

Session 11: A Place for Science in the Catholic Faith

HYMN: God Created Earth and Heaven



God created earth and heaven,
 God commanded light to be,
 separated light from darkness,
 set the bounds for land and sea.
 While God's Spirit on the waters
 in His love did gently brood,
 life on earth began to quicken,
 and God saw that it was good.

God made man in His own image,
 gave him pow'r to think and choose,
 made him lord of all creation:
 ev'rything is his to use.
 Let us praise our loving Father—
 let us thank Him as we should
 for the gifts of His creation,
 which His love has made so good!

God, Who fill the earth with beauty;
 God, Who bind each friend to friend;
 God, Who name us co-creator;
 God, Who will that chaos end—
 grant to us creative spirits,
 minds responsive to Your mind,
 hearts and wills Your rule
 extending,
 all our acts by Love refined.

God, Who give to life its goodness;
 God, Creator of all joy;
 God, Who give to us Your freedom;
 God, Who bless each tool and toy—
 teach us how to praise and thank
 You,
 deep within Your praises sing,
 'till the whole creation dances
 to the music of its King.

PRAYER:

See Eph 1:17-19.

Let us pray: O God,
 grant us a spirit
 of wisdom and insight
 to know You clearly.
 Enlighten our innermost vision,
 that we may know the great hope
 to which You have called us,

the wealth of Your glorious heritage
 to be distributed
 among the members of the Church,
 and the immeasurable scope
 of Your power
 in us who believe.

Through our Lord Jesus Christ,
 Your Son,
 Who lives and reigns with You
 in the unity of the Holy Spirit,
 God, for ever and ever.
 — Amen

READING:

Wis 7:13,15-22,26

A Reading from the Book of Wisdom
 Simply I learned about wisdom,
 and ungrudgingly do I share —
 her riches I do not hide away.

Now God grant I speak suitably
 and value these endowments
 at their worth,
 for He is the Guide of wisdom
 and the Director of the wise.

For both we and our words
 are in His hand,
 as well as all prudence
 and knowledge of crafts.

For He gave me sound knowledge
 of existing things,
 that I might know
 the organization of the universe
 and the force of its elements,
 the beginning and the end
 and the midpoint of times,
 the changes in the sun's course
 and the variation of the seasons,
 cycles of years,
 positions of the stars,
 natures of animals,
 tempers of beasts,
 powers of the wind
 and thoughts of men,
 uses of plants
 and virtues of roots—
 such things as are hidden I learned,
 and such as are plain,
 for wisdom,
 the artificer of all, taught me.

For she is the refulgence
 of eternal light,
 the spotless mirror
 of the might of God,
 the image of His goodness. —

Session 11

The Word of the Lord
— *Thanks be to God*

IN BRIEF: WHAT THE CHURCH TEACHES

An atheist believes
that God does not exist.
He explicitly rejects
the intimate and vital bond
between God and humans.

A scientist,
who studies God's creation,
need not be an atheist.
Both basic scientific research
and applied research
are expressions
of the dominion over creation
that God gave Adam and Eve.
Science and technology
are precious resources
when placed at the service of man.

However, by themselves,
they cannot disclose
the meaning of existence
or human progress.

BIBLE READING

Ps 1-38

In the Bible this week
you will start reading the Psalms.

Do not just read them,
but pray them,
for in them
you will find everything
you could ever want to say to God.

For example, next week
we will study "Divine Revelation":
namely, what God has told us
about Himself and His plan for us.

In the Psalms we say,
"The revelation of Your word
sheds light,
giving understanding to the simple."

A Place for Science in the Catholic Faith

Introduction

Many people are taken in by the "myth" of "incompatibility between the spirit of science and its rules of research on the one hand and the Christian faith on the other."¹ They mistakenly think that "he who proceeds with a commitment to scientific research no longer has need of God; [and] *vice versa*, [that] he who wishes to believe in God cannot be a serious scientist, because between science and faith there is an irremediable conflict."²

No; on the contrary, "many scientists, past and present, see rigorously conducted scientific research as not only compatible, but even happily capable of integration, with the sincere and joyous recognition of the existence of God."³

Certainly the knowledge found in God's Revelation⁴ and the knowledge found by science are different. For example, compare the Bible story of Adam and Eve with the scientific theory of biological evolution.⁵

However, science and Revelation cannot be opposed to each other, for they both show us truth, and "truth cannot contradict truth." If it seems to, "we may be sure that some mistake has been made, either in the interpretation of the sacred words," or in the discussion surrounding the dispute.⁶

The explanation is that science and Revelation represent "two different orders of knowledge";⁷ they bring out "different aspects of reality."⁸

It was "tragic mutual incomprehension" that led to the Church's condemnation of Galileo. To avoid such mistakes in future, both sides must have "an informed awareness of the field and of the limits of their own competencies."⁹

This course is about God and how we relate to Him. In this talk, we will see how we relate to God in the human activity we call science.

What scientists do

Modern scientists restrict their study to what they can observe repeatedly by means of the senses.¹⁰ Then they search their observations for *patterns*.

From babyhood, we all see such patterns. For example, when we push things hard enough, they move; when we stop pushing, they stop; if we do not support them, they fall. We learn enough of such patterns for us to function in the world.

To this extent, we are all scientists. However, "real" scientists observe more events more accurately;¹¹ and discover deeper,¹² wider,¹³ and more detailed¹⁴ patterns.

For example, by age 16, students know that things pushed harder speed up more quickly, and that massive trucks speed up less quickly than cars; but in Physics, they perform the following experiment to describe these patterns mathematically.

We have measured the mass of a cart. We pull it with a spring scale, which measures our force. To record its speed, we have it pull a paper tape through a vibrator like an old doorbell or firebell, which makes a dot on it every 1/60th of

1 Pope John Paul II: Address to the Pontifical Academy of Sciences October 31 1992

2 Pope John Paul II: General Audience July 17 1985

3 "There have always been, and still are today, men of science who, in the context of their human scientific experience, have positively and beneficially believed in God. Fifty years ago a survey was made of 398 of the most illustrious scientists in the world, in which 16 declared themselves unbelievers; 15, agnostics; and 367, believers" (Pope John Paul II: General Audience July 17 1985). See A. Eymleu: *La Part des Croyants Dans les Progrès de la Science*.

4 That is, what God has revealed to us.

5 That is, the theory as developed by biologists, not the interpretations others mistakenly give it: e.g. "materialist," "reductionist," and "spiritualist" (Pope John Paul II: *Reflection on Science at the Dawn of the Third Millennium*, 4; see Appendix 1.

6 See Pope Leo XIII: *Providentissimus Deus*, 23.

7 Pope John Paul II at a 1982 symposium marking 350 years since the publication of Galileo's book.

8 Pope John Paul II: Address to the Pontifical Academy of Sciences October 31 1992

9 Pope John Paul II: Address to the Pontifical Academy of Sciences October 31 1992

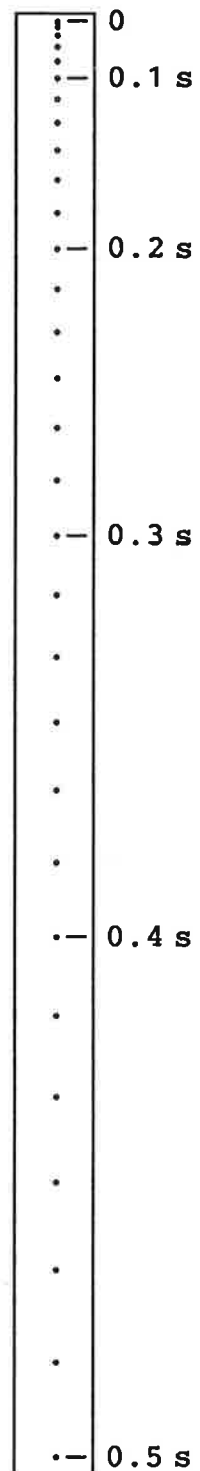
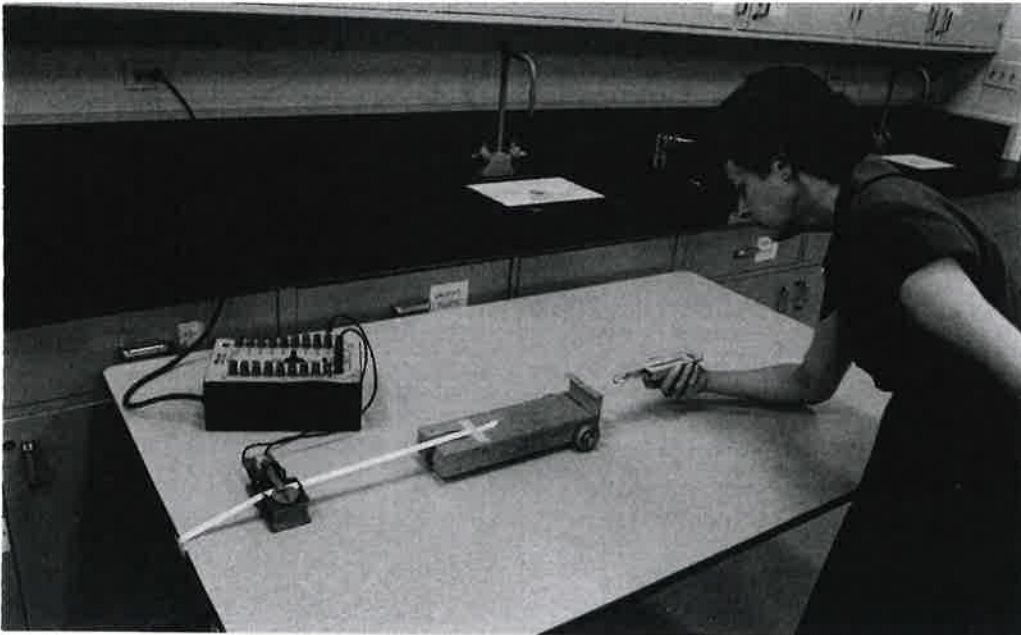
10 That is, by seeing, hearing, feeling, tasting, or smelling.

11 In Physics, they usually take measurements.

12 That is, not so obvious, not just on the surface.

13 That is, encompassing more observations.

14 In Physics, this means more mathematical.



a second. Thus we obtain a record like the one at the right.

From the spacing of the dots on the tape, students can calculate how much speed the cart picks up per second; *i.e.*, its acceleration a . In this way, the class accumulates the data shown in the table on the next page. Each line gives the acceleration a of a cart of a different mass M pulled with a different force F .

Finally, the students look for a *pattern* in their data. Guided by the teacher, they plot the graph shown. Thus they see the pattern first observed by Isaac Newton.¹⁵ Its angle is almost 45° ,¹⁶ showing that $a = F/M$ or, as it is usually written, $F = Ma$.

Finding patterns

Now the universe "is crazier and more of it than we think, incorrigibly plural."¹⁷ Not even two electrons are identical, for at any given moment, they occupy different positions. In fact, every real thing or event in the universe — including its place and its time — is absolutely unique.¹⁸

But for scientists to find patterns in what they observe, they must look for *similarity* and *repetition*. That is what "pattern" means. Accordingly, when scientists observe a thing or an event, they deliberately ignore everything that makes it unique.

For example, when I taught students how to analyze motion on a slope, I would start by drawing a skier on a ski run. Then I would reduce him to a small dot and label it with his mass. One year, a student said, humourously, "Poor guy! How would you like to be reduced to a dot, with nothing but a mass?"

The joke made the class realize that we could not describe "motion on a slope" *in general* unless we ignored everything that made our skier unique: the date, the time, the place, his name, his health, the colour of his hair, *etc.* — in fact, everything that made him *concrete* and *historical*.

Similarly, to find patterns in the motion of the planets, Johannes Kepler¹⁹ ignored their names, sizes, colours, atmospheres, temperatures, *etc.*

15 English physicist 1642-1727.

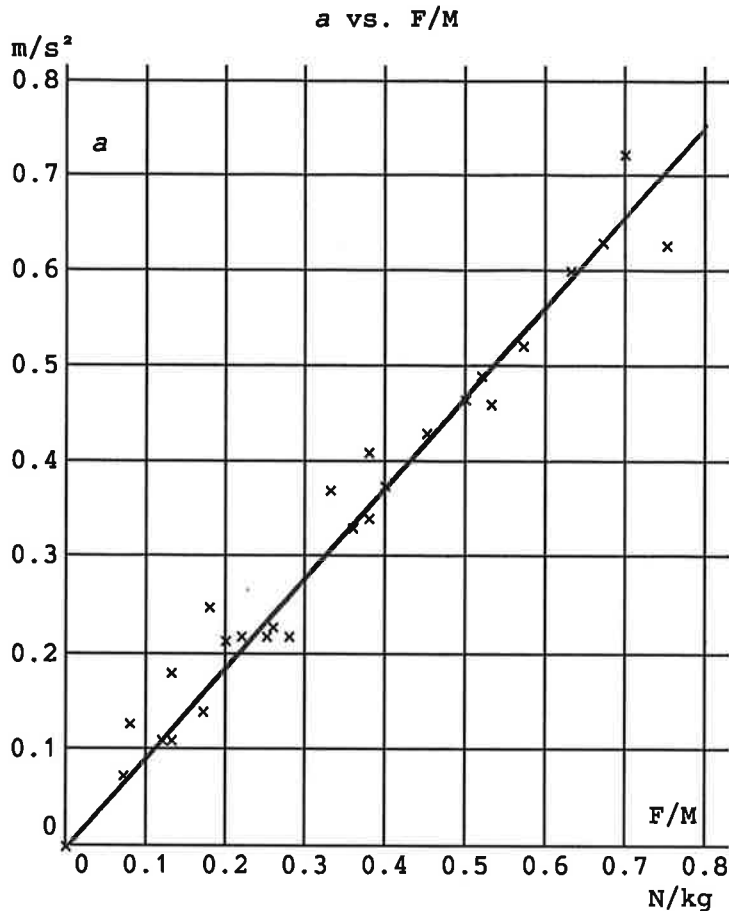
16 Its "slope" is almost 1. The slope of the graph shown is 0.94, but the difficulty of pulling a moving cart with a constant force by means of a spring scale adequately accounts for the 6% difference.

17 Louise MacNeice: *Snow*

18 Behind it lies "the whole history of the real universe" (C.S. Lewis: *Prayer: Letters to Malcolm*, VII).

19 German astronomer 1571-1630.

F	M	a	F/M
N	kg	m/s ²	N/kg
0.0	4.0	0.000	0.00
0.3	4.0	0.073	0.08
0.8	4.0	0.215	0.20
1.3	4.0	0.370	0.33
1.6	4.0	0.375	0.40
1.8	4.0	0.430	0.45
2.3	4.0	0.521	0.58
2.8	4.0	0.723	0.70
0.5	4.0	0.110	0.13
1.0	4.0	0.220	0.25
1.5	4.0	0.340	0.38
2.0	4.0	0.465	0.50
2.5	4.0	0.600	0.63
3.0	4.0	0.627	0.75
1.0	1.5	0.630	0.67
1.0	2.0	0.490	0.50
1.0	2.8	0.330	0.36
1.0	3.8	0.230	0.26
1.0	6.0	0.140	0.17
1.0	8.5	0.110	0.12
1.0	3.0	0.370	0.33
1.0	1.9	0.460	0.53
1.0	2.6	0.410	0.38
1.0	3.6	0.220	0.28
1.0	4.5	0.220	0.22
1.0	5.5	0.246	0.18
1.0	8.0	0.181	0.13
1.0	12.0	0.127	0.08



But when we observe Venus, Mars, and Jupiter in the night sky, we do not see the patterns Kepler found. Instead, we "feel the drunkenness of things being various."²⁰ We see each planet "festooned with those particularities" in which "science, as such, has no interest" and therefore, "for her own purposes, quite rightly discounts."²¹ To see Kepler's patterns, we have to go to his work.

Pattern — or order — "does not display itself of itself; if it can be said to be there at all, it is not there for the mere looking. There is no way of pointing a finger or a camera at it; order must be discovered, and, in a deep sense, it must be *created*. What we see, as we see it, is mere disorder."²²

In summary: Scientists observe the physical universe and look for patterns in their observations. Now let us consider what God does.

What God does

"God is the Lord of the universe, whose order He established and which remains wholly subject to Him and at His disposal."²³ To the things He creates — angels, humans, animals, plants, planets, rocks, molecules, atoms — He not only gives "being and existence, but also, and at every moment, upholds and sustains them in being, enables them to act, and brings them to their final end."²⁴

Accordingly, we must imagine God running the universe by a continuous, ongoing decision. It is not like a toy that He winds up and then leaves to run on its own;²⁵ it is more like a game of solitaire, which requires His constant attention.²⁶

20 Louis MacNeice: *Snow*

21 See C.S. Lewis: *Prayer: Letters to Malcolm*, VII.

22 Jacob Bronowski: *The Nature of Scientific Reasoning*, 9

23 CCC 269

24 CCC 301

25 This is the heresy of Deism (see CCC 285), whose tenets were condemned by Pope Pius IX in *Maxima Quidem* (1862) and the *Syllabus of Errors* 2-3 (1864). "With creation, God does not abandon His creatures to themselves" (CCC 301). See Joseph Ratzinger: *God and the World*, Part I, 2, "Where is God?"

To continue this analogy, imagine two-dimensional creatures whose universe is the surface of a card table. On this table, someone is playing solitaire. The creatures can see the cards on the table, but they cannot see the player, for they are incapable of perceiving dimensions outside their universe.

If these creatures observe the cards on the table, they will notice patterns in their behaviour. For example, they will notice that cards of the same suit²⁷ pile up on top of one another in sequence from ace to king. If they observe the cards long enough, they will learn what are called *the rules of solitaire*.

Now we, who are not confined to the surface of the table, can see the player. We can see that it is he who determines everything on the table, not one card falling to the table without his purpose and knowledge.²⁸

We can see how foolish the two-dimensional creatures on the card table would be to declare that there is no "player," but that cards "play themselves"; or that cards "know" the rules, so that a 3 on top of a pile is "caused" by the 4 below it; or that the rules are unchangeable, based on the nature of the cards.

Think of God as the Player and the universe as His card table. We, who inhabit the universe, can observe what happens there, but we cannot see God. Nevertheless, it is He Who determines everything. The Bible "affirm[s] God's absolute sovereignty over the course of events"; His care for the world is "concrete" (i.e., real, not imaginary) and "immediate" (i.e., direct, without anything between).²⁹

Therefore, if *my* cart, in *my* lab, on the day I perform the experiment, speeds up at a certain rate when I exert a certain force on it, it is because God makes *that* cart at *that* time accelerate at *that* rate.

$F = Ma$, then, is *our* description of a pattern in what God normally does.

Secondary "causes"

We say "normally" because God does not *have* to stick to the patterns we find.³⁰ He sometimes does something quite unusual, or even unique. We call it a *miracle*:³¹ something that — like everything else — is "wrought by divine power," "but apart from the order usually observed in nature."³²

However, God is not capricious; He does have normal or usual ways of doing things.³³ His creation is "ordered";³⁴ He has "arranged all things by measure and number and weight."³⁵ In practice, then, His creation is *predictable*.

For example, scientists can use the pattern $F = Ma$ to predict the motions of galaxies, stars, planets, space vehicles, satellites, and cars.³⁶ In fact, in order to do science at all, they *must assume* that their patterns apply always and everywhere.³⁷

You can confidently predict that if you want your car to accelerate, you must exert a force on it. Force is not *logically* necessary, in the sense that God could not possibly make the car accelerate otherwise, but it is necessary *in practice*.

Accordingly, even though we know that God causes everything, we say that force causes acceleration. We call God the *Principal* Cause and force the *secondary* cause.

Because "God is the first Cause" of all that is and all that happens, the Bible

26 God sees the whole universe all at once: past, present, and future (see the talk on "God: Unity and Trinity"). It is only because we observe it one moment at a time that we have to describe God's action as "constant," "continuous," "ongoing," "at every moment."

27 Spades, diamonds, clubs, or hearts.

28 Jesus said, "Not a single sparrow falls to the ground without your Father's consent" (Mt 10:29).

29 CCC 303

30 Like the card player in the analogy, He can "play the cards" in any way He chooses.

31 From the Latin *mirus* ("wonderful").

32 Thomas Aquinas: *Contra Gentiles*, III, cii. For more about miracles, see the talks on "Who is Jesus Christ?" and "Divine Revelation," Appendix 3.

33 In other words, miracles are relatively rare; that is why we have a special name for them.

34 CCC 299

35 Wis 11:20

36 Both cars on the roads and cars in collisions.

37 "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" (Pope John Paul II: Address to the Pontifical Academy of Sciences October 31 1992). By its nature, this assumption cannot be checked scientifically (that is, by observation); it must be accepted as an axiom. Accordingly, all scientific predictions really include the proviso "if God continues to do things according to His usual pattern," or (more simply) "God willing."

often attributes actions to Him without mentioning any secondary cause. "This is not a primitive mode of speech, but a profound way of recalling God's primacy and absolute lordship over history and the world."³⁸

For example, we read that God "dismisses the light, and it departs"; He "calls it, and it obeys Him trembling."³⁹ "He tells the number of the stars; He calls each by name."⁴⁰ "When He calls them, they answer, 'Here we are!' shining with joy for their Maker."⁴¹

Nevertheless, God normally "operates in and through secondary causes."⁴²

"Theories" and "laws"

Once a pattern is generally accepted, scientists often call it a "theory." The word does not denote uncertainty, but suggests a *pattern* as distinct from an *observation*.⁴³

Scientists may also call it a "law." Instead of saying that an object behaves according to the pattern $F = Ma$, they say that it "obeys Newton's Law."

Unfortunately, "law" and "obey" imply that $F = Ma$ is a *rule* that *commands* objects to behave in a certain way, just as the Ten Commandments or the laws of the land command humans.⁴⁴

No; the "laws" of science do not *make* things happen; they are simply the patterns we find in what *God* normally does.

New observations

Now these patterns can be changed or even abandoned.

$F = Ma$ has not been abandoned; we still teach it in school and use it to predict the motion of "normal" objects.

However, in the late 1800's, scientists observed that objects with speeds near the speed of light do not fit this pattern. In 1905, in order to include these fast objects, Albert Einstein published a deeper, wider pattern we call "special relativity."

Also, about the same time, scientists discovered particles so small that the very act of observing them changed their behaviour unpredictably. For example, in order to measure a particle's position, you have to shine light on it. Unfortunately, the impact of even a single photon of light changes the particle's speed. In fact, the more accurately you measure its position, the less certain you can be of its speed, and *vice versa*.⁴⁵ No improvement in measuring techniques can ever reduce this uncertainty, as far as we know; it seems to be fundamental to our observation of small particles and therefore fundamental to any pattern we find in their behaviour.

Accordingly, scientists came up with a new pattern we call "quantum mechanics." $F = Ma$ predicts *exactly* how fast an object will accelerate, but quantum mechanics predicts only the *probability* that a particle has a speed or a position between given limits; e.g. the probability that its speed is between 299,790 km/s and 299,791 km/s.

Similarly, in cribbage, you cannot predict *exactly* what cards you will get, but only the *probability* that you will get a particular hand. For example, from a deck of 52 cards, you can get 20,358,520 different combinations of six cards, so we say that the probability of getting any particular combination is $1/20,358,520 = 0.0000049\%$.

In summary: scientific patterns change to accommodate new observations.

Fashions in science

But they are also changed or abandoned according to *fashion*.⁴⁶

38 CCC 304

39 Bar 3:33

40 Ps 147:4

41 Bar 3:35. Also see Wis 42:15-25, 43:1-35.

42 See CCC 308.

43 As in "the theory of music."

44 We see this misunderstanding — which can lead to the heresy of Deism (see CCC 285) — among students who have not performed the experiment described above and so do not know the source of the pattern $F = Ma$.

Asked why a cart speeds up at a certain rate, they will often reply, "It *has* to — it's a *law*!" We see the same misunderstanding in the hymn *Praise the Lord, Ye Heav'ns, Adore Him*: "Laws which never shall be broken for their guidance He has made."

45 Werner Heisenberg (1901-1976) published what became known as his "Uncertainty Principle" in 1925.

For example: in 1597 Kepler found and published a pattern which — with 95% accuracy — linked the five spaces separating the six⁴⁷ known planets to the five geometric solids that could be made from identical regular polygons.⁴⁸ As a result, he was invited to assist the astronomer Tycho Brahe⁴⁹ at Prague's new observatory.

When Brahe died, Kepler inherited his extremely accurate, decades-long records of the planets' positions in the night sky, and he began searching them for patterns in the planets' motions.

Like all his predecessors, Kepler thought in terms of circles — the perfect figure which, surely, God would have used. At one point, he discovered a pattern based on circles that described Mars' motion to within 0.13°, but he rejected it because he knew that Brahe's observations were rarely wrong by even as much as 0.03°. ⁵⁰

Over the next decade, Kepler found three more patterns. 1) Each planet orbits the Sun in an ellipse⁵¹ (not a circle) with the Sun just off centre.⁵² 2) As it moves, each planet changes speed so that the line joining it to the Sun "sweeps out" area at a constant rate. 3) The cube of a planet's average distance from the Sun divided by the square of its year⁵³ is the same for every planet.⁵⁴

These last three patterns have endured. They describe even modern spacecraft — which, during their journeys to other planets, orbit the sun like the planets.⁵⁵

But scientists have abandoned Kepler's geometric pattern — not just because they discovered new planets,⁵⁶ but also because fashions changed. Scientists today would never *expect* a connection between the planets and the geometric solids. Nor would they search for a pattern based on what they thought God would have done.⁵⁷

Scientific proof

Scientists accept⁵⁸ a pattern as long as it continues to fit all their observations and to be the simplest and most appealing⁵⁹ they can think of. However, as we have seen, these patterns, or theories, can change.⁶⁰

- 46 For example, there are signs that in quantum mechanics, Louis de Broglie's pilot-wave theory, which "lost out" to the Copenhagen theory at the 1927 Solvay Conference in Brussels, is being revived. See Natalie Wolchover in *Quanta Magazine*, June 30 2014: "Have We Been Interpreting Quantum Mechanics Wrong This Whole Time?" and Dan Falk in *Quanta Magazine*, May 16 2016: "New Support for Alternative Quantum View."
- 47 Ancient astronomers knew only five (Mercury, Venus, Mars, Jupiter, and Saturn), but just before his death in 1543, Nicolaus Copernicus published *De Revolutionibus Orbium Coelestium*, in which he suggested that the Earth, as well as these five planets, could be thought of as orbiting the Sun. In 1551, Erasmus Reinhold published the *Prussian Tables*, a set of astronomical tables based on Copernicus' work, and astronomers and astrologers quickly adopted it in place of its predecessors.
- 48 As a soccer ball is made from pentagons and hexagons. It had been known for some 2,000 years that there are five regular, convex polyhedrons with congruent faces of regular polygons and the same number of faces meeting at each vertex: the tetrahedron (4 triangles), the cube or hexahedron (6 squares), the octahedron (8 triangles), the dodecahedron (12 pentagons), and the icosahedron (20 triangles). Plato and Aristotle had related them to earth, water, air, fire, and aether respectively.
- 49 Danish astronomer 1546–1601, then a major scientist.
- 50 See *The Project Physics Course*, Unit Two, Chapters 6–7 and the relevant acknowledgements on page iv.
- 51 A flattened circle, like a circle viewed obliquely. The planets' orbits are almost circular: the so-called "eccentricity" e of a circle is 0, and, for the planets Kepler knew, e is between 0.007 and 0.206.
- 52 At one of the two *foci* of the ellipse.
- 53 That is, the time it takes the planet to orbit the sun once.
- 54 "I had by unceasing toil through a long period of time, using the observations of Brahe ... overcome by storm the shadows of my mind, with such fullness of agreement between my 17 years labour on the observations of Brahe and this present study of mine that I at first believed that I was dreaming" (Johannes Kepler: *Harmony of the World*).
- 55 From Kepler's patterns, Physics 12 students can calculate how long the spacecraft will take, where the target planet should be in the sky at launch, the spacecraft's speed at launch, the extra energy necessary to land safely on the target planet, etc.
- 56 Uranus was first observed in 1781, Neptune in 1846, and Pluto in 1930. (Whether or not Pluto is considered a planet, it does orbit the Sun.) Did anyone in Kepler's time, perhaps, argue that there could be no more than six planets because Kepler's "law" would forbid it?
- 57 Kepler was not a slave to fashion. Previous astronomers had followed Aristotle in thinking that "heavenly" bodies did not require forces to maintain their motion, but Kepler agreed with Galileo (1564–1642) that the planets are subject to forces just like earthly objects.
- 58 Some people say "believe," but faith is not the appropriate response to a scientific theory or pattern.
- 59 For example, Ptolemy's Earth-centered model of the Sun and the planets was gradually replaced (for some purposes) by Copernicus' model (proposed by Aristarchus of Samos 2,000 years before) not because the former could not account for new observations, but because the latter was simpler.
- 60 "Explanation is of two kinds. One goes to the root of the matter, as in natural science when a sufficient proof is advanced to show that the velocity of astronomical motion is constant. The other is less

Is there ever a point, then, at which a scientific theory can be considered *proved*?

Yes, but only in the sense that we consider our everyday beliefs to be proved: that is, they will do to be going on with; they are good enough to act on. Never can a scientific theory be proved in any more rigorous sense.

* * * * *

Science or God?

"God is the first Cause" of everything, but normally He "operates in and through secondary causes."^{6 1} In science, these secondary causes are said to *account for* their effects, just as force accounts for an object's acceleration. Here are some examples:

- Brahe observed the Solar System. Kepler found patterns in Brahe's observations. Newton *accounted for* these patterns with his "law" of universal gravitation.^{6 2}
- Sailors observed the fit between the coasts of Africa and South America when they began to map the shores of the Atlantic about 400 years ago.^{6 3} In 1812, Alfred Wegener *accounted for* this fit by his theory of continental drift,^{6 4} suggesting that South America and Africa had once been joined.
- In 1848, physicist Hippolyte Fizeau observed that the spectra^{6 5} of stars match spectra on earth, but are shifted toward the red. He *accounted for* this shift by suggesting that all the stars are moving away from us,^{6 6} as if the universe is expanding. In 1931, Georges Lemaître^{6 7} *accounted for* this expansion by suggesting that the universe had undergone a "big bang."^{6 8}
- From Aristotle^{6 9} on, biologists^{7 0} observed physical and genetic similarities among species.^{7 1} In 1859, Charles Darwin^{7 2} *accounted for* them by his theory of biological evolution,^{7 3} which asserts that all species had a common ancestor.^{7 4}

Do we *have to* "account for" our observations and patterns like this? Can we not just say "that's the way God made things"?

We can do either or both.

In Shakespeare's play *Hamlet*, Ophelia, driven mad by Hamlet's rejection, climbs on to a branch of a tree overhanging a stream. The branch breaks, she falls into the water, and eventually she drowns.^{7 5} We can account for her death by saying either "Shakespeare wanted her to die" (primary cause) or "the branch broke" (secondary cause). The two accounts are derived from two different orders of

radical, but lays down a hypothesis and shows that the observed effects are in accord with the supposition, as when astronomy employs a system of eccentrics and epicycles [Ptolemy's "wheels"] to justify our observations about the motions of heavenly bodies. It does not carry complete conviction, because another hypothesis might also serve" (Thomas Aquinas: *Summa Theologiae*, 1a, 32, 1 ad 2).

61 CCC 308

62 Still accepted today, derived by Newton from Kepler's "rules." Newton "began to think of gravity," hitherto considered to be a purely earthly phenomenon, as "extending to the orbit of the Moon," and "from Kepler's rule," he "deduced that the forces which keep the planets in their orbs must be reciprocally as the squares of their distances from the centers about which they revolve: and thereby compared the force requisite to keep the Moon in her orb with the force of gravity at the surface of the Earth, and found them to answer pretty nearly" (William Stukeley: *Memoirs of Sir Isaac Newton's Life*).

63 Since then, geologists have seen alignments between fossils and rock strata in the two continents.

64 Still used today in modified and expanded form.

65 The "rainbows" seen when the stars are observed through prisms or (better) diffraction gratings.

66 Similarly, the pitch of a siren on a vehicle is lower when it is moving away from the hearer.

67 A Belgian cosmologist and Catholic priest, a member of the Pontifical Academy of Sciences 1936-1966 and its president 1960-1966.

68 A scientific description not of God's creation of the universe out of nothing, but of an event that occurred very shortly afterward. (See the International Theological Commission: *Communion and Stewardship: Human Persons Created in the Image of God*, 67; see Appendix 2.) It has received much support from cosmological observations ever since.

69 384-322 BC

70 Including Thales (ancient Greek philosopher c 625-546 BC), Lucretius (Roman poet c 99-55 BC), Leonardo da Vinci (Renaissance scientist 1452-1519), and Jean Baptiste Lamarck (French zoologist 1744-1829).

71 The Human Genome Project, completed in 2003, revealed even more than scientists had expected.

72 1809-1882

73 Still used today, although much modified and expanded.

74 Twenty years after Darwin published *On the Origin of Species*, John Fordyce asked him whether he believed in God, and whether theism and the evolution of species were compatible. Darwin replied that "a man may be an ardent theist and an evolutionist," citing Charles Kingsley and Asa Gray as examples, and adding that "in my most extreme fluctuations I have never been an atheist in the sense of denying the existence of a God" (Letter 12041, May 7 1879). See Appendices 1 and 2.

75 See William Shakespeare: *Hamlet, Prince of Denmark*, Act 4, Scene 7.

knowledge, but they are both true, for Shakespeare made the whole play.⁷⁶

Different species have remarkable similarities. We can account for them by saying either "God made them similar" (Primary Cause) or "they evolved"⁷⁷ from the same ancestor" (secondary cause). The two accounts are derived from two different orders of knowledge, but they are both true, for God is "Lord of the universe" and "Master of history."⁷⁸

Therefore, if we account for the patterns in what we observe by saying simply that God is responsible, we do not make a mistake. However, we *opt out of science*. As Fr. George Coyne SJ, former director of the Vatican Astronomical Observatory, put it,⁷⁹ "Of course, God is responsible for everything that happens. *But I don't accept that answer: I'm a scientist.*" In other words, he believes in God as the Primary Cause, but *as a scientist*, he looks for secondary causes.⁸⁰

Similarly, when I asked my students why a cart accelerated, I wanted them to analyze the forces on it; I did not want them to say, "God made it accelerate."⁸¹

Questions and answers

Now let us consider some common questions.

If God "rules everything,"⁸² how can we speak of "chance" or "coincidence"?

To see what "chance" and "coincidence" mean, consider the following.

Julie walks on the sea wall every day at the same time. One day she meets Bob.

Julie went for a walk without any plan, design, or expectation of meeting Bob. She, then, says that the meeting happened "by chance."

However, without Julie's knowledge, Bob had planned it. He fully expected to meet her. He, then, says that the meeting happened "on purpose" or "by design."

Julie will continue to speak of "chance" or "coincidence" as long as she remains ignorant of Bob's design. Once she becomes aware of it, she will stop.

In summary: we speak of "chance" or "coincidence" insofar as we are ignorant of any "purpose," "design," or "plan."⁸³

Now God created the universe by design, on purpose, with a certain plan.⁸⁴ His purpose is "to make room for created persons in the communion of the uncreated Persons of the Blessed Trinity through adoptive participation in Christ."⁸⁵ His plan is "to bring all things in the heavens and on earth into one under Christ's headship."⁸⁶ His design will reach its perfection at "the end of time," when the

76 See C.S. Lewis: *God in the Dock*, "The Laws of Nature."

77 Always, where humans are concerned, meaning on the physical side only.

78 CCC 269

79 In a talk at Westminster Abbey, Mission BC, in 2002.

80 Accordingly, when Cardinal Christoph Schönborn of Vienna said that "any system of thought that denies or seeks to explain away the overwhelming evidence for design in biology is ideology, not science" (*New York Times*, July 7 2005), Fr. George V. Coyne SJ replied that "intelligent design isn't science even though it pretends to be. If you want to teach it in schools, [it] should be taught when religion or cultural history is taught, not science" (*USA Today*, August 6 2005).

81 I would not mark this answer wrong, but I would give it zero *in Physics*.

82 See CCC 368.

83 Even Bob could speak of "chance" insofar as he was not sure whether Julie actually would go for that walk: she could die, become ill, or simply change her mind. Mathematically, we describe an event about which we are uncertain by giving its "probability," which depends not only on what the event is, but also on how much (or how little) we know about it.

For example, what is the probability that Julie will live to be 75? If all we know about her is that she is female, we search the records and find that (say) 64% of all females born have reached 75, so our answer is 64/100. But if we are now told that she is already 67, our answer changes to (say) 88/100, for, according to the records, (say) 88% of all 67-year-old females have lived to be 75. Probabilities like this, calculated from experience, are called a *posteriori* probabilities.

For another example: suppose A pulls an ace from a deck of cards without telling B what the card is. Now B pulls a card at random from the rest of the deck. What is the probability that B will get an ace? B will say 4/52 (all he knows is that there are four aces in 52 cards), but A will say 3/51 (he knows that there are only three aces in the remaining 51 cards). Probabilities like this, calculated in advance, are called a *priori* probabilities.

84 See Gn 1,2. Also see the talk on "Creation and the Fall." The *Catechism* speaks of God's "plan" 99 times.

85 International Theological Commission: *Communion and Stewardship: Human Persons Created in the Image of God*, 65; see 68. See Appendix 2. Also see the talks on "God: Unity and Trinity" and "The Communion Among the Saints in the Body of Christ."

86 Eph 1:10. See CCC 280, 1042-1043.

universe "will be renewed" and "perfectly re-established in Christ."⁸⁷

In the meantime, as God "carries out His plan,"⁸⁸ the universe remains "in a state of journeying" toward its "ultimate perfection." We call "the dispositions by which God guides His creation toward this perfection" *divine providence*.⁸⁹

"By His providence, God protects and governs" what He has made. Everything is "open and laid bare to His eyes, even those things which" — from our point of view — "are yet to come into existence."⁹⁰ It is God Who, "at every moment,"⁹¹ does everything, and He does it on purpose, by design. Whatever happens is part of His plan,⁹² for He is its "sovereign Master."⁹³

However, *to us*, "the ways of His providence are often unknown." Only at the end, "when our partial knowledge ceases" and we see God "face to face,"⁹⁴ will we see fully how He "has guided His creation" to the end for which He created it.⁹⁵

Until then — as long as we remain ignorant of "the mysterious ways of God's almighty power"⁹⁶ — it is not wrong for us to say that an event has occurred "by chance," *provided we mean* simply that because of our ignorance of God's design, we could not have predicted it.⁹⁷

Similarly, since the characters in *Hamlet* are completely ignorant of Shakespeare's design, they may rightly say that Ophelia drowned by chance,⁹⁸ meaning that they could not have predicted that the branch would break.

Some people say that the complex yet ordered universe could not have developed "by chance"; it must be by God's design. Is this reasoning sound?

No. To see this, take an easier problem first.

Suppose I tell you that I picked six cards from the top of a shuffled deck and got nine, ten, jack, queen, king, and ace of spades.⁹⁹ You might very well say, "That couldn't have happened by chance!"

If you properly understand "chance," you mean that, before I picked the cards, the probability that I would get that combination was so low that, for me to get it, someone had to stack the deck.

However, as we have seen, the probability of getting *any* particular hand of six cards is equally low: $1/20,358,520 = 0.0000049\%$. And clearly the lowness of that probability does not mean that the deck always has to be stacked for me to get that hand.

The only way to find out whether the deck has been stacked is to ask the people

87 CCC 1042

88 CCC 302. Jesus said, "My Father is at work until now, and I am at work as well" (Jn 5:17).

89 "Providence" is derived from "provide." See CCC 302.

90 CCC 302

91 CCC 301

92 Notwithstanding the fact that "angels and men, as intelligent and free creatures, have to journey toward their ultimate destinies by their free choice and preferential love" (CCC 311). See the talk on "God's Will."

93 CCC 306. "God has foreseen all, He has neglected nothing. His eye, which never sleeps, watches over all. He is present everywhere and gives to each being the means of preservation" (Basil the Great: *Hexameron*, Homily 7, 5).

94 1 Cor 13:12

95 CCC 314

96 CCC 273

97 In ignorance, we may speak of "chance" where someone better informed speaks of "design" (see the example of Julie and Bob). However, many people mistakenly think of "chance" and "design" as mutually exclusive.

Accordingly, many atheists "seek to prove that it is scientific to think" — *i.e.*, unscientific not to think — "that all things lack guidance and order as though they were at the mercy of chance" (Pope Benedict XVI, General Audience November 9 2005).

Many theists think that miracles occur by God's design, but everything else "by chance," apart from Him. Accordingly, they refuse to speak of "chance" and try to demonstrate that everything important is miraculous — outside "the order usually observed in nature" (Thomas Aquinas: *Contra Gentiles*, III, cii). Others (Deists) hold that having created the universe, God leaves it to unbreakable "laws" that lead "by chance" to physical good or evil outside His design. (This is the heresy of Deism; see CCC 285.)

On the contrary, it is God Who, "at every moment," keeps all created things in being and "enables them to act" (CCC 301), however much or little we understand His design. Moreover, He "freely willed to create a world in a state of journeying toward its ultimate perfection," so that "with physical good, there exists physical evil" in the world until the end (CCC 310).

98 William Shakespeare: *Hamlet, Prince of Denmark*, Act 4, Scene 7

99 Not necessarily in that order.

who could have stacked it.

Now to estimate the probability that the universe would develop to its present state, scientists imagine that N different universes could have developed. Therefore, before the universe started to develop, the probability of its reaching its present state could be said to be $1/N$. Because N is so great, $1/N$ is very low.¹⁰⁰

However, as in choosing cards, the lowness of this probability does not *prove* that the universe *has* to have developed by anyone's design. To find out whether it has, we must ask the only Person Who could have designed it.

And, in the Book of Genesis, He answers *yes*.

People say that Newtonian physics leaves no room for God to act, while quantum mechanics does. Does that make sense?

No. Once again, we must realize that God has "absolute sovereignty over the course of events"; "the solicitude of divine providence is *concrete* and *immediate*."¹⁰¹

It is God Who determines everything in the physical universe, like the player who determines everything on the card table. Neither Newtonian physics nor quantum mechanics is anything more than a pattern we perceive in the "cards" God "plays."

To think of these patterns as "laws" that constrain God is to think like the foolish creatures on the card table, who may admit that the player made the laws, but think that from then on, the laws actually *cause* the game, operating independently of the player.¹⁰²

Accordingly, these people wrongly claim that Newtonian physics, because it predicts *exactly* how fast an object will accelerate, forces God — the Player — completely out of the picture, while quantum physics, because it predicts only probabilities, leaves Him room to determine the exact details.

No. "As universal transcendent Cause, God is not only the cause of existence but also the cause of [secondary] causes." His action "does not displace or supplant" them, but "enables them to act according to their natures and, nonetheless, to bring about the ends He intends"¹⁰³ — although "we have no way of understanding precisely how this is possible."¹⁰⁴

Did God create humans or did they evolve by chance?

God created humans, like everything else, by His design. He said, "Let us make man in Our image, after Our likeness," and that is what He did.¹⁰⁵

Now this likeness to God, which is what distinguished Adam and Eve from the animals, was spiritual, chiefly in their souls;¹⁰⁶ it could not be observed or described scientifically.¹⁰⁷

However, their *bodies* could.¹⁰⁸ The question of how God made the first human

100 If fundamental constants like the speed of light or the mass of the electron had been different by a factor of even one millionth, the universe might have been very different — perhaps without human bodies as we know them. Accordingly, some scientists describe the universe as "fine-tuned."

Unfortunately, what they suggest by this metaphor is that God "aimed" at human life like a cook making a soup — "If I want a universe with life, I'll have to cut down the salt and add a few potatoes" — or a man building a machine — "If I want humans, I'll have to increase the speed of light." They imply that God *must* have fine-tuned the universe at creation, for (as they believe) He has been bound ever since by the scientific "laws" He created to run it. Again, this is the heresy of Deism (see CCC 285). "A God like that would severely test my faith," said Fr. George Coyne SJ in a talk at Westminster Abbey, Mission BC, in 2002.

101 CCC 303

102 The heresy of Deism (see CCC 285).

103 "In freely willing to create and conserve [preserve] the universe, God wills to activate and to sustain in act all those secondary causes whose activity contributes to the unfolding of the natural order that He intends to produce" (International Theological Commission: *Communion and Stewardship: Human Persons Created in the Image of God*, 68-70; see Appendix 2).

104 God is not "a Supreme Being squatting outside the world and intervening in it on occasion.... God is capable of a noninvasive and noninterruptive intimacy with that which He has made" (Robert Barron: *The Priority of Christ*, 12).

105 See Gn 1:26-27.

106 See *The Penny Catechism*, 4. It included "self-knowledge," "self-possession," the ability to enter into "communion with other persons" (CCC 357), the capacity "to know and love" their Creator, and the possibility of sharing, "by knowledge and love, in God's own life" (CCC 356).

107 Scientists study only what can be observed by means of the senses.

108 Similarly, in God's creation of *any* new human, His direct creation of the spiritual soul cannot be the object of scientific study (see Pope John Paul II: *Reflection on Science at the Dawn of the Third*

bodies is a scientific question: did He make them out of nothing,¹⁰⁹ "the clay of the ground,"¹¹⁰ or pre-existing living things?

According to the theory of biological evolution, God used radiation and chemicals as secondary causes (which we, in our ignorance, say "acted by chance") to change the bodies of organisms gradually from those of one-celled sea animals, through those of dinosaurs, to those of the great apes, and thence to those of humans.¹¹¹

According to this theory, then, the *bodies* of the first humans were like those of apes.¹¹² However, human bodies have continued to evolve, producing the present "rich variety of persons, cultures, and peoples."¹¹³

The theory of biological evolution must be judged on *scientific* grounds. Does it account for all the evidence? Is it the simplest we can think of? Pope John Paul II said it must be recognized as "more than a hypothesis," but not pushed past the limits of science.¹¹⁴ More recently, the Church has called it practically "certain."¹¹⁵

The Church quoted the Bible against Galileo. Can we quote it against evolution?

No. On October 31 1992, Pope John Paul II formally acknowledged that the Church had made a mistake in condemning Galileo.¹¹⁶

The Bible "speaks to us of the origin of the universe and its make-up not in order to provide us with a scientific treatise, but in order to state the correct relationships of man with God and with the universe.... Any other teaching about the origin and makeup of the universe is alien to the intentions of the Bible."¹¹⁷ 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."¹¹⁸

Who cures people: God, nature, or doctors?

God does everything. "It happened naturally" means that God did it in His usual ways. "The doctors did it" means that they co-operated with God.

Usually, however, this question means, "Was the cure natural or miraculous?"

If enough similar cures have been observed, this is one of God's normal ways of curing people, so we call it natural. If not, God has done it in a different way, an unusual way, so we call it a miracle. But in either case, *it is God Who has done it.*

If science is good, why does the Church condemn genetic engineering?

"Science and technology are precious resources" when they "promote" man's "integral development for the benefit of all."¹¹⁹ However, the Church condemns¹²⁰ some scientific *methods*, like the breeding of humans purely for research.¹²¹

Millennium, 6; see Appendix 1), but the contributions of the human parents can.

109 See Gn 1:27.

110 Gn 2:7

111 Science can describe these life forms, date them "with increasing precision," and discover "very valuable signs indicating what is specific to the human being." However, as we have said, "the moment of transition to the spiritual cannot be the object of this kind of observation" (Pope John Paul II: *Reflection on Science at the Dawn of the Third Millennium*, 6; see Appendix 1).

112 The Bible says nothing about the *bodies* of the first humans. And for us to imagine that God would have been willing to stamp His likeness on a creature that looked like a modern white man or woman, but not on a hairy ape, is to underestimate His condescension. God loves us not because we are lovable, but because He is Love. See the talks on "Creation and the Fall" and "Love of God and Neighbour."

113 CCC 361

114 The "convergence" of evidence, "neither sought nor fabricated," from independent fields of knowledge is "a significant argument in favour of this theory." However, in God's creation of humans, it cannot account for "the moment of transition to the spiritual" or our experience of metaphysical knowledge, self-awareness, self-reflection, moral conscience, freedom, or aesthetic and religious experience (Pope John Paul II: *Reflection on Science at the Dawn of the Third Millennium*, 6; see Appendix 1).

115 International Theological Commission: *Communion and Stewardship: Human Persons Created in the Image of God*, 63. See Appendix 2.

116 Scientifically, the Solar System can be described equally accurately by Ptolemy's Earth-centered model or Copernicus' Sun-centered model — something Galileo apparently did not understand. We now use the second model (for certain purposes) because it is simpler.

117 Pope John Paul II: Address to the Pontifical Academy of Sciences October 3 1981

118 Pope John Paul II: Address to the Pontifical Academy of Sciences October 31 1992

119 "Basic scientific research" — the study of the manner in which God normally does things — "as well as applied research" — the study of how scientific knowledge can be put to use — "is a significant expression of man's dominion over creation," which God gave Adam and Eve. See Gn 1:28; CCC 2293.

120 Similarly, a sculptor might condemn the methods of a geologist if they involved destroying a sculpture.

121 "Science cannot tell between good and evil." It needs "to know and to be told by authority what is good"

Genetic research holds promise for human health, but also raises serious threats to society and its weakest member, the human embryo. There are the risks of eugenics,^{1 2 2} the danger of producing mutations that will harm individuals or the race, and the "delicate problems" raised by diagnosing genetic traits in adults. Scientists must respect the individual person even "from the moment of conception."^{1 2 3}

Could there be life on other planets?

There could. Some stars have planets like ours. However, life does not emerge automatically from the "right" physical conditions. On the other hand, we have no compelling reason to think that we are the universe's only intelligent beings.^{1 2 4}

We cannot calculate the "probability" of life on other planets as we calculate probabilities in a card game,^{1 2 5} because we do not know all the steps by which life developed even on our own planet. The probability based on our experience^{1 2 6} is zero. We can only hope to recognize life on other planets if we find it.^{1 2 7}

The Church has no position on this topic.^{1 2 8}

'Two different orders of knowledge'

To summarize, then: God determines all the details of the whole physical universe at every moment, from the smallest elementary particle to the greatest galaxy. The business of science is to discover and describe patterns in these details.

Scientists describe these patterns without referring to God. Analogously, the two-dimensional creatures on the card table can describe patterns among the cards without referring to the player.

Thus the patterns scientists discover neither *require* nor *prevent* belief in God.^{1 2 9} In fact, the whole question of whether or not the universe is governed "by a transcendent, intelligent, and good Being" goes "beyond the proper domain of the natural sciences."^{1 3 0}

For some people, science fosters belief; for others, it hinders belief. People evaluate evidence differently; what convinces one does not convince another.^{1 3 1}

"Science and faith represent two different orders of knowledge" which are "autonomous"^{1 3 2} in their processes.^{1 3 3} However, they finally converge on "the discovery of the integral reality which has its origin in God."^{1 3 4}

(Dr. Jérôme Lejeune, in an interview in Rome November 18 1994). As a genetics professor at the University of Paris, Dr. Lejeune helped discover the extra chromosome that causes Down's Syndrome. He was a papally appointed member of the Pontifical Academy of Sciences from 1974 until he died in 1994.

122 Selective human breeding.

123 Pope John Paul II: Address to a seminar sponsored by the Pontifical Academy of Sciences November 20 1994

124 See Fr. George Coyne SJ: interview with Catholic News Service October 23 1992.

125 What mathematicians call the *a priori* probability.

126 What mathematicians call the *a posteriori* probability.

127 It may be difficult to recognize if it does not require oxygen or water, for example.

128 See Joseph Ratzinger: *God and the World*, Part I, 3, "The Crown of Creation." For an imaginative Christian treatment of the topic, see C.S. Lewis: *Out of the Silent Planet* and *Peregrina*.

129 "The step to religious affirmation is not achieved *per se* by virtue of the experimental scientific method" (Pope John Paul II: General Audience July 17 1985).

130 See CCC 284. On the one hand, those "who adduce random genetic variation and natural selection as evidence that the process of evolution is absolutely unguided are straying beyond what can be demonstrated by science" (International Theological Commission: *Communion and Stewardship: Human Persons Created in the Image of God*, 69; see Appendix 2). On the other hand, when Pope Pius XII said that Fr. Georges LeMaitre's "Big Bang" theory validated the Catholic faith, LeMaitre said, "As far as I can see, such a theory remains entirely outside any metaphysical or religious question. It leaves the materialist free to deny any transcendental Being" (Odon Godart and Michal Heller: *Cosmology of LeMaitre*).

131 See the *Introduction* to this course; watch the 1957 movie *Twelve Angry Men*. "There must, perhaps, always be just enough lack of demonstrative certainty to make free choice possible; for what could we do but accept if the faith were like the multiplication table?" (C.S. Lewis: Letter, quoted in Sheldon Vanauken: *A Severe Mercy*, V).

132 Possessing the right of self-government.

133 Pope John Paul II at a 1982 symposium marking 350 years since the publication of Galileo's book

134 Pope John Paul II: Address to the Pontifical Academy of Sciences October 31 1992

Conclusion

What place is there for science, then, in the Catholic faith?

Science adds nothing to God or His work, for God made not only the universe, but also science, scientists, and their ability to see patterns in His work.

Human beings can know God without being scientists. And, with Isaiah, even scientists must say to God, "It is You Who have accomplished all we have done."¹³⁵

However, through science, God can give us "sound knowledge of existing things," that we "might know the organization of the universe and the force of its elements."¹³⁶ Thus, to believers, science presents new aspects of God,¹³⁷ inviting us to "even greater admiration" for His greatness and prompting us to "give Him thanks for all His works."¹³⁸

With Mary, then, scientists can say that they "magnify"¹³⁹ God and His works. In fact, as scientists, they have a certain responsibility to do so.¹⁴⁰

"If I were Francis of Assisi,¹⁴¹ I would say: O galaxies of the immense heavens, give praise to my Lord, for He is omnipotent and good. O atoms, O protons, O electrons, O bird-songs, O blowing of the leaves and of the air, in the hands of man as in a prayer, sing out the hymn which returns to God!"¹⁴²

135 Is 26:12

136 See Wis 7:17, quoted in CCC 283.

137 A scientist is "a privileged witness of the plausibility of religion" (Pope John Paul II: General Audience July 17 1985). "If a man loves God knowing a little about Him, he should love God more from knowing more about Him; for each new thing known about God is a new reason for loving Him" (Frank Sheed: *Theology and Sanity*, 1).

"When I look at the universe I think, 'We are created in the image and likeness of God.' In some sense, the whole universe is created in the image and likeness of God.... The evolution of the universe toward living organisms and the human brain shows beautifully that the image of God was in the universe from the very beginning, in seminal form. That means a lot more to me as a scientist than it would otherwise" (Fr. George Coyne SJ: Interview with Catholic News Service December 1996).

Newton believed that the "most elegant order" he and Kepler had discovered in the Solar System "could not have been born without the design and power of an intelligent and powerful being," who "rules all things, not as the soul of the world, but as Lord of the Universe.... From blind metaphysical necessity that is absolutely identical always and everywhere, no variety in things can be born. The whole truth of things, including places and times, could only have arisen from the ideas and the will of a necessarily existent Being" (Isaac Newton: *Scholium Generale*, quoted by Pope John Paul II in an address to the Pontifical Academy of Sciences November 12 1983).

"What is eternally incomprehensible in the world is that it is comprehensible" (Albert Einstein: *Journal of the Franklin Institute*, Volume 221, 3, March 1936). The "intelligibility" of the universe "leads us, in the last analysis, to that transcendent and primordial Thought imprinted on all things" (Pope John Paul II: Address to the Pontifical Academy of Sciences October 31 1992).

138 CCC 283.

139 See Lk 1:46.

140 "Christians have the responsibility to locate the modern scientific understanding of the universe within the context of the theology of creation" (International Theological Commission: *Communion and Stewardship: Human Persons Created in the Image of God*, 62; also see 66; see Appendix 2). "The consideration of creatures [*i.e.* "created things"] has its part to play in building the Christian faith. And for this reason it is said, 'Now I will recall God's works; what I have seen, I will describe. At God's word were His works brought into being; they do His will as He has ordained for them'" (Sir 42:15). "It is, therefore, evident that the opinion is false of those who asserted that it made no difference to the truth of the faith what anyone holds about creatures, so long as one thinks rightly about God" (Thomas Aquinas: *Summa Contra Gentiles*, Book 2, 2-3).

141 Compare Francis of Assisi: *Canticum of Creation*.

142 Physicist Enrico Medi (1911-1974): Address to the International Catechetical Congress, Rome, 1971; quoted by Pope John Paul II in his General Audience July 17 1985.

Appendix 1: Reflection on Science at the Dawn of the Third Millennium

Vatican City (CNS) — Here is the translation of the body of Pope John Paul II's French-language message to members of the Pontifical Academy of Sciences October 22 1996. The translation appeared in the October 30 issue of the English edition of the Vatican newspaper, L'Osservatore Romano, with the exception of a mistranslation that was corrected the following week.

1. In celebrating the 60th anniversary of the academy's re-foundation,¹ I would like to recall the intentions of my predecessor Pius XI, who wished to surround himself with a select group of scholars, relying on them to inform the Holy See in complete freedom about developments in scientific research, and thereby to assist him in his reflections.

He asked those whom he called the Church's *senatus scientificus* to serve the truth. I again extend this same invitation to you today, certain that we will be able to profit from the fruitfulness of a trustful dialogue between the Church and science.²

2. I am pleased with the first theme you have chosen, that of the origins of life and evolution, an essential subject which deeply interests the Church, since Revelation, for its part, contains teaching concerning the nature and origins of man.

How do the conclusions reached by the various scientific disciplines coincide with those contained in the message of Revelation? And if, at first sight, there are apparent contradictions, in what direction do we look for their solution?

We know, in fact, that truth cannot contradict truth.³ Moreover, to shed greater light on historical truth, your research on the Church's relations with science between the 16th and 18th centuries is of great importance.

During this plenary session, you are undertaking a "reflection on science at the dawn of the third millennium," starting with the identification of the principal problems [that are] created by the sciences and [that] affect humanity's future. With this step you point the way to solutions that will be beneficial to the whole human community.

In the domain of inanimate and animate nature, the evolution of science and its applications gives rise to new questions. The better the Church's knowledge is of their essential aspects, the more she will understand their impact.

Consequently, in accordance with her specific mission, she will be able to offer criteria for discerning the moral conduct required of all human beings in view of their integral salvation.

3. Before offering you several reflections that more specifically concern the subject of the origin of life and its evolution, I would like to remind you that the magisterium of the Church has already made pronouncements on these matters within the framework of her own competence. I will cite here two interventions.

In his encyclical *Humani Generis*, my predecessor Pius XII had already stated that there was no opposition between evolution and the doctrine of the faith about man and his vocation, on condition that one did not lose sight of several indisputable points.⁴

For my part, when I received those taking part in your academy's plenary assembly on October 31 1992, I had the opportunity with regard to Galileo to draw attention to the need of a rigorous hermeneutic for the correct interpretation of the inspired word. It is necessary to determine the proper sense of Scripture, while avoiding any unwarranted interpretations that make it say what it does not intend to say.

In order to delineate the field of their own study, the exegete and the theologian must keep informed about the results achieved by the natural sciences.⁵

1 The Pontifical Academy of Sciences, the only such supranational body in the world, was founded as the *Linceorum Academia* ("Academy of the Lynx-Eyed") in Rome August 17 1603 by Federico Cesi. Galileo Galilei was appointed a member August 25 1610, signing himself thenceforth "Galileo Galilei Linceo." The academy failed after Cesi's death in 1630 and disappeared after 1651, but Pius IX re-established it in 1847 under the name *Pontificia Accademia dei Nuovi Lincei* ("Pontifical Academy of the New Lynxes"); in 1922 it moved to its current home in the Casina Pio IV in the Vatican Gardens; and in 1936 Pius XI gave it its current name and statutes. Governed by a president and council, its mission is to honour pure science, ensure its freedom, and encourage scientific research. Its 80 members are chosen by the academy from the most eminent scientists of the world without ethnic or religious discrimination and appointed for life by the Pope.

2 See Pope John Paul II: Address to the Academy of Sciences October 28 1986.

3 See Pope Leo XIII: *Providentissimus Deus*, 23.

4 See Pope Pius XII: *Humani Generis*, 36-37.

5 See Pope John Paul II: Address to the Pontifical Biblical Commission April 23 1993, announcing the document "The Interpretation of the Bible in the Church."

4. Taking into account the state of scientific research at the time as well as the requirements of theology, the encyclical *Humani Generis* considered the doctrine of "evolutionism" a serious hypothesis, worthy of investigation and in-depth study equal to that of the opposing hypothesis.

Pius XII added two methodological conditions: that this opinion should not be adopted as though it were a certain, proven doctrine and as though one could totally prescind from Revelation with regard to the questions it raises. He also spelled out the condition on which this opinion would be compatible with the Christian faith, a point to which I will return.

Today, almost half a century after the publication of the encyclical, new knowledge has led to the recognition of the theory of evolution as more than a hypothesis. It is indeed remarkable that this theory has been progressively accepted by researchers, following a series of discoveries in various fields of knowledge. The convergence, neither sought nor fabricated, of the results of work that was conducted independently is in itself a significant argument in favour of this theory.

What is the significance of such a theory? To address this question is to enter the field of epistemology. A theory is a meta-scientific elaboration, distinct from the results of observation but consistent with them. By means of it a series of independent data and facts can be related and interpreted in a unified explanation. A theory's validity depends on whether or not it can be verified; it is constantly tested against the facts; wherever it can no longer explain the latter, it shows its limitations and unsuitability. It must then be rethought.

Furthermore, while the formulation of a theory like that of evolution complies with the need for consistency with the observed data, it borrows certain notions from natural philosophy.

And, to tell the truth, rather than the theory of evolution, we should speak of several theories of evolution. On one hand, this plurality has to do with the different explanations advanced for the mechanism of evolution, and on the other, with the various philosophies on which it is based. Hence the existence of materialist, reductionist, and spiritualist interpretations. What is to be decided here is the true role of philosophy and, beyond it, of theology.

5. The Church's magisterium is directly concerned with the question of evolution, for it involves the conception of man: Revelation teaches us that he was created in the image and likeness of God.⁶

The conciliar constitution *Gaudium et Spes* has magnificently explained this doctrine, which is pivotal to Christian thought. It recalled that man is "the only creature on earth that God has wanted for its own sake."⁷ In other terms, the human individual cannot be subordinated as a pure means or a pure instrument, either to the species or to society; he has value *per se*. He is a person. With his intellect and his will, he is capable of forming a relationship of communion, solidarity, and self-giving with his peers.

St. Thomas [Aquinas] observes that man's likeness to God resides especially in his speculative intellect, for his relationship with the object of his knowledge resembles God's relationship with what He has created.⁸

But even more, man is called to enter into a relationship of knowledge and love with God Himself, a relationship that will find its complete fulfillment beyond time, in eternity.

All the depth and grandeur of this vocation are revealed to us in the mystery of the risen Christ.⁹ It is by virtue of his spiritual soul that the whole person possesses such a dignity even in his body.

Pius XII stressed this essential point: Though the human body takes its origin from pre-existent living matter, the spiritual soul is immediately created by God.¹⁰

Consequently, theories of evolution which, in accordance with the philosophies inspiring them, consider the spirit as emerging from the forces of living matter or as a mere epiphenomenon of this matter, are incompatible with the truth about man. Nor are they able to ground the dignity of the person.

6. With man, then, we find ourselves in the presence of an ontological difference, an ontological leap, one could say. However, does not the posing of such ontological discontinuity run counter to that physical continuity which seems to be the main thread of research into

6 See Gn 1:27-29.

7 Vatican II: *Gaudium et Spes*, 24

8 *Summa Theologiae*, Part I-II, Question 3, Article 5, ad 1

9 See Vatican II: *Gaudium et Spes*, 22.

10 See Pope Pius XII: *Humani Generis*, 36.

evolution in the fields of physics and chemistry?

Consideration of the method used in the various branches of knowledge makes it possible to reconcile two points of view which would otherwise seem irreconcilable.

The sciences of observation describe and measure the multiple manifestations of life with increasing precision and correlate them with the time line. The moment of transition to the spiritual cannot be the object of this kind of observation, which nevertheless can discover at the experimental level a series of very valuable signs indicating what is specific to the human being; the experience of metaphysical knowledge, of self-awareness and self-reflection, of moral conscience, freedom, or again of aesthetic and religious experience, falls within the competence of philosophical analysis and reflection, while theology brings out its ultimate meaning according to the Creator's plans.

7. In conclusion, I would like to call to mind a Gospel truth which can shed a higher light on the horizon of your research into the origins and unfolding of living matter.

The Bible, in fact, bears an extraordinary message of life. It gives us a wise vision of life inasmuch as it describes the loftiest forms of existence. This vision guided me in the encyclical which I dedicated to respect for human life, and which I called precisely *Evangelium Vitae* ["The Gospel of Life"].

It is significant that in St. John's Gospel life refers to the divine life which Christ communicates to us. We are called to enter into eternal life, that is to say, into the eternity of divine beatitude. To warn us against the serious temptations threatening us, our Lord quotes the great saying of Deuteronomy: "Man shall not live by bread alone, but by every word that proceeds from the mouth of God."¹¹

Even more, "life" is one of the most beautiful titles which the Bible attributes to God. He is the living God.

Appendix 2: Human Persons Created in the Image of God

Here is an excerpt entitled "Science and the Stewardship of Knowledge" from the above-named document, published July 23 2004 by the International Theological Commission. Paragraph 64 has been omitted because it recapitulates Appendix 1.

62. The endeavor to understand the universe has marked human culture in every period and in nearly every society. In the perspective of the Christian faith, this endeavor is precisely an instance of the stewardship that human beings exercise in accordance with God's plan. Without embracing a discredited concordism, Christians have the responsibility to locate the modern scientific understanding of the universe within the context of the theology of creation. The place of human beings in the history of this evolving universe, as it has been charted by modern sciences, can be seen in its complete reality only in the light of faith, as a personal history of the engagement of the triune God with creaturely persons.

63. According to the widely accepted scientific account, the universe erupted 15 billion years ago in an explosion called the "Big Bang" and has been expanding and cooling ever since. Later there gradually emerged the conditions necessary for the formation of atoms, still later the condensation of galaxies and stars, and about 10 billion years later the formation of planets.

In our own solar system and on earth (formed about 4.5 billion years ago), the conditions have been favorable to the emergence of life. While there is little consensus among scientists about how the origin of this first microscopic life is to be explained, there is general agreement among them that the first organism dwelt on this planet about 3.5-4 billion years ago.

Since it has been demonstrated that all living organisms on earth are genetically related, it is virtually certain that all living organisms have descended from this first organism. Converging evidence from many studies in the physical and biological sciences furnishes mounting support for some theory of evolution to account for the development and diversification of life on earth, while controversy continues over the pace and mechanisms of evolution.

While the story of human origins is complex and subject to revision, physical anthropology and molecular biology combine to make a convincing case for the origin of the human species in Africa about 150,000 years ago in a humanoid population of common genetic lineage. However it is to be explained, the decisive factor in human origins was a continually increasing

¹¹ Dt 8:3; Mt 4:4

brain size, culminating in that of *homo sapiens*. With the development of the human brain, the nature and rate of evolution were permanently altered: with the introduction of the uniquely human factors of consciousness, intentionality, freedom, and creativity, biological evolution was recast as social and cultural evolution.

65. ... human persons are created in the image of God in order to become partakers of the divine nature¹ and thus to share in the communion of Trinitarian life and in the divine dominion over visible creation. At the heart of the divine act of creation is the divine desire to make room for created persons in the communion of the uncreated Persons of the Blessed Trinity through adoptive participation in Christ.

What is more, the common ancestry and natural unity of the human race are the basis for a unity in grace of redeemed human persons under the headship of the New Adam in the ecclesial communion of human persons united with one another and with the uncreated Father, Son, and Holy Spirit. The gift of natural life is the basis for the gift of the life of grace.

It follows that, where the central truth concerns a person acting freely, it is impossible to speak of a necessity or an imperative to create, and it is, in the end, inappropriate to speak of the Creator as a force, or energy, or ground. Creation *ex nihilo*² is the action of a transcendent personal agent, acting freely and intentionally, with a view toward the all-encompassing purposes of personal engagement.

In Catholic tradition, the doctrine of the origin of human beings articulates the revealed truth of this fundamentally relational or personalist understanding of God and of human nature. The exclusion of pantheism and emanationism in the doctrine of creation can be interpreted at root as a way of protecting this revealed truth. The doctrine of the immediate or special creation of each human soul not only addresses the ontological discontinuity between matter and spirit, but also establishes the basis for a divine intimacy which embraces every single human person from the first moment of his or her existence.

66. The doctrine of *creatio ex nihilo* is thus a singular affirmation of the truly personal character of creation and its order toward a personal creature who is fashioned as the *imago Dei*³ and who responds not to a ground, force, or energy, but to a Personal Creator. The doctrines of the *imago Dei* and the *creatio ex nihilo* teach us that the existing universe is the setting for a radically personal drama, in which the triune Creator calls out of nothingness those to whom He then calls out in love. Here lies the profound meaning of the words of *Gaudium et Spes*: "Man is the only creature on earth that God willed for his own sake."⁴

Created in God's image, human beings assume a place of responsible stewardship in the physical universe. Under the guidance of divine providence, and acknowledging the sacred character of visible creation, the human race reshapes the natural order, and becomes an agent in the evolution of the universe itself. In exercising their stewardship of knowledge, theologians have the responsibility to locate modern scientific understandings within a Christian vision of the created universe.

67. With respect to *creatio ex nihilo*, theologians can note that the Big Bang theory does not contradict this doctrine insofar as it can be said that the supposition of an absolute beginning is not scientifically inadmissible. Since the Big Bang theory does not in fact exclude the possibility of an antecedent stage of matter, it can be noted that the theory appears to provide merely indirect support for the doctrine of *creatio ex nihilo*, which, as such, can be known only by faith.

68. With respect to the evolution of conditions favourable to the emergence of life, Catholic tradition affirms that, as universal transcendent cause, God is not only the cause of existence but also the cause of causes. God's action does not displace or supplant the activity of creaturely causes, but enables them to act according to their natures and, nonetheless, to bring about the ends He intends.

In freely willing to create and conserve the universe, God wills to activate and to sustain in act all those secondary causes whose activity contributes to the unfolding of the natural order that He intends to produce. Through the activity of natural causes, God causes to arise those conditions required for the emergence and support of living organisms, and, furthermore, for their reproduction and differentiation.

1 See 2 Pt 1:3-4.

2 "Creation out of nothing"

3 "Image of God"

4 Vatican II: *Gaudium et Spes*, 24

Although there is scientific debate about the degree of purposiveness or design operative and empirically observable in these developments, they have *de facto*⁵ favoured the emergence and flourishing of life. In such reasoning, Catholic theologians can see support for the affirmation entailed by faith in divine creation and divine providence. In the providential design of creation, the triune God intended not only to make a place for human beings in the universe but also, and ultimately, to make room for them in His own Trinitarian life. Furthermore, operating as real, though secondary causes, human beings contribute to the reshaping and transformation of the universe.

69. The current scientific debate about the mechanisms at work in evolution requires theological comment insofar as it sometimes implies a misunderstanding of the nature of divine causality. Many neo-Darwinian scientists, as well as some of their critics, have concluded that, if evolution is a radically contingent materialistic process driven by natural selection and random genetic variation, then there can be no place in it for divine providential causality. A growing body of scientific critics of neo-Darwinism point to evidence of design (*e.g.*, biological structures that exhibit specified complexity) that, in their view, cannot be explained in terms of a purely contingent process and that neo-Darwinians have ignored or misinterpreted.

The nub of this currently lively disagreement involves scientific observation and generalization concerning whether the available data support inferences of design or chance, and cannot be settled by theology. But it is important to note that, according to the Catholic understanding of divine causality, true contingency in the created order is not incompatible with a purposeful divine providence. Divine causality and created causality radically differ in kind and not only in degree. Thus, even the outcome of a truly contingent natural process can nonetheless fall within God's providential plan for creation.

According to St. Thomas Aquinas: "The effect of divine providence is not only that things should happen somehow, but that they should happen either by necessity or by contingency. Therefore, whatsoever divine providence ordains to happen infallibly and of necessity happens infallibly and of necessity; and that happens from contingency, which the divine providence conceives to happen from contingency."⁶

In the Catholic perspective, neo-Darwinians who adduce random genetic variation and natural selection as evidence that the process of evolution is absolutely unguided are straying beyond what can be demonstrated by science. Divine causality can be active in a process that is both contingent and guided. Any evolutionary mechanism that is contingent can only be contingent because God made it so. An unguided evolutionary process — one that falls outside the bounds of divine providence — simply cannot exist because "the causality of God, Who is the first Agent, extends to all being, not only as to constituent principles of species, but also as to the individualizing principles.... It necessarily follows that all things, inasmuch as they participate in existence, must likewise be subject to divine providence."⁷

70. With respect to the immediate creation of the human soul, Catholic theology affirms that particular actions of God bring about effects that transcend the capacity of created causes acting according to their natures.

The appeal to divine causality to account for genuinely causal as distinct from merely explanatory gaps does not insert divine agency to fill in the "gaps" in human scientific understanding (thus giving rise to the so-called "God of the gaps"). The structures of the world can be seen as open to non-disruptive divine action in directly causing events in the world.

Catholic theology affirms that the emergence of the first members of the human species (whether as individuals or in populations) represents an event that is not susceptible of a purely natural explanation and which can appropriately be attributed to divine intervention. Acting indirectly through causal chains operating from the beginning of cosmic history, God prepared the way for what Pope John Paul II called "an ontological leap... the moment of transition to the spiritual."⁸ While science can study these causal chains, it falls to theology to locate this account of the special creation of the human soul within the overarching plan of the triune God to share the communion of Trinitarian life with human persons who are created out of nothing in the image and likeness of God, and who, in His name and according to His plan, exercise a creative stewardship and sovereignty over the physical universe.

5 "As a matter of fact"

6 Thomas Aquinas: *Summa Theologiae*, I, 22, 4 ad 1

7 Thomas Aquinas: *Summa Theologiae*, I, 22, 2

8 *Reflection on Science at the Dawn of the Third Millennium*, 6; see Appendix 1.