REPORT 28

COMMITTEE ON CREATION AND SCIENCE

I. Introduction

A. *Mandate*

Synod 1988 appointed a study committee composed of representatives from the areas of natural science, philosophy of science, and theology and assigned to that committee the following mandate:

> To address the relationship between special and general revelation as found in Belgic Confession Article II and in Report 44 of the Synod of 1972 focusing primarily on the implications for biblical interpretation and the investigation of God's creation. This task should include, but not be limited to, such matters as the following: The concept of "vehicle/packaging/contents," the designation of Genesis 1 as "primeval history," the creation of Adam and Eve in God's image, the fall into sin, and the doctrines of creation and providence as they relate to evolutionary theory. The task should also include an investigation of the difference, if any, in our subjection to God's special and God's general revelation.
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> (*Acts of Synod 1988*, p. 598)

B. *History of the mandate*

The issue of creation and evolution first appeared on synod's agenda in response to three general principles adopted by the 1949 Reformed Ecumenical Synod. After voicing several objections to these principles, the CRC Synod of 1959 accepted as information the revised formulation adopted by the Fourth Ecumenical Synod of Potchefstroom (1958). The key principle was worded as follows:

> Observing the historicity of Gen. 1 and 2 implies *inter alia* an acceptance of Divine Creation, maintenance, and government of the entire world, and accordingly implies that the church should repudiate any concept of evolution which (1) entirely eliminates God, (2) regards Him as dependent on the process of creative evolution, or (3) regards Him as merely incidentally intervening in the natural course of evolution. Generally, because it has to preach the Word of God, which is not a scientific treatise and which should not be bound to any particular exegetical exposition, the Church should observe the utmost discretion in making all kinds of pronouncements in connection with scientific matters.
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> (*Acts of Synod 1959*, p. 81)

It should be noted that while the Reformed Ecumenical Synod affirmed the historicity of Genesis 1 and 2 and rejected approaches that viewed these chapters as "visionary," as "symbolic," or as "allegorical myth," the synod refused to endorse a specific exegetical theory. While the synod also rejected atheistic and materialistic evolution and any view asserting in whole or in part autonomous natural development, the synod refused to reject theistic evolution, preferring to leave that matter to Christian scholarship to investigate. These "guiding principles" were not in any way confessionally binding and were intended only to be considered seriously by the member churches of the Reformed Ecumenical Synod. The 1959 Synod of the CRC received them as information.

Responding to three overtures requesting the church to study the matter of creation and evolution, Synod 1966 appointed a committee to advise Synod 1967 as to the membership and mandate of such a committee. However, Synod 1966 was aware of the limitations under which such a committee would operate. Listen to the wisdom of the advisory committee:

> A study such as requested by these overtures is a matter of immense magnitude. One cannot simply instruct a committee "to study the teaching of Scripture in relation to the subject of creation and evolution" or to "define the doctrinal position of the CRC with regard to . . . theistic Evolution" and expect it wholly to fulfill this mandate. These subjects involve the entire matter of the relation of science and Scripture, a matter which has vexed the Christian community ever since the rise of science in the modern world. This problem, as is also true of certain other theological problems, is probably incapable of complete resolution in this life.
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> (*Acts of Synod 1966*, pp. 76-77)

This same advisory committee also believed that a committee studying these issues would not be able to produce a "creedal" type of statement and suggested that reassuring persons "in the pew" was not an easy matter, because the membership of the church reflects "many different backgrounds with vastly different kinds and levels of training." Although a committee and a mandate were proposed, Synod 1967 did not implement the decision of 1966 because there was no case before it and because "this is a study we may confidently trust can and will be carried on by interested and competent and responsible persons in the community of our common faith" (*Acts of Synod 1967*, pp. 76-77).

The study was continued by competent persons, and Synod 1988 had the issue before it. This issue was occasioned especially by the publication in 1986 of Dr. Howard Van Till's book *The Fourth Day*, but it also involved questions about the teachings of Professors Clarence Menninga and Davis Young. Since all three were professors at Calvin College, the Board of Trustees appointed a special committee to evaluate their published statements and to determine whether "these statements are in accord with the synodically adopted guidelines for the interpretation of Scripture and with the doctrinal statements of the Christian Reformed Church" (*Acts of Synod 1988*, p. 591). Without summarizing the committee's findings (cf. *Acts of Synod 1988*, pp. 592-94), we would note only that while the committee spoke of some questions that challenge us and some weaknesses and lack of precision in presentation, it noted only two areas of concern: first, whether Van Till's use of "primeval history" adequately maintains the event character of the early chapters of Genesis and, second, whether the unique creation of man as the imagebearer of God can be compatible with an evolutionary development. Having raised such questions and concerns within a context of many positive assertions commending not only the personal faith of the three professors but also their diligence in subjecting their scholarship to Christ's service, the committee recommended that the Board of Trustees declare that

> The writings of Professors Menninga, Van Till, and Young fall within the limits set by the synodically adopted guidelines for the interpretation of Scripture and by the doctrinal statements of the Christian Reformed Church; but, at the same time, the Board reminds the professors of the limitations that these guidelines place upon the interpretation of Scripture.
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> (*Acts of Synod 1988*, p. 595)

When the Board of Trustees adopted this recommendation, many in the church were not satisfied. Consequently, thirty-two overtures and eight communications, presenting a variety of concerns and requests, were sent to Synod 1988. In response the synod not only adopted a variety of declarations concerning the issues at hand; it also saw fit to appoint the present study committee with its mandate. The grounds presented for the appointment of this study committee clearly indicate the goals which the synod hoped such a study would fulfill:

a. The concerns voiced by the churches through the overtures need to be addressed by a study of this nature.
b. Such a study will give clarity to points of ambiguity as noted in the ad hoc committee report, and, thereby, give substantive content to the Board of Trustees in their reminder to the professors.
c. Such a study will benefit the total Christian community in understanding the relationship between special revelation/Scripture and general revelation/creation.
d. Such a study, although judged necessary for the church by the Synod of 1966, was never carried out.
e. Such a study will facilitate the continuing work of Calvin College and its faculty as leaders in the promotion of Christian scholarship.

(*Acts of Synod 1988*, p. 598)

We hope this study report will meet some of the aims articulated above. But surely the synod would not take it amiss if we ask that the grounds stated above be understood in the light of the sober realism expressed by the 1966 advisory committee as quoted above. The issues with which we are confronted require a lifetime of thought and investigation, and even that may not be enough.

C. *Analysis of the mandate*

It is important to note that this mandate does not instruct the committee to function as a judicial committee which judges the beliefs and teachings of specific persons. Insofar as synod wishes to judge the beliefs of such persons, it is doing so through the agency of the Board of Trustees. This committee was constituted as a study committee to assess the significant issues which are at stake in the present debate concerning origins. However, since the mandate contains several terms taken from H. Van Till's book, it will be necessary for the committee to respond to several positions developed in that book. Still, we would remind synod that we were mandated to investigate issues, not persons. Consequently, although the three professors are part of the history leading to our mandate, their names will not appear in the body of the report except where the mandate makes it necessary for us to refer to a particular book.

The mandate places the discussion in the broadest context possible, namely, in the context of the relationship between special and general revelation. While acknowledging that in the Reformed tradition this is precisely the right context for such a discussion, we suggest also that it makes the mandate rather overwhelming, for the implications of the relationship between general and special revelation must be hammered out ever anew in terms of specific issues. Changes of insight or perspective on either side may raise again the whole issue of the relationship between general and special revelation. Originally we hoped to make a creative contribution to that debate, but we would no longer claim such a label for our modest efforts. We hope only

that we have done reasonable justice to our mandate, that the more obvious errors have been rejected, and that the Reformed tradition has so shaped our perspectives that the guidelines established will assist in creating a continuing fruitful discussion which may lead to clearer insight into the relationship between special and general revelation.

D. Outline of the report

The occasion for this report is the apparent clash between the biblical account of and contemporary scientific perspectives on origins. While the church is familiar with the biblical account, it is less familiar with contemporary scientific claims. Since this report necessarily makes reference to such claims, we have included as an appendix a simplified summary of the current scientific view of origins. While this summary includes opinions about the present difficulties and future possibilities of this view, it makes no general evaluation from either a biblical, theological, or philosophical point of view. It intends only to inform as simply and succinctly as possible concerning the present scientific consensus.

The line of argumentation followed by this report is apparent from the following outline. It begins with the basic confessional and theological affirmations concerning the mutual interdependence of general and special revelation which determine the shape of the problem for the Reformed tradition. While, on the one hand, Scripture in its own way sheds light on the interpretation of general revelation, the Reformed tradition holds, on the other hand, that general revelation in its own way also sheds light on the interpretation of Scripture. Out of these emphases arise the present questions and debate. Following this development of basic perspectives, the report addresses the specific questions contained in its mandate. The outline is as follows:

II. General and special revelation in the Reformed tradition

The question we face in understanding the relationship of biblical teaching and scientific theory is one directly shaped by our tradition. The Reformed tradition challenges its adherents to be busy with the task of bringing their faith to bear upon the variegated activities of human life: faith and agricultural practices, faith and politics, faith and economics, faith and science. This challenge is exciting, but it is often not simple. Sometimes it is difficult to know with certainty which judgment, opinion, or position does the greatest justice to the requirements of the Christian faith. Thus, in our striving to be faithful we often live with some ambiguities and uncertainties and discover that humility before God and others is the only appropriate stance.

A. The relationship of general and special revelation

We confess that the one God—Father, Son, and Holy Spirit—is this world's Creator and Redeemer. The Word by whom all things were made is the same Word that became flesh in Jesus Christ. We are confronted by two books of revelation through which this one God reveals himself. The classic description of these two revelations is found in the Belgic Confession (Art. 2):

> We know him by two means:
> First, by the creation, preservation, and government of the universe, since that universe is before our eyes like a beautiful book in which all creatures, great and small, are as letters to make us ponder the invisible things of God. . . .
> Second, he makes himself known to us more openly by his holy and divine word, as much as we need in this life, for his glory and for the salvation of his own.

Each of these books is divine revelation and comes to us with divine authority, the first book as well as the second. Thus the report on *The Nature and Extent of Biblical Authority* (Report 44) affirmed that although God's revelation in creation and history is a nonverbal revelation, we must confess its divine authority. "All of general revelation is addressed to us by God with divine authority" (*Acts of Synod 1972*, p. 506). And not only does general revelation come to us with divine authority, but there is even a sense in which general revelation is basic to special revelation. The Belgic Confession describes it as "first," first not only in time but also in the sense of being primary, constituting the matrix into which special revelation comes and against the background of which special revelation is understood. As Louis

Berkhof affirmed, "Scripture can be fully understood only against the background of God's revelation in nature" (*Manual of Reformed Doctrine*, p. 31). Hence we may not, and in fact cannot, ignore the first book of revelation. Abraham Kuyper expressed this teaching in a very pointed way by saying that if, without any addition, one says, "I am bound by Scripture," then one has made a very incomplete confession. For there is another Word of God to which we are also bound, a different Word, the language which God speaks through nature (*Band aan het Woord*, 1899, p. 9). Thus we confess that there are two books of revelation, which are different yet mutually interdependent.

The fall into sin neither eroded the content of general revelation nor destroyed its authority. The fall did turn humanity into an unfaithful respondent to this revelation of God coming to us through creation and history. Consequently, the sinner needs the Scriptures as the "spectacles" by which, through faith in Jesus Christ, one is enabled to read God's revelation in creation faithfully. We now need both books of revelation to understand each.

But has not the fall rendered general revelation defective, incomplete, insufficient? The answer depends on the perspective from which that question is asked. If the question concerns the adequacy of general revelation for salvation, then the answer must clearly affirm the necessity of special revelation for salvation, for the essential difference between general and special revelation is that special revelation makes known the covenant of grace. Such is the key theme reiterated again and again by Herman Bavinck in his address on common grace. The key difference between special revelation and all previous revelation is special grace, or the covenant of grace, which now appears as something marvelously new and in which Elohim, the God of creation and nature, makes himself known as Yahweh, the God of the covenant. But even though this revelation of grace is new and finds its ultimate manifestation in Jesus Christ, nevertheless, this revelation of grace attaches itself to the revelation of God already in existence. Thus, while general revelation is not sufficient to the task of overcoming the destructive consequences of the fall in either human knowing or doing, special revelation neither ignores general revelation nor displaces it but rather assumes it and builds upon it. General revelation is not defective in terms of its own purposes, and it continues to function as revelation for us even after the fall into sin. The two books of revelation function in harmony, and any perceived difficulty we may have in understanding their essential unity lies only in the hearts, minds, and perceptions of the human respondents.

This essential unity and mutual interconnectedness of general and special revelation has important implications for understanding the nature and purpose of special revelation. If special revelation assumes and builds upon general, or creation, revelation and if the central principle or theme of special revelation is the renewing grace of God, then it follows that special revelation does not intend to create a new supernatural order of things or a new world. As H. Bavinck says about grace, "It creates no new cosmos but rather makes the cosmos new" ("Common Grace," *Calvin Theological Journal*, Apr. 1989: 61). In other words, the original created order established by God has been preserved and maintained by God, and its essence has not been destroyed by sin. Sin did not create another world; it marred an existing world that continues to exist. Grace is given to remove sin, to purify, to redeem, to restore, but the grace of God does not introduce a single substan-

tial foreign element into the creation. Consequently, the original created order, with all of its implications for home and state, for society and science, by which God still makes himself known, still confronts all of us. Our renewed life in Christ must be lived within the structure and orders of life which God reveals and makes possible by his creation, preservation, and governance of the universe.

What does general revelation reveal? The primary answer is that it reveals God. The Belgic Confession refers to Romans 1:20 and declares that general revelation makes us ponder the invisible things of God, that is, his eternal power and his divinity. The Scriptures speak eloquently of this theme: "The heavens declare the glory of God; the skies proclaim the work of his hands. Day after day they pour forth speech; night after night they display knowledge" (Ps. 19:1-2, NIV). Thus God speaks to us through the works of his hands, revealing not only his nature and his presence but also that he is the source of all that is good.

This biblical perspective shaped Calvin's discussion of the knowledge of God the Creator. Since human happiness rests in knowledge of God, God "not only sowed in men's minds the seed of religion . . . but revealed himself and daily discloses himself in the whole workmanship of the universe. As a consequence, men cannot open their eyes without being compelled to see him. . . . Wherever you cast your eyes, there is no spot in the universe wherein you cannot discern at least some sparks of his glory" (*Institutes* I. 5. 1). The more perfect way of seeking God is not by speculation which attempts to penetrate to the divine essence, but rather by contemplating God "in his works whereby he renders himself near and familiar to us, and in some manner communicates himself" (I. 5. 9). General revelation is thus an ongoing activity of God by which he makes himself both known and present to us, for "this skillful ordering of the universe is for us a sort of mirror in which we can contemplate God, who is otherwise invisible" (I. 5. 1).

So compelling is this general revelation that Calvin concludes, ". . . it is not a doctrine that must first be learned in school, but one of which each of us is master from his mother's womb and which nature itself permits no one to forget, although many strive with every nerve to this end" (I. 3. 3). Of course, Calvin's entire discussion of this knowledge of God acquired through general revelation is from the perspective of that "primal and simple knowledge to which the very order of nature would have led us if Adam had remained upright" (I. 2. 1). However, because of the fall, humanity brushes God aside and by ascribing all things simply to nature turns nature into a cloak that hides the face of God (I. 5. 4). Consequently, since through the fall humanity has become like "old or bleary-eyed men" with weak vision, who can scarcely construe two words on a printed page, humankind needs the Scriptures as "spectacles" in order to read distinctly the revelation that comes through creation, history, and God's governance of the universe. The Scriptures, by gathering up the confused knowledge of God in our minds and dispersing our dullness, clearly show us the true God (I. 6. 1).

B. General revelation and science

If general revelation is an ongoing activity by which God reveals himself and if this is "not a doctrine that must first be learned in school" and thus

not in the first place a matter of scientific investigation, what precisely is the relation of science to general revelation? Can we claim that science increases our knowledge of general revelation, or at least our awareness of it?

G. C. Berkouwer does not think so. His opinion is that "it is wrong to say, as is sometimes done, that the natural sciences 'investigate' God's general revelation; and surely it is just as wrong to state that we owe our knowledge of God's revelation in nature primarily to the natural sciences" (*General Revelation*, p. 289). While he grants that scientific investigation of God's handiwork is part of our calling, Berkouwer insists that, since general revelation concerns knowledge of God *himself*, it is not apprehended "first of all" by scientific investigation, but by faith. Is Berkouwer correct? Or does his position too easily separate general revelation from the created reality through which it occurs, and thus faith from science? Surely, if God reveals himself *in* nature, then this means that we know him *in* our experience of nature, including our scientific experience. Even Berkouwer, by using the qualifiers "primarily" and "in the first place," acknowledges that we must affirm some connection between science and general revelation, although he does not elaborate on this point.

What then is the relationship between scientific investigation of nature and general revelation? One way of approaching the question is to think of general revelation as the manifestation of God's wisdom in the world and of science as the discovery of that wisdom. This is an approach taken by Calvin when he writes,

> There are innumerable evidences both in heaven and on earth that declare his wonderful wisdom; not only those more recondite matters for the closer observation of which astronomy, medicine, and all natural science are intended, but also those which thrust themselves upon the sight of even the most untutored and ignorant persons, so that they cannot open their eyes without being compelled to witness them. Indeed, men who have either quaffed or even tasted the liberal arts penetrate with their aid far more deeply into the secrets of the divine wisdom.
>
> (I. 5. 2)

In general revelation God gives evidence of his wisdom in creation, and, according to Calvin, that wisdom is made manifest to all people, both learned and unlearned. But those who have special training in the academic disciplines, including natural science, penetrate into aspects of God's wisdom that are hidden to others. By so closely tying science to divine wisdom, Calvin does two things: not only does he give a high status to scientific activity, but he does so by making it a religious activity, one which deals directly with an aspect of the character of God. In dealing with the created order, scientists are dealing, whether they acknowledge it or not, with the God who reveals his wisdom in the world. Perhaps this perspective of Calvin accounts for L. Berkhof's description of general revelation as consisting in "an embodiment of the divine thought in the phenomena of nature, in the general constitution of the human mind, and in the facts of experience or history" (*Manual of Christian Doctrine*, pp. 26-27). Certainly this perspective on general revelation as a manifestation of the thought of God or, more particularly, of the wisdom of God is a clear teaching of Scripture.

A significant example of this biblical teaching is the parable of the God-instructed farmer in Isaiah 28:23-29. The parable is about a farmer who knows how to plant and thresh properly. This farmer, says the prophet, "is in-

structed aright; his God teaches him." And the wisdom the farmer displays in threshing without crushing the grain "also comes from the Lord of hosts; he is wonderful in counsel and excellent in wisdom." God instructs the farmer not directly from the Scriptures, for that is not their purpose, but through the wisdom of God embedded in the creation itself. God has placed the human race on earth and has instructed us to be earthkeepers. He does not reveal to us by special revelation the means, the methods, the techniques by which to do this. All of that must be learned. Yet in learning how to do this, we are not left without guidance from the Lord, for the guidance, knowledge, and wisdom that are necessary are embedded in the creation itself. By working with the creation, by sifting it through our fingers, by tilling the ground, by peering through microscopes and telescopes, we learn creation's secrets, we discover its order, how it functions, how it sustains and produces life. In other words, we discover embedded in it the wisdom of God. That is why, when the farmer has it right, when he discovers contour plowing and proper crop rotation, or when a scientist discovers DNA, that marvelous arrangement of the genetic code that controls the development of organic life, we may say with Isaiah, ". . . his God teaches him, this also comes from the Lord of hosts; he is wonderful in counsel, and excellent in wisdom."

This biblical teaching on wisdom indicates that there should be no divorce between human knowing (including investigation and discovery) and divine instruction. Of course, this does not mean that we can simply equate the two, since human knowing is always imperfect knowing, whereas God's instruction is free from error. Still, when we have it right, when what we believe is true and what we do corresponds to God's order in the creation, then the Scripture says not that Nature teaches us but that God teaches us.

By emphasizing that human knowledge is a response to divine revelation, we are saying that it is at bottom a religious affair; it inescapably involves faith in some way. Faith is involved in whether or not we acknowledge that our knowing is a matter of penetrating the secrets of God's wisdom. Faith is also involved in recognizing that there are depths to God's wisdom that human knowledge can never fathom, that this wisdom, while reflected in and revealed through the creation, exists before it and beyond it. And faith is involved in whether or not we let the light of God's special revelation illumine our understanding of creation, whether we put on the spectacles of Scripture to read the book of nature. In other words, it is a matter of faith whether we allow our thinking to be shaped by presuppositions or control beliefs that find their warrant in Scripture or instead rigorously exclude them as a matter of principle. It is because of the profoundly religious character of human knowing that Scripture states so emphatically, "The fear of the Lord is the beginning of knowledge," and, "the fear of the Lord is training for wisdom" (Prov. 1:7; 15:3). Ultimately, it is only by faith that we can truly and rightly hear the voice of wisdom, which structures and gives meaning to this creation. Hence the search for knowledge can go wrong not just because people make mistakes in observation and judgment, but it can go wrong and will go wrong because of a single mistake at the beginning. Gerhard von Rad correctly summarizes this teaching of Proverbs on wisdom: "One becomes competent and expert as far as the orders in life are concerned only if one

begins from knowledge about God . . . effective knowledge about God is the only thing that puts a man into a right relationship with the objects of his perception" (*Wisdom*, pp. 67-68). Thus, according to Proverbs, faith does not hinder knowledge; on the contrary, it liberates knowledge. Faith enables us to see the connection between our knowledge and the wisdom of God.

Proverbs declares also that the severing of that connection between our knowledge and God's wisdom brings into human life disintegration, distress, and chaos. Thus the Christian scientist (or economist or farmer) may never sever the tie between his or her knowledge (scientific or otherwise) and revelation (both special and general). For when the tie is severed, that is, when fear of the Lord is set aside and the voice of wisdom is not heeded, then calamities strike (Prov. 1:24-31). Our knowledge must reflect the wisdom of God, by which created reality has been structured and receives its meaning. Accordingly, Scripture represents wisdom as saying, "whoever finds me, finds life and has obtained favor from the Lord, but whoever misses me, injures himself; all who hate me love death" (Prov. 8:35). Since humans are made in God's image and made for covenant relation with him in whom all things hold together, unbelief is necessarily driven to substitute some creature for the Creator (Rom. 1). This inevitably leads to a distorted perception of the creation in its wholeness, with its God-ordained order and coherence. And when humans without God deify something in creation, the fabric of creation itself becomes distorted. Thus the "antithesis" (the spiritual conflict between life led by God's Word and Spirit and unbelieving human attempts to order life autonomously) comes especially to the fore in the matter of worldview and of the total arrangement of life and society in creation.

Though knowledge and faith are intimately connected, it does not follow that science which rejects or methodologically excludes God and religion is cut off from general revelation. It remains true that scientific investigation, whatever its presuppositions, deals with the materials of general revelation, with the data and structures of created reality and historical process, through which God reveals himself and his wisdom. Perhaps one should not claim that every fact or observation is by itself revelation. That would be analogous to the claim that each separate word in the biblical text abstracted from its function in a sentence, paragraph, or book is revelation. When a word is so abstracted, we do not know its revelational meaning, and similarly discrete and isolated facts, such as the freezing point of water or the melting point of platinum, are in themselves hardly revelation. However, such facts are parts of larger structures, and their significance can be understood only as parts of larger patterns of meaning and design. From this perspective one can say that science certainly deals with the empirical phenomena through which general revelation occurs and by which the divine wisdom speaks. Nevertheless, the dimensions of depth and the ultimate context which are part of that revelation and that divine voice can be ignored or distorted.

If all this is so and if faith is integral to knowledge, should we not just ignore the knowledge and the theorizing of unbelieving scholars? Have not sin and unbelief so suppressed their receptivity to the truth that their work can no longer have any benefit for us? Although some Christian traditions may affirm such a position, the Reformed tradition does not support such a

stance. Speaking of the arts and sciences found in secular writers, Calvin writes,

> let that admirable light of truth shining in them teach us that the mind of man, though fallen and perverted from its wholeness, is nevertheless clothed and ornamented with God's excellent gifts. If we regard the Spirit of God as the sole fountain of truth, we shall neither reject the truth itself, nor despise it wherever it shall appear, unless we wish to dishonor the Spirit of God.
>
> (II. 2. 15)

And again,

> if the Lord has willed that we be helped in physics, dialectic, mathematics, and other like disciplines, by the work and ministry of the ungodly, let us use this assistance. For if we neglect God's gift freely offered in these arts, we ought to suffer just punishment for our sloths.
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> (II. 2. 16)

Following in Calvin's footsteps, H. Bavinck declared,

> There is thus a rich revelation of God even among the heathen—not only in nature but also in their heart and conscience, in their life and history, among their statesmen and artists, their philosophers and reformers. There exists no reason at all to denigrate or diminish this divine revelation.
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> ("Common Grace," *Calvin Theological Journal*, Apr. 1989: 41)

Thus the Reformed tradition places on its adherents a moral obligation, in fact, a religious duty, to acknowledge truth wherever it is found. How the tradition accounts for moments of truth in an unbelieving response to revelation is not the key issue for us. Calvin spoke of a "general grace," the subsequent Reformed tradition of "common grace," and today some prefer to speak of certain structures of created reality which inescapably impose themselves on all persons. In any case, the tradition does not allow us an easy appeal to the noetic effects of the fall as a reason for simply dismissing secular or unbelieving scholarship. We are at least compelled in any specific case to assess the extent (if any) to which sin has distorted the truth.

The Reformed tradition has from the beginning acknowledged also that the consequences of the fall upon the human mind are not the same in all areas of knowledge. Calvin used a rough distinction between knowledge of earthly and heavenly things. Under "earthly" he referred to things which have their significance with regard to the present life, including government, various mechanical and management skills, as well as the liberal arts, which included science. In this area he granted considerable ability to the unregenerate human mind to understand correctly (II. 2. 13-14). A. Kuyper distinguished the material or exact sciences from the humanities and argued that the difference between believing and unbelieving science is more clearly apparent in the latter than in the former. Today, although the Kuyperian perspective has been developed in various ways, all in that tradition would grant the basic point that the effects of sin, and conversely the renewing power of the gospel, are more difficult to demonstrate in a science such as physics than in psychology, history, or jurisprudence. Thus we have an obligation not only to treat general revelation seriously but also to treat seriously the understanding of a specific domain of reality presented by unbelieving science. Of course, we must always be ready to critically assess to what extent sin has affected a particular understanding and to what extent special revelation must be brought to bear upon a particular understanding. The Reformed tradition has been characterized by just such a critical engage-

ment with science, distinguishing what is true and what is not, what leads away from the revelation of God and what stands in harmony with it.

The implications of the relationship between general and special revelation for the investigation of God's creation are complex. An awareness of these implications does not directly solve questions stemming from an investigation of a specific area of the creation. At best these implications establish an overall framework or perspective in terms of which specific issues must be discussed. Such a framework rules out simplistic appeals to the noetic effects of the fall, to general revelation unrelated to the reshaping perspectives of special revelation, or to special revelation isolated from its relation to general revelation. We have been privileged by God to respond to his revelation, but we should not assume that our human struggle to understand and maintain the unity of that revelation will ever be a simple task.

C. *General revelation and biblical interpretation*

Since the report on *The Nature and Extent of Biblical Authority* (Report 44 [1972]) has addressed this issue, this section will simply recall its essential position.

While acknowledging the Reformation principle that Scripture is its own interpreter, Report 44 argued that this principle intends in essence to affirm that Scripture may not be interpreted contrary to its own intention. One may not subject the Scriptures to methods of interpretation which are based on principles which contradict the proclamation of Scripture itself. However, that principle does not mean that one may isolate the Scriptures from other forms of knowledge. Ever since the Reformation itself used and developed the principles of grammatical-historical-theological exegesis, the Reformed tradition has gladly used insights gained from historical and archaeological research to help clarify the intended meaning of Scripture. Because we have acknowledged the historical character of the divinely inspired Scriptures, we have been willing to use the results of a great variety of scientific research in matters of language, culture, and history to illumine its meaning. Even perspectives of natural science have had an impact on our interpretation of Scripture. The classic case is the Copernican revolution. Thus H. J. Kuiper could write in *The Banner*,

> When we read that at Joshua's command the sun and the moon stood still, this should not be taken literally, as if these two heavenly bodies were actually stopped in their courses (Josh. 10:12, 13). We know that this would have been destructive for the entire solar system. The very form of the words reveals their poetic flavor. The passage merely teaches that by the miraculous power of God, the light of the day's victory over the Canaanitish hosts was prolonged far beyond its usual time.
>
> (17 July 1959)

This example illustrates a traditional understanding, continued in Report 44, that perspectives from science can become the occasion for a new understanding of Scripture provided that the new understanding remains in harmony with the revelatory intent of Scripture. The Scriptures may not be isolated from what we know to be true in the arena of creational revelation. Such affirmations only establish the guidelines within which a discussion about the proper interpretation of Scripture takes place. In each specific case one must demonstrate that a change in understanding does justice to and does not contradict the intention of Scripture itself.

When change in the understanding of a specific part of Scripture is dramatic—as was the change in paradigm from a Ptolemaic to a Copernican worldview, which entailed a virtual revolution in how reality was perceived—it will take some time for that change of view to be developed and accepted. Thus the ancient advice of St. Augustine still seems to be the epitome of wisdom. Speaking about the interpretation of the creation account and the six days, Augustine warned that one should not too quickly declare that something is in conflict with Scripture, lest lack of expertise make one appear foolish in the eyes of unbelieving science and lest serious study convince one of the contrary. Such caution is an appropriate expression of the church's wisdom and humility in handling the revelation of God.

D. The unity of knowledge

The Christian belief in the one God who is Creator and Redeemer is the ultimate foundation of our commitment to the unity of knowledge. The belief that the same God reveals himself in creation and history and in Scripture establishes the Reformed commitment to the belief that the diverse threads of reality form a unified pattern reflecting a deep unity in the wisdom of God.

Consequently, the Reformed tradition has tilted against all dualisms, all attempts to declare certain arenas of reality or our perceptions of them as unaffected by sin and thus not in need of the renewing power of the gospel. While acknowledging degrees of difference, it has refused to hermetically seal off in advance any area of human knowledge or activity and to declare that special revelation has no impact on it. All of our knowledge is ultimately related to God. How it is related and to what degree this manifests itself in a specific discipline or arena of knowledge must be worked out in a case-by-case approach. Yet even when we have done this in the light of present knowledge and have discovered areas where we find no specific impact of special revelation or no distinctive Christian interpretation, we should not erect a system that precludes any future interaction. Knowledge changes, and, as the history and philosophy of science demonstrate, human knowledge and theorizing are open to multiple influences. In practice even natural science is not a purely naturalistic or empirical enterprise. Various impulses can have a shaping effect on theory. What these influences are and from what direction they may come cannot be predicted in advance. Therefore, Christians, committed to general and special revelation and to a God who is continually revealing himself and his wisdom, must keep themselves open to both horizons of knowledge, for what God may choose to teach us through either means cannot be predicted in advance.

III. Genesis 1-11 as primeval history

In our dealing with the matter of primeval history and the first eleven chapters of Genesis, it will be useful to distinguish clearly between the special kind of historiography, or history writing, found in these chapters and the name *primeval history*, which is often used to designate these chapters.

A. The historiography of Genesis 1-11

Attention to the first of these two issues has become necessary because of our increased knowledge of the history of humanity prior to Abraham. This knowledge has been gained through the sciences of history, archaeology, and

anthropology. Thus this issue concerns the impact of general revelation upon our understanding of special revelation. If we stood in a tradition that instructed us in our reading of Scripture to ignore either general revelation or the results of science, the question of how Genesis records history would not arise.

We come to understand the character of historical documents by comparing them with other sources of knowledge dealing with the same or similar events or by comparing them with other historical accounts. For example, none of the gospels intends to present a complete historical record of the ministry of Jesus (John 20:30; 21:25). Each presents a selection of the things Jesus said and did. Yet were it not for the Gospel of John's record of the Passovers, indicating that the ministry of Jesus lasted three years, we could have inferred from the synoptic gospels that Jesus' ministry lasted only one year. Thus, if we could not compare the synoptics with John, we would have drawn erroneous inferences about the history of Jesus. Since all historical accounts are selective, without additional sources of knowledge or comparative accounts, we can easily draw incorrect inferences from a historical account. We can make it say what it never intended to say. Although there are elsewhere in the Bible specific references to persons and events treated in Genesis 1-11, there is no second historical account with which we can compare these chapters. Yet during the last two centuries our knowledge of human history prior to Abraham, prior to 2000 B.C., has increased dramatically. The comparison of the biblical historical account with this knowledge has led to new interpretations of the way history is written in these chapters.

What precisely is the character of the Bible's account of the earliest history of the world and humankind? This question constitutes the nub of the problem we are dealing with, and at present there is no consensus among evangelical biblical scholars. The best we can do is to present an example which we believe does justice to what is known about pre-Abrahamic history, to what Report 44 says about the necessity of distinguishing between an event and the way it is reported even while maintaining the event character of biblical historical narrative, and to the revelational significance of the historical account.

The example is the Tower of Babel story. The traditional interpretation of this account in Genesis 11 seems to conflict with the findings of historical linguistics, for there is a great deal of evidence that the diversity of languages precedes Babylonian culture. Since *babel* in Hebrew is the standard word for Babylon and since the Tower of Babel very probably refers to a characteristic institution of Babylonian culture, the temple tower (or "ziggurat"), the biblical narrative refers to a civilization which already knew a diversity of languages, such as Akkadian, Sumerian, and Egyptian, to mention only three well-known languages from the Ancient Near East. According to linguistic evidence available today, it would seem that the diversification of language must have taken place long before the rise of the Old Babylonian culture.

Because of this conflict some propose to read the story as a parable illustrating human pride but not as a historical narrative related to an event or to a series of events. But "parable" seems not to do justice to the overall tenor and context of the story, which functions as a part of the broad historical prologue to God's call of Abraham and the history of God's chosen people.

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Thus various other interpretations have been proposed. One suggests that, while the story does indeed concern Babylon, the judgment of God refers not to the origin of languages but to a breakdown in communication. The word translated as "language" can refer to "talk" or to "speech" in a more general sense. Then the whole episode speaks of the religious pride of the Old Babylonian empire, centered in the ziggurat dedicated to the god Marduk in the City of Babylon, and of God's judgment on this proud manifestation of pagan culture. Ultimately it was a breakdown of communication, of mutual understanding, which brought disaster upon the first great empire of recorded history. Others, however, think it necessary to retain the reference to languages and then suggest either that Genesis 11 as a historical event must be assumed to be prior to the table of nations in Genesis 10 or that Genesis 11 should be understood as a history that compresses into a single event a process that elapsed over a period of time. In all of these interpretations connecting Genesis 11 to Babylon, the interpreter is assuming that an extensive and complex historical tableau is being described in a highly stylized manner and from a perspective that compresses history into a single focus to serve the purposes of the history of salvation. In addition, by its use of this history, however stylized the shape of its report, the Bible intends to illumine the basic nature of human history when it is divorced from the God who is Creator and Redeemer. Hence, Babylon continues to serve, even in the book of Revelation, as a symbol of the cities and empires which humanity erects in opposition to God. Beginning with the story of the Tower of Babel, Babylon is both a historical city and, in Augustine's terms, a symbol of the City of This World in rebellion against the City of God.

Without placing a stamp of approval upon any single interpretation, we suggest that the approaches mentioned above satisfy the requirements of Reformed hermeneutics. Our increased knowledge of early human history has underscored the highly stylized and compressed nature of the biblical account and cautions us against drawing historical inferences unrelated to the revelational intention of the account. In such historiography the Bible does not intend to present the entire history in which the narrative is rooted, and the stylized character of the account prevents us from inferring what the total historical picture may have been. In spite of these limitations imposed on us by the nature of these biblical narratives, the function of the historical narrative concerning the Tower of Babel in the unfolding history of redemption remains clear.

In general we can say that the primary intention of the historical narratives in Genesis 1-11 is to serve the understanding of the unfolding history of redemption, not to present us with a detailed history of pre-Abrahamic times.

B. The designation "primeval history"

We turn now to the second issue mentioned above, namely, the designation *primeval history* for the first eleven chapters of Genesis. Since the nineteenth century, German commentaries have used the label *Urgeschichte* for these chapters, which has been translated in English as "primeval history," "primal history," "primordial history," or "primitive history." The term has become a handy capsule formulation of the content of the initial chapters of Genesis, which describe the earliest history of the world and humanity. The problem with the term in German is that it can refer either to

history or to story, to facts or to story as presenting not empirical fact but psychological or moral truth. In fact, for the majority of German scholars the term does refer more to story than to history. Consequently, conservative German theologians have been suspicious of its use because often it has been associated with the denial of historicity.

However, in the English-speaking world the situation is different. The English term favors history over story. Primeval history is *history* and is therefore a term that is widely used by English-speaking biblical scholars who maintain the historicity of Genesis 1-11. In the context of English-speaking biblical scholarship, there is little room to question the propriety of the term *primeval history* to designate the first eleven chapters of Genesis.

This topic of primeval history became part of our mandate because of its use by H. Van Till in *The Fourth Day*. There he associates it with a hermeneutic requiring a distinction between vehicle, packaging, and contents. This combination of primeval history and vehicle/packaging/contents has raised the question whether Van Till's use of primeval history maintains the event character of Genesis 1-11.

Van Till suggests that primeval history identifies the literary genre of Genesis 1-11. While we could enter into a technical debate about this matter by pointing out that Genesis 1-11 includes a diversity of genres and by arguing that primeval history refers more to contents than to the literary form of the narratives, we wish rather to indicate only the effect this position has on the interpretation of Genesis 1-11.

According to Van Till, the basic procedure in biblical interpretation is to distinguish vehicle, packaging, and contents and then to separate the contents from the vehicle and the packaging. Since vehicle refers to genre, one must in this scheme extract the biblical teachings from the vehicle called primeval history. Since the packaging includes symbolism and cultural patterns forming the context or description, as well as the specific story or account of an event (*Fourth Day*, p. 15), Van Till advocates a rather complete separation between what is said and how it is said. He writes, "... the stories serve as 'packaging' that contains the message-content conveyed by the vehicle of primeval history" (p. 82). Thus, for example, Genesis 1 teaches us about God and about the status, origin, governance, value, and purpose of the creation—all of which deal with external questions concerning the relationship of God to the creation—but not about the internal matters, questions concerning the properties and behavior of the creation or its cosmic history.

What about this separation of external and internal matters? We would affirm, of course, that Genesis 1-11 does teach about God and the status, origin, governance, value, and purpose of the creation. The problem is whether these chapters intend to teach anything about internal matters. No one of us would claim to find scientific-like statements or propositions in Scripture—as though a biblical author had just looked through a microscope or telescope. We have all absorbed Calvin's suggestion that Moses did not speak the language of the astronomers and that if one wished to learn astronomy, one had to go to the astronomers. Hence our tradition would not lead us to expect to find much in Scripture concerning the "internal matters" of astronomy. Since natural science is primarily concerned with the category of questions that deals with physical properties, physical behavior, and forma-

tive history, we would not expect to find in Scripture much that bears upon such questions. Consequently, large areas of natural science possess not even the possibility of conflict with the Scriptures. However, Van Till himself acknowledges that the doctrine of *creatio ex nihilo* does have direct bearing on physics and astronomy. Thus we should not conclude that the teaching of Scripture has no bearing on such internal matters. Besides, Genesis 1-11 deals with much more than matters of interest to physics and astronomy. For example, it makes pronouncements of direct interest to the science of history. Can we then so easily adopt a hermeneutic that knows in advance that Genesis 1-11 addresses only external questions and never addresses matters that are related to or could become internal to a specific science? We do not think so.

In addition, we would briefly point out that current literary theory rejects any form-content distinction by which the message of a text can be separated from the form of the text in which it comes. Every jot and tittle of a text, its literary genres, its poetic features, its precise vocabulary, its language, its grammar and syntax, its puns and word plays, its metaphors and similes, and much more are all essential and indispensable for proper understanding of that text's meaning. While form and content may be analytically distinguished, they may not be separated in the process of interpretation. The form is as essential to the text's meaning as the content is. The form of the content is what gives the message its meaning, so that the message can be apprehended and understood. Thus the ancient "formal" features of the biblical text are not matters to be stripped away like so much packaging. Rather, every aspect of the text is there to be understood and interpreted so that God's people can hear what the Spirit is saying to the churches today.

Is primeval history, as Van Till suggests, like a parable in illustrating truth (p. 83), and if it is, does it still have an event character? All agree that the narrative called primeval history does not describe events as a court historian or as a modern journalist does. The question is whether primeval history describes events at all. Van Till suggests that unlike parable it "does refer to a historical past with a character essentially the same as that illustrated by the narratives" (p. 83). Although this statement includes a reference to a historical past, the emphasis falls on the character of that past which is being illuminated in the story. The past described in the primeval history has the same *character* as that described in the stories, but the stories are only parables and not references to events or persons. If this interpretation of Van Till's position is correct, primeval history is understood as a special kind of parable, one that reveals the character of the past to illumine the ongoing history of redemption.

Is parable the best analogy? There is in Scripture at least one parable which, according to older and some more recent interpreters, does refer to specific historical events in Israel's history. The parable of the marriage feast (Matt. 22) may contain references to the prophets God sent to warn Israel in the Old Testament. If that interpretation is accepted, then a parable can contain references to specific historical events or to a series of such events. But since parable usually refers to a general lesson or truth without reference to a specific historical past, we think that parable is probably not the best analogy. Our earlier discussion of the Tower of Babel suggested that that narrative was more history specific than a parable usually is. While agreeing that

the narratives of primeval history have a universal significance because they reveal the fundamental characteristics and tendencies of human history in its relationship to God, we differ with Van Till by holding that these narratives retain a more specific connection to the history narrated than simply reflecting its character. Even though questions concerning the nature of this specific connection to history must be continually assessed in the light of our knowledge of human history, we do not believe that the biblical interpreter can say on the basis of literary (genre) considerations that Genesis 1-11 intends no such specific connections at all.*

IV. Interpretation of the creation account

At the heart of our mandate lie questions concerning the doctrine of creation and the interpretation of Genesis 1 and 2. We should be clear at the outset that no one in our denomination is questioning the first article of the Apostles' Creed: "I believe in God the Father, Almighty, Maker of Heaven and Earth." All confess gladly that the creation of this universe by God is the foundational belief without which Christian doctrine, Christian life, and the Christian interpretation of reality cannot stand. Our questions concern only the interpretation of Genesis 1 and 2: Beyond the obvious teaching that God has created all things and that "without him was not anything made that has been made" (John 1:3), what additional teachings does a proper interpretation of Genesis 1 and 2 require us to believe? On what issues must we take our stand without compromise in our time?

These questions have arisen because of advances in science. Many of these questions are not new but have been discussed throughout the twentieth century. Today, however, the discussion has again become very lively, and numerous books about it are being produced. Theologians and scientists who are Christian are still today trying to assess the relationship between Genesis and the contemporary findings of the scientific community. This does not mean that the dominant or changing views of science should be allowed simply to dictate the interpretation of Genesis. Report 44 warned against the possibility of allowing science simply to control or to dictate the interpretation of Scripture, but it also asserted that scientific discovery can become the occasion for reexamining a traditional interpretation and in this way can lead to a reinterpretation of certain aspects of the Bible (*Acts of Synod 1972*, p. 515). Preserving this fine balance between scientific perspectives and biblical interpretation means simply that we must not interpret the Scripture contrary to its own intention and that there must be indications within Scripture which suggest or support or at least allow the new interpretation. Just as the entire Christian Church once reinterpreted certain texts and departed from a centuries-old traditional interpretation under the impact of the Copernican revolution, so today we may not foreclose the possibility that something similar could occur under the impact of certain contemporary scientific perspectives. Whether it should occur or should not is, of course, the issue being debated.

* Synod 1990 referred the question concerning the interpretation of the universal extent of the Flood to this committee (Art. 59, B, 2). The committee did not become aware of this referral until late summer, after which there was no time to enter into a study of this issue. However, the perspectives developed in this section on primeval history would apply also to the story of the flood.

A. Views held within the CRC during this century

Since many of the issues before us have been debated throughout this century, it is important for the church to acknowledge its own past. The CRC has never seen fit officially to go beyond the creedal affirmations concerning Genesis 1 and 2. Within these creedal boundaries it has been willing to allow theologians, scientists, and others to propose various theories about the interpretation of Genesis 1 as well as various methods of understanding the relationships between Genesis and science. In adopting such a stance, the CRC has been following the wisdom of the church that has governed since the days of St. Augustine. As H. Bavinck writes, even though the Christian church has traditionally understood Genesis 1 as history and not as myth, it is remarkable that there is not a single church confession that has made pronouncements about the days of Genesis (*Gereformeerde Dogmatiek* II: 458). Consequently, various positions have been tolerated by the Christian church in general and by the CRC. Hence our descriptions of views held in the past are only the descriptions of views, held by various persons, which the church allowed or tolerated and not of views officially approved by the church.

Early in this century the big issue was the age of humanity and of the earth. Could persons holding orthodox beliefs accept the scientific estimates about the age of the earth? It is interesting that three theologians who were held in great esteem by the CRC and whose views were widely influential thought that a person could be both thoroughly orthodox and open to the proposals of modern science on this question. B. B. Warfield was the most outspoken; he asserted that "the question of the antiquity of man has of itself no theological significance. It is to theology, as such, a matter of entire indifference how long man has existed on earth" (*Princeton Theological Review*, 1911, p. 1). Warfield based his assertion on work done by W. H. Green, who pointed out the schematic nature of the early biblical genealogies and concluded that their compressed nature makes it impossible to know how many generations actually existed from Adam to Abraham. Thus for Warfield the question of the antiquity of the human race was a purely scientific one in which theology as such has no concern. A. Kuyper created an openness to a longer period of time by arguing that the first three days of Genesis were extraordinary days whose length could not be determined. H. Bavinck believed that since the matter of time did not belong to the essentials of the faith, various opinions could be allowed. He himself preferred to speak simply of extraordinary days which are God's workdays. As divine workdays, each day is filled with secrets and things hidden, as though the days of Genesis hide as much or even more than they reveal. In fact, in one place he writes that there almost seemed to be a "disharmony" between the fact and the description of it in the creation account. So much was hidden beneath the simple account, glimpses of which science was now presenting (*Gereformeerde Dogmatiek* II: 458). This theological openness to questions of the time or duration of the creation process has its roots in the ancient church. It was St. Augustine, the orthodox teacher of the church, who held that the days of Genesis 1 give us no temporal information whatsoever because the creation occurred in a single moment of time, as indicated by Genesis 2:4, "*In the day* that the Lord God made the heavens and the earth," a position held in the Eastern Orthodox churches from the time of Augustine until the present.

Whether one agrees with Augustine or not, ever since his time the Christian church has been reluctant to make pronouncements about either the time of creation or its duration.

Consequently, one can discover statements from leaders in the CRC, as early as the 1920s and 1930s, expressing appreciation for the way in which modern science had expanded our knowledge of nature, including the age of the earth. Even editors of *The Banner* openly declared that the literal reading of the early chapters of Genesis that produced Ussher's chronology was in error. A review of literature produced within the CRC from 1910-1950 clearly demonstrates that the views of Warfield, Kuyper, and Bavinck had been accepted and that within the CRC a person was free to adopt viewpoints which departed from a literal interpretation of either the genealogies found in the early chapters of Genesis or the days of creation (cf. G. A. Remelts, "The Christian Reformed Church and Science, 1900-1930: An Evangelical Alternative to the Fundamentalist and Modernist Responses to Science" [*Fides et Historia*, Jan. 1989: 61-80]).

The developing viewpoints of these early decades can be illustrated by the work of Professor John De Vries. Already in the 1930s he advocated accepting the age of the earth as being two billion years, and although he recognized that accepting such an age might create some problems, he believed that a final solution would give glory to God the Creator. His own method of handling the problems of biblical interpretation was developed in his book, *Beyond the Atom*, published in 1948. His point of view is known as the Period Theory of creation, in which each day is considered as an indefinite period of time. In addition, this theory holds that the order of the creative events is just what modern science requires. Thus Genesis 1 and the views of science can be brought together by the simple expedient of interpreting the days of Genesis 1 as indefinite but lengthy periods of time. This theory was widely held by evangelical scholars in the 1950s and 1960s and during those decades was perhaps the dominant view among Christian scientists holding membership in the American Scientific Affiliation. While there were some in the CRC who opposed this theory, Professor De Vries took great delight in the assurance he received from Professor Martin Wyngaarden, at that time professor of Old Testament at Calvin Seminary, that such an interpretation of "day" was exegetically possible. Officially the CRC took no position on this matter, even though Dr. De Vries was a professor of chemistry at Calvin College. Bavinck's view that various possibilities could be allowed because this matter of time did not belong to the essentials of the faith seems to have shaped the official mindset of the CRC.

B. Recent literary viewpoints

While the Period Theory of creation was widely held by evangelical scientists and theologians for several decades and is still advocated by many today, during the past two decades other interpretations of Genesis 1 have gained acceptance. One such theory, called the Framework Theory, has its roots in the views of St. Augustine. Like Augustine this theory argues that the days of Genesis 1 do not inform us concerning the time or the duration of the creative process. But while Augustine was largely motivated by philosophical reasons, the contemporary advocates of this theory appeal more to literary considerations. For example, N. H. Ridderbos, in his book *Is*

There a Conflict Between Genesis 1 and Natural Science? (Eerdmans, 1957), points to the eight works of creation, four occurring during the first series of three days and four during the second series; to the similarities of the works of separation during the first three days; and to the fact that Day 1 corresponds to Day 4, Day 2 to Day 5, Day 3 to Day 6. Thus there is an appeal to the artistic arrangement of the creation week, which is more literary in nature than chronological. Henri Blocher, in his book *In the Beginning* (Inter-Varsity Press, 1984), adds to these literary considerations the observation that the author of Genesis uses patterns of 10, 3, and 7: for example, ten times we find "God said," three times concerning mankind and seven times concerning the rest of creation; three benedictions; three times the use of "create," and on the third occasion it is used thrice; seven times statements of approval by God. By making appeals to such literary considerations, which indicate how the story has been artistically crafted and stylized, advocates of this position argue that such considerations are sufficient to suggest that the author is using artistic patterns which do not intend to teach a literal succession in time. If such a view is adopted, the areas of potential conflict with science are greatly reduced because, in distinction from the Period Theory, the Framework Theory concludes that Genesis 1 intends to teach nothing concerning either the time or even the necessary order of the creative events.

While accepting many of the literary considerations mentioned above, others point out that a comparison of the biblical accounts with comparable literature from the Ancient Near East is very helpful in gaining perspectives on the proper understanding of Genesis 1. One viewpoint suggests that, in the context of the Ancient Near East, creation is viewed as an act of divine kingship. Genesis 1 presents creation as a series of royal edicts of the Great King, who is establishing and ordering his kingdom and revealing his sovereignty over all that exists. Moreover, the creation account seems to be spoken from the vantage point of God's throne room in heaven. It is as though the author were standing in God's heavenly council chamber and witnessing what happens there. By way of contrast, the perspective of the creation account which begins in Genesis 2:4 seems to be that of an author who stands on the earth within human history. If one is convinced by this literary perspective, then obviously one must avoid treating these days as though they were the ordinary days of our experience, either as twenty-four-hour days or as aeons of time. God's actions have been described after the manner of human actions, but this has been done only to describe what would otherwise be indescribable.

Although these approaches to Genesis 1 based on literary considerations vary among themselves, all agree that Genesis 1 must be understood as a unique mode of revelation in which God accommodates his revelation to human capacities of imagination and understanding. According to these views, a literal reading, which treats the Genesis 1 description of acts of God as though they were in fact comparable to a description of acts of human persons, clearly misreads the mode of revelation and the kind of literature that Genesis 1 uniquely is.

We have not presented an exhaustive account of interpretive approaches to Genesis 1. There are others. For example, some think it best to treat Genesis 1 as a hymn of praise. Even though Genesis 1 is technically not poetry, its style moves with a stately cadence that could indicate its use as a

confessional hymn. If so, as would be the case with a psalm or hymn, its advocates conclude that we should not expect Genesis 1 to be addressing directly the kinds of questions science asks.

While the discussion above does not exhaust the possibilities, it does intend to alert the church to a variety of interpretive viewpoints which today hold some attraction for evangelical scholars. Because the church should not adopt specific interpretive or exegetical theories, this report has presented only the general outlines of several theories without arguing for any one of them in detail. If the theological tradition of our church continues as sketched above, the church will undoubtedly feel compelled to allow a variety of exegetical theories concerning Genesis 1. Nevertheless, in order to allow such a variety of viewpoints, the church must have assurance that a given theory will not infringe on any essential faith commitments. To tolerate an exegetical theory within a confessional context requires that the church knows not only what a given theory does not teach but, more important, what a given theory does maintain as the essential teachings of the creation account.

C. Exegetical theories and essential teachings of Genesis 1

Genesis 1 stands as a grand overture to the entire panorama of God's establishment of his kingdom in this world and as a prologue to covenant history. Genesis 1 is unique. Its teachings about God, humankind, and the nature of created reality cause it to stand out as distinctive revelation among the attempts of other religions to describe and account for the nature of these realities.

The God of Genesis 1 is absolutely sovereign, without beginning, the only one who exists before the existence of the creation. He is one, not many, neither competing with other forces for sovereignty nor himself an aspect of created reality. He is Creator; all else is creature—dependent upon his creative Word for its existence. He is good, faithful, benevolent, not capricious, arbitrary, threatening. Genesis 1 is far removed from the mythical stories and the polytheistic pantheons of the ancient world.

The creation account implies a creation *ex nihilo*. This refers, of course, to the initial act of creation, for the days of creation describe actions by which God, through his Word and Spirit, gives order to that which is orderless and life to that which appeared lifeless. Thus everything that is is radically contingent, dependent not independent, subject to the will of the Creator. And the order in which all exist and to which all are called is a kingdom designed for peace and shaped by righteousness.

The Genesis narrative highlights the idea of dynamic order in God's work of creation. Step by step various levels of created reality appear in response to God's Word. The world takes shape in stages. Not everything happens all at once. Nor does Genesis leave us with the picture of a single continuous process. Emphasis falls on the successive separation of a variety of distinctive creaturely types. God's handiwork reveals a rich diversity of creatures suited to clearly differentiated orders of reality. We therefore speak, for example, of the plant, animal, and human kingdoms.

Man and woman form the climax of God's creation, created in his image, placed as his representatives on earth, stewards over the peaceable kingdom which God established. Their work of managing the earth and

developing culture is not a necessary evil but a consequence of being created in the image of God. Their sexuality is designed by God for blessing, but it is neither an aspect of divinity nor an avenue for manipulating God or discovering his will; nor is it the source of evil. Man and woman are created good, morally upright and morally responsible. They are created to live in community with each other, to establish the human family, which is the family of God.

Yet beyond the first climax of creation lies a second. The purpose and goal of the entire creation lies in the sabbath rest of God. Man and woman are made for communion with each other and both for communion with God. Their work is religion, but when life and work are severed from the Sabbath, both lose their proper meaning. Man and woman have been created to serve God and to enjoy him forever.

These are some of the grand themes of Genesis 1, themes which are not silenced by subsequent human disobedience. Even though the fall into sin brought evil and discord into the good creation, Genesis 1 continues to reveal the truth about God, the creation, and the kingdom which God is establishing. No theory of interpretation may silence these basic themes, and we judge that none of the theories mentioned above do so. They all affirm these fundamental teachings of Genesis 1. What then is our problem?

D. The problem of interpretation

The problem facing the CRC is not that some of its members reject Genesis 1. The problem is how to interpret Genesis 1. The problem is focused on two questions asked by science: *when* did creation occur and *how* did the various parts of the creation and its living creatures come to be? These questions in turn raise questions about the revelatory intention and limits of the creation account: does the creation account intend to answer the *scientific* question of how something came to be, what limits does God's action of accommodating his revelation in Scripture to the human situation impose upon our curiosity, and what limits do we encounter in the very words that are used to describe the creation?

Since the question of the time of creation and the age of the earth has been discussed among us for the greater part of this century and since the theological judgment has been widely accepted among us that the age of humanity or of the universe is of no consequence for maintaining orthodoxy, we judge that the question concerning how things came to be is the more crucial one in the contemporary debate. Of course, these two questions are intertwined. Yet we also judge that the early chapters of Genesis contain sufficient indications to alert us to the fact that these chapters contain highly stylized and compressed accounts of history and that, consequently, they do not intend to establish and are not suitable for establishing either a specific pre-Abrahamic chronology or the time of creation. Hence this section will focus mainly on the question whether and to what extent Genesis 1 provides answers to the scientific question concerning how things came to be.

There are within the CRC and the broader evangelical community at least three positions concerning how Genesis 1 speaks to issues of contemporary science on origins. By looking at each and at some of their respective arguments, we can illumine the nature of the question and the focus of the problem.

1. The Literal Reading: The literal reading has a long and noble history, yet at least since the days of St. Augustine (5th century A.D.) the church has often wondered how literal its reading of Genesis 1 should be. Today in our scientific age the literal reading tends to treat Genesis 1 as though it were directly a scientific statement: for example, the days are literally twenty-four-hour periods within which God actually performed his creative activity; each creative Word of God represents a significant discontinuity with what preceded and allows for little continuity of process; creation occurred in the relatively recent past and within a 144-hour time span. Some proponents of the literal view allow a gap between Genesis 1:1 and 1:2 which may have lasted millions of years, but the rest of the chapter is taken as a straightforward historical report. Consequently, this view opposes most current scientific views of origins, at least insofar as these cannot be accommodated by the gap theory, and is often associated with what has become known as "Creation-Science." From this perspective Genesis 1 directly presents the scientific model of reality, which organizes all data and within which all data must be interpreted. Genesis 1 is not an accommodation to our capacities but a straightforward presentation of scientific fact.

2. The Period Theory: The Period Theory discovers accommodation at one point. Although the days of Genesis 1 look like ordinary days, they are actually periods of time almost unimaginable in length. The evidence for this discovery is primarily scientific, the conviction that the data on which scientific estimates of age are based are sufficiently convincing to warrant treating these estimates as fact. In addition, the theory rests also on the biblical use of *day* for a longer period of time, as in Genesis 2:4, where day refers to the entire period of creation. Because of this expansion of the time frame for creation, this theory is open to considerable process and development within each period of time, open to what is sometimes called microevolution. However, like the literal reading, the Period Theory insists that between the periods there is no continuity of process which can account for the succeeding levels of creation. The creative commands of God indicate discontinuity between the periods of creation, a discontinuity which should be traceable by science. Hence this theory rejects any evolutionary position which assumes continuity of development from the beginning of creation to its conclusion. Unlike the literal reading, it does not advocate a recent creation, nor does it assume that everything in the creation account is directly a revelation of scientific fact. Consequently, advocates of this theory are in agreement with wide areas of contemporary science and accept many of its claims, but they believe that they must reject the overarching claims of a macroevolutionary theory on both biblical and scientific grounds.

3. Literary Theories: Literary theories, whether Framework Theory or others, share a common conviction, namely, that Genesis 1 is not a literal description of the creative process but a revelation which God accommodates to the human situation, a revelation which has been shaped and patterned according to the structure of an ordinary week. Since Genesis 1 reveals a past to which no human person was witness, Genesis 1 should not be interpreted as though it were a human eyewitness account of the acts of

developing culture is not a necessary evil but a consequence of being created in the image of God. Their sexuality is designed by God for blessing, but it is neither an aspect of divinity nor an avenue for manipulating God or discovering his will; nor is it the source of evil. Man and woman are created good, morally upright and morally responsible. They are created to live in community with each other, to establish the human family, which is the family of God.

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God nor as a scientific account. Instead, these theories highlight the fact that there is some distance between the description of the creative acts and the acts themselves.

Some of the literary features on which these theories are based have already been mentioned. In addition to such features, advocates of these theories would also point to the limits that the words used in the creation account place upon us (cf. J. Stek, "What Says the Scripture," chap. 7 in *Portraits of Creation*, Eerdmans, 1990). For example, while the word for *create (bara)* is always reserved for the action of God and while in Genesis 1:1 it implies a creation out of nothing, elsewhere in the creation account and in the rest of the Old Testament it does not by itself imply a creation out of nothing. When one examines the words which function as synonyms of *create (make, form)*, it becomes obvious that God's creative activity can involve the use of materials already formed, as in the case of the animals produced by the earth and created by God or in the case of the creation of man and woman. In addition, this language of creation is used in the Old Testament not only for the origin of all things in the beginning but also for the origin of everything that ever was, is, or will be, including Israel, every individual person, historical disasters, a house, a city, and even the wind, the snow, and the rain. God has created and still creates all sorts of things. Everything owes its being to him and every "new" thing that appears is created by him. Consequently, one cannot determine from the word itself, whether it is *create, form,* or *made,* how God did it. God's acts of creation may be "out of nothing," at least originally, or they may not. Creation may refer to an instantaneous action, or it may refer to a process like creation in the womb. When it is said that God creates the wind, one need not conclude that there is an absence of natural causation. Even when it is said that God creates by his Word or by his command, one cannot infer that such an action refers to an instantaneous creation. For creation by fiat describes not only the original creation but also God's commands for the falling of rain and snow, for drought and famine, for the appearance of ravens and of Cyrus. Creation by word, by command or fiat, expresses God's sovereignty over all and that all originates with him, but it does not inform us directly whether he has chosen to create out of nothing, by means of an already existing agent (the earth), or by means of natural processes that owe their existence to him (conception/birth, natural law).

Because of such considerations, both of literary structure and of the limitations imposed on us by the basic creation vocabulary, advocates of literary theories usually conclude that Genesis 1 does not directly address the scientific question of *how* things came to be. They would agree with H. Bavinck's view that there is some difference between (Bavinck spoke of "almost disharmony between") the biblical description and the actual creative acts of God. Whether science *can* inform us or, more pointedly, whether contemporary science *has* informed us about these creative acts is the matter of dispute. Some advocates of literary theories reject the macro-evolutionary picture of contemporary science; some do not. Usually the reasons for rejection or for acceptance are scientific in nature. Some think that the scientific evidence stands clearly against evolutionary theory, at least with a view to the origin of humankind. Others think that while at

present the evidence is not sufficient to prove the theory, the evidence is sufficient for continuing scientific work along the lines of the theory. Thus there can be a serious dispute about scientific claims among those holding a similar interpretive approach to Genesis 1. Yet, since most advocates of these literary theories believe that Genesis 1 does not directly answer the scientific question as to how God caused things to be, they agree that the dispute must be settled primarily on scientific grounds.

As we have noted earlier, all of the advocates of the various interpretations of Genesis 1 affirm all of the teachings of Genesis 1 described in the preceding section, including the teaching that man and woman have been created in the image of God. The major point of dispute concerns the degree to which Genesis 1 speaks directly to the scientific questions concerning when and how things came to be. Though our theological tradition has rendered the question about the time of creation less of a burning issue, the question about how things came to be has become the nub of the problem. On this question the members of the church at large and the members of this committee are not in full agreement. However, before we present a concise statement of the essential disagreements and the reasons for them, it is necessary first to raise questions about the use of the term *evolution*, about evolutionary theory in general, and about the essential differences between the biblical worldview and the popular evolutionary worldview.

V. Evolutionary theory and Genesis 1

The term *evolution* has had primarily negative connotations among evangelical Christians. For many it necessarily implies a rejection of Genesis 1, a disbelief in a creator-God, and an advocacy of ethical relativism. The theory of evolution is held responsible for the rise of communism, sexual freedom, and other social evils. As such, evolution is not considered to be a concept that Christians should advocate. Is this commonly held opinion fully accurate, or is it perhaps one-sided? Does evolution have any validity whatsoever? Are there important distinctions to be made?

A. The evolutionistic worldview versus the Christian worldview

Evolutionism is more than a scientific theory. It is a worldview, an answer to the essential questions of who we are, where we came from, and where we are going. Consequently, evolutionism functions as a quasi-religious perspective, a worldview that is in fact anti-Christian. And the danger is that it does this in the name of science. Scientific description and worldview perspectives are often thoroughly intertwined and many evolutionists have claimed that the extension of their evolutionary perspectives into the fields of history, sociology, economics, ethics, and religion is simply a necessary and legitimate inference from their scientific theory.

For example, one of the leading evolutionary biologists today, Richard Dawkins, once held a belief in God based on evidence for design in the creation. However, through his work as a biologist he has become convinced of an apparent lack of design or even foolish design as judged by standards of engineering. He has concluded that if there is a God who like a watchmaker designed this world, he must be a blind watchmaker, not necessarily a malicious or cruel designer, but certainly a blind one. Of course, a deity who works with no foresight or purpose is no deity at all. So Richard Dawkins

has become an atheist who claims that evolutionary theory provides the intellectual foundation for his atheism. In Dawkins's hands evolutionary theory and evolutionary worldview are intermingled. There are many who draw similar conclusions. They claim that there is no purpose in the evolutionary process, just random change. Humanity has randomly appeared on the scene, and while as human beings we may be glad that it did, there is no purpose in it and no special value to be ascribed to humanity. Obviously such claims go far beyond any reasonable scientific description of the data.

As a worldview, evolutionism is a form of naturalism which believes that Nature is all that there is, that it is self-originating and self-sustaining. Nothing exists outside of Nature, no external power or person who is responsible for the origin and preservation of the cosmos. Everything that happens is simply the result of the behavior of matter. For many naturalists there exist no ultimate values, no absolute ethical norms. Nature is autonomous and is not part of some ultimate plan. Everything that exists is transient and ever changing. Naturalism, whether ancient or modern, stands in open conflict with the Christian worldview.

The Christian worldview has a view of nature, but it is a de-divinized nature, no longer autonomous. Nature is full of life and capable of producing life, but it has received these capabilities from the hand of the Creator, and it exercises these capabilities at his command and under the aegis of his Spirit. Thus at the command of God the earth brought forth vegetation, and the waters brought forth swarms of living creatures (Gen. 1:11, 20). Nature is neither self-originating nor self-sustaining. It is a creature brought into existence and sustained by God to serve his purpose. The creation story is an account of the creative activity of God by which he separates and distinguishes one thing from another; gives to each creature its own nature, purpose, and powers; and establishes an order in which his creatures can live. This ordered creation is purposeful and has in view the life and work of man and woman, created in God's image, commissioned as stewards of the creation, called to represent and serve God. This biblical worldview stands in antithetical relationship to the contemporary naturalistic evolutionary worldview. Here there is a clash of two opposing faiths.

The creation account is dominated by God's activity of separating, distinguishing, and thereby imposing an order on his creation. Everything has a place; everything receives a function which contributes to the orderly whole. Such is the biblical perspective. God is a God of order, and he calls humanity to live within and according to the order he has established. Henri Blocher claims that naturalisms, whether ancient or modern, have a fascination with intermixture and a longing for a universal dissolution of differences. Somehow it is hoped that by breaking categories, by acting contrary to the "natural" order of things, one can release spiritual power and even overcome the distinction of good and evil. Such a spirit is very much alive today. According to Blocher, behind this desire to cross boundaries and to confuse everything lies

> the anarchic revolt of mankind who wishes himself to be free of all law—having neither God nor master. Not only is it moral law but also natural law which must appear intolerable to our God-defying liberty. . . . Together with revolt goes resentment against being, as it is given and shaped: the desperate will not to be oneself. There is also weariness of definition and dissatisfaction with the finite; what is there to hope for, then, shut up within categories?
>
> (*In the Beginning*, p. 72)

Certainly, naturalistic evolutionism has contributed to the spirit of revolt described above. This spirit seems to believe that anything can become anything and that human freedom lies in overcoming boundaries. The Christian believer knows better. God's order does not assail our liberty but establishes it. Sin, not our created nature nor the created orders of this world, destroys freedom, and sin must be overcome and has been overcome in Jesus Christ. But with naturalistic worldviews, as Blocher says,

> Once the knowledge of God is lost, the sense of God wanders among created things, and not finding him, seeks for his substitute in their dissolution. Once the knowledge of God is lost, mankind accuses finitude of causing his disorder, whereas that disorder is the fruit of disobedience. Once the communion is lost, mankind wants to replace it with confusion.
>
> (p. 73)

Obviously, evolutionism as a naturalistic worldview functions as a religious interpretation of reality. As such it is an atheistic faith completely opposed to the basic teachings of the Bible. Since these worldview assumptions and perspectives of evolutionism are often not distinguished from evolution as a scientific theory, it is no wonder that many evangelical Christians totally reject any concept of evolution. Evolution is considered simply to be an anti-Christian theory, and when it becomes a total naturalistic worldview, it certainly is.

B. Evolution as a scientific theory

While there is ample evidence that evolution is for many both a scientific theory and a naturalistic worldview, one must acknowledge that there are Christian scientists who accept evolution as a scientific theory but reject the naturalistic worldview associated with it. They believe it is possible to fit evolution as a scientific theory into a Christian worldview. For example, John C. Polkinghorne, a British physicist-theologian, has pointed out the astonishing fact that the contemporary evolutionary model of the origin of the universe has contributed to a greater openness to the possibility of the existence of God. Some scientists by simply doing their science have been led to this position. Many have been impressed by the intelligibility of the physical universe, the fact that much of its structure can be grasped in mathematical formulas by the human mind, as an indication of an Intelligence who planned it all. Polkinghorne argues also that the clear purpose of the evolutionary process has been the appearance of humanity. Everything points in that direction, from the rate of expansion of the universe from the time of the Big Bang (any slight change would have left humanity out of the picture) to the composition of the stars. Thus he finds an argument for a Creator in the grand design of the universe understood along the lines of evolutionary theory. While one cannot use such arguments as proof of a Creator, Polkinghorne believes that an argument can be made to show that the Christian answer is a more intellectually satisfying answer than that supplied by atheistic naturalism (cf. "Creation and the Structure of the Physical World," *Theology Today*, Apr. 1987: 53-68). Thus, whether we accept the evolutionary hypothesis or not, we must be aware that there are Christians who accept evolution as a scientific theory but who radically reject the atheistic naturalism often associated with it.

That evolution can be distinguished from such naturalistic assumptions should come as no surprise to us. Already in 1899 in his rectorial address on evolution, Abraham Kuyper made essentially the same distinction. On the one hand, he completely rejected Darwinism because it taught the mechanical origin of all things without purpose or plan and assumed a materialistic doctrine of an autonomous nature. On the other hand, he raised the question whether the Christian faith could permit the possibility of a spontaneous evolvement of the species in the organic world from one single primary cell. His answer was that without reservation that question must be answered affirmatively. We cannot impose on the Creator our style. Kuyper argued that "if it thus had pleased the Lord not to create the species as such, but to have one species arise from the other, by designing the preceding species in such a way that it could produce the next higher, the creation would have been just as wonderful" (cf. *Evolutie*, 1899, p. 47). We would point out that for Kuyper this was only a theoretical possibility. He acknowledged only that there could be an evolutionary theory which was not inherently anti-Christian provided it was not mechanistic or naturalistic and was rather understood as God's method of creating, which achieved God's purpose and plan. However, for both biblical and scientific reasons, Kuyper himself did not believe that this was the way God did it, and he consequently rejected evolutionary theory.

Basically, evolution holds that physical and biological reality exhibit a specific type of dynamic. (For various meanings of *evolution* as used by science, cf. Appendix, Section III, D.) There is and has been ongoing and continual change in the physical world at large, for example, in the life cycle of a star or in the development of species, such as the various species of fern or the various species of horse that have descended from a common ancestor or the various species of gull that circle the earth in the northern hemisphere. In the physical world these changes are brought about by the interaction of various physical processes governed by physical law, and in the biological world the changes result from the accumulation of minor genetic changes often reinforced by geographical isolation. Thus the contemporary biological interpretation of the development of species (speciation) is along evolutionary lines. This is called microevolution.

Should such an interpretation be problematic for a biblically informed Christian? We think not. There is nothing in either the doctrine of creation or providence that militates against it. If God chose to create species possessing considerable genetic possibilities of adaptation and change, such a creation would only demonstrate his infinite wisdom. For without such possibilities, in a changing environment species would be much more fragile than they actually are. In addition, the evidence for such speciation is sufficient to warrant the claim that this is scientific fact. Thus we believe that microevolution—the minor changes involved in the speciation process—can be accepted without danger to either a Christian view of Scripture or a Christian worldview.

What about macroevolution, that aspect of evolutionary theory dealing with change above the level of species and including the belief in common descent? It has become quite common for Christians to accept microevolution but to reject macroevolution as in conflict with the account of origins in Genesis 1. To such a distinction some evolutionary biologists reply that all

evolution is the result of microevolutionary changes in species and that it is only the nonscientist who thinks it possible to distinguish micro- from macroevolution and who thinks that macroevolution is somehow more difficult to account for. But even if the mechanisms are the same, it can be pointed out that, on the available evidence, microevolution can be given a much higher degree of probability than macroevolution. The present evidence for macroevolution is highly retrospective, because it is an accumulation of microevolutionary changes. It includes the use of fossil evidence and requires extensive use of inference based often on fragmentary data. Frequently "transitional forms" are missing, and their past existence must be simply inferred. Consequently, it becomes much more difficult to trace connections between phyla and classes (than between species) because there are major gaps in the fossil record. While evolutionists may give "plausible" explanations for these gaps, it is obvious that the reconstructions required for a complete macroevolutionary history are at present and at best an exercise in probability that falls far short of proof. Thus while the proposed mechanisms for micro- and macroevolution may be the same, at present the evidence for the former is better than the evidence for the latter (cf. R. T. Wright, *Biology Through the Eyes of Faith*, chap. 7, "The Darwinian Revolution").

The question confronting the church is this: is it permissible for a biblically informed Christian to accept macroevolution as a working hypothesis and to participate in such research? Or is there something in this theory that is inimical to the biblical account of origins? Do we know directly from special revelation that this theory is antiscriptural and thus off limits for the scientist who is a Christian?

C. Evolutionary theory and Genesis 1—three views

Obviously the answers to the questions mentioned above depend on the church's interpretation of Genesis 1. While this report acknowledges the possibility that in a given case an appeal to Scripture can rule out a specific scientific theory, before the church exercises that possibility, it must be assured that its interpretation of Scripture is in harmony with the biblical intention and that its understanding of the specific scientific theory and its proposed evidence is accurate. Although the church as institute has neither the authority nor competence to judge the validity of a scientific theory on strictly scientific grounds, it does have the obligation to see whether a given theory violates the clear teaching of Scripture and/or is inimical to the central concerns of the Christian worldview. The problem which confronts the church today in answering these questions is the fact that there are within the church differing views of the meaning and intention of Genesis 1, as well as differing evaluations of the theories and data presented by science.

In answering the questions before us, the church must speak biblically and confessionally. It must speak from the perspective of its common confession and from that understanding of Scripture which the church considers, in the light of its total understanding of special and general revelation, to be the clear and compelling teaching of the Word of God. It is not the church's task to construct a scientific case in answer to the questions asked. Hence also in this ecclesiastical report we have not considered it our task to develop a scientific case either for or against various aspects of evolutionary theory.

Instead, the question facing the church is this: do we know that evolutionary theory is inherently and self-evidently antiscriptural and thus off limits for the scientist who is a Christian? In this question we are speaking, of course, of evolutionary theory as a *scientific theory* and not as a *naturalistic worldview.*

At present in the church one hears three different types of answers to that question. While variations within these types are possible, for the sake of convenience and clarity we believe that the essential positions can be summarized under three answers. These answers range from a vigorous affirmation that evolutionary theory is inherently antiscriptural, to a mediating position which holds that some aspects of evolutionary theory are and other aspects are not antiscriptural, to the view which holds that Scripture does not directly address the issue and that therefore the questions about evolutionary theory must be argued primarily scientifically and not confessionally.

1. Inherently antiscriptural

   The vigorous affirmation that evolutionary theory is inherently antiscriptural is usually associated with a traditionally literal reading of Genesis 1. If one holds to a young earth and to a literal interpretation of the days of Genesis 1, there is simply no time for evolution to occur. In addition, in common with certain other readings of Genesis 1, the days are understood as distinct creative periods which are sharply demarcated from each other. Consequently, there are significant discontinuities between creatures called into existence on the respective days of creation. Each day reveals a new creative act of God, and thus what is brought into being on each day is a *de novo* creation, not to be accounted for by a physical or biological process continuing from the previous day.

   This reading of Genesis claims as confessional teaching a young earth, separate creative acts accomplished within twenty-four-hour periods, and a clear and absolute distinction in origin and in essence between plants, animals, and humanity. Within this biblical and confessional viewpoint there is no possibility of any evolution with respect to origins, although some very limited forms of microevolution could have occurred subsequent to creation. Frequently in this view the fossil record is considered to be not a record of origins but rather the deposit of the flood. Since this reading of Genesis 1 is understood well, it is not necessary to describe it further in detail. While the difficulties of this position have been pointed out in the past and continue to be part of the ongoing debate, there are many in the church who continue to hold it.

   However, during this century the church has not required adherence to this strictly literal view. Other interpretations of Genesis 1 have been permitted. On the basis of these other positions, what is the answer to the question whether general evolutionary theory is inherently antiscriptural?

2. A mediating answer

   The mediating answer distinguishes general evolutionary theorizing with reference to the development of the physical universe from such theorizing with reference to organic life and the origins of humanity. The reasoning is as follows. Influenced either by the expanded time frame of the Period Theory or by the abandonment of literal time frames in the various literary theories, this view assumes the possibility of an old universe and an ancient creation. Convinced by the literary structuring of

Genesis 1 and the clearly stylized history and schematic genealogies of Genesis 1-11, this view advocates, with Warfield, the position that the biblical account does not intend to present a chronology of origins. Hence neither the age of humanity nor the age of the universe can become a matter of confessional orthodoxy or a measure of the faithful reading of the Scriptures. Consequently, the estimated age of the universe given by contemporary science (15 billion years) or even the possibly evolutionary development of the universe (Big Bang theory) is not viewed as a threat to the biblical doctrine of creation. While the Bible clearly teaches that God created the universe and that he made the stars also, its description of how God did this and the time it took is not a scientific portrayal of the processes involved.

Whether the present scientific view of the matter is right or wrong is considered a separate question. While the Big Bang theory is plausible, its scientific certainty has not been finally determined. Since every scientific theory is underdetermined by the evidence and since some bits of important counterevidence exist for every significant theory, modifications of the present theory and even the overthrow of the present scientific consensus are possible outcomes. For the church the only significant issue is whether the present scientific consensus concerning the age of the universe and its possible evolutionary history is inimical to its own confession. This view judges that it is not. Thus in this view it is permissible to hold such an evolutionary theory of the development of the physical universe provided that it does not rest on naturalistic assumptions and does not posit the eternity or autonomy of the material universe. The universe originates by the command of God and develops and is upheld by the Word of God. The developing and developed universe is God's creation achieving God's purpose.

While permitting the above as compatible with a Christian worldview, many believe that the confession of the church and a faithful reading of the Scriptures require a rejection of a macroevolutionary theory of origins in regard to the organic world. Whatever literary features may be agreed upon and whatever literary theories may be accepted, it still seems self-evident that the central thrust of the story of creation refers the origin of the various stages of creation directly to the creative activity of God. As God sets about in his work of dividing and separating the various aspects of reality and carving out their distinctive characteristics, his creative activity (Word of command) is the *event* which initiates and brings into being the fully articulated world of plants, animals, and humanity. The creation occurs in stages, not everything at once nor as a single continuous process. Each stage originates in a creative command of God. Hence, although plants, animals, and humanity may possess certain characteristics in common, in origin and in being they are distinct creations possessing their own nature and essence.

The creation story highlights especially the distinctive origin, nature, and essence of humanity. Prior to the creation of man and woman, there is a deliberation within the Godhead concerning this creative activity. God decides to place on earth creatures who bear his image. Whatever content one gives to the "image of God," and theologians have made various proposals, it is clear that men and women are distinct and unique in their

being and in their task. As morally responsible creatures they represent God himself on earth and function on his behalf. Thus the creation story itself as well as the uniqueness which Scripture clearly ascribes to humanity requires in this view the belief that humanity originates as a *de novo* creation of God without being derived from preexisting levels of created organic life. Because humanity is the imagebearer of God, prior levels of created existence could not have had the capacity to produce such a distinctive being. In traditional language the argument is that no developmental process can account for the origin of the human soul. Without entering the debate about how best to speak of *soul* or *spirit*, this view holds that whatever is distinctive about human nature—the fact that humanity requires fulfillment in fellowship with God and others, the fact that humanity has the capacity for choice within a framework of moral accountability, and whatever other human qualities one may add—this distinctive human nature requires for its origin a distinctive creative action of God. This view holds also that the teaching of the temporal fall into sin of our first parents, by which the whole of humanity fell, is better protected by the position which affirms that humanity originates in a *de novo* creation by God.

Because of such reasons this view believes that an animal-ancestry theory of the origin of humanity contravenes the clear teaching of the creation account as well as the Christian confession concerning the uniqueness of humanity. Therefore, the Christian church and scientists who are Christian should reject the animal-ancestry view of the origin of humanity as contrary to Scripture and to the church's confession. However, within this view the age of humanity can remain an open question, and microevolutionary development within the human race can be accepted. One need not assume that Adam in all his features looked just like modern humanity. Nevertheless, whenever the human race began, this view holds that at that juncture one must posit a distinct creative act of God as the only sufficient cause for the origin of humanity.

3. Not inherently antiscriptural

There is a third position, which believes that a proper interpretation of Genesis 1 allows greater openness with reference to general evolutionary theories. Since this third view is in complete agreement with the second position described above concerning the age of the universe and its possible evolutionary development, there is no need to repeat this material and the arguments on which it is based. The third view also has no dispute with the second position concerning the obvious fact that the origins of the various levels of organic life must be ascribed to the creative commands of God and that the unique characteristics of human nature owe their origin to the creative will and action of God. Surely such is the clear teaching of Genesis 1. The only dispute between the second and third positions is the question whether this clear biblical teaching about origins enables us to say anything scientifically about how things came to be. The arguments are as follows.

Part of the argument concerns the function of the creation account. It has been characteristic of the Reformed hermeneutical tradition to insist that texts be understood as they function within the broader sweep of the

history of redemption. It is always necessary to ask about the intention or purpose of a given passage and its function within the entire scope of Scripture. Because of this perspective the Reformed tradition has not fallen prey to the temptation to translate specific texts directly into scientific theories. The tradition has always sensed that such is not the intention of Scripture. Within the view here being described, this focus on function looms large.

What about the function of the creation account? While some suggest that Genesis 1 functioned as a celebrative hymn in the liturgy of Israel—and conclude that certainly one should not expect in a psalm or hymn information directly relevant to scientific theorizing—scholars are not in agreement concerning this proposal. They do agree, however, that Genesis 1 functioned within Israel as a critique of the mythical accounts of origins found in the Nature religions which surrounded Israel. Genesis 1 provides a distinctive worldview (cf. IV, C and V, A) which is the foundation for biblical faith and obedience. Thus Genesis 1 describes the world which God called into being and its order. Such knowledge is essential for Old Testament and New Testament faith. But does the worldview function of Genesis 1 include as well information translatable into scientific theory concerning how God brought this ordered world into existence?

Earlier in this report a comment of Herman Bavinck was mentioned in which he spoke of a difference, almost a disharmony, between the actual facts of creation and the description of it in Genesis 1. What led him to this astonishing conclusion was the developing awareness of the geological and fossil record. Bavinck interpreted this record as providing information about the creative process and recognized that one would never have guessed that such was the case simply by reading Genesis 1. Science, he believed, was legitimately opening vistas into the creative activity of God. We are faced then with this question: what depths of reality lie hidden within the creative Word of God?

Earlier in this report (IV, D, 3) we described some of the limits that the language of the creation account places upon us. While the creation account emphasizes that all creatures owe their origin and being to the creative Word of God, the language of creation does not by itself instruct us concerning how God brought it about. For example, according to Job 37:6 rain and snow fall at the command of God. Obviously this command of God is for biblical faith a causal event, but from a modern scientific perspective this command is not a cause of the sort traceable by science. Instead science traces the lawful patterns governing weather. Such lawful patterns do not cancel belief in a command of God, for they need not be considered autonomous patterns, but science cannot get behind the lawfully ordered universe. Is it then possible that the creative commands of God in Genesis 1, even though they are causal events which originate reality, may likewise not be traceable by science? Is it possible that by his creative Word God set in motion laws and processes that brought into being reality as we know it? Some believe that such is indeed a possibility, that the language of Genesis 1, when seen in the light of similar language used elsewhere in Scripture, makes it impossible to know with absolute certainty whether God used processes or not. Even the more graphic description of the creation of man from the dust does not finally answer

the question. This language is clearly anthropomorphic. God is described as though he were a potter, but since God does not literally work with his hands, we are left with uncertainty concerning what the literal process may have been. To the extent that we cannot be certain, science is free to investigate and theorize about the matter. Whether science can successfully sustain such an inquiry into origins remains an open question.

Does this position inevitably surrender the unique nature of humanity? Does it perhaps allow for the position that sin is not really sin? No, it does not. While one must recognize that certain sociobiologists who have accepted a naturalistic evolutionary worldview have interpreted certain human actions which Christian teaching labels sinful as being merely natural behavior stemming from an evolutionary past, their argument is neither scientifically nor philosophically compelling. The way in which God brought humanity into existence, whatever that may have been, cannot negate the distinctive human nature that has been created. The biblical worldview teaches that human beings are uniquely created in the image of God and are consequently morally responsible creatures. Even if certain human behavior bears a resemblance to that of other creatures, human behavior is the expression of a morally responsible agent, and that fact renders such behavior essentially different. Thus also in this position there is an absolute insistence on the unique characteristics that constitute human beings as the imagebearers of God. This position disagrees with the second view only in concluding that neither the language of the creation account nor the necessity of maintaining the uniqueness of humanity requires a rejection of a macroevolutionary theory.

This position does not intend thereby to assert that such a macroevolutionary theory is correct. It asserts only that whether or not such a theory is possible cannot be conclusively determined by the interpretation of the biblical account. Whether macroevolution is valid or not is left to the debate of the scientists. Of course, Christians who are scientists must insist on and maintain the perspectives and beliefs that constitute the Christian worldview.

VI. An analysis of the problem confronting the church

While various exegetical proposals have been made which make the apparent conflict easier to handle, the church must not overlook the sharp contours of the problem it now confronts. Since the problem is complex, we here present as simply and as sharply demarcated as possible the contours of the relationship of the Bible and science on questions of origins.

A. Put in its simplest terms, the problem is that the Bible and modern science give apparently incompatible accounts of the origins of the universe and humanity and that none of the proposals for harmonizing them is completely satisfactory.

B. A plain reading of the first chapters of Genesis, as it was almost universally accepted by Christians until the nineteenth century, indicates that God made the world in six days a few thousand years before Abraham, that the various kinds of plants and animals were created by him according to their kind, and that Adam and Eve were uniquely created in God's image. Eve

was made from Adam's rib, and together they were the first parents of the human race. Originally they were perfect and holy, but after the fall they and their descendants became corrupt and sinful, desperately in need of redemption.

C. Modern science, globally speaking, sees the beginning of the universe in the so-called Big Bang, a complex physical process which took place billions of years ago, and sees the origin of humanity as taking place millions of years ago as part of a vast process of physical evolution whereby humans are descended from primates, primates and all other species of animals are descended from lower life-forms, and these in turn ultimately derive from some forms of inorganic matter resulting from the Big Bang. Morally and religiously there is no great discontinuity between animals and the first humans or between the first humans and their descendants. The whole process of evolution can be explained in terms of physical mechanisms.

D. On the face of it, these two different accounts of origins clash and cannot be easily reconciled. Not only do they appear to be logically incompatible, but they represent dramatically different perspectives on the place of humanity within the world, on the significance of sin, and on the need for redemption. Moreover, they are reinforced by the authority of the Bible on the one hand and by the authority of science on the other. The modern world has been characterized by the competing claims to final authority on the part of the Christian Bible and secular science. It will not do to minimize the reality and the importance of the apparent conflict between these two conceptions of the beginnings of the world and human life. It has been, and continues to be, the occasion for a crisis of faith in the lives of many believers.

E. To say that there is an "apparent" conflict between the biblical and scientific accounts is to say two things. On the one hand it means that the conflict is apparent in the sense that it is obvious and evident. It is important to acknowledge that at first glance, and perhaps even at second and third glance, there really is a conflict here. The two conceptions appear to be irreconcilable. On the other hand, to speak of "apparent" conflict here means to affirm as a religious confession that the conflict is ultimately *only* apparent, that at some level which we cannot penetrate (either because of the present state of our knowledge or because of our limitations as humans) the conflict is resolved. We confess that in the mind of God there is no contradiction or incompatibility even when we do not understand how this is so.

F. The apparent conflict between the biblical and scientific accounts of origins is dealt with in various ways. One is to make a simple choice between them. So secular scholarship generally rejects the biblical account outright and chooses for the scientific one instead. Similarly, some forms of fundamentalism hold that belief in the Bible has as a necessary consequence the unqualified rejection of the scientific account. As Christians who accept the Bible as the infallible Word of God, we obviously reject wholeheartedly the former alternative. But as Reformed Christians who recognize the authority of general revelation and the legitimacy of the scientific enterprise as a God-given task, we also resolutely reject the second alternative. Being Reformed means that we accept the problem in all its difficulty.

G. As Reformed Christians we also reject another way of evading the difficulty, namely, that of separating faith and science. By introducing a kind of dualism between religion and the scientific enterprise, this approach in effect defines the problem out of existence, since it postulates that answers to religious questions (supplied by the Bible) cannot, by definition, come into conflict with answers to scientific questions (supplied by science). This basically Kantian approach to the problem of faith and science has been vigorously opposed in the Reformed tradition. We affirm instead that faith and life must be of a piece, that all of life must be lived in obedience to God and in subjection to his Word. This is true as much of science as it is of personal relationships, business practices, or politics. We therefore reject any view of religion which limits its scope or any view of science which in principle excludes from its practice the influence of faith and the light of Scripture. On the contrary, we actively promote the kind of Christian scholarship, also in the sciences, which challenges the secular assumptions of the academic mainstream.

H. Instead of resorting to dualism, the Reformed tradition in which we stand has sought to mitigate the tension between Bible and science by stressing the importance of *interpretation* on both sides of the equation. It is legitimate to inquire whether the data of both Scripture and science can be reinterpreted to bring them closer to harmony.

I. On the side of Scripture there have been a number of proposals to change the traditional interpretation of the early chapters of Genesis. Some have proposed that the "days" of Genesis 1 were special days of indeterminate length (e.g., Bavinck and Aalders), others that the days are "cardinal points of concentration" which allow for periods of development in between them (e.g., Helberg), and still others have defended the so-called Framework Theory, according to which the six-day pattern of Genesis 1 is a literary device, not a report of discrete lengths of time (e.g., M. Noordtzij and N. H. Ridderbos). We can also mention here the proposal of S. du Toit that the creation account of Genesis 1 must be read as prophetic historiography, in which distances and perspectives tend to merge into each other and are not to be taken as exact representations. In general, there has been active consideration of the literary genre of the Genesis creation account. For the subsequent chapters of Genesis the view prevailed that the genealogies are not to be considered complete and that in general the historiography of Genesis 1-11 is highly stylized and compressed and does not necessarily follow chronological order. In this way some of the more obvious apparent discrepancies between the Bible and science, at least as far as chronology is concerned, were reduced.

J. It should be noted, however, that there are strict limitations on the extent to which the Genesis text can be reinterpreted within the Reformed tradition. However stylized, literary, or symbolic the stories of Genesis may be, they are clearly meant to refer to real events. Especially in the case of God's acts of creation, Adam and Eve as first parents, the fall of humanity into sin, and the giving of the so-called mother promise (Gen. 3:15), the reality of the events described is of foundational importance for the entire history of redemption.

It is the presupposition of the New Testament and historic Christian orthodoxy. Any interpretation which calls into question the event character of the story told in these first and fundamental chapters of the Bible must be firmly rejected, whatever difficulties this may cause with respect to the scientific evidence.

K. On the side of science, there have also been a number of proposals to change the standard interpretation of the evidence or at least to challenge the prevailing evolutionistic interpretation. There are gaps in the fossil record, there are theoretical difficulties with the proposed mechanisms of evolution, there are ontological difficulties with respect to the emergence of higher functions from inorganic matter, there is an assumed uniformitarianism throughout, and so on. Especially in recent years there have appeared some extensive critiques of standard evolutionary theory both by Christian creationists and others. Some thoughtful work is being done by scientists in our own circles in this area. The traditional emphasis in Reformed thinking on the role of presuppositions in science has also been reinforced in recent work on the nature of rationality by our philosophers. A positivistic view of the religious neutrality of science is increasingly being shown to be untenable.

L. It should be noted here, too, however, that there are strict limitations on the extent to which the scientific evidence can be reinterpreted in the context of present knowledge. Although it is no doubt true that statements of evolutionary theory as established fact far exceed the evidence and that there is an overall naturalistic and humanistic framework of reference into which the facts are often fitted, it is also true that there is a considerable body of evidence for which evolutionary theory has greater explanatory power than any comparable alternative theory available today. That evidence cannot be discounted or dismissed by Reformed scientists, because they believe that the givens of creation, the actual phenomena of the world (as distinct from their selection and construal in human observation and theory formation), come to us with the divine authority of general revelation and may not be denied. To paraphrase a remarkable statement by Herman Bavinck, the facts of biology are just as much words of God as the Scriptures, and to be accepted in faith. It is because of the weight of the evidence that virtually all Christian biologists, including strict creationists, agree that a limited degree of evolution (microevolution) is undeniable.

M. The upshot is, therefore, that the apparent conflict between Bible and science on the question of origins cannot be completely resolved in the present state of our knowledge—in fact, it is fair to say that it is far from being resolved. No matter how much we may critically reevaluate the traditional reading of Genesis (short of denying its historicity) and no matter how much we may stress the religious nature of science (short of denying the authority of general revelation), there is still a considerable gap between exegetically responsible readings of Genesis and scientifically responsible interpretations of the physical and biological givens. The attempts to bridge the gap tend to be speculative and controversial, and none are widely accepted in Reformed or evangelical circles. The pressures are great to resort to either

fundamentalism or dualism, but that would be to abandon the heart of the Reformed vision of life.

N. Although there is a great challenge to vigorously pursue creative research and reflection on both sides of the issue, it is unlikely that the tension between the Bible and science on origins will diminish significantly in the foreseeable future. As the Reformed philosopher Herman Dooyeweerd put it, on this issue we are going to have to live with a *docta ignorantia*, a well-informed admission of ignorance. Perhaps we will have to conclude that our inability to find an intellectually satisfying solution to this problem is one of the ways in which our faith in God and his Word is being put to the test in the modern world. Yet we have no reason to lose heart, because we have the promise that our faith is the victory that overcomes the world (1 John 5:4).

VII. Words of counsel and advice

Although the members of this committee have disagreed on one very significant point, they are fully agreed in acknowledging that the final answer to the question of how one should relate Genesis 1 to scientific theory is not yet known. Hence the church and its members should be cautious and should not assume too quickly that the definitive answer is to be found in this or that approach. While various plausible theories have been advanced for interpreting the text of Genesis 1, each exegetical theory falls short of unanimous acceptance. So long as the various interpretations do not compromise the essential confession of the church, the church must allow its members the freedom to advocate such theories. The church itself should not be in the business of endorsing exegetical theories. Instead, the church must "respect such freedom of biblical interpretation as falls clearly within the bounds of our creedal forms of unity, while recognizing, of course, that in all things we are bound by the Word of God" (*Acts of Synod 1972*, Report 44, point 6 of Pastoral Advice).

While our reading of Genesis 1 is subject to some degree of change, scientific theory is also continuously open to correction and change. Scientific theory is not an arena of absolute certainty. While the degree of probability of certain scientific theories borders on practical certainty, certainty is not the characteristic of others. Certainly the macroevolutionary theory of origins has not been proven. Even naturalistic evolutionists admit as much. Consequently, scientists who are members of the church and who are pursuing theories of origins should not claim greater certainty for their opinions and theories than in fact exists. They should always be open to whatever counterevidence there may be and be candid about difficulties and uncertainties, especially when dealing with issues that impinge on the faith commitments of the church. While certain non-Christian scientists treat the evolutionary hypothesis as an article of faith because they have no other faith and the loss of this faith would shake their framework of meaning, one would expect that scientists who are Christian would retain a greater degree of objectivity with reference to the data because of the freedom derived from the gospel.

Those scientists who believe that the contemporary macroevolutionary theory is in error and that it is their task to develop a theory more in harmony with their more literal understanding of the Genesis record must also

be careful not to claim certainty for that which is merely opinion. Once they enter the arena of scientific theory, their theories and proposals must be supported by the standards of evidence and the quality of argument that faithful science requires. While nonscientists in the church can easily be persuaded by presentations that sound scientific, such presentations do the church and the Christian faith much harm if the proposals cannot stand the light of legitimate scientific peer review. The relationship between Genesis 1 and contemporary science presents an exciting and challenging arena for discussion. The Christian faith can be harmed by excessive claims on either side of the debate. Let no one claim more than he or she must. Let everyone approach the evidence with respect, humility, and patience. The task is challenging, and we cannot know in detail where all the evidence may lead, but our faith is secure because the world with all of its evidence belongs to God.

Sometimes there are persons in the debate who assume that the issues can be reduced to the single issue of uniformitarianism versus non-uniformitarianism. Obviously there have been naturalistic evolutionists who were absolute uniformitarians and believed that whatever exists or happens is occasioned by some preceding natural cause, that there are no discontinuities, nothing that is miraculous. Clearly Christians cannot be absolute uniformitarians, for they believe in the God who works miracles for the redemption of his people and the cosmos: they believe in the resurrection of Jesus Christ. But the issue for the Christian who is a scientist investigating origins is not that simple. How many miracles did God perform in bringing the world to its fully developed form? If the creation language of God's Word of command is not necessarily the language of discontinuous miracle (cf. IV, D, 3), then how does one know? Even the scientist who is a Christian is free to investigate the matter. Since science is an attempt to explain lawful order, one would expect even the Christian engaged in science to ask whether explanatory mechanisms or lawful patternings exist as the means God used. Of course, one would expect the Christian even in his science to remain open to the possibility of a miraculous explanation that transcends science, for the God he serves is one who does perform miracles.

The church as institute cannot solve all the problems implicit in our mandate. In the midst of the present debate, the church continues to make its confession of God the Creator, the world as created and ordered by God, and humanity as created in God's image, fallen, and restored in Christ. In the light of that confession, scientists within the church must have the freedom to propose and debate their theories. They must even have the freedom to be wrong, and they should exhibit a willingness to be challenged and to stand corrected. Our scientific theories should not become our idols. Nevertheless, we must expect the debate to be vigorous and even at times to disturb the peace of the church. We would suggest only that, before our scholars make significant proposals which affect current beliefs or positions held within the church, they submit their proposals to rigorous peer review and that their peers provide such review. In this way the church would be protected to some degree from private opinion or erroneous theory being presented as scientific fact.

Postscript

Although our mandate required a report focused on questions of origins, we are all aware that we live in a time of severe ecological crisis. We are being confronted with the basic question whether our life-style and economic structures are so abusing the creation that we are beginning to prevent it from functioning as an instrument of God's life-giving goodness. From the greenhouse effect resulting from pollution of the atmosphere to fertile crop land lost to urbanization, from the degradation of water quality to deforestation, species extinction, and the massive problem of managing toxic wastes, we are almost overwhelmed by the sorry consequences of a life-style we have enjoyed. Creation *itself* is giving testimony not only to God as Creator but also to human beings as destroyers. We cannot escape the question whether we are functioning as the God-appointed stewards of the creation.

What one thinks fundamentally about origins should have an effect on ethical decisions and questions of life-style. We must not only know the right doctrine about creation and possess appropriate scientific theories; we must also live rightly in this world which is God's creation. As stewards we must treat it with respect and preserve its capacities to declare God's glory and to manifest his goodness. Our scientific investigations should lead us to understand and praise the Creator, and our debate about origins should remind us of our tasks and duties as the God-appointed stewards of his creation.

VIII. A summary of conclusions

Because our mandate is so wide-ranging and the report rather extensive, we thought it helpful to present a summary of conclusions arrived at in this report. This summary is not exhaustive, but it does highlight the key issues discussed in the report. We therefore call it to the attention of the church.

A. The Reformed understanding of the mutual interrelationship of special and general revelation contains within it an inherent bias against any dualism which declares that areas of reality can be isolated from the impact of either general or special revelation. Although what that impact is can be determined only by faithful and patient openness to what God is saying through both revelations, the church should not hesitate to warn against any view of science which in principle rules out the influence of faith, the norms of general revelation, or the light of Scripture from scientific theorizing.

B. The authority of general revelation, no less than that of special revelation, is a divine authority, which must be acknowledged without reservation. One may not seek to escape apparent conflicts between faith and science by avoiding either of the two basic modes of God's authoritative revelation.

C. A biblical hermeneutic which is based on any kind of separation of form from content, of vehicle from message, of packaging from content, cannot do justice to the interpretation of Scripture, since the very form of scriptural revelation is integral to its meaning.

D. The concept of primeval history can be used appropriately only if it retains an essential connection to history, in the sense of affirming the event character of the narrative. The precise nature of this essential connection to

history is a legitimate arena of inquiry, using whatever knowledge is available from both special and general revelation. It is consistent with sound Reformed exegesis, moreover, to acknowledge that the historical narratives of Genesis 1-11, like those of other parts of Scripture, are stylized and compressed and may not follow chronological order. It is also consistent with sound Reformed exegesis to acknowledge that the historical narratives of Genesis 1-11 may be theologically stylized, so that a historical event or entity is shaped in the narrative to carry a theological significance far beyond the historical event or entity on which the narrative is based.

E. The present apparent conflict between Christian faith and science over questions of origins cannot be easily resolved. Not only are there various interpretations of the evidence confronting natural science; there are also various plausible interpretations of Genesis 1. Thus all sides in the debates about origins should acknowledge that they do not have a completely satisfactory solution to the problem and that therefore certain criticisms made by some of their opponents are at least partially justified. In the midst of such disputes, the church must firmly confess that which is the clear teaching of Scripture and central to the Christian faith; but cognizant of the legitimate freedom of science to examine the evidence and of the legitimate freedom of exegesis to interpret Scripture, the church must not bind consciences beyond that confession.

F. The Scripture clearly teaches that God is the Creator of all that is, that he created all things good, that man and woman were made in his image to serve on God's behalf as stewards of the world that he made. This biblical teaching of Creation stands in judgment over all naturalistic, evolutionistic worldviews.

G. The Creation account (Gen. 1:1-2:3) accents clearly the idea of separation—distinction, diversity, differentiation—in God's original work of creation and in created reality as we experience it today. It reveals the absolutely fundamental distinction between Creator and creature as well as the lines of demarcation repeatedly drawn between various orders of created reality.

H. The Scripture clearly teaches that Adam and Eve, the progenitors of the human race, fell into sin and thus brought the whole of humanity under God's judgment of death. The only remedy for this sin and death is the righteousness and life that come through Jesus Christ, the second Adam. This biblical teaching concerning the fall and redemption stands in judgment over any evolutionary theory which negates the moral accountability of humanity for sin or reduces sin to merely natural tendencies.

I. Although the mandate called specifically for reflection on questions of origins, the church must recognize that creation concerns not only origins but all that exists even in the present. Living in God's creation imposes on humanity clear obligations of faithful stewardship.

J. Concerning some of the implications of this clear biblical teaching (see Conclusions F, G, H), our conclusions are not unanimous. Some hold that this clear biblical teaching necessarily requires an explicit rejection of any

theory which posits the existence of evolutionary forebears of the human race, that there is a clear clash of paradigms between prevailing evolutionary theories and the biblical account of origins. They argue that it is extremely difficult, if not impossible, to see how a responsible exegesis of Genesis 1-3 does not rule out the evolutionary account of human origins. Others are not fully convinced that this clear biblical teaching requires such a rejection, for various reasons. For instance, some think that close attention to biblical language does not at present obviously indicate that the Bible provides an answer to that question, that the biblical language itself imposes limitations on what we can infer from it. Some take Scripture (Job 38:4; I Cor. 13:8) to teach that God has no intention that we know all the answers in this area. Some believe that we are called to somehow take account of both of God's revelations whether we currently know how to do that or not and that traditional conclusions would be compelling on scriptural grounds were it not that nature seems to be authoritatively telling us something else. That is not to say that the scientific theories are right, but only that neither we nor the church is presently in a position to state authoritatively that Scripture speaks definitively on this issue.

IX. Declarations

From the days of St. Augustine the church has been advised not to accept or to reject too hastily existing scientific theory. We believe that such advice represents wisdom, for we are held responsible for two books of revelation. While we believe that the two books of revelation cannot contradict each other, we also acknowledge that we do not always know precisely how the two books relate to each other in detail or at a specific point. In times of such uncertainty, when the evidence may not yet have been either fully discovered or completely assessed, the church must testify to that which is central to the teaching of Scripture and to her own confession. Beyond that there should be an attitude of patient confidence as we wait for the resolution of the present debate.

Thus we recommend that the church adopt the following declarations. We would note that these declarations add nothing new to the church's confessions but simply articulate in the context of the present debate what is central to the church's confession on these matters.

We note that the following declarations and the subsequent points of pastoral advice (Section X) are presented unanimously by the committee except for Declaration F, which is a minority recommendation submitted by R. Maatman and G. Spykman. Although A. Wolters is in agreement with this minority view, he does not think it wise for synod to make an official pronouncement on the matter.

A. The church confesses that both general and special revelation, each in its own unique way, address us with full divine authority. We affirm, therefore, that the whole of life must be lived in obedience to God and in subjection to his Word, that faith and life must be of one piece. This is true as much of science as it is of personal relationships, business practices, or politics. We reject any view of the Christian faith which limits its scope or any view of science which in principle excludes from its practice the influence of faith and the light of Scripture. On the contrary, we actively encourage the kind of

Christian scholarship which challenges the secular assumptions of the academic mainstream by advocating the integration of Christian faith and learning.

B. The church wishes to honor its commitment to the freedom of exegesis by not imposing upon its members an authorized interpretation of specific passages in Scripture, insisting only that such exegetical freedom be carried on within the limits of the analogy of Scripture and the confessional guidelines of its creeds.

C. The church wishes also to respect the freedom of science by not canonizing certain hypotheses, models, or paradigms proposed by the sciences while rejecting others, insisting only that all such theorizing be subject to the teaching of Scripture and the confessions.

D. The church confesses the unity of the human race both in creation and the fall and the renewed unity of humanity in Jesus Christ. God made from one all nations of the earth (Acts 17:36), and through this same one, sin entered the world so that all have sinned (Rom. 5:18-19). All those who receive the abundance of grace and the free gift of righteousness through Jesus Christ now reign in life (Rom. 5:17) and have become the one new humanity (Eph. 2:15). The church rejects all theorizing that undercuts or denies this biblical teaching of sin and redemption.

E. The church confesses that humanity is uniquely created as the imagebearers of God and rejects all theorizing that tends either to minimize or to obliterate this created uniqueness.

F. (A minority recommendation): The church declares, moreover, that the clear teaching of Scripture and of our confessions on the uniqueness of human beings as imagebearers of God rules out all theories that posit the reality of evolutionary forebears of the human race (cf. V, C, 2).

X. Pastoral advice

We recommend that the church approve the following points of pastoral advice to give guidance in shaping the continuation of the discussion.

A. As instruction for the church and as a testimony to the world, the church urges its scholars to highlight in their sciences the basic perspectives that revelation provides.

B. The church urges its scholars who seek to provide guidance to the church on sensitive issues of faith and learning to first submit their ideas and theories to peer review as the most appropriate arena for adequate scholarly assessment of their biblical, confessional, and scientific validity.

C. The church reminds its scholars of the legitimate concerns of the members of the church regarding the significant issues of origins and urges its scholars in their speaking and writing to exercise prudence and to clearly distinguish what is merely plausible scientific speculation from what is accepted theory and/or fact.

D. The church urges its scholars, including theologians and natural scientists, to exercise an appropriate critical restraint with respect to "the assured results" of their investigations and the "clear consensus" of their disciplines, mindful that interpretations of Scripture as well as theories of reality are ever in need of reformation (*semper reformanda*).

E. The church reminds its members of the validity of the scientific enterprise as a way of carrying out the cultural mandate.

F. The church reminds its members of the necessity of distinguishing in the context of the present debate what is essential to the faith from what is not and of the importance of allowing open and vigorous discussion on matters pertaining to the latter. Fellowship within the body of Christ should not be broken over such matters.

G. The church encourages institutions of higher learning to provide forums for bringing together scholars from various disciplines to interact on critical questions concerning origins and thus assist the church in achieving greater clarity on these matters.

H. The church reminds its members to be careful not to allow disputes over the origins of creation, however important they are, to diminish or obscure our calling as stewards of the creation.

XI. Recommendations for synodical action

Your committee respectfully submits the following recommendations:

A. That synod recommend the study report (Sections I-VII, XII) to the churches as a helpful presentation of the problems surrounding the creation-science debate and of Reformed perspectives concerning these problems within the context of the relationship of general and special revelation.

B. That synod call the attention of the church to the nine points of Summary Conclusions (Section VIII, A-I), noting also the tenth point (VIII, J), on which there is not unanimity.

C. That synod adopt Declarations A-E (Section IX).

D. That synod consider the following with regard to Declaration F (Section IX):

1. The minority urges synod to adopt Declaration F (Section IX) for the following reasons:
   a. The impetus for rejecting such theories is implicit in the kind of theorizing rejected in Declaration E: the evolutionary idea of an animal ancestry for the human race does in fact erode the doctrine of the uniqueness of human beings as imagebearers of God.
   b. It is extremely difficult, if not impossible, to see how a responsible exegesis of Genesis 1-3 does not rule out the evolutionary account of human origins.

c. This declaration, though negatively stated, expresses the positive thrust of the Belgic Confession, Heidelberg Catechism, and Report 44 in their cumulative teaching concerning human origins.

d. From time to time crises arise in the life of a church, often unprecedented, which call for taking a clear stand on some vital issue. The question of human origins is one such issue. On this score developments in our church communities over the past quarter century have brought us now to such a moment of decision.

e. This declaration touches on one of the most sensitive points in our current disputes. Evasive action on this issue can only add to the tensions already present among us. The well-being of the church calls for a candid statement on this important matter.

f. The question of animal antecedents to the human race is the most difficult aspect of evolutionary theory for Christians to accept. If this idea of a primate lineage be allowed, it is difficult to see how the entire theory has not thereby been conceded.

2. Though deeply appreciative of the motives for the minority recommendation and not wishing to commit the church to any particular scientific theory of origins, the majority urges synod not to accede to the minority recommendation for the following reasons:

   a. Historically the Christian church in general has been reticent to issue formal declarations or confessional statements in this area. The Christian Reformed Church also has not considered it necessary to issue such a confession regarding this matter. There is wisdom in such a position.

   b. Many members of the Christian Reformed Church are working in this area and are considering the evidence and, what is not yet clear, the impact it may have both on scientific theory and the understanding of the biblical account. The church should allow them to contribute to a resolution of the problem. Further study in this area is necessary.

   c. The church should not bind the consciences of its members beyond what is the clear and indubitable teaching of Scripture and the creeds (cf. Section VIII, Summary Conclusion J, the second part).

E. That synod approve the eight points of Pastoral Advice (Section X).

F. That synod grant the privilege of the floor to D. Holwerda and A. Wolters as representatives of the study committee and G. Spykman as representative of the minority recommendation.

G. That synod declare the committee's mandate fulfilled and therefore discharge the committee.

Committee on Creation and Science
A. Wolters, chairman
D. Holwerda, reporter
D. Ratzsch, secretary
J. De Koning
A. Dragt

R. Maatman
G. Spykman
R. C. Van Leeuwen

Note 1: James Vander Laan participated in much of the work of the committee but for personal reasons found it necessary to resign before the completion of the report.

Note 2: One member of our committee, Calvin B. De Witt, has not signed this report because of his conviction that the debate on origins should not proceed until our greater task in creation—its care and keeping—is restored in faith and practice. At this time of increasingly complete human alienation from the creation, a time of unprecedented destruction of the Earth and extinction of God's creatures, he believes that furthering this debate seriously diverts the church and its members from reflecting God's care and keeping in their vocations (cf. Gen. 2:15), with ominous consequences. For God will destroy those who destroy the earth (Rev. 11:8). He also believes that furthering this debate misdirects our attention to debating beginnings and origins to the exclusion of debating the widespread adoption of evolutionistic attitudes, such as, only the fittest survive, I must be looking out for number one, and similar attitudes which create a ruthless and uncaring competition in our society and contribute to an increasing alienation from the creation.

APPENDIX

Brief Summary of Current Scientific View of Origins

The concerns addressed by this report have arisen in part because of the perceived conflicts between the current scientific view of origins and what traditionally has been understood as the biblical view of origins. The purpose of this appendix is to give, as background, a brief summary of the current scientific view of origins. The appendix will present a short chronology of origins, something about the nature of the scientific approach to origins, and a short preview of possible future scientific explorations and what they are intended to reveal. Because of the nature of this appendix, little if any attempt will be made to evaluate the validity or adequacy of current scientific views.

Key to the scientific approach to origins is the concept that the underlying physical laws of our universe are the same everywhere in the universe and also have not changed in time. For example, according to this concept, the speed of light is the same in the vicinity of the distant stars as it is on Earth. Also, the speed of light is the same now as it was in Old Testament times. Some of the evidence for this concept is presented later in this appendix. Here it is sufficient to note that this concept is required both to deduce facts about the past and to make reasonable predictions about the future. If what is known now about some process is correct, then from this knowledge one can hope to deduce something about what has happened in the past, and in some cases one can predict that something similar may again happen in the future.

As will be described later, the existence and nature of these underlying physical laws may be seen (by the eyes of faith) as evidence for design of the highest order and subtlety in the structure of our universe at its most fundamental level. The natural inference from this evidence is that design of such brilliance and profundity requires a Master Designer.

I. Short chronology of origins

The current scientific view is that our universe is not static but rather is constantly changing. Consequently, our universe has a history. Furthermore, this history has been going on for a very long time. Thus, in describing the history of our universe, it is necessary to use very large numbers. In particular, it is necessary to speak of millions (1 million = 1,000,000) and billions (1 billion = 1,000 million = 1,000,000,000) of years. In this context, it should be understood that all large numbers will be approximate. Some are claimed to be known only within a factor of two, and others may be known to within 20 percent.

For the purposes of this appendix, the presentation of what has happened in the past must of necessity be limited to a simple chronology of a few key events because the history of our universe is so rich that even a full description of what little is known would fill a very large library. Consequently, it will be possible to present only a short chronology, consisting of two columns. One column gives a list of approximate times, and the other describes briefly what happened during each particular epoch. Finally, it should be explained that when it is said that such and such "appears" at a certain time, it is simply meant that the historical (mostly fossil) record indi-

cates that such and such was present at that time and was not present before that time.

The chronology begins with events that affect our universe as a whole:

Time	*Event*
20 to 10 billion years ago	Our entire universe at this time was concentrated in a very small volume. A full description of the state of our universe at this time is currently beyond the powers of present-day physics. Our universe would be roughly described as being very hot and very dense. The conditions were so extreme that ordinary matter as we know it did not then exist, and space and time were, at least initially, strongly distorted. Technically speaking, physicists would say that the fundamental underlying "quantum fields" (whose "low-lying excitations" are manifest as ordinary matter) were in very "highly excited states." Such an initially hot and compressed universe may be expected to expand and cool. This expansion should be governed by Einstein's general relativity equations for the geometry of space-time. In popular terms, this initial expansion is referred to as the Big Bang. The Big Bang is often taken to be synonymous with the beginning of our universe. However, it may be that there were prior events that led up to the Big Bang and that something can someday be said about these events.
1 millionth of 1 millionth second later	Our universe has expanded and cooled to the point where the quantum fields later are less excited, and consequently their state can be more nearly described in terms of "ordinary matter" as we know it. That is, there are quarks, electrons, positrons, neutrinos, photons (light, x-rays, gamma rays), and other such particles that are all familiar to present-day high-energy physicists.
1 millionth second later	Our universe has expanded and cooled further to the point where quarks bind together in groups of three to make protons and neutrons. This process continues until all free quarks are used up.
3 minutes later	Further expansion and cooling has occurred so that protons and neutrons can combine to form helium nuclei. The amount of helium nuclei relative to the number of protons (hydrogen nuclei) that should be formed can be predicted (based on the current knowledge of nuclear physics), and it agrees with experimental measurements of the present-day helium/hydrogen abundances in our universe. Heavier elements are not formed because of certain details of nuclear physics that are also understood but are beyond the scope of this discussion. Hence at this time our universe consists of photons, electrons, positrons, neutrinos, protons, and helium nuclei.

700,000 years later	Further expansion and cooling have occurred so that electrons can combine with protons and helium nuclei to form neutral hydrogen gas and neutral helium gas. This process uses up all the free electrons and protons and helium nuclei. Prior to this time, and unmentioned before, all positrons have been destroyed by colliding with electrons to form photons. Consequently, there are now no free charged particles. Our universe now consists of photons, neutrinos, and neutral hydrogen and helium gas. By itself, this step is no more remarkable than some that have been omitted from this chronology. However, now that the constituents of our universe are electrically neutral, it follows that the photons will no longer interact with the hydrogen and helium. That is, the contents of our universe are now essentially transparent to photons. Thus most photons that are observed today in our universe (apart from starlight) should be pretty much the same photons that were present 700,000 years after the Big Bang. The only difference is that they should now have much longer wavelengths, since they have continued to cool off as our universe has continued to expand. Indeed, based on known laws of physics, they should now be largely microwaves with a temperature of about 3 degrees Celsius above absolute zero. Such microwaves, with exactly these properties, have recently been observed in exquisite detail by specially designed instruments aboard the COBE (Cosmic Background Explorer) satellite launched by NASA in fall 1989.
10 through 6 billion years ago	Our universe continues to expand and cool to the place where gravitational forces can begin to play a role. Gravity causes the hydrogen and helium gas to form billions of large clumps. In turn, billions of smaller clumps of matter (again hydrogen and helium) form within the larger clumps. The smaller clumps are raised to locally high temperatures as they fall into each other under gravity. Eventually the temperature and density of the smaller clumps reach the conditions at which thermonuclear fusion takes place (conditions generally well understood from nuclear physics and experience with hydrogen bombs), and the smaller clumps become stars. The larger clumps, consisting now of billions of stars, are what we call galaxies. Thus there are now billions of galaxies, and each contains billions of stars. In some of the larger galaxies, the material in the center continues to fall together to form black holes (as predicted by Einstein's general relativity equations for the geometry of space-time). This in-falling material is heated to enormous temperatures and emits copious quantities of light. These galaxies are the quasars. (Some recent evidence and theory suggest that it may take two nearby

	galaxies to make a quasar: one to house a black hole and the other to provide the in-falling material.)
	At this point it is worth remarking that if our universe is in fact expanding, then the galaxies should be moving farther apart. In particular, the galaxies that are moving the fastest should be those that are the farthest away (just as in a horse race the fastest horse is also the horse that is farthest from the back of the pack). This is indeed observed to be the case. In fact, the time of the Big Bang is obtained by extrapolating the observed galactic expansion backward in time to estimate how long ago our universe was concentrated within a very small volume.
	The scope of the chronology now narrows to consider only the continued history of our own galaxy, the Milky Way:
10 through 6 billion years ago	The first-formed stars in our galaxy convert the hydrogen and helium out of which they were originally formed into heavier elements (lithium . . . carbon, nitrogen, oxygen . . . all the way in the periodic table up to iron) by the process of nuclear fusion. Elements heavier than iron are formed by collisions with neutrons. These reactions take place the fastest in the biggest stars, and these stars soon (on stellar time scales) use up all their fuel. When a large star uses up all its fuel, it first collapses to a very dense state and then violently explodes to produce a supernova. In this dense state and subsequent explosion, more heavy elements are formed. Moreover, in this explosion all the elements that have been made in the star are spewed back into interstellar space. Thus, after some time, our galaxy contains some heavier elements as well as the remaining initial hydrogen and helium. With the current knowledge of nuclear physics, it is possible to predict how much of each element should be formed by these processes. It is found that these predictions agree well with the experimentally measured abundances of all the various elements in our galaxy.
5 billion years ago	Some of the hydrogen and helium gas in our galaxy, along with some of the heavy elements formed in earlier stars, again clumps under the action of gravity to form a star. This star is our sun. Thus our sun is what is called a second-generation star, since it is made in part out of material that has been formed in previous stars. Indeed some of the material in our sun may have gone through several star-formation to star-dissolution (by supernova explosion) cycles.
4.7 billion years ago	Some of the material in the vicinity of our sun clumps together (again under the action of gravity) to form the planets that comprise our solar system. These planets are also made both out of helium and hydrogen and the heavier elements produced in earlier stars. The inner planets (Mercury, Venus, our Earth, and Mars) are made

	mostly out of heavier elements and are solid. The outer planets are made mostly out of lighter elements and are gaseous. Considerable material remains between the planets.
4.6 billion years ago	The planets sweep up the debris surrounding them to bring the solar system to its present form. The surface of the Earth at this time is much like that of our present-day moon: rocky, without atmosphere, and without water.
	The scope of the chronology now narrows further to consider only the continued history of our own planet, the Earth:
4.5 through 4.4 billion years ago	The Earth melts because of heat from the radio-active decay of some of the radio-active elements in its composition. The heavier elements (mostly iron) flow to the center of the Earth to form a heavy molten core. The surface of the Earth cools to form a thin solid crust.
4.4 through 4 billion years ago	Hotter molten material from below flows upward by convection to produce volcanoes. These volcanoes spew out (in addition to lava) nitrogen, carbon dioxide, and water vapor. Water and carbon compounds also arrive from meteor and comet bombardment. The Earth now has an atmosphere of nitrogen, carbon dioxide, and water vapor. There is less oxygen in the atmosphere than at present. (The oldest rocks on Earth, dated at 3.8 billion years, show no sign of rust. Rocks were presumably formed even earlier on Earth but subsequently were destroyed by remelting.) However, the exact amount of oxygen that is present at this time has not yet been firmly established. Most of the water vapor condenses, and rains fall. Oceans, seas, lakes, and streams are produced, and the hydrological cycle begins.
4 through 3.5 billion years ago	Period of "chemical evolution"? (This entry in the chronology is followed by a question mark because there is presently little evidence concerning chemical evolution.) It is presumed that during this period, starting with water, carbon dioxide, and nitrogen, ever more and more complex organic molecules are formed as a result of various competing chemical reactions and chains and cycles of chemical reactions.
3.5 billion years ago	Simple single-cell life forms (organisms having the capability for metabolism and reproduction) appear, and microfossils of these cells, some of which seem to resemble blue-green algae and some of which seem to resemble bacteria, are formed. There is still less oxygen in the atmosphere than at present.
2.8 through 2.2 billion years ago	Rocks formed through this period begin to show signs of rust, thus indicating that oxygen is now present in the atmosphere in substantial amounts. It is presumed that the

	blue-green algae-type cells have produced this oxygen by photosynthesis. Oxygen is poisonous to most of the now existing life forms, and these life forms become extinct.
2.2 billion years ago	From this time on single-cell marine life becomes abundant.
1.4 billion years ago	Complex cells appear. These cells have compartments for a nucleus, mitochondria, and chloroplasts.
850 to 570 million years ago	Simple multicellular life forms appear, such as jelly fish, sea pens, and segmented worms. The oldest fossils of invertebrates are 675 million years old.
410 to 345 million years ago	Ferns and club mosses appear as the first green plants on dry land. Centipedes and millipedes also appear on dry land. Fish begin to appear in the water.
345 to 280 million years ago	Insects appear on dry land. Amphibians appear, going between the water and the land.
280 to 225 million years ago	Reptiles appear on land. Coniferous forests also appear.
195 to 136 million years ago	Mammals first begin to appear. Dinosaurs flourish.
136 to 67 million years ago	Flowering plants (plants with seeds) first appear. Birds also appear. Dinosaurs become extinct.
67 million years ago	First primates appear.
3.5 million years ago	Bipedal hominids leave footprints similar to human footprints in soft volcanic ash.
2 million years ago	Homo habilis appears and makes stone tools.
1.6 million to 500 thousand years ago	Homo erectus appears and spreads throughout the Old World.
100 thousand years ago	Early Homo sapiens and Neanderthal appear. They use fire. They bury their dead.
30 thousand years ago	Modern Homo sapiens is found in all parts of the world except the Americas. Earliest art appears.
12 thousand years ago	Modern Homo sapiens appears in the Americas.
10 thousand years ago	First farming and animal husbandry begin.

5 thousand years ago	Technology for making and working bronze is discovered.
5 thousand years ago	Sumerian civilization flourishes in Ur.
4 thousand years ago	Abraham leaves Ur.

II. Nature of scientific approach to origins

Laplace was a late-eighteenth-century French mathematician/astronomer. The emperor Napoleon, after having heard of an astronomy book written by Laplace, met Laplace and remarked, "Monsieur Laplace, they tell me that you have written this large book on the System of the Universe, and have never mentioned its Creator." To Napoleon's remark Laplace replied, "I had no need of that hypothesis."

The absence of any appeal to the supernatural is a characteristic feature of scientific accounts of origins. One explanation of this absence is that some scientists are avowedly atheistic and are specifically motivated to work on origins questions by their desire to substantiate their atheistic views. While this may indeed be the case for some scientists, there are also at least two other reasons for the lack of appeal to the supernatural.

The first reason is that supernatural explanations tend to put an end to the human scientific enterprise. For example, suppose one says that, when God made the Earth and the other planets, he chose to make the inner planets (including the Earth) out of heavy material and the outer ones out of light materials. Then that pretty much puts an end to the matter: there is no point in trying to find some physical explanation for this fact in terms of what factors might play a role when planetary systems form. For example, one does not wonder if some understandable mechanisms, involving, say, gravity and density and temperature, might lead to some significant separation between lighter and heavier elements. Of course, one can still look for explanations that involve purpose. For example, one can still attempt statements of the form "God put the heavier elements in the inner planets and the lighter elements in the outer planets because, if he did it this way, then our solar system would have the good property that man, when he lives on Earth will have iron available to make farm tools and uranium to make nuclear power."

The second reason is that scientists genuinely wish to convey the concept that those events which happened in the past, as momentous as they may seem to be, were no more supernatural than events which occur now or could occur now. Put another way, everyday current physical processes are no less supernatural than events in the past. That is, events in the past and in the present both follow the same underlying physical laws. This concept, already briefly described in the beginning of this appendix and sometimes referred to as the uniformity of physical laws throughout space and time, has several consequences. Shortly some of these consequences will be described for cosmology. However, before we look at these consequences, it is necessary to make a small detour in the discussion in order to clarify in more detail what is being presumed.

At the beginning of the short chronology of origins (Section I), it was stated that, according to the current scientific view, our universe is constantly changing. A more precise statement of the current scientific view is that our universe is indeed constantly changing, but it is doing so according to rules (physical laws) that are themselves unchanging. There are at least four reasons for the view that the laws themselves are unchanging:

A. It is the simplest working hypothesis with which to begin.

B. As part of its business, the U. S. National Institute of Standards and Technology (NIST) regularly measures the known "fundamental constants" of nature (such as the speed of light, the mass of the electron, the charge of the proton, etc.) and in effect checks for changes in the physical laws. NIST finds (at least at the present time) that all the constants are in fact constant within an experimental error amounting to a change of at most one part in 100 billion per year. This error is so small that, if one assumes a uniform change in the physical constants, then in 10 to 20 billion years (the time since the Big Bang) the physical constants could have changed by at most 10 to 20 percent.

C. One can also infer from indirect measurement that some physical constants and some combinations of physical constants have indeed been constant for hundreds of millions to billions of years. For example, when the Earth was younger, there was much more uranium 235, the isotope of uranium used in nuclear reactors, than there is now. (Uranium 235 is radioactive and slowly disintegrates over time into lighter elements.) About 1.8 billion years ago in Gabon, West Africa, there was a particularly rich uranium ore deposit. In fact, there was so much uranium 235 in this deposit that when it got wet due to flooding and ground water, it became a natural nuclear reactor. (The water acted as a moderator just as it does now in modern nuclear-power reactors.) This natural reactor operated at relatively low power levels for hundreds of thousands of years until it ran out of fuel. As reactors do today, this reactor also produced nuclear wastes. The concentrations of the various isotopes in the nuclear wastes and the remaining uranium from this natural reactor have been analyzed and have been found to be exactly what would be expected based on the present-day experience with reactors and the present-day radioactive-decay rates. Thus, it can be inferred that both nuclear-reaction rates and radioactive-decay rates were the same 1.8 billion years ago as they are now.

As a second example, one can infer from the spectroscopic study of the light from distant stars that the laws of atomic physics have not changed since the time the light was emitted in the far distant past.

D. The general mind-set of theoretical physicists (encouraged by past successes and recent progress) is to believe that someday it will be discovered that all physical laws can be derived from one simple but yet profound grand mathematical principle. This principle is expected to be so simple that it can be written on a single sheet of paper and yet so profound that it will imply all known and as yet unknown physical laws. Thus, at the deepest level, it is expected that there is only one law (grand mathematical principle) of physics. (Correspondingly, there is only one physical constant: for example, some fundamental length such as the classical radius of the electron. All

other physical constants should be computable from this one physical constant and the one law.) Moreover, this law is likely to have a geometric character in the sense that it will be unique and incapable of being altered (changed) in any consistent way. (A simple example of such a geometrical concept: among all closed curves, only the circle has the property of having a minimum perimeter for a given enclosed area.) Consequently, by its very nature, this law (and all its consequences) must be unchanging. Thus, the possibility of change in physical laws is expected to be excluded in principle.

Some progress has been made, as indicated above, in the effort to identify a single underlying fundamental law. Such efforts are popularly referred to as Grand Unified Theories (GUTs) or Theories of Everything (TOEs).

With this background concerning the nature of physical laws in mind, it is possible to resume the main discussion. It was stated earlier that the uniformity of physical laws throughout space and time has several consequences. As promised, some are listed below for cosmology:

—By a comparison of the features of various different stars, it should be possible to learn something about how stars were formed and what is now taking place in stars. Moreover, information gained about nuclear physics by experiments carried out on Earth using "atom smashers" should have relevance to stars.

—Where circumstances are right, star formation should still be taking place in our galaxy and other galaxies.

—By a comparison of the features of different planets in our solar system, it should be possible to learn something about how the planets were formed and what kind of processes produced their presently observed properties. Here again, laboratory experiments on the behavior of materials under high pressure and temperature might be relevant.

—Where circumstances are right, new planetary systems should be currently forming around new stars in our galaxy and other galaxies.

—While the circumstances in our universe may no longer be right for galaxy formation, it still should be possible to learn something about the process of galaxy formation. It has been possible to learn about gravity and the motion of matter from experiments done on Earth and the observation of nearby objects in our own galaxy. One could attempt to learn about galaxy formation by comparing the different properties of the various galaxies and by making use (in detailed computer models) of what has been learned about gravity and motion.

—There is even the possibility, still largely speculative, that there may be universes other than our own and that universe formation itself may still be taking place. It may never be possible to directly prove or disprove this assertion by any conceivable observation, since by the very nature of things, it may be impossible for signals and information to be exchanged between different universes. Nevertheless, it may be possible and valuable to consider whether known or still-to-be-discovered laws of physics might be able to describe the origin of our and perhaps other Big Bangs. For example, could some circumstance or condition in our universe ever give rise to another Big Bang which would lead to the formation of some other universe?

Sometime after he had confronted Laplace about the absence of a Creator in his universe, Napoleon, who was greatly amused by his earlier conversation with Laplace, related his question and Laplace's reply to another French mathematician/astronomer, Lagrange. To this, Lagrange exclaimed concerning the "hypothesis" of God, "Ah! It is a beautiful hypothesis that explains a multitude of things." By this statement Lagrange presumably meant that the existence of God as the ultimate author of all explained the coherence of the universe and gave meaning to existence. In some cases, contemporary scientists are coming to somewhat similar conclusions. Calvin, in trying to describe the doctrine of Providence, once used the analogy that the universe is like a great ship, and God is its helmsman. Suppose Calvin's analogy is extended by imagining that we are able to enter the control room of the universe. There we find numerous knobs with dials set on various numbers. These are the settings that describe the various physical constants of the universe, such as the mass of the electron, the mass of the proton, the electrical charge of the electron, the analogous parameters that control the strengths of nuclear and gravitational forces, the speed of light, etc. Suppose further that we are allowed to turn these knobs, thereby giving these constants different values. Then, based upon the current understanding of the universe, one can infer that even small adjustments of the knobs, would change the universe in qualitatively drastic ways. A few of these are listed below:

—The production of carbon in stars depends critically on the intermediate formation of a certain metastable isotope of beryllium. If the strength of the nuclear force were slightly decreased from its current "setting," this isotope could not be formed, and consequently there would be no carbon in the universe. Without carbon there would be no organic chemistry and hence no life in the universe.

—If the strength of the nuclear force were increased from its current setting, then many more protons would have combined with neutrons to form helium in the period three minutes after the Big Bang. There would thus be much more helium and much less hydrogen for subsequent star formation. However, a sun that has only helium as a major source of nuclear fuel cannot burn long enough for the Earth to have a history of the length described above in Section I. Also, with less hydrogen, water and most organic compounds (which contain hydrogen) would be less abundant. The presumption is that the universe would again be without life.

—If the strength of the gravitational force were increased, the matter in stars would be held together more tightly and would burn much more rapidly. Thus, the sun would again burn out very quickly, and there again would be insufficient time for life.

—If the strength of the gravitational force were decreased, the formation of galaxies, stars, and planets would be adversely slowed down and might not even occur.

—If the charge of the electron or the mass of the electron or proton were altered, the strength of hydrogen bonding, which is essential for the formation and functioning of DNA, would be greatly changed. Thus,

there would then be no genetic code, and life (at least as presently understood) would be impossible.

These and many other examples illustrate that the universe appears to be finely tuned. That is, the values of the fundamental physical constants (the settings of the knobs in the control-room analogy) seem to have precisely those values required for the universe to possess the magnificently rich and beautiful structure and variety that exist. These striking coincidences may be taken as evidence for design of the highest order and subtlety in the structure of the universe at its most fundamental level. The natural inference from this evidence is that design of such brilliance and profundity requires a Master Designer. Moreover, if the speculations to the effect that all physical laws are in fact derivable from one grand mathematical principle (Grand Unified Theory) prove to be correct, then only one combination for the setting of the knobs is in fact allowed. Thus, in this case, the design of the universe is at the same time a profound mathematical creation. The natural inference from this conclusion is that mathematics of such profundity (and indeed even the mathematics that is already known to be relevant to the universe) requires a Master Mathematician of incomprehensibly great intellect.

III. Future Explorations

If our civilization continues into future centuries and if scientific activities continue apace, then one may anticipate many new discoveries that may be expected to have important implications for questions of origins. Indeed, the modern scientific enterprise in general has just barely begun, and what might possibly be learned and understood in the future far exceeds all the knowledge that has been accumulated to date. The purpose of this section is to list and briefly describe some scientific programs that are planned or being planned for the near future and to indicate what they might be expected to reveal. Some inferences are also made about what might happen in the distant future.

Most of these scientific programs are not primarily aimed at questions of origins. The discussion that follows includes only those aspects of these programs that do touch upon origins. Also, the list of programs included here is far from complete. For ease of presentation, the listing is organized under headings related to various questions of origins. Finally, by the nature of this section (and particularly with regard to programs that may be carried out in the distant future) speculation may sometimes exceed the bounds of the plausible. With these caveats, various areas of interest and what might be hoped to be learned about each are described in the various sections below.

A. Time and nature of the Big Bang; origin of galaxies

The Hubble space telescope, recently launched by the space shuttle, has special experiments designed to look at both the relatively nearby galaxies and the most distant galaxies. These observations are expected to improve the current knowledge of galactic distances, thereby giving improved values for the actual time of the Big Bang. Because light has a finite travel time, scientists will actually be seeing the distant galaxies as they were when they were young. Such information, when compared with that for nearby galaxies, is expected to give insight into the process of galaxy formation. It is

also known that the distribution of galaxies throughout space is not uniform. Rather, they seem to be concentrated together to form thin layers that surround huge voids. Consider the bubbles that make up the foam in bubble bath. Imagine that these bubbles and the foam they form are expanded to enormous proportions. Then the distribution of galaxies is such that they would lie on the walls of these bubbles, and the space surrounded by these bubbles would be essentially empty. This arrangement of galaxies into great walls surrounding vast voids has to be accounted for in any theory of galaxy formation. The Hubble telescope is expected to gather data also on this question.

Plans are currently being made for the construction of the Superconducting Super Collider (SSC) at an estimated cost of $10 billion. The SSC is designed to produce two beams of high-energy protons that collide head on. When such collisions occur, it is expected that (within the small volume of the collision region) conditions of temperature and pressure will be produced similar to those in our universe shortly after the Big Bang. Through the study of what happens when such collisions occur, more is expected to be learned about the behavior of matter (specifically quarks and other predicted but as yet undiscovered particles) under such conditions. This information will in turn be useful, among other things, for a better understanding of what may have occurred shortly after the Big Bang. The primary purpose of the SSC is to discover information about the behavior of matter that may be of use in constructing Grand Unified Theories.

More information on the nature of our universe at the time when it became transparent to photons (approximately 700,000 years after the Big Bang) is expected to be obtained from the COBE satellite and its planned successors. In this connection there is already a major puzzle: the measurements from COBE indicate that the matter distribution in our universe was very uniform shortly after the Big Bang. Indeed, it was so uniform that (based on extensive computer simulations involving what is known about gravity and the motion of matter) there is some question as to whether ordinary gravity is capable of accounting for galaxy formation at a sufficiently rapid rate so that galaxies could come into existence as soon as 10 to 6 billion years ago. One suggested solution to this apparent puzzle is that there may exist what is called *dark matter*. This is a new kind of matter, whose existence is as yet not directly detected (although there are some theoretical models involving quantum fields that suggest that its existence would not be mathematically inconsistent), that would not interact with ordinary light and therefore would be dark (invisible). Furthermore, our universe would consist mostly of dark matter. This matter would exert large gravitational forces, and its presence would account for the rapid formation of galaxies despite the initial great uniformity of the early universe. From studies of the orbits of stars in galaxies there is independent evidence that also suggests the presence of large quantities of unseen matter in our and other galaxies. Experiments are currently being planned to search for dark matter directly in the laboratory and in the vicinity of our solar system, using new types of particle detectors.

B. Formation of stars and planetary (solar) systems; life cycle of stars

The Hubble telescope also has experiments to study star formation and to search for the presence of planets around other stars. It is already known

that star formation is still taking place in our galaxy (and presumably other galaxies as well). Observations made with the Hubble telescope are expected to reveal more about star formation processes. Since this telescope has (at least when repaired) very high resolution, it should be able to detect the presence of planets around nearby stars if such planets exist. It is already known that a great many stars are in fact double star systems in which two stars are in orbit about each other. The presumption is that if double star systems are common, then it might also commonly happen that some of the material that might have formed the second star might instead have formed a planetary system. If this is so, then planetary systems should be common. It is hoped that the Hubble telescope will give substantial information on this question.

Recently NASA has solicited proposals from the scientific community for a new Origins of Solar Systems Research Program. Two key paragraphs concerning planned future observations to be made in this program are given below:

> For the first time in humanity's long speculations on this topic [the origin of solar systems], astronomers have obtained strong hints of the existence of planetary systems other than our own. The Infrared Astronomical Satellite has discovered dust rings around mature stars such as Vega and Beta Pictoris; there is infrared evidence for low mass companions to several stars; and observations at millimeter, infrared, and optical wavelengths suggest that nebular disks surround many newly formed solar-type stars. Thus we stand on the threshold of having direct observational evidence to explain the origin of our solar system, which must have involved the process of neutral and charged-particle interactions, volatile and grain agglomeration, planetesimal formation, planetary accumulation, and disk dispersal. Theories and observations of star formation have reached a stage where the development of disks or binary star systems, or both, is viewed as a natural byproduct of the gravitational collapse of a rotating molecular cloud core.
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> ....
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> The study of the origin of life is part of the continuum of investigations into the origin and evolution of the biogenic elements and compounds from their nucleosynthetic origin, through transformations within interstellar and solar-nebular environments, to their eventual delivery to the early Earth and emergence as cellular life forms. From this evolutionary context comes the increased conviction that life, as we know it, arose as a natural consequence of the formation of the solar system. The evolution of life has both profoundly influenced, and has itself been constrained by Earth and its astrophysical environment; life is indeed a planetary phenomenon. It is now time to expand these studies to test this evolutionary sequence to consider whether it may have been repeated in other solar systems.

There is already in operation an extensive automatic computer-operated star-monitoring program for stars in our galaxy. This program observes thousands of stars each night and compares their individual light output with that of previous nights. The purpose of this program is to detect potential supernova stars prior to the main phase of their explosions. At present such stars are noticed only when the explosion is so far along that they have become extremely bright. By being able to routinely observe many stars through their complete supernova phase, scientists should be able to learn much more about the formation of the heavier elements in stars. Indeed, observations of the supernova that occurred in 1987 have already improved the understanding of this important process.

The automatic star-monitoring project also has the byproduct that it will search to see if the sun might also be part of a double star system. If a companion star exists (already dubbed Nemesis) and if this star has the right orbit, then its periodic orbit around the sun could produce periodic major meteor/comet showers (each time it passes through the Oort comet cloud) which could in turn produce the periodic major extinctions of life that are suggested by the fossil record. (In this scenario, one such very major shower made the dinosaurs extinct.) If Nemesis is indeed observed (if it exists at all, it presently should be very far from the sun), then its period around the sun can be measured, and this period can be compared with that inferred from the fossil record.

With regard to the major nuclear processes occurring deep within the sun (and presumably all other ordinary stars), there has been a long-standing puzzle that not enough neutrinos seem to be reaching the Earth from the sun. (From what is known of nuclear physics based on terrestrial laboratory experiments, copious neutrinos should be produced in solar nuclear reactions.) The preliminary results of a recent major joint American-Soviet-European experimental program mounted to detect neutrinos coming from the sun are also negative. It may be that less is understood about what is going on inside the sun than is currently thought. (Scientists, perhaps even more than other mortals, are also inclined to the sin of pride.) Alternatively, it may be that the sun is indeed producing neutrinos as expected. However, these neutrinos may undergo a change in type (due to so-called neutrino oscillations) in the process of traversing the solar material to get to Earth, and the present detectors are sensitive to only one type of neutrino. Future experiments are planned to explore this possibility.

C. Planetary formation

Plans are currently being made for a permanent base on the moon and for manned landings on Mars. Continued unmanned probes are planned for some other planets. There is currently a satellite orbiting and making radar images of Venus. In time it will be possible to compare the structure ("geology") of the various planets with the possibility of learning more about their formation. Such comparisons have already begun, based on current knowledge. For example, something is already known about the presence of major continents and vast mountain ranges and deep valleys on Venus and Mars. The surface of Mercury is cratered like the moon. Active volcanos have been detected on Io, one of Jupiter's moons.

D. Origin of life; common descent; development of complex life forms

A common presumption in the biological sciences is that life arose from nonlife by purely natural processes. Moreover, although there is presently relatively little in the way of definitive ideas as to what these natural processes could be, a common presumption is that it is ultimately not all that "hard" for simple living organisms to be formed by some (presumably chemical) means, in the sense that simple life seems to appear in the chronology of the Earth within 500 million years of the time that conditions on Earth became reasonably hospitable to life. It is known that relatively simple organic molecules such as monosaccharides (sugars) and polysaccharides and amino acids and proteins can be formed relatively easily (and in roughly the

abundances found in living organisms) from water, carbon dioxide, and nitrogen under the action of heat, electrical discharge (lightning), and ultraviolet light. Simple organic molecules are also found in some meteorites. Many mechanisms and processes have been proposed for going beyond this stage to form more complex organic molecules and eventually simple life forms; but nothing particularly definitive is yet available, and general studies of this sort have just begun. It is known that even the very simplest life forms that are presently observed are enormously complex when viewed from a chemical perspective. It is also known that these putative processes of "chemical evolution" cannot occur in the presence of oxygen. Note that the abundance of oxygen is an uncertain item in the chronology during the time that chemical evolution is presumed to have occurred.

A second common presumption in the biological sciences is that the early life forms had descendents which in turn had descendants which in turn had descendants, etc., and that all life forms that exist on Earth today have ancestors which can be found somewhere in this ever-branching family tree of common descent. Moreover, all the life forms whose relics appear in the fossil record (many of which are now extinct) also appear somewhere in this tree. (There are, incidentally, many more kinds of life forms that have become extinct than there are that still exist: almost all kinds of life forms that ever existed are now extinct.)

There is, of course, an enormous variety of existing life forms and an even greater variety in the fossil record. Many of these are very complex. Also, from the fossil record it is evident that the earliest life was relatively "simple" in structure and that there seems to be, at least in broad outline, some kind of chronological progression from little to greater variety and from simpler to more complex life forms. Thus, a common third presumption in biology is that there must also be some (natural) mechanisms by which variety can arise and by which more complex life forms can arise from simpler life forms. Judging from the chronology of life on Earth, this process required about 3.5 billion years to advance from simple life to the most complex life forms that currently exist. There is, however, evidence from the extensive fossil record in the Burgess shale formations in British Columbia that in Cambrian times (570 to 530 million years ago) there was a relatively rapid increase in variety and complexity (the so-called Cambrian explosion). Consequently, these presumed mechanisms by which variety and complexity arise must be able to act relatively rapidly in some circumstances.

At this point it is useful to make another detour in the discussion to consider the word *evolution* and to describe the range of ways in which this term is used in science. Literally, the word *evolve* means "to unroll or open." As commonly used, the term *evolution* contains in varying proportions at least five aspects or concepts: change, gradual continuous change, change in a particular direction, change from a simpler to a more complex state, and change from a worse to a better state. Evidently the fifth aspect, change from a worse to a better state, involves some kind of moral or value judgment. Since such judgments generally lie outside the realm of science, the term evolution when (carefully) used in science cannot generally involve this fifth aspect.

The remaining aspects of the term *evolution* are relevant to science. However, it is important to recognize now that in any particular case or usage of

the term, the remaining four aspects may be present only to some degree or entirely absent.

For example, the burning of a candle may be described as an evolutionary process. This process does involve a gradual continuous change in one direction. However, there is no evident progression from a simpler to a more complex state.

As a second example, the life cycle of a star (starting with its formation by the clumping of interstellar gas and ending with a supernova explosion) is commonly referred to by the term *stellar evolution*. In this process there is change in a particular direction. However, there is again no impressive progression from a simpler to a markedly more complex state. Also, at least during the supernova phase, the change is far from gradual.

As a third example, consider the chronology that begins with the Big Bang and extends through the formation of the planets. This process might be called *physical evolution*. In this process there does seem to be some kind of pattern of progression from the simpler to the more complex. However, the progression is not great, and it is more or less understood, at least in broad outline.

By contrast, consider the process that is presumed to be involved in going from nonlife to simple life. This process, already referred to as *chemical evolution*, involves an enormous change in complexity. Although some processes that lead to the formation of complex molecules have been observed and understood, nothing of the magnitude of the complexity of change involved in going from nonlife to simple life has yet been observed or understood.

Next, consider biological change. Processes in organisms involving a small number of mutations or chromosome fusions have been observed, and the corresponding changes produced in the organisms are more or less understood. Such processes are sometimes referred to as *micro biological evolution*. Generally, relatively little change in complexity is involved in microevolution. By contrast, the presumed process, sometimes called *macro biological evolution*, that eventually leads from simple life to complex life again involves an enormous change in complexity. Although it may be argued that macroevolution is nothing more than a large succession of microevolutionary events, it is not immediately obvious, because of the enormous changes in complexity involved, that this is the case.

In summary, there are various scientific uses of the term *evolution*, and some uses entail much more change in complexity than other uses. It is true that in the chronology that begins with the Big Bang and extends through the formation of the planets (what has been called *physical evolution*) there does appear to be some kind of pattern of progression from the simpler to the more complex. However, the magnitude of this progression pales in comparison to the increase in complexity that is involved in going from nonlife to simple life to complex life (*chemical evolution* and *macro biological evolution*). Thus, although it may indeed be true that progression from the simple to the complex is what ought to be expected as a major theme in the history of our universe, it is not obvious that this must be true on a great scale in the biological world simply because it is present to a much lesser (and more or less understood) degree in the progression from the Big Bang to galaxies and stars and planets. Thus, for example, the existence of stellar evolution does not obviously imply that there must also be biological macroevolution.

After this brief discussion of various kinds of evolution, it is possible to return to the main topic of this section. If it is true that the modern scientific enterprise has just barely begun, it is even more true that modern biology has just begun. There are many projects that are planned or under way that may be expected to give significant information on the nature of life, its possible origin, and its development. One of these is molecular biology. Significant advances have been made in the understanding of the genetic code and its relation to DNA. Plans are currently under way to determine the complete genetic code for many simpler organisms and eventually for man (the so-called Human Genome Project). It is presumed, and currently appears plausible, that essentially all the physical characteristics of all organisms are determined by the sequences of guanine, cytosine, adenine, and thymine groups in their DNA molecules. (The exception to this is some viruses, which use RNA instead of DNA in a way that is also more or less understood.) If it can be understood in detail what DNA sequences code for what biological properties and structures, then it should be possible in principle to demonstrate whether or not common descent is indeed possible. (For example, if some organism is presumed to have some other organism as a distant ancestor, then it must ultimately be demonstrated that there is a succession of viable organisms with only slightly different DNA that could serve as a continuously connected succession of ancestors. If major changes in the DNA from generation to generation are required, then it must be demonstrated that there are known mechanisms such as chromosome doubling that are involved.) Also, if common descent is in fact biologically possible, then by suitable genetic engineering it should in principle (although perhaps not in practice) be possible to produce any putative ancestor. On a significantly more modest scale, it may be possible to infer something about common descent by comparing in detail the DNA of existing organisms. (It is already known that there are substantial similarities in the DNA of a great many organisms.) Conversely, if none of these things prove possible, then it may be possible to say definitively that common descent did not occur.

If and when the nature of living processes is better understood at the molecular level, it may be possible to make definitive statements about whether or not there exist various chemical processes by which simple living organisms can be formed (chemical evolution). For example, relatively simple self-replicating molecules have recently been synthesized in the laboratory. Although some work has been done in this broad area of the origins of life, the whole subject is in its infancy. Here again the outcome of such work cannot be predicted presently on scientific grounds. It may be that the possibility of the chemical origin of life can be established. Conversely, it may be possible to prove that the origin of life by chemical evolution is impossible.

If various processes are discovered by which life can be formed, then it remains to be demonstrated that these processes can occur "naturally." In this connection, two space projects may be of interest. First, detailed exploration of Mars will give more definitive information about whether life exists or ever existed there. (The results of the unmanned Mars probes to date show no evidence of existing life.) A second project, recently approved by NASA, involves the use of specially built computers and receivers in conjunction with radio telescopes to Search for Extra-Terrestrial Intelligence (the

SETI program). The SETI program would cost about $10 million per year and would be run in conjunction with the present ongoing radio-telescope program. The presumption of SETI is that if our galaxy has many stars (which indeed it does) and if the presence of planets around stars is common (which remains to be demonstrated) and if the step from nonlife to life is not all that difficult and if there are mechanisms by which life becomes more complex, etc., then there may be "intelligent" life forms elsewhere in our galaxy who are either intentionally or inadvertently transmitting the equivalent of radio, television, and microwave signals. The equipment involved in the SETI program would make it possible to detect signals of this type originating anywhere within our galaxy provided only that they were being transmitted at power levels comparable to those used on Earth. It is argued by the proponents of SETI that, although the likelihood for its success is very uncertain, the cost is not high and the potential payoff is enormous. The U. S. Congress has currently refused funding for SETI, but it is likely to be carried out eventually in any event as the byproduct of other radio-astronomy work.

Even with regard to the fossil record there is still much to be learned about the history of life. For example, the study of the Burgess shale began only in 1970, and most of what is currently known about fossils has been learned in the past fifty years.

Finally, there is much to be learned about whether there are indeed adequate physical mechanisms that lead to increased complexity in life forms. It is usually presumed that this is achieved by mutation, "survival of the fittest" selection, and genetic (sexual) recombination. In this scheme mutations (changes in the DNA) occur as the result of random and not so random process such as cosmic rays, chemical errors in DNA replication, and whatever other process can be envisioned for failure to preserve the genetic code from generation to generation. Most of these mutations are harmful, and the affected offspring fail to reproduce or reproduce only in small numbers. By contrast, those offspring with favorable mutations reproduce in larger numbers, thereby producing a (usually) slightly different kind of organism. If this process (microevolution) is repeated over and over again through a large number of generations in small isolated populations, the result is presumed to lead to a variety of organisms, some of which may be substantially more complex.

It is known that this microevolutionary process does indeed occur at least on some small scale. The question remains whether it occurs at a fast enough rate to account for, within the time available, the observed present variety and complexity of life forms. For example, how long does it take by this process to obtain a highly functional eye complete with an elaborate focusing optical system that produces a high quality image and an elaborate nervous system that analyzes this image?

Recently it has been proposed that there may be other mechanisms at work as well as those just described. Some of these mechanisms arise out of the study of so-called self-organizing systems in the field of computer science and dynamical systems. Others involve the behavior of physical systems that are driven by external energy sources and are far from equilibrium.

It is possible that these studies may eventually demonstrate that under certain circumstances matter, by its very nature, has both the potentiality and

the proclivity to organize. Put another way, it may be that matter has been designed at its most fundamental levels in such a brilliant way as to make these processes (and perhaps other processes still undreamed of) occur. Conversely, it may ultimately be shown that there are no physical mechanisms that could possibly account for the enormous complexity and variety of life. Again, studies of this sort are just beginning.

E. Human origins and the nature of man

It is commonly presumed by biologists and anthropologists that humans and the (other) primates have a common ancestry. Here again relatively little is actually known, much of what is known is recent, and there is still much that potentially can be learned. Known fossil remains of Homo habilis and Homo erectus are still relatively rare, and new finds are significant. For example, fossils of parts of Homo erectus were found in 1984, and parts of Homo habilis were found in 1986. In total, the fossil sample for Homo erectus comes from perhaps 100 individuals in bits and pieces and fewer than 50 archaeological sites. Further search for and study of such fossils is likely to provide significant new information.

Future studies in molecular biology are also likely to provide new information about human origins. For example, the present dominant interpretation of the fossil record is that varieties of early Homo sapiens descended separately and independently from varieties of Homo erectus in several different locations in the Old World, beginning about 1 million years ago. By contrast, an analysis of present human mitochondrial DNA is interpreted to suggest that all of early Homo sapiens originated in and migrated out of Africa about 200,000 years ago. In this scenario, Homo erectus in Europe and Asia either died out or was eliminated by early Homo sapiens.

As a second example, it will eventually be possible to compare the human genetic code in detail with that of (other) existing primates to see exactly what are the similarities and the differences. It is even conceivable that it may be possible to determine whether in principle there could have been viable chains of ancestors for man and the (other) existing primates which lead back to a common ancestor. To be even more speculative, if the existence of such ancestors is in principle possible, it may in principle be possible (although perhaps not feasible in practice and perhaps morally impermissible) to produce, through genetic engineering, creatures like Homo erectus and other earlier putative human ancestors. Conversely, it may eventually be scientifically provable that man could not possibly have had a common ancestry with the primates.

With regard to some of the "human" qualities of man, it can be speculated that much will be learned from a study of the functioning of the human brain and the brains of various animals. There is also much that will be learned from attempts to model and simulate reasoning processes and "intelligence" with the aid of computers. Both these areas of study have also just barely begun.

Finally, to return to still speculative but far more secure ground, it should be possible by further archaeological studies to learn more about early and modern Homo sapiens and the development of culture and civilization.

IV. Conclusions

Our universe is incredibly vast and magnificent. It appears to be governed by a fixed set of laws. These laws have wide application and appear to form a logically (mathematically) consistent whole. From a knowledge of these laws it appears to be possible to understand present phenomena, to study what occurred in the past, and in some cases to make predictions about the future. The modern scientific enterprise, which seeks to discover, understand, and use these laws, has just barely begun. Much has been learned, but far more remains to be learned. If scientific activities continue apace in the next few centuries, one may anticipate many new discoveries that may be expected to have important implications for questions of origins. In particular, it should be possible to make much more definitive statements about the nature and origin of both the physical universe and its many diverse life forms, including man.