



Address to the Plenary Session on ‘The Emergence of Complexity in Mathematics, Physics, Chemistry and Biology’



The Supreme Pontiff declares that contemporary culture, during this age of specialisation, requires a ‘constant effort to synthesise knowledge and to integrate learning’. Otherwise the world runs the risk of having a ‘shattered culture’: ‘a true culture cannot be conceived of without humanism and wisdom’. The Pope then dwells in detail on the Galileo case and observes that theologians should keep themselves regularly informed about scientific advances. He states clearly that the myth of the Galileo case had encouraged the erroneous idea that science and the Christian faith were in opposition but declares that this ‘sad misunderstanding now belongs to the past’. Human advance takes place both through an individual drawing closer to God and through the development of culture, scientific research and technology.

Your Eminences,

Your Excellencies,

Ladies and Gentlemen,

1. The conclusion of the plenary session of the Pontifical Academy of Sciences gives me the pleasant opportunity to meet its illustrious members, in the presence of my principal collaborators and the Heads of the Diplomatic Missions accredited to the Holy See. To all of you I offer a warm welcome.

My thoughts go at this moment to Professor Marini-Bettòlo, who is prevented by illness from being among us, and, assuring him of my prayers, I express fervent good wishes for his restoration to

health.

I would also like to greet the members taking their seats for the first time in this Academy; I thank them for having brought to your work the contribution of their lofty qualifications.

In addition, it is a pleasure for me to note the presence of Professor Adi Shamir, of the Weizmann Institute of Science at Rehovot, Israel, holder of the Pius XI Gold Medal, awarded by the Academy, and to offer him my cordial congratulations.

Two subjects in particular occupy our attention today. They have just been ably presented to us, and I would like to express my gratitude to Cardinal Paul Poupard and Fr. George V. Coyne for having done so.

2. In the first place, I wish to congratulate the Pontifical Academy of Sciences for having chosen to deal, in its plenary session, with a problem of great importance and great relevance today: the problem of 'the emergence of complexity in mathematics, physics, chemistry and biology'.

The emergence of the subject of complexity probably marks in the history of the natural sciences a stage as important as the stage which bears relation to the name of Galileo, when a univocal model of order seemed to be obvious. Complexity indicates precisely that, in order to account for the rich variety of reality, we must have recourse to a number of different models.

This realisation poses a question which concerns scientists, philosophers and theologians: how are we to reconcile the explanation of the world – beginning with the level of elementary entities and phenomena – with the recognition of the fact that 'the whole is more than the sum of its parts'? In his effort to establish a rigorous description and formalisation of the data or experience, the scientist is led to have recourse to *metascientific concepts*, the use of which is, as it were, demanded by the logic of his procedure. It is useful to state exactly the nature of these concepts in order to avoid proceeding to undue extrapolations which link strictly scientific discoveries to a vision of the world, or to ideological or philosophical affirmations, which are in no way corollaries of it. Here one sees the importance of philosophy which considers phenomena just as much as their interpretation.

3. Let us think, for example, of the working out of new theories at the scientific level in order to take account of *the emergence of living beings*. In a correct method, one could not interpret them immediately and in the exclusive framework of science. In particular, when it is a question of the living being which is man, and of his brain, it cannot be said that these theories of themselves constitute an affirmation or a denial of the spiritual soul, or that they provide a proof of the doctrine of creation, or that, on the contrary, they render it useless.

A further work of interpretation is needed. *This is precisely the object of philosophy*, which is the study of the global meaning of the data of experience, and therefore also of the phenomena gathered and analysed by the sciences.

Contemporary culture demands *a constant effort to synthesise knowledge and to integrate learning*. Of course, the successes which we see are due to the specialisation of research. But unless this is balanced by a reflection concerned with articulating the various branches of knowledge, there is a great risk that we shall have a 'shattered culture', which would in fact be the

negation of true culture. A true culture cannot be conceived of without humanism and wisdom.

4. I was moved by similar concerns on 10 November 1979, at the time of the first centenary of the birth of Albert Einstein, when I expressed the hope before this same Academy that 'theologians, scholars, and historians, animated by a spirit of sincere collaboration, will study the *Galileo* case more deeply and, in frank recognition of wrongs from whatever side they come, dispel the mistrust that still opposes, in many minds, a fruitful concord between science and faith'.¹ A Study Commission was constituted for this purpose on 3 July 1981. The very year when we are celebrating the 350th anniversary of Galileo's death, the Commission is presenting today, at the conclusion of its work, a number of publications which I value highly. I would like to express my sincere gratitude to Cardinal Poupard, who was entrusted with coordinating the Commission's research in its concluding phase. To all the experts who in any way took part in the proceedings of the four groups that guided this multidisciplinary study, I express my profound satisfaction and my deep gratitude. The work that has been carried out for more than ten years responds to a guideline suggested by the Second Vatican Council and enables us to shed more light on several important aspects of the question. In the future, it will be impossible to ignore the Commission's conclusions.

One might perhaps be surprised that, at the end of the Academy's study week on the subject of the emergence of complexity in the various sciences, I am returning to the Galileo case. Has not this case long been shelved and have not the errors committed been recognised?

That is certainly true. However, *the underlying problems of this case concern both the nature of science and the message of faith*. It is therefore not to be excluded that one day we shall find ourselves in a similar situation, one which will require both sides to have an informed awareness of the field and of the limits of their own competencies. The approach provided by the theme of complexity could provide an illustration of this.

5. A *twofold question* is at the heart of the debate of which Galileo was the centre.

The first is of the epistemological order and concerns *biblical hermeneutics*. In this regard, two points must again be raised. In the first place, like most of his adversaries, Galileo made no distinction between the scientific approach to natural phenomena and a reflection on nature, of the philosophical order, which that approach generally calls for. That is why he rejected the suggestion made to him to present the Copernican system as a hypothesis, inasmuch as it had not been confirmed by irrefutable proof. Such, therefore, was *an exigency of the experimental method* of which he was the inspired founder.

Secondly, the geocentric representation of the world was commonly admitted in the culture of the time as fully agreeing with the teaching of the Bible, of which certain expressions, taken literally, seemed to affirm geocentrism. The problem posed by theologians of that age was, therefore, that of the compatibility between heliocentrism and Scripture.

Thus the new science, with its methods and the freedom of research which they implied, obliged theologians to examine their own criteria of scriptural interpretation. Most of them did not know how to do so.

Paradoxically, Galileo, a sincere believer, showed himself to be more perceptive in this regard than the theologians who opposed him. 'If Scripture cannot err', he wrote to Benedetto Castelli, 'certain of its interpreters and commentators can and do so in many ways'.² We also know of his letter to Christine de Lorraine (1615) which is like a short treatise on biblical hermeneutics.³

6. From this we can now draw our first conclusion. The birth of a new way of approaching the study of natural phenomena demands *a clarification on the part of all disciplines of knowledge*. It obliges them to define more clearly their own field, their approach, their methods, as well as the precise import of their conclusions. In other words, this new way requires each discipline to become more rigorously aware of its own nature.

The upset caused by the Copernican system thus demanded epistemological reflection on the biblical sciences, an effort which later would produce abundant fruit in modern exegetical works and which found sanction and a new stimulus in the Dogmatic Constitution *Dei Verbum* of the Second Vatican Council.

7. The crisis that I have just recalled is not the only factor to have had repercussions on biblical interpretation. Here we are concerned with *the second aspect of the problem, its pastoral dimension*.

By virtue of her own mission, the Church has the duty to be attentive to the pastoral consequences of her teaching. Before all else, let it be clear that this teaching must correspond to the truth. But it is a question of knowing how to judge a new scientific datum when it seems to contradict the truths of faith. The pastoral judgement which the Copernican theory required was difficult to make, in so far as geocentrism seemed to be a part of scriptural teaching itself. It would have been necessary all at once to overcome habits of thought and to devise a way of teaching capable of enlightening the people of God. Let us say, in a general way, that the pastor ought to show a genuine boldness, avoiding the double trap of a hesitant attitude and of hasty judgement, both of which can cause considerable harm.

8. *Another crisis*, similar to the one we are speaking of, can be mentioned here. In the last century and at the beginning of our own, advances in the historical sciences made it possible to acquire *a new understanding of the Bible and of the biblical world*. The rationalist context in which these data were most often presented seemed to make them dangerous to the Christian faith. Certain people, in their concern to defend the faith, thought it necessary to reject firmly-based historical conclusions. That was a hasty and unhappy decision. The work of a pioneer like Fr. Lagrange was able to make the necessary discernment on the basis of dependable criteria.

It is necessary to repeat here what I said above. It is a duty for theologians to keep themselves regularly informed of scientific advances in order to examine, if such be necessary, whether or not there are reasons for taking them into account in their reflection or for introducing changes in their teaching.

9. If contemporary culture is marked by a tendency to scientism, the cultural horizon of Galileo's

age was uniform and carried the imprint of a particular philosophical formation. This unitary character of culture, which in itself is positive and desirable even in our own day, was one of the reasons for Galileo's condemnation. The majority of theologians did not recognise *the formal distinction between Sacred Scripture and its interpretation*, and this led them unduly to transpose into the realm of the doctrine of the faith a question which in fact pertained to scientific investigation.

In fact, as Cardinal Poupard has recalled, Robert Bellarmine, who had seen what was truly at stake in the debate, personally felt that, in the face of possible scientific proofs that the earth orbited round the sun, one should 'interpret with great circumspection' every biblical passage which seems to affirm that the earth is immobile and 'say that we do not understand, rather than affirm that what has been demonstrated is false'.⁴ Before Bellarmine, this same wisdom and same respect for the divine Word guided St. Augustine when he wrote: 'If it happens that the authority of Sacred Scripture is set in opposition to clear and certain reasoning, this must mean that the person who *interprets Scripture* does not understand it correctly. It is not the meaning of Scripture which is opposed to the truth, but the meaning which he has wanted to give to it. That which is opposed to Scripture is not what is in Scripture but what he has placed there himself, believing that this is what Scripture meant'.⁵ A century ago, Pope Leo XIII echoed this advice in his Encyclical *Providentissimus Deus*: 'Truth cannot contradict truth, and we may be sure that some mistake has been made either in the interpretation of the sacred words, or in the polemical discussion itself'.⁶

Cardinal Poupard has also reminded us that the sentence of 1633 was not irreformable, and that the debate, which had not ceased to evolve thereafter, was closed in 1820 with the *imprimatur* given to the work of Canon Settele.⁷

10. From the beginning of the Age of Enlightenment down to our own day, *the Galileo case* has been a sort of 'myth', in which the image fabricated out of the events was quite far removed from reality. In this perspective, the Galileo case was the symbol of the Church's supposed rejection of scientific progress, or of 'dogmatic' obscurantism opposed to the free search for truth. This myth has played a considerable cultural role. It has helped to anchor a number of scientists of good faith in the idea that there was an incompatibility between the spirit of science and its rules of research on the one hand and the Christian faith on the other. *A tragic mutual incomprehension* has been interpreted as the reflection of a fundamental opposition between science and faith. The clarifications furnished by recent historical studies enable us to state that this sad misunderstanding now belongs to the past.

11. From the Galileo affair we can learn a *lesson which remains valid* in relation to similar situations which occur today and which may occur in the future.

In Galileo's time, to depict the world as lacking an absolute physical reference point was, so to speak, inconceivable. And since the cosmos, as it was then known, was contained within the solar system alone, this reference point could only be situated in the earth or in the sun. Today, after Einstein and within the perspective of contemporary cosmology, neither of these two reference

points has the importance they once had. This observation, it goes without saying, is not directed against the validity of Galileo's position in the debate; it is only meant to show that often, beyond two partial and contrasting perceptions, *there exists a wider perception which includes them and goes beyond both of them.*

12. Another lesson which we can draw is that *the different branches of knowledge call for different methods.* Thanks to his intuition as a brilliant physicist and by relying on different arguments, Galileo, who practically invented the experimental method, understood why only the sun could function as the centre of the world, as it was then known, that is to say, as a planetary system. The error of the theologians of the time, when they maintained the centrality of the earth, was to think that our understanding of the physical world's structure was, in some way, imposed by the literal sense of Sacred Scripture. Let us recall the celebrated saying attributed to Baronius: '*Spiritui Sancto mentem fuisse nos docere quomodo ad coelum eatur, non quomodo coelum gradiatur*'. In fact, the Bible does not concern itself with the details of the physical world, the understanding of which is the competence of human experience and reasoning. There exist two realms of knowledge, one which has its source in Revelation and one which reason can discover by its own power. To the latter belong especially the experimental sciences and philosophy. The distinction between the two realms of knowledge ought not to be understood as opposition. The two realms are not altogether foreign to each other; they have points of contact. The methodologies proper to each make it possible to bring out different aspects of reality.

13. Your Academy conducts its work with this outlook. Its principal task is to promote the advancement of knowledge, with respect for the legitimate freedom of science⁸ which the Apostolic See expressly acknowledges in the statutes of your institution.

What is important in a scientific or philosophic theory is above all that it should be true or, at least, seriously and solidly grounded. And *the purpose of your Academy* is precisely *to discern and to make known*, in the present state of science and within its proper limits, *what can be regarded as an acquired truth* or at least as enjoying such a degree of probability that it would be imprudent and unreasonable to reject it. In this way unnecessary conflicts can be avoided.

The seriousness of scientific knowledge will thus be the best contribution that the Academy can make to the exact formulation and solution of the serious problems to which the Church, by virtue of her specific mission, is obliged to pay close attention – problems no longer related merely to astronomy, physics and mathematics, but also to relatively new disciplines such as *biology* and *biogenetics*. Many recent scientific discoveries and their possible applications *affect man more directly than ever before*, his thought and action, to the point of seeming to threaten the very basis of what is human.

14. Humanity has before it *two modes of development*. The first involves culture, scientific research and technology, that is to say *whatever falls within the horizontal aspect of man* and creation, which is growing at an impressive rate. In order that this progress should not remain completely external to man, it presupposes a simultaneous raising of conscience, as well as its

actuation. The second mode of development involves what is deepest in the human being, when, transcending the world and transcending himself, man turns to the One who is the Creator of all. It is only this *vertical direction* which can give full meaning to man's being and action, because it situates him in relation to his origin and his end. In this twofold direction, horizontal and vertical, man realises himself fully as a spiritual being and as *homo sapiens*. But we see that development is not uniform and linear, and that progress is not always well ordered. This reveals the disorder which affects the human condition. The scientist who is conscious of this twofold development and takes it into account contributes to the restoration of harmony.

Those who engage in scientific and technological research admit, as the premise of its progress, that the world is not a chaos but a 'cosmos'; that is to say, that there exist order and natural laws which can be grasped and examined, and which, for this reason, have a certain affinity with the spirit. Einstein used to say: 'What is eternally incomprehensible in the world is that it is comprehensible'.⁹ This intelligibility, attested to by the marvellous discoveries of science and technology, leads us, in the last analysis, to that transcendent and primordial Thought imprinted on all things.

Ladies and Gentlemen, in concluding these remarks, I express my best wishes that your research and reflection will help to give our contemporaries useful directions for building a harmonious society in a world more respectful of what is human. I thank you for the service you render to the Holy See, and I ask God to fill you with his gifts.

1 AAS 71 (1979), pp. 1464-1465.

2 Letter of 21 November 1613, in *Edizione Nazionale delle Opere di Galileo Galilei*, dir. A. Favaro, edition of 1968, vol. V, p. 282.

3 Letter to Christine de Lorraine, 1615, in *Edizione Nazionale delle Opere di Galileo Galilei*, dir. A. Favaro, edition of 1968, vol. V, pp. 307-348.

4 Letter to Fr. A. Foscarini, 12 April 1615, cf. *Edizione Nazionale delle Opere di Galileo Galilei*, dir. A. Favaro, vol. XII, p. 172.

5 St. Augustine, *Epist.* 143, 7; *PL* 33, 588.

6 *Leonis XIII Pont. Max. Acta*, vol. XIII (1894), p. 361.

7 Cf. Pontificia Academia Scientiarum, *Copernico, Galilei e la Chiesa. Fine della controversia (1820). Gli Atti del Sant'Uffizio*, edited by W. Brandmüller, E.J. Greipl and Leo Olschki (Florence, 1992).

8 Cf. *Gaudium et Spes*, n. 36, § 2.

9 In *The Journal of the Franklin Institute*, vol. 221, n. 3, March 1936.