Jnanadeepa

Pune Journal of Religious Studies
ISSN 2249-1503
www.punejournal.in

DOI: 10.5281/zenodo. 4264141

Stable URL: http://doi.org/10.5281/zenodo. 4264141

Science and Priestly Formation: Historical Roots and Current Necessity

Job Kozhamthadam SJ

Abstract: It is no exaggeration to say that an institution can be expected to be as good as its leaders are, especially when it comes to a comparatively well-organized one like the Catholic Church. From the same line of logic it follows that the leaders can be only as good as the formation they receive since even a talented person with a low quality formation can turn out to be a poor leader, whereas, given a high quality formation, even a mediocre person can make a competent leader. Hence the paramount importance well-run organizations attach to the formation of their young members. No investment, however high, is ever deemed superfluous when it comes to the formation of the new entrants. Although the concept 'formation,' being very general and comprehensive, resists any attempt at a precise definition, a basic minimum expectation from a carefully-planned and well-executed formation programme seems to be the moulding of mature and integrated persons capable of responding creatively and responsibly to the legitimate yearnings of the human person, both for oneself and for other fellow humans. Obviously, these yearnings are complex and multi-faceted, comprising the spiritual, physical, psychological, social, etc., dimensions. Any programme should be geared to the development of the talents of the individual persons without compromising the common good of the organization. A good programme should provide the trainees with both formation and information. It should also keep in view the present and future needs, the immediate as well as the remote demands, both at the individual and organizational levels.

Christ. Keywords: Church, Church and science, Priestly formation, Formation and information

Cited as:

Kozhamthadam, Job. (2001). Science and Priestly Formation: Historical Roots and Current Necessity (Version 1.0). Jnanadeepa: Pune Journal of Religious Studies, January 2001 (4/1), 123-148. http://doi.org/10.5281/zenodo. 4264141

2001-01-02 | Updated on Nov 10, 2020

JPJRS 4/1 (2001) 123-147

Science and Priestly Formation
Historical Roots and Current Necessity

Job Kozhamthadam SJ
Dept of Systematic Philosophy, JDV, Pune 411014

It is no exaggeration to say that an institution can be expected to be as good as its leaders are, especially when it comes to a comparatively well-organized one like the Catholic Church. From the same line of logic it follows that the leaders can be only as good as the formation they receive since even a talented person with a low quality formation can turn out to be a poor leader, whereas, given a high quality formation, even a mediocre person can make a competent leader. Hence the paramount importance well-run organizations attach to the formation of their young members. No investment, however high, is ever deemed superfluous when it comes to the formation of the new entrants.

Although the concept 'formation,' being very general and comprehensive, resists any attempt at a precise definition, a basic minimum expectation from a carefully-planned and well-executed formation programme seems to be the moulding of mature and integrated persons capable of responding creatively and responsibly to the legitimate yearnings of the human person, both for oneself and for other fellow humans. Obviously, these yearnings are complex and multi-faceted, comprising the spiritual, physical, psychological, social, etc., dimensions. Any programme should be geared to the development of the talents of the individual persons without compromising the common good of the organization. A good programme should provide the trainees with both formation and information. It should also keep in view the present and future needs, the immediate as well as the remote demands, both at the individual and organizational levels.

Any well-planned programme of formation should remain sensitive to two aspects: continuity and context, continuity with the past history and well-established traditions of the organization and openness to its current needs and aspirations. An organization that remains blind to its past is heading into a blind alley; an organization that remains deaf to the cries of the day is doomed to the death of irrelevance. This paper is a modest attempt to study certain aspects of the formation of the leaders of the Catholic Church, particularly the role of scientific studies in their formation. Are scientific studies important for a leader of the Church today? If so, what place should they be accorded in the formation programme of priests and

The author may be contacted at: De Nobili College, Ramwadi, Nagar Road, Pune-411014, India, <denobili@pn2.vsnl.net.in>.

religious? I propose to approach this topic from two perspectives: of continuity and of context, from the perspective of a long-standing tradition of the Church and from that of the current conditions she is in. I will argue that from both these perspectives it follows that familiarity with and genuine appreciation of the developments in science and technology are necessary for priests and religious destined to be leaders of their communities.

I. Science and the Catholic Clergy: A Historical Overview

Historically, the Church's attitude towards science has been a mixture of opposition and support, discouragement and encouragement, isolation and involvement. This section discusses a few episodes of this engagement between the Church and science.

1. Some Discouraging Voices

Although an active interest in the sciences of the day was kept alive at all periods of history, there were leaders and thinkers who underestimated the role of science and scientific inquiry. For instance, the well-celebrated scholar in the early Church Tertullian wrote:

> Now, pray tell me, what wisdom is there in this hankering after conjectural speculations? What proof is afforded to us, notwithstanding the strong confidence of its assertions, by the useless affectation of a scrupulous curiosity, which is tricked out with an artful show of language? It therefore served Thales of Miletus quite right, when, star-gazing as he walked with all the eyes he had, he had the mortification of falling into a well.... His fall, therefore, is a figurative picture of the philosophers; of those, I mean, who persist in applying their studies to a vain purpose, since they indulge a stupid curiosity on natural objects, which they ought rather [to direct intelligently] to their Creator and Governor.[1]

It may be noted that Thales is considered the main founder of Greek (Western) science. The anecdote presented here is indicative of the antipathy Tertullian entertained towards the scientist's work. For him observing the positions and motions of stars was indulging in stupid curiosities!

St. Augustine, the great Father and Doctor of the Church, too, at times displayed a similar attitude, as was evident from his statement:

> When it is asked what we ought to believe in matters of religion, the answer is not to be sought in the exploration of the nature of things, after the manner of those whom the Greeks called 'physicists.' Nor should we be dismayed if Christians are ignorant about the properties and the number of the basic elements of nature, or about the motion, order and deviations of the stars, the map of the heavens, the kinds and nature of animals, plants, stones, springs, rivers, and mountains; about the divisions of space and time, about the signs of impending storms, and the myriad other things which these 'physicists' have come to understand, or think they have.... For the Christian, it is enough to believe that the cause of all created things, whether in heaven or on earth, whether visible or invisible, is nothing other than the goodness of the Creator, who is the one and the true God.[2]

Judging from this passage it is quite clear that St. Augustine was no

patron of the sciences. There were others too with similar negative views.

It is well-documented that many Church leaders opposed Galileo's discoveries and scientific ideas. It is said that some of them refused to look through Galileo's telescope believing that it was a device of the devil. In the nineteenth century, Cardinal Manning of England, reacting against Darwin's theory of evolution, declared it 'a brutal philosophy' since it holds that "there is no God, and the ape is our Adam."[3] The travails and sufferings Teilhard de Chardin had to undergo because of his pioneering efforts to christianize the theory of evolution are all too well known to be discussed here.

This kind of view and attitude seem to have given rise to what is sometimes called the Draper-White thesis, according to which the Church persistently discouraged scientific investigation, and remained a major obstacle to the growth of science.[4] However, recent research is unearthing more and more evidence to show that this was very much a one-sided and exaggerated view. In particular, such a view betrays a naive perception of the complexity involved. Quite often the issues involved were far more than matters of religion and mere religious authorities. In the next section we will see that there is considerable evidence to conclude that in many ways the Church had a positive attitude towards science.

2. *Science and the Church: The Positive Engagement*

All through the centuries many clerics showed a genuine appreciation of science and the scientific attitude. It may be noted that even in the Middle Ages the monasteries in various parts of Europe became custodians of the scientific heritage, including the Greek science, especially of precious ancient manuscripts and related items. During the Middle Ages the works of Robert Grosseteste, Bishop of Lincoln, and of Roger Bacon, a Franciscan who taught at Paris and Oxford, on optics and experimental science have been well-recognized by scholars. The churchmen also played an important role in translating some of the important manuscripts of ancient science. After all, Copernicus himself was a canon of Frauenburg and very closely associated with the official Church.

Considerable evidence exists to show that the constructive association of the clergymen with science was not just one of passive appreciation but of active participation. True, hardly any one of them ever measured up to the stature of a Descartes, Kepler, or Newton, but they made substantial contribution to the origin and development of science, especially when it was in its infancy. The impressive statistics presented by several recent scholars speak for themselves, both with regard to the sheer number of scientists involved and the diversity of areas covered. Poggendorf in his *Dictionnaire de Sciences Exactes*[5] from antiquity to 1863 lists 8847 scientists. Of these 10% were priests and religious. Among these the Jesuit order occupies a preeminent place. Sommervogel's twelve volume work *Bibliotheque de la Compagnie de Jesus* gives the names and works of 631 Jesuits for the first two centuries of Jesuit history.[6] According to Dhruv Raina,

"Between the years 1600 and 1773, ... Jesuit scientists had authored more than 4,000 published works, about 600 journal articles appeared after 1700, and about 1000 manuscripts were available. The Society's known publications include 6,000 scientific works covering areas such as Aristotelian natural philosophy, medicine, philosophy, astronomy, and mathematics."[7] It is well-known that many of Galileo's vocal and loyal supporters like Cardinal Dini were highly-placed ecclesiastics. Some of the scientific activities the churchmen engaged in were highly impressive. The fact that these persons received active support and positive encouragement from the Church was a clear indication that she was no mere distant admirer of the great scientific adventure unfolding before her.

3. *Institutional Involvement: The Jesuits*

The Jesuits participated in the excitement of the scientific revolution in a remarkable way. They rendered all-round service to science, particularly in its infancy. According to Ashworth, the Jesuit order "stands out from all others as the scientific order without rival in seventeenth-century Catholicism."[8] John Heilbron says that the Jesuit order was the "single most important contributor to experimental physics in the seventeenth century."[9] The world-renowned historian of science George Sarton has put it most beautifully: "One cannot talk about mathematics in the 16th and 17th centuries without seeing a Jesuit at every corner."[10] Ashworth points out that they "were interested in every newly discovered phenomenon, from electrostatic attraction to the barometer to the magic lantern, and the Jesuits played a major role in discovering many new effects on their own as diffraction and electrical repulsion."[11] As was mentioned earlier, of the 8847 savants in Poggendorf's list a little more than 10% were Catholic clergymen. Of these about 45% were Jesuits. In other words, of all the noteworthy scientists from antiquity to the year 1863, about 5% were from the ranks of the Jesuit order – an impressive record indeed.

The Jesuits not only participated in the creation and development of scientific ideas but also in their dissemination to other countries and peoples. For instance, they were the first to confirm Galileo's telescopic discoveries. Galileo published them in his *Starry Messenger* in 1610. Within five years the Jesuit missionaries in Peking gave an account of these historic discoveries.

The Jesuit interest in science had its origin in the inspiration of its founder St. Ignatius himself. A positive attitude to the material universe was fundamental to his spirituality and worldview. Watching the stars and contemplating their beauty and majesty was a regular routine for him, as he wrote in his *Autobiography*: "His (St. Ignatius's) greatest consolation was to look at the starry heavens. He contemplated them often and for long periods of time, because from it there was born inside of him an extremely strong impulse to serve Our Lord." Ignatius who pioneered the reorganization of the formation of Catholic clergy was noted for his rare foresight and vision. He always emphasized

the importance of scientific ideas and scientific worldview in the life of the leaders of the Church. Even before he gave the final shape to *The Constitutions of the Society of Jesus,* he prepared a set of regulations in 1546 to guide the young Jesuit scholastics studying in Padua, according to which they were to study logic, natural philsophy, metaphysics, mathematics, and moral philosophy before their theological studies. It was even specified in the same document that "during this course of studies the scholastics were to have no book of theology in their rooms, lest they be tempted to distractions and suffer the same fate as Ignatius in Alcala."[12] Serious study of the sciences of the day was prescribed as an integral part of the curriculum of the Jesuit scholastics.

Later on when the *Constitutions* were finalized, study of the natural sciences and mathematics was presented among the items to be taught in the universities of the Jesuits.[13] Furthermore, when the *Ratio Studiorum* was officially promulgated in 1599, science and related topics were prescribed as part of the regular philosophy programme. It is true that the natural philosophy[14] and related topics studied by the Jesuit students in those days were basically Aristotelian, modified by a strong emphasis on mathematics and the mathematically based sciences such as astronomy and optics.[15] Obviously, what they studied was not the latest in science, but the fact remains that what was considered to be science in most academic circles of the day found a place in the formation programme of the Jesuits.

3.1 The Collegio Romano

The *Collegio Romano* which opened its gate in February 23, 1551, was unanimously considered as the flagship not only of Jesuit education but also, in some significant ways, of Catholic education in Europe for many years. It played a major role in the development and dissemination of science and the scientific spirit. It could count among its faculty members several outstanding scientists.

It may be noted that Galileo was closely associated with the *Collegio Romano* and its professors for a long time, particularly in the early years of his career. As William Wallace has pointed out, several of his early scientific ideas he got during his student days at the *Collegio.*[16] The Jesuits had a very warm and cordial relationship with Galileo in the years before his condemnation in 1633.

Not only the Jesuit scientists of the day but even some of the Jesuit theologians also had imbibed the spirit of the scientific revolution, particularly in the early part of the seventeenth century. The Spanish Jesuit theologian Benito Pereyra, who died in 1610, wrote this remarkable passage concerning the attitude one should have towarrds scriptural interpretation: "In dealing with the doctrine of Moses we must be careful to avoid saying confidently and without reservation anything which contradicts manifest experiences and the reasonings of natural philosophy or the other sciences. Since every truth is in harmony with all other truth, the truth of holy writ cannot be opposed to the solid reasons and findings of human knowledge."[17]

Unfortunately, the promising Jesuit participation in the scientific revolution gradually lost its vitality and creativity. As Richard Blackwell remarks, from the time of the decree of 1616 onwards "the character of discourse about astronomy among the Jesuit scientists underwent a gradual but distinctive evolution toward rigidity."[18] "With the notable exception of some isolated scientists of the first rank (e.g., Roger Boscovich and Girolamo Saccheri in the eighteenth century), Jesuit science was never to regain the promise it exhibited in the period from Clavius to Scheiner."[19] The reasons for this regressive trend were many, and have been discussed elsewhere.[20]

This regressive turn did not lead to a cessation of Jesuit science. Many Jesuits continued to do science, but, to a considerable extent, they were isolated from the mainstream science, and most of them failed to be part of the exciting revolution that was sweeping many parts of Europe. Had it not been for this unfortunate turn of events, the history of Jesuit participation in the scientific revolution would have been very different.

3.2 Jesuit Scientists in India

Jesuit science continued to make its mark in various parts of the world. Several Jesuits from Europe who came to India made important contributions to the development of science in India. According to Raymond Mercier, the Jesuit scientists' "geographical observations in particular were fundamental in effecting the revolution in the accuracy of longitudes."[21] They made substantial contributions to Indian geography and astronomy by determining the longitudes and latitudes of many major cities and towns, by constructing reliable maps of the country, by observing accurately many important celestial phenomena, by studying ancient Sanskrit texts on astronomy and science, etc. Some notable names were Anthony Monserrate (1536-1600), Anthony Rubino (1578-1643, J. Richaud (1633-1693), Jean-Venant Bouchet (1655-1732), Claude Stanislaus Boudier (1686-1757), and Joseph Tieffenthaler (1710-1785).

Perhaps the most notable instance of Jesuit contribution to the development of science in India in the eighteenth century was their collaboration with Sawai Jai Singh, the statesman astronomer, who made a valiant and all-out attempt to inject new life into astronomy in India in order to bring it on a par with Western astronomy. He most enthusiastically sought the assistance of Jesuit scientists from Europe, and extended to them the best of Indian hospitality, making sure that they got all the facilities they needed. Several Jesuits like Francois Pons, Claude Boudier, Anthony Gabelsberger, and Andrew Strobl collaborated with Jai Singh.

Despite certain limitations, the collaboration had good results. Jai Singh was so pleased with the Fathers that he chalked out extensive plans for more comprehensive collaboration with the Jesuits. However, it must be admitted that the science they transmitted remained very much amateurish and mediocre, compared to what was available in Europe at that time. Still very much

imprisoned in the Aristotelian-Ptolemaic world view, their science failed to participate significantly in the scientific revolution afoot in contemporary Europe.

3.3 Jesuit Science in China

Another country which benefited from the Jesuit expertise and enthusiasm in science was China. Matteo Ricci (1552-1610) occupies a unique place in the history of Jesuit science in China, not only for inaugurating the Jesuit scientific collaboration there, but also for his own outstanding contribution, for his prophetic vision and for his deep sense of mission. Some other outstanding Jesuit contributors to the development of science in China were Wenceslaus Pantaleon Kirwitzer, John Schreck or Terrentius (1576-1630), John Adam Schall von Bell (1591-1666), Ferdinand Verbiest (1623-1688) and Antoine Gaubil (1689-1759). Thanks to the outstanding efforts of these talented band of Jesuits, in some respects astronomy in China at this time reached a level comparable with the best in the world.

3.4 The Vatican Observatory

The Vatican Observatory (*Specola Vaticana)*, founded[22] in 1891 by Pope Leo XIII, is undoubtedly a living testimony to the high regard and importance the Church attaches to science and scientific research. In his refounding document *Motu Proprio, Ut Mysticam,* the Pontiff clarified the objective of the observatory: "That every one might see clearly that the Church and her Pastors are not opposed to true and solid science, whether human or divine, but that they embrace it, encourage it, and promote it with the fullest possible dedication."[23] The Pontiff makes it very clear that the Church has a tradition of encouraging science: "In the meantime, the Church has not neglected those disciplines which investigate nature and its forces. Schools and museums have been founded so that young scholars might have a better opportunity to deepen those studies. Among the Church's children and ministers there are some illustrious scientists whom the Church has honoured and assisted as much as she could by encouraging them to apply themselves with complete dedication to such studies."[24]

Before Pope Leo XIII many others too took a keen interest in the progress of science.[25] Even religious sisters contributed their share to scientific development, by carrying out the boring, tedious, but vitally important task of making accurate measurements and carefully collecting important data. In the history of the Vatican Observatory, it is recorded that in 1910 the director of the observatory, Fr. Johan Hagen, S.J., sought the help of the Sisters of the Institute of the Child Mary of St. Bartholomew Capitano. Promptly responding to this appeal, three sisters worked from 1910 to 1921 to complete the colossal task of the Astrographic Catalogue. They rendered valuable service in the measurement of the plates of the Astrographic Catalogue with the Repsold micrometer. All these historical data go to show that the interest the Church took in and the encouragement it extended to scientific study and re-

search were confined neither to a particular group nor to a limited time.

II. Some Recent Developments in the Catholic Church

A major characteristic of a good programme of formation is its ability to sensitize the students to the concrete context they are in, and to equip them to respond to the opportunities and challenges offered by the times. With regard to our topic of the role of science in the formation of the leaders of the Church in India, this context involves a number of important factors, mainly the recent developments in the Church, the recent developments in science, and the current conditions in India.

1. Vatican II

The Second Vatican Council was undoubtedly the most important event in the history of the Catholic Church in the twentieth century. It not only opened the windows of the Church so that much-needed fresh air could blow into it, but also made it possible for scholars and non-scholars alike to refresh themselves in an atmosphere of openness to new ideas, of sensitivity to the complex conditions of the contemporary world, of sympathetic understanding towards dissonant views, and of daringness to venture into unexplored areas. Many of its ideas and insights are yet to be fully explored, and, still more, to be effectively implemented. This is particularly true of its statements and pronouncements on science & technology, and the challenges and opportunities offered by these new developments. Some may arguably point out that a comprehensive programme of aggiornamento would have expected a separate document on the importance and impact of science & technology. Although this did not happen, the Council, through its insightful statements and judicious recommendations, scattered in various documents, proclaims eloquently that it is sensitive to the amazing advances in this area and serious about how they impinge on the life and activities of the Church.

1.1 Appreciation of the Achievements of Science

Gone are the alleged stormy days of "Draper-White warfare." Instead the refreshing breeze of dialogue and collaboration is blowing in, thanks to a positive attitude towards science and its achievements. According to Vatican II, far from being the devious devices of the devil, they are a boon to humanity, ordained by divine dispensation. "By divine favour, especially in modern times, human genius has produced from natural material astonishing inventions in the field of technology." "As a Mother," the document continues, "the Church welcomes and watches such inventions with special concern.... Mother Church, to be sure, recognizes that if these instruments are rightly used they bring solid nourishment to the human race."[26] In a way, science is a powerful affirmation of human dignity and greatness, and provides humans with a most effective means to collaborate with the Creator in the ongoing plan of creation.[27]

A prudential, judicious engagement in science can elevate humans to a higher and more sublime level of

moral and intellectual life. "Furthermore, when a man applies himself to the various disciplines of philosophy, of history, and of mathematical and natural science, and when he cultivates the arts, he can do very much to elevate the human family to a more sublime understanding of truth, goodness, and beauty, and to the formation of judgements which embody universal values."[28]

1.2 Science As a Means to Meet the Challenges

Continuing its positive attitude, the Council further says that science and technology provide us with the best means to respond to the challenges and exigencies of our contemporary world. After a penetrating and perceptive analysis of the various ferments in the air today and the accompanying restlessness and aimlessness, it rightly points out that "today's spiritual agitation and the changing conditions of life are part of a broader and deeper revolution." In its attempt to spell out the far reaching consequences of this revolution, it admits that the conditions of the world are changing profoundly. For one thing, the traditional base of intellectual formation is getting changed. Today intellectual formation is "ever increasingly based on the mathematical and natural science and on those dealing with man himself, while in the practical order the technology which stems from these sciences takes on mounting importance."[29] The technological revolution afoot in our world is transforming the face of the earth. The sweeping wave of the new scientific spirit is reshaping both our cultural sphere and mode of thought. Not only the physical sciences, but the social and life sciences also are affecting our world profoundly.[30] Another salutary outcome of this revolution principally triggered by developments in science & technology is the shift from an individual or person-centred worldview to a community-centred one. "The destiny of the human community has become all of a piece, where once the various groups of men had a kind of private history of their own."[31] The overall outcome of these revolutionary changes is that the old static worldview has given way to a dynamic one, with drastic consequences.[32]

In this new world naturally a new series of problems has arisen, "a series as important as can be, calling for new efforts of analysis and synthesis."[33] The Council believes that in tackling these problems a new approach using new techniques is needed, and here the findings of science & technology should play an active role.

1.3 The Pastoral Dimension of Science

The Council readily acknowledges and appreciates the positive values accruing from the scientific spirit. They are:

> Scientific study and strict fidelity toward truth in scientific research, the necessity of working together with others in technical groups, a sense of international solidarity, an ever clearer awareness of the responsibility of experts to aid men and even to protect them, the desire to make the conditions of life more favourable for all, especially for those who are deprived of the opportunity to exercise responsibility or who are culturally poor.[34]

From these considerations flow the apostolic dimension of science & technology because the values mentioned above can prepare the ground for sowing the seeds of the gospel. "All these values can provide some preparation for the acceptance of the message of the gospel – a preparation which can be animated with divine love by Him who came to save the world."[35]

In pastoral care, too, science and its findings can be beneficial. "In pastoral care, appropriate use must be made not only of theological principles, but also of the findings of the secular sciences, especially of psychology and sociology. Thus the faithful can be brought to live the faith in a more thorough and mature way."[36]

1.4 The Autonomy of the Sciences Upheld

The Council takes special pains to acknowledge and uphold the rightful autonomy of the sciences.[37] Nor is it ashamed to admit its past lapses. It accepts that this principle of independence was not always preserved in the past and deplores the mistakes committed.[38] At the same time, the Council is quick to point out that it does not endorse the false sense of independence, which "is taken to mean that created things do not depend on God, and that man can use them without any reference to their Creator...."[39]

Some of the excesses and consequent dangers the scientific spirit can lead to have not escaped the Council.[40] For instance, at times a belittling of religious beliefs, an agnosticism towards matters of religious life, etc. are looked upon as "requirements of scientific progress or of a certain new humanism."[41] But the document goes on to say that "these unfortunate results, however, do not necessarily follow from the culture of today, nor should they lead us into the temptation of not acknowledging its positive values."[42]

1.5 The Impact of Science on Theology

The Council is of the opinion that theology is an important beneficiary from these scientific developments because they can "stimulate the mind to a more accurate and penetrating grasp of the faith. For recent studies and findings of science, history, and philosophy raise new question which influence life and demand new theological investigations."[43] Hence, the Council urges theology to be in constant touch with developments in the sciences.[44]

These developments in science and technology have significant bearings on morality as well since they put us in close association with the contemporary life situation. Hence the Council exhorts all Christians:

> May the faithful, therefore, ... blend modern science and its theories with Christian morality and doctrine. Thus their religious practice and morality can keep pace with their scientific knowledge and with an ever-advancing technology.[45]

Having appreciated the tremendous power science wields in our world by influencing not only how we live, but also how we think, the Council advocates the teaching of scientific ideas and methods in educational institutions.

In its "Declaration on Christian Education" it takes special pains to remind all that although primary education is important and must be continued, "considerable importance is to be attached to those schools which are demanded in a particular way by modern conditions, such as so-called professional and technical schools,...."[46] The Council is even more direct and emphatic when it says: "Since the sciences progress chiefly through special investigations of advanced scientific significance, Catholic colleges and universities and their faculties should give the maximum support to institutes which primarily serve the progress of scientific research."[47]

From what has been said already, the conclusion follows naturally that the Council wants the imparting of the scientific spirit to be made an integral part of priestly formation. This point is made explicit in the "Decree on Priestly Formation," particularly when it talks about the teaching of philosophy. "Philosophy should be taught in such a way that students will be led to acquire a solid and coherent understanding of man, of the world, and of God. Basing themselves on a philosophic heritage which is perennially valid, students should also be conversant with contemporary philosophical investigations, especially those exercising special influence in their own country, and with recent scientific progress."[48]

2. *John Paul II*

In an insightful and timely message Pope John Paul II has expressed his deep appreciation of the power science wields and the need we have for mastering science to derive the maximum benefit for the good of humanity. Written in the form of a letter to Fr. George V. Coyne, S.J., the Director of Vatican Observatory, on June 1, 1988, it not only underscores the positive attitude towards science, but also breaks important new ground for active and productive collaboration between science and theology. It may arguably be considered a foundational document of the Catholic Church for collaboration between science and religion.

2.1 A Call for Constructive Dialogue

This document is a clarion-call to science and religion for uniting their efforts in a dynamic and mutually respectful interchange. "A divided community fosters a fragmented vision of the world," it says, whereas "a community of interchange encourages its members to expand their partial perspectives and form a new unified vision."[49] Indeed, the Pontiff unhesitatingly declares, "We need each other to be what we must be, what we are called to be."[50] This is so because science and religion are the most powerful forces in the world, wielding tremendous influence, having a great tradition, and shouldering heavy responsibilities. "We (the Church and the Pontifical Academy of Sciences, representing science in this context) bear before God enormous responsibilities for the human condition because historically we have had and continue to have a major influence on the development of ideas and values and on the course of human action."[51]

The Pope is highly optimistic that such a constructive dialogue is possible because both science and religion deep down share similar goals and aspirations. Science, for instance, despite the innumerable multiplicity of physical phenomena, reveals a powerful drive towards convergence, a drive most conspicuously expressed in its search for GUTs (Grand Unified Theories) and TOEs (Theory of Everything). In the Christian religion, too, a similar trend towards mutual understanding and greater unity is gathering momentum, particularly in recent times.

The interaction envisaged consists in a "common search based on critical openness and interchange."[52] It is an interaction in which each discipline should continue to enrich, nourish and challenge the other to be more fully what it can be and to continue to contribute to our vision of who we are and who we are becoming."[53] At the same time the Pontiff warns against all excesses and all attempts at compromising the independence and autonomy of each discipline.[54]

The Pope makes a few extremely important concrete suggestions to those engaged in theological study and reflection. Since theology, as understood traditionally, is *fides quaerens intellectum* (faith in its effort to attain understanding), "it must be in vital interchange today with science just as it always has been with philosophy and other forms of learning. Theology will have to call on the findings of science to one degree or another as it pursues its primary concern for the human person, the reaches of freedom, the possibilities of Christian community, the nature of belief and the intelligibility of nature and history."[55] Indeed, this ability to critically and fruitfully dialogue with contemporary science is the touchstone of theology's vitality: "The vitality and significance of theology for humanity will in a profound way be reflected in its ability to incorporate these findings [of contemporary science]."[56] It seems to me that these statements are of paramount importance for us today, since they seem to say that in the past philosophy provided theology with data and methodology for theologizing, but today the sciences should take an active role in supplying theology with both data and methodology. If my interpretation is in the right direction, then the Pope is assigning to science a central role in the process of theologizing. Obviously, here also, as everywhere else, prudence and discretion are necessary. "Theologians must understand them (i.e., scientific findings) and test their value in bringing out from Christian belief some of the possibilities which have not yet been realized."[57]

The suggestion above is well in keeping with the great tradition of the Church, the paradigm case being the great work of St. Thomas in the thirteenth century when he masterfully integrated the Christian faith with Aristotelian natural philosophy. Today the Pontiff places this challenge before the theologians: "Theologians might well ask, with respect to contemporary science, philosophy and the other areas of human knowing, if they have accomplished this extraordinarily difficult process as well as did these medieval masters."[58] He does not hesitate to point out the sad fact that the required sort of intense dialogue with contemporary sci-

ence has, on the whole, been lacking among those engaged in theological research and teaching.[59]

The Pope makes an ardent plea to theologians and those engaged in similar activities to make a serious and sincere effort to keep themselves abreast with the developments in science. According to him:

> some theologians, at least, should be sufficiently well-versed in the sciences to make authentic and creative use of the resources that the best-established theories may offer them. Such an expertise would prevent them from making uncritical and overhasty use for apologetic purposes of such recent theories as that of the "Big Bang" in cosmology. Yet it would equally keep them from discounting altogether the potential relevance of such theories to the deepening of understanding in traditional areas of theological inquiry.[60]

According to the Holy Father, "only a dynamic relationship between theology and science can reveal those limits which support the integrity of either discipline, so that theology does not profess a pseudo-science and science does not become unconscious theology."[61]

What has been said is no mere speculation but is something that calls for urgent action. "The matter is urgent. Contemporary developments in science challenge theology far more deeply than did the introduction of Aristotle into Western Europe in the thirteenth century. Yet these developments also offer to theology a potentially important resource."[62]

It should not be thought that this interaction is just a one way process to help theology only. Science too stands to profit from it, because "science develops best when its concepts and conclusions are integrated into the broader human culture and its concerns for ultimate meaning and value."[63] Indeed this dialogue is a mutually enriching process. "Science can purify religion from error and superstition; religion can purify science from idolatry and false absolutes. Each can draw the other into a wider world, a world in which both can flourish."[64]

2.2 *Challenges from Science*

Fides et Ratio, the most recent encyclical of Pope John Paul II, is an important document on priestly formation because it underscores the prime importance the official Church attaches to the study of philosophy. As the very title of the letter indicates, the whole encyclical attempts to show the close relationship between faith and reason.[65]

Since the main focus of this encyclical is philosophy, it touches on science only occasionally. The encyclical is fully aware of the power and importance of science in our society today. It is aware of the extraordinary advances of the sciences in recent times, stirring the admiration of all.[66] In fact, "so far has science come, especially in this century, that its achievements never cease to amaze us." He calls scientists "the brave pioneers ... to whom humanity owes so much of its current development ... whose research offers an ever greater knowledge of the universe as a whole and of the incredibly rich array of its component parts, animate and inani-

mate, with their complex atomic and molecular structures."[67]

However, in this letter most of his statements on science seem to point out some of the dangers science can lead to. According to him, developments in certain types and aspects of science have led to relativism and agnosticism.[68] A sad consequence of this turn of events is that the importance of reason has been seriously undermined. Reason has "lost its capacity to lift its gaze to the heights, not daring to rise to the truth of being."[69]

Modern science, for the most part, has given up its search for absolute certitude, and settled for statistical or probabilistic knowledge. Many would like to extend this finding to all forms of knowledge, including metaphysical knowledge. The Pope rejects this view as pessimistic and unfounded. In his view, deep down all have a "desire to reach the certitude of truth and the certitude of its absolute values."[70] Hence, provisional knowledge, lacking certainty, leaves them unsatisfied and unhappy. "Hypotheses may fascinate, but they do not satisfy."[71]

Certain developments in science gave rise to a positivistic attitude "which not only abandoned the Christian vision of the world, but more especially rejected every appeal to a metaphysical or moral vision." Consequently, "certain scientists, lacking any ethical point of reference, are in danger of putting at the centre of their concerns something other than the human person and the entirety of the person's life. Further still, some of these, sensing the opportunities of technological progress, seem to succumb not only to a market-based logic, but also to the temptation of a quasi-divine power over nature and even over the human being."[72]

This letter too highlights the importance of science in the modern world. It also subscribes to the view that familiarity with it is necessary for anyone responsible for leading and guiding the society of today.

2.3 Need for Integration: Jesuit General Congregations on Science

The Jesuits have continued both their traditional interest in science and their usual sensitivity to the challenges and opportunities offered by it. This is well borne out in the decrees of the recent General Congregations (GC), especially GC 31, GC 32, and GC 34. It is quite clear that the Jesuit society considers science one of the most potent influences in our world today, and asks its members to respond responsibly to the new vistas opened up by science.

GC 31, which followed the footsteps of Vatican II and drew much inspiration from it, has taken special pains to highlight the importance and relevance of science, as is evident in its statements: "Scientific and technological advancement is a major factor in our times. The positive sciences exert an ever increasing influence on the mentality of men and on the very structure of our daily lives."[73] This would entail special training for those destined to work in this field. The Congregation clearly states: "In fact, the Society should have men with doctoral decrees

who become truly eminent in these fields."[74] It considers the field of science and technology an area "laudably carried on by our Society,"[75] and hence needs immediate attention.

In its Fourth Decree "Our Mission Today," GC 32 presents a brief description of some of the major changes brought about by developments in science and technology. According to it:

> The second decisive factor for our preaching of Jesus Christ and his Gospel is this: the new opportunities – and problems – disclosed in our time by the discoveries of technology and the human sciences. They have introduced a relativism, often of a very radical kind, into the picture of man and the world to which we were accustomed, with the result that the traditional perspectives have altered almost beyond recognition. Changes of this kind in the mind-sets and structures of society inevitably produce strong repercussions in our lives as individuals and as members of society. As a result, there has been a gradual erosion of traditional values, and gradual diminution of reliance on the power of traditional symbols. New aspirations arise which seek to express themselves in the planning and implementation of practical programmes.[76]

Reading the signs of the times would involve recognizing these new aspirations and identifying appropriate responses to them. A good familiarity with the scientific spirit is a prerequisite to do this. Hence GC 32 adds: "A solid education should also be fostered in literature, the arts, sciences, history, and the various aspects of the culture of the region where the apostolate will be carried on."[77]

GC 34 emphasizes the need for relating Catholic theology "to the secular disciplines, especially philosophy and social and natural sciences, in order to discern, illuminate, and interpret the opportunities and problems of contemporary life."[78] Finally, the Congregation makes an earnest plea for respecting intellectual freedom and the legitimate autonomy of various secular disciplines, particularly the sciences. It warns that "for those with faith to deny 'rightful autonomy of science' can lead to tragedies well-known in the history of recent centuries. We who have learned to pray before the 'Eternal Lord of all things,' must, therefore, be especially careful to avoid the same mistakes under new forms."[79] The main thrust of all these official decrees of the recent GCs is self-evident: the Society of Jesus is acutely aware of the extreme importance of science and technology in our day, and exhorts its members to keep themselves abreast with the developments in this field. It extends wholehearted support and encouragement for those engaged in this ministry.

III. Some Key Issues

The twenty-first century is bound to be a scientific century, a century dominated by science and technology. Science will play a crucial role in determining not only how we live, but also how long we will live, not only how we think, but also what we think. In a way science may decide what we live for since it will have a say in determining our value system. Auspicious as well as ominous projections have been made about the future of our world in the face

of the explosive developments in contemporary science. According to Michio Kaku, "the Age of Discovery in Science will give way to the Age of Mastery in the twenty-first century."[80] On the other hand, experts like Bill Joy, chief scientist of Sun Microsystems, point out the formidable dangers that can arise from the possible accidents and misuse of these powerful scientific developments.[81]

According to Kaku, the floods of scientific eruption will hit us through three channels: the quantum revolution, producing new sources of energy, the computer revolution, producing artificial intelligence capable of even outsmarting humans, bio-molecular revolution, allowing the manipulation of life almost at will. It seems to me that this explosive growth of science will place in the hands of humans almost unlimited knowledge, almost unlimited power, almost unlimited control over nature, and almost unlimited scope for expansion.

1. Cosmology

Cosmology, which used to be very much a field of pure speculation, has become an exciting field of research and study, right at the cutting edge of present-day physics. New ideas, new theories, new books, and research papers are flooding the scientific world. Thanks to the detailed information revealed by these studies, we are able to wonder at the vastness, majesty, and grandeur of our universe. The number of stars in our universe is staggering indeed. And when we know that our sun is just one ordinary star among almost innumerable others, we feel being reduced to utter insignificance. Are we alone in this universe? Is there any reason why God should create intelligent humans only on this tiny planet? If there are intelligent beings on other planets, what kind of salvation/redemption history do they have? The religious and theological significance of these and similar questions is self-evident.

Concerning the origin and end of the universe too science has a lot to contribute. The Big Bang theory[82], originally proposed by the Belgian priest-scientist Georges Lemaître, and the heat-death theory[83] have interesting insights and intriguing questions for theology to reflect upon. Many interesting points can be mentioned about the Big Bang. For instance, as I have pointed out elsewhere, this theory at best tells us not about any "creation out of nothing," but of a process of "transformation of the initial stuff."[84] William Stoeger of Vatican Observatory remarks that the Big Bang "could not have been just a single event or geometric point – rather it had to be a whole manifold, or three-dimensional spatial surface, of events or geometric points."[85] Commenting on its claim as a theory of cosmogony, he continues: "The Big Bang, however we describe it within the framework of cosmology, should not be considered as a beginning either of the universe or of time in any specific or definite sense, much less of creation in the theological sense of that word. Rather, it underscores the fact that our universe at one time was very, very different from now – and was once dominated by such extreme conditions that none of the categories we now rely upon

to describe physical reality would have been applicable."[86]

Perhaps the most significant and potentially most powerful challenge to religion from cosmology came from Stephen Hawking's "no-boundary theory," which claims to show that there was no creation, and hence the creator becomes superfluous. This and similar theories should alert the theological world on the need to familiarize themselves with the important breakthroughs in cosmology.

2. *The Theory of Evolution*

The theory of evolution poses a most formidable challenge to traditional theology and religious views since it challenges not only certain claims but also the very worldview on which they are founded. In addition to challenging a literal understanding of the biblical passages of creation, it exposes the bankruptcy of a static worldview and urges the need for a dynamic worldview.

Today the Catholic Church is showing a certain openness to this theory. Gone are the days of cheering the Anglican bishop Samuel Wilberforce of Oxford, who championed the traditional creationist view against Darwin. Gone too are the days of silencing Teilhard de Chardin and his supporters for their heroic efforts at christianizing the evolutionary perspective. Recent Popes, particularly Pius XII and John Paul II, have shown openness to this perspective. The influence of Teilhard and his evolutionary worldview on Vatican II is clearly visible in the "Pastoral constitution on the Church in the Modern World." Indeed, the document goes on to say: "The human race has passed from a rather static concept of reality to a more dynamic, evolutionary one."[87] Furthermore, in his message to the Pontifical Academy of Sciences, on October 23, 1996, Pope John Paul II said that "it is now possible to recognize that the theory of evolution is more than a hypothesis."[88]

The theory of evolution is gaining more and more fresh evidence, thanks to the astonishing growth of genetics and related areas; the evolutionary perspective is sweeping practically all fields of knowledge. It seems to me that the evidence in favour of the evolutionary perspective is becoming more and more convincing, and so theologians and other thinkers can no longer hold out against it. Once more, the need for updating oneself in the scientific developments taking place all around is self-evident.

3. *Artificial Intelligence (AI)*

AI is another amazing boon of present day science. AI along with the dizzyingly fast computing power of the computers has transformed the world of information. Thanks to the invention of internet, information super highways, etc., the almost-instant creation and sharing of valuable information have become easily accessible to almost anyone.

AI poses a very serious challenge to long-established religious views, particularly to the concept of spirituality and the soul. One of the principal theses of AI is that the human brain is nothing but a super-programmemed super-

computer. Since the human brain and mind are intrinsically linked, the human mind also should be considered a super-computer. If this is accepted, then the mind gets reduced to a material reality. Since the human mind and human soul are intimately related, the soul too becomes a material reality, albeit an extremely complex and highly sophisticated one. Obviously, if the AI thesis is established, all talk about spirituality and the soul becomes a matter of the ignorant past.

AI will have other challenges too. Many scholars are optimistic about a computer revolution which will "incorporate intelligence into all of our artifacts as desired, and permit the creation of artificial intelligences which will be comparable to or beyond the human brain capabilities."[89] The power of computers will increase exponentially. Nanotechnology using super-chips will be able to build micro-fine machines which, when placed inside sophisticated robots, will have unimaginable capabilities, exceeding even those of humans. How will these and related developments affect humans and their society? Who will guide and supervise these beings of super-capabilities? All these are questions which go beyond the domain of pure scientists, and so religious leaders and others will have a say on the matter. Any twenty-first century leader will have to be informed about the basics of this field. Priests and other religious leaders cannot keep themselves aloof from this area.

4. The Genetic Revolution

The first several decades of the twentieth century were noted for startling breakthroughs in physics. However, during the last few decades the central stage shifted to biology, particularly to genetics. It is expected that researches in genetics will dominate the scientific world in the coming decades. Genetic engineering is already being carried out in many places. With genetic research scientific study is making a new turn: in other forms of scientific research the focus was on what humans have or want to have, but in genetic research the focus is on what humans are. Other researches involve mostly the conditions or surroundings of humans, but this one involves humans themselves. Obviously, it will have far-reaching ethical, religious, and social consequences.

The Genome Project[90] is the most talked-about research area today. Just a few weeks ago both the National Human Genome Research Institute of Bethesda, Maryland, and the Celera Genomics of Rockville, Maryland, announced the almost complete draft of the human genome. The Human Genome Project is an international venture to identify and understand our entire genome or genetic constitution. It attempts to study how the entire set of genes[91] of a human person has been arranged. Just as an anatomical study of the human body reveals how its different parts are wired, the genome sequence reveals how the 80,000 to 100,000[92] genes in a human body are organized.

The genome project is a mixed bag as far as the future of humans is concerned, since it is full of promises and risks. This opens up the possibility of easy access to a vast amount of useful information. As an editorial of the *New York Times* stated: "The prospect is that in the next few years humanity will understand – and be able to control, at least in part – the fabulously intricate mechanism through which each species of living organism transmits its essential properties to the next generation."[93] Its medical benefits are many - for understanding and curing many hitherto mysterious diseases, for rectifying many genetic defects and deficiencies, etc. Soon the entire genetic sequence of an individual could be made available on a CD. This information can be used to diagnose whether one has any one of the 5000 or more known genetically linked diseases or whether that person is prone to any one of them. This will speed up timely treatment and effective cure.

This has undesirable consequences too. This highly personal information may be used against the person concerned. Privacy and personal freedom of the individual may be in jeopardy. For some people knowledge about his/her genetic deficiency may become a source of anxiety and despair, especially when the person is too poor to meet the hefty expenses involved for genetic techniques.

5. *Genetic Engineering and Cloning*

Genetic engineering is micro-engineering at the level of genes by which genes are isolated, transferred to other cells, replicated and activated. Cloning basically is a form of genetic engineering employed for making multiple copies of a segment of DNA or gene.[94] This leads to the production of true copies of the parent organism. The cloning of Dolly in 1997 by Dr. Ian Wilmut and his team at the Scottish Roslin Institute took the world by surprise.[95] This was only the beginning. In less than a week a monkey was cloned in Oregon, USA. Similar feats were carried out in many parts of the world on different animals. In the years to come cloning will become commonplace. In 1998 two scientists of the Geron Corporation isolated pluripotent human embryonic stem cells, giving rise to the stem cell debate. Stem cells are cells capable of dividing without limit and giving rise to specialized cells. Pluripotent cells are those having the ability to give rise to many tissues of an organism.

The most logical question in this context is: first a sheep, then a monkey, why not a human being next? To preempt such a possibility many countries have already banned by law the cloning of humans. However, unofficially it is said that human cloning is right around the corner. This is not surprising since these techniques are already moving into the hands of private companies, with their own interests. For instance, the Geron Corporation of USA has already acquired Roslin Bio-Med, a commercial subsidiary of the Roslin Institute. With so many private companies in so many different countries with ideas and ideals of their own, spectres like that of an over-ambitious owner of

a basketball team placing an order with a cloning company for a dozen seven-footers, cannot be ruled out!

The ethical aspects of cloning and the production and use of stem cells are topics of heated controversy. Leaders of all religions will have to confront these issues in the days to come. Already many groups have come to the fore to articulate their views.[96]

No doubt, cloning and other techniques of genetic engineering have many beneficial results. It can rectify many genetic defects, cure many otherwise incurable diseases and disabilities, improve the quality of animals and crops. It will have many undesirable consequences as well. For instance, it will be very difficult to prevent a certain company in some country from going ahead with human cloning. Such a cloning will reduce humans to the level of mere animals, thereby bringing irreparable harm to human dignity. The sanctity of marriage, the bond of deep love existing between spouses and between parents and children, etc., will suffer incalculable damage. Since the expensive process of cloning will remain unaffordable for poor persons and nations, it will contribute greatly to the ever widening gap between the rich and the poor. These things are no mere scientific fictions, but are events taking place or about to take place all around us. Hence leaders of the Church cannot remain passive speculators. They need to be well-informed about it for their own sake and for the sake of others under their care.

IV. New Thinking in Science and Its Implications

1. Developments in Philosophy of Science

Recent developments in the philosophy of science have affected our understanding of science in a radical way. They have, in a real sense, "humanized" and "demythologized" the old understanding of science and scientists. In the past, thanks to the influence of rationalism in the nineteenth century and logical positivism in the first half of the twentieth century, science and scientists were thought to be very different from others. Scientific knowledge was considered to be absolutely rational, objective, certain, and unchanging. Scientists were looked upon as a "breed apart," a special kind of persons, free from passions and prejudices. However, contemporary researches into the nature and practice of science have revealed a different picture. Today it is getting more and more accepted that scientific knowledge basically is no different from other forms of knowledge. If there is a difference, it is a matter of degree only, not of basic kind. For instance, scientific knowledge may be less subjective than others. Furthermore, scientists are very much like other professionals; they are also swayed by personal preferences and biases.

These and related ideas have significant implications. For one thing, they have opened the door for science-religion dialogue. In the past scientists and rationalists thought that scientific knowledge, being characterized by rationality, objectivity, and certainty, was radically different from religious knowl-

edge which lacked these qualities. Hence, there could be no real meeting place between the two. This claim can no more be sustained today.

These developments in the philosophy of science also bring home the fact that science is not meant only for a select elite group. Its basic ideas are accessible to any person willing to learn. So no educated person can excuse himself/herself from taking some pains to learn the important ideas of present day scientific developments.

2. *Science-Religion Dialogue*

Another reason why acquiring a basic knowledge of science should become part of the formation programme of priests and religious comes from the new surge of interest in science-religion dialogue. It is surprising to note that all the many astounding developments in science and technology, all the knowledge and power the scientific world has amassed, do not seem to have eclipsed the human person's interest in religion. According to a study conducted in 1997, "40% of the American scientists believe in a personal God – not merely an ineffable power and presence in the world, but a deity to whom they can pray."[97] It is reported that more than 90% of the Americans believe in a personal God.[98] An important paper in *Scientific American,* written in response to the *Newsweek* article, says that in America "scientist's beliefs have changed little since the 1930s."[99] This clearly shows that despite all the tremendous upheaval brought about by science and technology during the past decades, religion has not lost its ground.

There is a conspicuously growing interest in science-religion dialogue in various parts of the world. Such a dialogue can enrich both science and religion. But to participate in this and to contribute to it meaningfully, one has to be informed about the important trends and ideas in the scientific world.

3. *The Indian Situation*

Another important consideration for making science education an integral part of the formation of priests and religious comes from the contemporary Indian situation itself. Despite the complexity of our political and social problems, despite the enormous challenges facing us mainly due to over-population and rampant corruption, India has made considerable progress in science and technology. Any Indian can take legitimate pride in the strides we have made in this area. Some studies place India eleventh among the most industrialized nations in the world. India still has the third largest number of scientists and engineers, in spite of the uncontrolled brain-drain. In software industry some studies place India second only to the US. When we realize that some of the topmost computer programmemers in the US are Indians or persons of Indian origin, we can imagine how strong we are in this field. Our achievements in the field of space technology and nuclear energy speak for themselves. India indeed is a scientifically and technologically advanced nation. In a country like India every educated person should have a certain level of familiarity with the important ideas and happenings in the field of science, particularly if she/he is expected to give leadership and guidance to a community.

It was some of these ideas that motivated the participants of the CCBI Consultation on Seminary Formation in Bangalore last year to extend unanimous support to the proposal to make courses in basic science, philosophy of science, scientific cosmology, and science & religion an integral part of the curriculum for priestly formation. In the same meeting I was commissioned to draw up a proposal to the CBCI for setting up a CBCI Committee for Science, Religion, and Society. The proposal was sent in July 1999, and we are waiting for a positive response. In the same spirit Jnana-Deepa Vidyapeeth started the Association of Science, Society, and Religion (ASSR), and it is hoped that other similar institutions will follow suit.

Conclusion

From our study it is quite clear that in our world today no one can remain neutral about these scientific developments. Much less can the present and future leaders of any community remain passive onlookers of the revolutionary scientific changes unfolding all around them. The future leaders of the Church need to be fully aware of the seriousness of the scientific challenges and the opportunities they offer. It is certainly unrealistic to expect all such leaders to be well-versed in the intricacies of science. What is most important is that they be sensitive to the full gravity of the situation. This is possible only if they are able to understand and appreciate the basic concepts and issues. Hence any good formation programme should make provision for familiarizing those in formation with contemporary developments in science and technology. The long-standing tradition of the Church assures us that such a pursuit is on the right track.

Notes

1. Quoted by David C. Lindberg, "Science and the Early Church,"in *God and Nature, ed. David C. Lindberg and Ronald L. Numbers* (Berkeley: University of California Press, 1986), p. 26.
2. *Ibid.* p. 31.
3. Quoted in Andrew D. White, *A History of the warfare of Science with Theology in Christendom* (New York: Braziller, 1955), p. 71.
4. See Lindberg, "Science and the Early Church," p. 20.
5. See John Schreiber, S.J., "Jesuit Astronomy," *Popular Astronomy* 12 (1904), 10.
6. See Joseph MacDonnell, S.J., *Jesuit Geometers* (Vatican City: Vatican Observatory Publications, 1989), p. 1.
7. Dhruv Raina, "French Jesuit Scientists in India," *Economic and Political Weekly* (January 30, 1999), PE-30.
8. *Ibid.*, p. 154.
9. John Heilbron, *Electricity in the Seventeenth and Eighteenth Centuries: A Study of Early Modern Physics (*Berkeley: University of California Press, 1979), p. 2.
10. George Sarton, "An Appeal for the Republication in Book Form of R. Bosman's Studies," ISIS 40 (1949), 3-6.
11. William B. Ashworth, Jr., "Catholicism and Science," p. 154.

12. Dennis A. Bartlett, "The Evolution of the Philosophical and Theological Elements of the Jesuit *Ratio Studiorum*: An Historical Study: 1540 - 1599," Dissertation, University of San Francisco, 1984, p. 28.
13. See *The Constitutions of the Society of Jesus*, tr. George D. Ganss, S.J. (St. Louis: The Institute of Jesuit Sources, 1970), Nos. 450-451, p. 214. See also *The Constitutions of the Society of Jesus: Annotated and Complemented by General Congregation 34* (Anand: Gujarat Sahitya Prakash, 1996), p. 121.
14. It may be noted that in those days what they meant by natural philosophy was the same as what we mean by natural sciences today.
15. See John L. Russell, S.J., "Catholic Astronomers and the Copernican System after the Condemnation of Galileo," *Annals of Science*, 46 (1989), 376.
16. See William Wallace, "*Galileo's Early Notebooks: The Physical Questions* (Notre Dame: The University of Notre Dame Press, 1977).
17. *Ibid.*, p. 259. This is Foscarini's version of Pereyra.
18. *Ibid.*, p. 153.
19. *Ibid.*, p. 164.
20. See Job Kozhamthadam, S.J., "The Jesuit Response to Copernicanism and Its Influence on the European Contribution to the Development of Science in Asia," *Jesuits in Science*, 15 (1999), 10-14.
21. Raymond Mercier, "The Astronomical Tables of Rajah Jai Singh Sawai," *Indian Journal of History of Science*, 19 (1984), 159.
22. In a way, this was a refounding since the observatory in some form had its beginning earlier.
23. Sabino Maffeo, S.J., *In the Service of Nine Popes: 100 Years of the Vatican Observatory* (Vatican City: Vatican Observatory Publications, 1991), p. 210.
24. *Ibid.*, pp. 207-208.
25. See Maffeo, *Service of Popes*, p. 3.
26. Vatican II, "Decree on the Instruments of Social Communications,: *The Documents of Vatican II*, ed. Walter M. Abbott, S.J. (London: Jeffrey Chapman, 1967), p. 319.
27. See Vat II, "Pastoral Constitution on the Church in the Modern World," no.57, Abbot, p. 262.
28. *Ibid.* , no.57, p. 263.
29. *Ibid.*, no. 5, p. 203.
30. See *Ibid.*, no. 5, p. 203.
31. *Ibid.*, no. 5, pp. 203-204.
32. See *Ibid.*, no. 54, p. 260.
33. *Ibid.*, no. 5, p. 204.
34. *Ibid.*, no. 57, pp. 263-264.
35. *Ibid.*, no.57, p. 264.
36. *Ibid.*, no. 59, p. 269.
37. See *Ibid.*, no. 59, p. 265.
38. See *Ibid.*, no. 36, p. 234.
39. *Ibid.*, p. no. 36, 234.
40. See *Ibid.*, no. 57, p. 263.

41. *Ibid.*, no. 7, p. 205.
42. *Ibid.*, no. 57, p. 263.
43. *Ibid.*, no. 62, p. 268.
44. See *Ibid.*, no. 62, p. 270.
45. *Ibid.*, no. 62, p. 269.
46. *Ibid.*, no. 10, p. 648.
47. *Ibid.*, no. 10, p. 649.
48. *Ibid.*, no. 15, p. 450.
49. Pope John Paul II, "Message of His Holiness Pope John Paul II," in *Physics, Philosophy, and Theology* (Vatican City: Vatican Observatory Publications, 1988), p. M8. PPT hereafter.
50. PPT, p. M14.
51. PPT, p. M2.
52. PPT, pp. M4-M5.
53. PPT, p. M7.
54. See PPT., p. M8.
55. PPT., p. M10.
56. PPT, p. M10.
57. PPT, p. M. 10.
58. PPT, p. M11.
59. See PPT, p. M.11.
60. PPT, pp. M11-12.
61. PPT, p. M14.
62. PPT, p. M12.
63. PPT, p. M13.
64. PPT, p. M13.
65. See "Encyclical Letter *Fides et Ratio* of the Supreme Pontiff John Paul II," (Mumbai: Pauline Publications, 1999), p. 3. FER, hereafter.
66. FER, p n. 69, p. 100.
67. FER, no. 106, p. 152.
68. See FER, no. 5, p. 9.
69. FER, no. 5, p. 10.
70. FER, no. 27, p. 44.
71. FER, no. 43, pp. 43-44.
72. FER, no, 46, pp. 70-71.
73. "The Training of Scholastics Especially in Studies," GC 31, no. 178, (Anand: Gujarat Sahitya Prakash, 1980), pp. 136-137.
74. *Ibid.*, p. 137.
75. "The Better Choice and Promotion of Ministries,"no. 375, *Ibid.*, p. 222.
76. "Our Mission Today," GC32, no.74 (Anand: Anand Press, 1970), p. 117.
77. *Ibid*, no. 177, p. 164.
78. "The Intellectual Dimension of Jesuit Ministries," GC34, no. 401 (Anand: Gujarat Sahitya Prakash, 1995), p. 145.

79. *Ibid*, no. 397, p. 143.
80. S. Mohan, book review of *Visions: How Science Will Revolutionize the Twenty First Century,"* Michio Kaku (Oxford: Oxford University Press, 1998), in *NISTADS News* 2 (2000), p. 25.
81. See Michael Elliott, "After Sheep and Pigs, Goo," Newsweek, March 27, 2000, p. 4.
82. A theory which says that the universe arose as a result of the explosion of a super-condensed "primeval atom."
83. A theory which says that the end of the universe is reached when all available energy gets converted into unavailable energy.
84. See Job Kozhamthadam, S.J., "Creation without a Creator," *Philosophy in Science* 6 (1995), 9-46.
85. William R. Stoeger, "Key Developments in Physics Challenging Philosophy and Theology," in *Religion and Science: History, Method, Dialogue*, eds. Mark Richardson and Wesley Wildman (New York: Routledge, 1996), p. 192.
86. *Ibid.*, p. 193.
87. "Pastoral Constitution on the Church in the Modern Word," Abbot, no. 5, p. 204.
88. Reported in *Catholic Chronicle*, December 20, 1996.
89. S. Mohan, op. cit., p. 26.
90. For a good discussion of the Genome Project see *Scientific American*, July 2000, pp. 38-57. See also *Outlook*, July 10, 2000, pp. 38-45.
91. Classically genes were considered units of heredity. They are arranged along chromosomes , and are usually segments of DNA. Genes contain specific information (code) for the construction of proteins.
92. This number is a matter of debate since, at least three different figures have been given by different research groups. The Institute for Genomic Research (TIGR) in Rockville, Maryland, USA, puts it at 120,000, while Brent Ewing and Phil Green of the University of Washington, Seattle, give it as 35,000. Another group considers 30,000 as the right figure. The difference arises because of the difficulty involved in identifying individual genes and counting them, and because the researchers differ in their definition of what constitutes an individual gene.
93. Quoted in *Unnatural Selection*, Lois Wingerson (New York: Bantam Books, 1998), p. viii.
94. Usually this replication Is done by inserting the segment to be replicated into an organism that will reproduce itself on a grand scale.
95. For a discussion of this event see Job Kozhamthadam, S.J., "The Cloning of Dolly: Some Reflections," *Vidyajyoti*, 62 (1998), 110-118.
96. See "Remarks in Response to News Reports on the Cloning of Mammals," in *Human Cloning: Religious Responses*, ed. Ronald Cole –Turner (Louisville: Westminster John Knox Press, 1997), pp. 142, 146.
97. Sharon Begley, "Science Finds God,"*Newsweek* July 27, 1998, p. 48.
98. *Ibid.*, p. 48.
99. "Scientists and Religion in America," *Scientific American*, September 1999, p. 78.