can face the natural world unafraid. Wherever nature is perceived as an extension of man's self or his group, or as the embodiment of the divine, science as we know it is precluded. This is evident in Assyrian culture, where an uncanny accuracy in astronomical observation developed, but in which the heavenly bodies were still experienced as the determinants of human destiny; hence no real scientific astronomy emerged (p. 24).

As a good example of this new Reformed approach to nature we cannot do better than examine Calvin's views on astrology. In his tract *Adversus Astrologiam* published in 1549, Calvin maintains that the study of the heavens by man is a proper and legitimate occupation, as long as man limits himself to the study of the motions and relationships of the celestial bodies. Calvin criticizes the theories of the so-called judicial astrologers basing his argument upon empirical evidence. He rejects all ideas of heavenly intelligences, the harmony of the spheres and the difference of heavenly from terrestrial substances. Admitting that the heavenly host may influence man's body in some ways, he rejects any idea that they have any control over his actions or fortunes. God alone governs by the laws of His universe.¹⁵

Stanford Reid points out that many of those who professed to be followers of Calvin after his death in 1564 did not succeed in freeing themselves as completely as Calvin had done from the authority of the great Aristotle. But even convinced Aristotelians could hardly follow Aristotle entirely, as long as they maintained the Biblical view of creation. He says:

Jerome Zanchi, an Italian theologian at Heidelberg University, in his *De Operibus Dei intra Spaciam Sex Diebus Creatis* written around 1570, spends considerable time attacking Aristotle's views on the eternality of matter, and even alters the Philosopher's teachings concerning the relation of form and substance by insisting that diversity and distinctions in the natural world arise solely out of the sovereign creative will of God. Similarly Peter Ramus in his *Scholae Mathematicae* (1569) stresses that God had created all things particularly the heavens on a mathematical pattern. In the same way Bernard Palissy sought in his art to reproduce "the works of God as they came from His hands", while Francis Bacon continually refers to God's creation of all things, and like the others takes for granted Calvin's "two level" interpretation of all reality.

When one studies the thought of Calvin's followers with regard to providence, natural law and secondary causes one finds again rather complete unanimity. Zanchi spends much time setting forth the Reformed doctrine of providence as the basis for the idea of natural law and the validity of natural causes. . . . Bacon sums the whole matter up when, after pointing out that final causes are matters properly metaphysical and physical causes relate only to this world, he insists that "neither doth this distinction call in question, or derogate from Divine Providence, but highly confirm and exalt it". To these men as to Calvin the relationships of things arose out of natural law, created and sustained by God's sovereign grace.

Similarly they all laid great stress upon the fact that this world of nature formed one vast machine, a term used numerous times by Zanchi and others. Even the smallest and most vile phenomena of creation form part of the great whole. . . . In this way the concept of "system" dominated their understanding of nature of which no part was too small or too unimportant for consideration and study . . .

To the Calvinist, then, nature is not a servant to be exploited or a temptress to be avoided. Rather, God has created nature that He might show forth His glory which man alone may recognise. Man with a "natural" body, but created in the image of God, has received the commission of God to "subdue the world and rule over it". The Calvinist saw nature as something objective to himself which he must endeavour to understand and use in order that he might truly fulfil his task upon earth. This provided him with an effective stimulus to scientific investigation.¹⁶

II *The Science of Nature*

The rediscovery of God's sovereignty over His creation not only resulted in the recovery of the Biblical idea of nature but also led in a sense to the rediscovery of God's world. *Calvinism restored to science its true domain*. The Protestant thinker came once again to see that God's lordship extended far beyond the Church to include 'the whole realm of nature'. He, therefore, found himself obliged to reject the medieval Roman Catholic dichotomy of 'nature and grace', of the natural and the supernatural, of the sacred and the secular, for if God rules sovereignly over all things in heaven and earth, no such bifurcation of reality into two realms can exist.

Whereas during the Middle Ages Christians had tended to focus their attention upon the vision of God in the next life and to look upon this world as being unworthy of attention now Protestants, without losing sight of the spiritual, recovered an interest in this world. As

the Calvinist believed that the curse of sin extended to all things, so now he believed that the grace of God also extended to all things. Hence one may not adopt the attitude that nature remains outside the purview of God's sovereign rule and redemption. God's sovereignty includes all things.

In his famous *Lectures on Calvinism*, Abraham Kuyper, Prime Minister of Holland and founder of the Free University, pointed out that Calvin, instead of simply treating Nature as an accessorial item as so many medieval theologians had been inclined to do, was accustomed to compare the Scriptures to a pair of spectacles enabling us to decipher again the divine thoughts, written by God's hand in the book of nature which had become obliterated because of the curse. He continues:

'Thus vanquished every dread possibility that he who occupied himself with nature was wasting his capacities in pursuit of vain and idle things. It was perceived, on the contrary, that for God's sake, our attention may not be withdrawn from the life of nature and creation; the study of the body regained its place of honour beside the study of the soul; and the social organisation of mankind on earth was again looked upon as being as well worthy an object of human science as the congregation of the perfect saints in heaven. This also explains the close relation existing between Calvinism and Humanism. In as far as Humanism endeavoured to substitute life in this world for the eternal, every Calvinist opposed the Humanist. But in as much as the Humanist contented himself with a plea for a proper acknowledgement of secular life, the Calvinist was his ally.'¹⁷

With this new interest in the Father's world came the insistence that man has the responsibility laid upon him by the great cultural and scientific mandate given to him at his creation 'to be fruitful and multiply, and replenish the earth, and subdue it and have dominion over it'. (Genesis I: 28). Again man is called 'to keep the garden and dress it'. Man's culture and science is thus understood in the Bible to be the result of a divinely imposed mandate. *Culture and science is in fact man's life task*. In this great cultural and scientific task man is called to examine all things, to take the raw materials of God's creation and by means of his science and technology to bring out all the potencies and possibilities that are hidden in nature. When thus developed man is called by God to lay his entire cultural and scientific product at the feet of Him Who is lord of man and of nature, in Whose image and for Whom man and all things were and are created.

This meant for Calvinists the rejection of the classical and medieval Roman Catholic conception of reality in terms of self-existent autonomous beings or of reality as part of a great impersonal chain of being moving towards predirected ends. Instead the Calvinist now thought of nature as the work of God's creation, created to accomplish His sovereign purpose and to show forth His sovereign glory. Thus man for a true understanding of himself and of the world must see all things 'in the light of eternity'. As Calvin stated at the beginning of his famous *Institutes of the Christian Religion*: 'The true knowledge of ourselves is dependent on the true knowledge of God.'¹⁸ The Calvinist thus recognizes that all things originate and continue by the power of providence. He believes that he should avoid nothing as

common or unclean in and of itself except sin. All else man should understand and interpret as God's possession and part of the Lord's great creation.

This did not mean for the Calvinist, however, that man should attempt to establish a series of basic rational principles, from which he could deduce all things. Such a procedure many of the medieval thinkers had followed, believing that only ultimate principles and final causes had any real and significant existence. To the Reformers, on the other hand, even the Christian knows ultimate truth only in a very fragmentary and broken manner. Thus Calvin repeatedly pointed out that because of both man's sinfulness and finitude one may see beyond this sphere of space and time only as God enlightens the eyes by revelation. If one would know the world in which one lives, one must begin by studying it at first hand, working from the facts which exist and which one may know empirically, not by working out abstractly or syllogistically the essences of things as St. Thomas Aquinas had tried to do. In coming to understand God's world, therefore, man must follow that world's contours and modalities for all the facts of the universe manifest themselves clearly to those who can see the glory of the sovereign God reflected in them.

Stanford Reid points out in his paper read before the Royal Society of Canada titled *Natural Science in Sixteenth Century Calvinistic Thought* that such an empirical approach to the investigation of nature found its origin in Calvin's own theological technique. He says:

'In order to understand Calvin's influence on the scientific method one must first look at his theological technique. Seeking to reform the church, he turned back to the original Christian source, the biblical text, which he believed to be the Word of God. His method of approach to the Scriptures was basically empirical for he rejected all speculation and all philosophising in favour of a strict grammatico-historical exegesis under the guidance of God's Spirit, which limits one to what the text actually says . . .

Calvin, however, did not stop with a theological method, for he held that God also revealed Himself in the works of His creation and providence. These latter man comes to know not by studying the Scriptures but by investigating nature itself. Here the two-level theory of reality came into play, for he insisted that one must investigate the things of this earth by appropriate mundane means, the only limitation being that unless men see this earth "in the light of eternity", by which he means in the perspective of faith in Christ, they will neither understand it truly nor use it properly. At the same time he also insisted that since God is the creator and sustainer man can never understand all God's works; he can only analyse their relationships and material causes recognising that even the *ordo naturae* because of its divine origin is never wholly subject to human rational analysis.' (*Institutes* I, V, 9: 11, ii, 13).¹⁸

In view of Calvin's doctrine of the total depravity of human nature due to both original and actual sin it may be asked how did he regard non-Christian scientific endeavours? The answer is that although he held that by the Fall man lost all capacity for the knowledge of God and of creation, the Lord in his common grace through the Holy Spirit does give even to unbelievers certain gifts by which they may investigate and understand this world. This knowledge and ability Calvin

taught was not 'natural' but came from God's special benevolence so that even the Christian had to acknowledge and thank God for what he calls the ancient philosopher's 'fine observation and careful description of nature'. How can we account for the good with the bad in the unregenerate? Calvin asks. He answers not by ascribing such goodness to some innate natural goodness in the heart of the unregenerate, but by recognizing in the heart even of the unregenerate God's common or general grace and help.

By means of his common or temporal conserving grace God maintains the life of all men, relaxes the curse which rests upon them by means of their disobedience, and arrests the process of corruption in their hearts, while his church mediates to them his saving special grace in Jesus Christ. Without God's common grace, which thus curbs the effects of sin in human life, including the life of scholarship, there could be no possibility of human culture and science at all, and pagan life and thought would collapse in complete anarchy and nihilism. Thus man's temporal life with all its various relationships such as family, marriage, state and business is preserved in heathen lands which have not heard the Gospel even when renewing, regenerating grace is not available. Even when men deny God, his goodness and benevolence towards them enables them to perform civil good, to honour legal contracts, think rational thoughts, compose great music and create great art, to love each other and to enjoy social graces and virtues. According to Calvin then it is God's common grace which alone makes human culture and science possible. Human society would have been utterly destroyed if the common grace of the Lord had not intervened. As such, common grace is the foundation of culture, since God's great plan for the creation is achieved through common grace. It is not spiritual and regenerative but temporal and material. It is based upon and flows forth from the confession of the absolute sovereignty of God and in order that the world should give God the honour that is due to Him.²⁰

Calvin's scientific methods of investigation influenced many other thinkers in other fields. If one turns to Petrus Ramus, Ambrose Pare, Bernard Palissy or Francis Bacon, all of whom held Calvinistic views and exercised wide influence upon the development of various sciences, one finds that they followed Calvin's method of arranging the facts of nature in categories so that they could see resemblances and relationships. Thus they began to develop a form of empiricism, whether in biblical studies, mathematics, the manufacturer of pottery, the healing of wounds or the development of a scientific method.

This brings us face to face with the question of the statements of the Scriptures concerning natural phenomena and events. Is the Bible the final authority on matters scientific? To this Calvin replied that when the Spirit of God speaks through the Law and the Prophets He does so not with rigorous exactness 'but in a style suited to the common capacities of man'.²¹ This of course would not involve the question of miracles, for they are special occurrences for some particular purpose, but for the knowledge of all normal natural happenings the study of the phenomena, not of the Scriptures, brings man true knowledge.

The dominant idea in Calvin's thinking on the subject of the relation between science and religion is the protestant doctrine of the general intelligibility of Scripture, which is a revelation not only to a privileged class of scholars but to all people. According to Calvin the Holy Spirit opens a common school for the learned and the unlearned and, therefore, chooses what is intelligible to all. If the *Book of Genesis* had been written in a scientific way, the uneducated might have pleaded in excuse that such subjects were beyond their capacity. The Bible is a book for laymen as well as scholars designed to orient their hearts in the religious dimension of reality by working in their hearts a true knowledge of God as well as themselves. *Calvin then never regarded the Bible as a sort of textbook for the natural sciences.* He pointed out that 'he who would learn astronomy and other recondite arts, let him go elsewhere.'³³ Evidently Calvin holds that God wished all people of all ages to understand His revelation and, therefore, accommodated Himself to us. The Holy Ghost says Calvin 'chose rather after a sort to stammer, than to shut up the way of learning from the vulgar and unlearned sort.'³⁴

Such an attitude to the Bible and nature meant that Calvin and his followers flatly rejected any form of biblicistic rationalism or mysticism. This anti-rationalist approach lay at the basis of his rejection of judicial astrology. Similarly Ramus and Bacon spent considerable time blasting at astrology, alchemy and the esoteric philosophy of Paracelsus who attempted to deduce all scientific truth by means of rationalization from the Scriptures and declared all other knowledge of nature false. Even philosophical rationalism came under attack. Ramus and Bacon flatly rejected the medieval Scholastic-syllogistic method as inadequate for science, since it dealt with notions rather than with facts of nature, while Palissy, Pare and the great Calvinist scientist of Holland, Isaac Beekman, defended their scientific work on grounds of experience alone. In his thesis for the degree of M.D. Isaac Beekman announced the principle of inertia as well as giving the right explanation of the ascent of water in a pumptube by the pressure not the weight. Hooykaas points out that it was Beekman, not Galileo who was the first scientist to give a dynamical deduction of the law of falling bodies.³⁵ For the same reason Beekman was ready to accept Harvey's discovery of the circulation of the blood, which he first heard about through his English friend George Ent, if it could be proved by experiment.

For these Calvinist scientists it is only through the facts of nature that man can learn about nature. In his tractate on astrology and in his pamphlet advocating the creation of an inventory of all religious relics in Europe, Calvin continually pointed to the need for ascertaining the facts. This in turn became the central theme of Calvin's 'scientific' disciples. Ramus made a considerable reputation for himself by rejecting every 'hypothesis' which did not keep strictly to the facts.³⁶ Palissy attacked Paracelsus, Raymond Lull and the alchemists on the same grounds, preparing a cabinet of geological specimens to support his case.³⁷ Bacon sums up the whole matter in his preface to the *Novum Organon* when he expresses the hope that he has brought about the marriage of 'the empirical and the rational faculties,' in

order that God may enable him to present further gifts to the family of men.²⁷

Bacon in fact believed that man had lost his dominion over nature because of his intellectual pride by which he would imitate the sin of his first parents. In *Historia Naturalis et Experimentalis* he wrote:

'We direct and domineer over nature, we will have it that all things are as in our folly we think they should be, not as seems fittest to the divine wisdom, not as they are found to be in fact. We clearly impress the stamp of our own image on the creatures and works of God, instead of carefully examining and recognising in them the stamp of the Creator Himself. Wherefore, not undeservedly, our dominion over creatures is a second time forfeited; and, though after the Fall of man some power over the resistance of nature was still left . . . yet this too, through our insolence, and because we desire to be like God and to follow the dictates of our own reason, we in great part lose.'²⁸

Bacon therefore entreats his contemporaries in almost biblical language that 'if . . . there be any humility towards the Creator, if there be any reverence for or disposition to magnify His works, if there be any charity for man, we should dismiss those preposterous philosophies, which have led experience captive and triumphed over the works of God, that we should approach with humility and veneration to unroll the volume of the Creation.'²⁹ To Bacon, 'the entry into the Kingdom of Man, founded on the sciences, is not very different from the entry into the Kingdom of Heaven, whereinto none may enter except as a child.'³⁰

If we compare Bacon's diagnosis with that of Calvin's friend, Simon Grynaeus of Basel (1550), it becomes evident that a great step forward had been made since the beginnings of the Reformation. The greatest impression after the discovery of the New World was made by the discrepancy between the geography, botany and zoology of the Ancients and the bare facts discovered not by human reason, but by the ordinary experience of sailors and travellers. Grynaeus, as well as Bacon, regarded the discovery of new parts of the earth as evidence of the restoration of our dominion over nature, but Bacon stresses the submission to facts, however unexpected they may be, whereas Grynaeus passes by this humiliating situation and glories in the fact that the human mind, by means of mathematics and astronomy, had in a certain respect anticipated these discoveries without immediate observation. Along with Ramus and Zanchi they thought not in terms of experimentation, but in terms of the statements of ancient classical authorities: Aristotle's *Meteors*, Pliny's *Natural History* and Strabo's *Geography*.

On the other hand with Calvinist scholars such as Palissy who prided himself on knowing no Latin or Greek, and with Pare the military surgeon, practical experience predominated. These men found their facts through rudimentary experimentation, whether in the firing of pottery vessels or in the testing out of new methods of tying up wounds.³¹ By the time Bacon wrote, under the influence of men such as Palissy and Beeckman, experimentation had begun to be the principal means of 'invention and discovery' in the study of nature.³²

Bacon had in fact learned the great lesson that we should 'seek for the sciences not arrogantly in the little cells of human wit, but with reverence in the greater world.'³³ He expects the restoration of science to come by the liberation of the mind 'from the serpent's venom that made it swell' and by a 'true humiliation of the spirit'.

Asking the pertinent question whether mathematics played any part in this concept of scientific method Stanford Reid answers:

'As far as one can tell, Calvin, Zanchi, Beza and the others had little interest in such matters. Francis Bacon went even further, expressing a fear of the subject since he felt that the mathematician always tended to over-simplify for the benefit of a neat numerical scheme. This provided part of the reason for his doubts concerning Copernicus. Ramus, on the other hand, from the time of his open conversion to Protestantism increasingly stressed the need for mathematical studies and their application to the science of nature. Seeing that he had little or no interest in actual experimentation, this may appear strange, but if one remembers that his basic method was one of arrangement in space, one can understand perhaps why geometry and arithmetic played such an important part in his scheme of things. Thus in Calvinistic thought relating to nature and natural phenomena, although the stress still lay on the qualitative rather than on the quantitative, the tendency to regard the geometrical arranging of the facts as the truly "scientific" method became increasingly prominent. In this way mathematics almost imperceptibly entered the picture.'³⁴

Another factor of considerable influence upon the development of modern science was the Protestant doctrine of the calling. From this doctrine of the great Reformers that man is called to serve God in whatever sphere or station of life he may find himself has been derived the moral and spiritual dynamic which brought about first the scientific revolution and then the industrial revolution. By endowing common labour with Christian dignity and value Luther and Calvin gave the workers of Reformed lands a new sense of their dignity and importance. R. H. Tawney well says of this doctrine that 'Monasticism was so to speak, secularized; all men stood henceforward on the same footing towards God.'³⁵

As an example of what this meant we may cite Isaac Beeckman, who was born at Middelburg in the Netherlands from a family of Flemish refugees. His father, Abraham Beeckman, was a manufacturer of candles and water conduits for breweries, aqueducts etc. With his younger brother Jacob, Isaac Beeckman went to Leyden to study theology. In the meantime he also found occasion to go for some months to Rotterdam to learn mathematics and nautics. Isaac returned to Middelburg in 1601. Instead of going out preaching he became an apprentice in his father's business and afterwards settled on his own account as a chandler at Zierikzee in 1611.

In those great days a university graduate carrying on a manual trade was not considered as degrading himself. The expression of the wedding service of the Dutch Reformed Church, admonishing every husband to be diligent in his 'divine calling' was no hollow phrase then; to be a theologian was not thought more godly than to be a chandler. In the fresh bloom of early Calvinist culture manual labour was still

held in high esteem and a joy with the result that Beeckman kept a lively interest in his ancestral profession."⁸

From the practical experience of life which such men of thought gained there grew an increasing number of inventions and practical technical discoveries. Of the importance of this connection between theoretical and practical life in regard to the invention of the telescope and the compound microscope Lewis Mumford writes in his great work on *Technics and Civilization*:

'It was a Dutch optician, Johann Lippersheim, who in 1605 invented the telescope and thus suggested to Galileo the efficient means he needed for making astronomical observations. In 1590 another Hollander, the optician Zacharias Jansen invented the compound microscope, possibly also the telescope. One invention increased the scope of the macrocosm; the other revealed the microcosm; between them, the naive conceptions of space that the ordinary man carried around were completely upset.'⁹

By uniting the logic of science with its experimental practice by their great doctrine of the calling the Reformers perhaps rendered their greatest contribution to the advancement of science. The material potentialities of the new scientific attitude towards the world might have waited in vain for their fulfilment, as had been the case with Greek science, had it not been for Luther's recovery of the biblical doctrine that man serves God just as much at his work bench as on his knees in church.

III *The Use of Nature and Science*

Neither Calvin nor those who came after him held any brief for mere learning as such. Man's knowledge and abilities must be applied to good use. This idea was by no means Calvin's discovery, but it fitted in well with his point of view and received support from those who followed him.

Calvin held on biblical grounds that God had placed man upon this earth to subdue and use it. Thus man should employ the good gifts of God for his own physical and emotional well-being. This utilitarian approach is also found in Calvin's successors, Zanch, Palissy, Pare, Ramus, Beeckman and Bacon.¹⁰ Yet all these Reformed men considered that the highest end of all scientific, as well as theological studies is ultimately the glory of God. As all of creation is the handiwork of God, so the study, analysis and explanation of it as well as the explanation of its wonders, all have as their ultimate end and purpose, the manifestation of the infinite wisdom, power and glory of Almighty God, Father, Son and Holy Spirit.

The point of view of the Reformation of seeing all things 'in the light of eternity' not only helped greatly in the development of an inductive method in science, it also provided a new moral approach to the use of the things of this world. Thanks to the recovery of the biblical doctrine of the cultural mandate to have dominion over the world Calvinists no longer saw the world as something evil from which man should fly as medieval Roman Catholics had tended to do. Rather holding to their doctrine of God's sovereignty, they believed that God has placed man in this world to exploit its potentialities to the best of his ability that he might thereby glorify God and the better serve

his fellow man. They believed that it is not only the business of science to think God's thoughts after him but also to reveal the value of scientific discovery for life. Mere abstract thinking about the world such as Plato and Aristotle had advocated as the ideal of the scientist the Calvinists did not think would do any one any good. Its value for the improvement of man's estate must also be shown. Under the Lord's direct orders, man has been given the tremendous responsibility of developing a material and social culture which would manifest the goodness and power of God, thus providing man with the material conditions for living 'the good life.' By virtue of this motive, the Calvinists instead of running away from human culture, sought to conquer it for Christ's sake. *They sought to glorify God in His church and to serve Him in His world.*

Such an approach to man's social and material environment provided the indispensable psychological ground work for the emergence of the modern scientific approach towards life. The medieval ideal that asceticism was the truly Christian attitude the Calvinists roundly rejected. At the same time they also rejected the Renaissance humanist ideal of man using creation merely for the satisfaction of his own wants. Instead, the Reformers insisted that man has the duty and responsibility of knowing his world in all its ramifications and of using and enjoying it to the glory of God. This meant use in moderation and in accordance with the righteousness which God demands of His people.

No Calvinist thinker so well epitomizes the new attitude than Francis Bacon. Instead of the old classical and medieval 'thus far and no farther,' attitude Bacon posited 'the still further' approach of the new era, the epoch when man at last would accept his lawful heritage as son and fellow worker of God. Writing of Bacon's new outlook upon the world Professor R. Hooykaas says:

'Bacon does not want to awaken the lust of power of the magician or the pride of the speculative philosopher; he does not want to be "a mighty God". On the contrary, he impresses upon his readers the necessity to alleviate the needs and sorrows of mankind, to invent machines to lighten the burden of labour, to find remedies against disease by chemical experiment, to ward off the menace of hunger by control of the growth of plants and making it less dependent on soil and climate. The Kingdom of Man is not opposed to the Kingdom of God, it is the consequence of it. . . . In apostolic language Bacon entreats his readers to fulfil the duty of love in conquering the afflictions of mankind, to abandon outworn beliefs and artificial despair and to join him in the crusade against superstition, disease and disasters.'²⁰

Many secular historians have recognized the importance of Bacon in the development of modern science but they have totally failed to link it to his Calvinistic presuppositions. Moreover, they have failed to see how his views derived from his fore-runners such as John Napier of Merchimstoun and the founding of Gresham College in London which began life primarily as a Ramist institution.

It is thus no accident that first the scientific and then the industrial revolutions arose in the homelands of Calvinist rather than Roman Catholic Christianity. Without the religious revolution of the Reformation the scientific and industrial revolutions would never have been possible.

The fact is that to a considerable extent the Calvinistic thinkers provided the only scientific method of the time which met the needs of the technical advances achieved by such men as Galileo, Stevin and others. They laid down the principles of method later carried further by Huygens, Boyle and above all Isaac Newton. Calvinism provided men with a new approach to nature which forced them to give up their faith in the authority of Aristotle. It undermined the medieval synthesis with its stress upon the factual and its insistence on the objective analysis of phenomena in order that all things might be subordinated to law and formed into a coherent system.

In all these ways the Calvinist approach to the whole question of nature opened up new fields of research and directed men into areas of investigation leading to results of which we have not yet seen the conclusion. Alone of all modern interpretations of Christianity Calvinism can still provide us today with an integration of religion and science in the ultimate Christian theistic environment of all created reality. As Bacon wrote in his preface to *Historia Naturalis et Experimentalis*:

If therefore there be any humility towards the Creator, any reverence for or disposition to magnify his works, any charity for man and anxiety to relieve his sorrows and necessities, any love of truth in nature, any desire for the purification of the understanding, we must entreat men again and again to discard these preposterous philosophies, which have led experience captive, and triumphed over the works of God, and to approach with humility and veneration to unroll the volume of Creation. May God, the Founder, Preserver and Renewer of the Universe, in His love compassion to men, protect the work of modern science both in its ascent to His glory and its descent to the good of Man, through His only Son Jesus Christ, God with us.'

NOTES

¹ A. C. Crombie, *Robert Grosseteste and the Origins of Experimental Science 1100-1700* (Oxford, 1953).

² R. Hooykaas: *Science and Theology in the Middle Ages* (Free University Quarterly, Vol. III, No. 2, 1954 (Amsterdam)).

³ A. C. Crombie: *Augustine to Galileo*, Vol. II, p. 122 (Mercury, 1961).

⁴ H. Haydn: *The Counter-Renaissance*, p. 245 (New York, 1960).

⁵ Sir William Cecil Dampier: *A History of Science*, p. 118ff. (Macmillan, 1946).

⁶ Herbert Butterfield: *The Origins of Modern Science, 1300-1800* Introduction p. viii. (Bell, 1949).

⁷ H. Butterfield, *ibid.*, p. 165.

⁸ R. G. Collingwood: *The Idea of Nature*, p. 3 ff. (Oxford, 1945).

⁹ Benjamin Farrington: *Greek Science*, Vol. I, p. 144 ff. (Pelican, 1949).

¹⁰ John Calvin: *Commentary on Genesis*, Vol. I, p. xxxi (Grand Rapids, 1948). cf. A. O. Lovejoy: *The Great Chain of Being* (Harvard, 1936).

¹¹ T. F. Torrance: 'The Influence of Reformed Thought on the Development of Scientific Method' *A Journal of Theology*, II, 1963, p. 41.

¹² John Calvin: *Commentary on Acts*, 17: 28 and *Institutes of the Christian Religion*, I, xvi., 4 ff.

¹³ Calvin: *Institutes*, 1, xiv., 20, 21. *Commentary on Psalm 104*: 1-4.

¹⁴ R. Hooykaas: *A New Responsibility in a Scientific Age*, Free University Quarterly, Vol. VIII, No. 2, October 1961.

R. Hooykaas: *Science and Reformation*, Journal of World History, No. 3 (1956, Paris), pp. 109-139, and 781-784.

¹⁵ John Calvin: *Admonitio Adversus Astrologiam, quam Iudiciariam Vocant*, 1549, Geneva.

¹⁶ W. Stanford Reid: Natural Science in Sixteenth Century Calvinistic Thought, *Transactions of the Royal Society of Canada*, Vol. I, Series IV; June, 1963, Section II, p. 309, available as *Christianity & Scholarship* (Craig Press, 1967).

¹⁷ Abraham Kuyper: *Lectures on Calvinism*, p. 120 (Grand Rapids, 1961).

¹⁸ John Calvin: *Institutes of the Christian Religion*, Vol. I, p. 47 ff. (Translated by John Allen, Eerdmans, 1949).

¹⁹ Stanford Reid; *op. cit.*, p. 312.

²⁰ For a further treatment of the doctrine of Common Grace consult E. L. Hebden Taylor: *The Christian Philosophy of Law, Politics and the State*, p. 60 and pp. 484 ff. (Craig Press, 1966).

²¹ John Calvin: *Commentary on Psalms No. 19: 4* and on *Jeremiah 1: 12, 13*.

²² John Calvin: *Commentary on Genesis 1:6*.

Pre-Revolutionary England (Secker and Warburg, 1963). Stanford Reid's essay on 'The Christian and Scientific Method' in his paperback *Christianity and Scholarship* (Craig Press), which includes his Royal Society (Canada) lecture; also my own paperback in the same University Series *Evolution and the Reformation of Biology*.

²³ John Calvin: *Commentary on Psalms*, 136, verse 7.

²⁴ R. Hooykaas: Science and Religion in the Seventeenth Century. *Free University Quarterly*, Vol. I, No. 3, July 1951, p. 169.

²⁵ R. Hooykaas: 'Humanisme, science et reforme' *Free University Quarterly*, No. V., 1958, p. 178 ff., 183 ff.

²⁶ Palissy: *Oeuvres*, pp. 394 ff. H. Morley, *Palissy the Potter* (London, 1852), Vol. II, p. 240 ff. Palissy's own works have been edited by Anatole France (Paris 1880).

²⁷ Francis Bacon: *Novum Organon*, Works, IV, 19.

²⁸ Francis Bacon: *Historia Naturalis et Experimentalis*, Works Vol. V., p. 132 (Ed. Spedding, London, 1858-59).

²⁹ F. Bacon, *ibid.*, p. 132.

³⁰ F. Bacon: *Novum Organum* Vol. I, 68 Works ed Spedding IV, p. 69.

³¹ For a biography of Ambrose Pare (1510-1590) see F. R. Packard, *Life and Times of Ambrose Pare* (New York, 1921). For a discussion of Palissy experimental approach consult J. Huizinga: *Men and Ideas* (New York, 1959), p. 304, where he writes that Palissy's 'place is among those minds who enthusiastically hunted and grubbed in nature to discover its secrets and thus prepared the way for a positivistic natural science'.

³² Francis Bacon: *The Advancement of Learning*, ed. G. W. Kitchin (London, 1915), p. 122 cf. Huizinga, *op. cit.*, p. 304.

³³ Francis Bacon: *The Great Instauration*, preface Works, IV, p. 21.

³⁴ Stanford Reid; *op. cit.*, p. 317.

³⁵ R. H. Tawney: *Religion and the Rise of Capitalism* (Penguin, 1938), p. 100.

³⁶ R. Hooykaas: *Science and Religion in the Seventeenth Century*.

³⁷ Lewis Mumford: *Technics and Civilization* (London, 1947), p. 126.

³⁸ Hooykaas; *Humanisme, science et reforme*, pp. 187 ff. J. Bohatec, *Bude und Calvin* (Braz, 1950), p. 263.

³⁹ R. Hooykaas: A New Responsibility in a Scientific Age, p. 9 ff. cf., R. Hooykaas: *Christian Faith and the Freedom of Science* (Tyndale Press, 1957).

⁴⁰ For the contribution of the English Puritans to the advancement of science in England consult; Christopher Hill: *The Intellectual Origins of the English Revolution* (Oxford, 1964). Also Christopher Hill; *Society and Puritanism in Pre-Revolutionary England* (Secker and Warburg, 1963).