The Philosophy of Sequence Stratigraphy Part I—Philosophic Background

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Abstract

Sequence stratigraphy has, to a notable extent, supplanted traditional uniformitarian stratigraphy. Some creationist geologists have embraced sequence stratigraphy as a singular opportunity for the redemption of the science of geology, while others have rejected it as the latest mutation in uniformitarian thinking. Still others remain unaware of the principles of this approach or undecided as to its merits. To properly evaluate the scientific validity of sequence stratigraphy and its applicability to geologic research within the context of a Biblical worldview one must have a basic understanding of the philosophy of science.

Introduction

Stratigraphy is the study of the arrangement of earth materials (particularly stratiform rocks), especially as to geographic position and chronologic order of sequence (Bates and Jackson, 1984). Various schools of thought have arisen within the discipline of stratigraphy during the past two centuries (Table I). These schools of thought have arisen from specific presuppositions and have been inextricably enmeshed in the specific philosophies or worldviews from which they sprang. "Classical uniformitarianism" or "quietism," attributed primarily to Hutton and Lyell, has dominated the history of stratigraphy, and its naturalistic worldview has been incorporated relatively seamlessly into neocatastrophism.

Several helpful works on the historical development of stratigraphy have been published (Ritland, 1981, 1982; Sunderland, 1986; Taylor, 1991). Particularly useful are papers by Woodmorappe (1996) and Mortenson (1997a, 1997b, 1998). The inconsistencies of traditional stratigraphic methods (principally the Lyellian approach) have been abundantly documented (Berthault, 1998; H. Clark, 1968, pp. 29–36; Froede, 1995; Mehlert, 1986; Snelling, 1992; Whitcomb and Morris, 1961, pp. 136–211; Woodmorappe, 1980, 1981, 1982; Zeller, 1964). Nevertheless, no consensus on how one should approach stratigraphy has emerged among creationists to date. Sequence stratigraphy, a recent development within the geologic establishment, has been suggested as a solution or partial solution to this problem by some (Bartlett, 1997; Berthault, 1997, 1999; Davison, 1995; Froede, 1994, 1997; Holt, 1996; Robinson, 1995, p. 57; T. Walker, 1996, p. 379), though others (both evolutionists and creationists) present objections (Jeletzky, 1978; Miall, 1986, 1992; Thorne and Watts, 1984; R. Walker, 1990; Woodmorappe, 1996). Evaluation of the scientific validity of sequence stratigraphy and its applicability to geologic research within the context of a Biblical worldview requires a basic understanding of the philosophy of science.

I will begin by reviewing basic principles of the philosophy of science. This will necessarily require discussion of the influence of worldviews, particularly uniformitarianism/naturalism and Christianity, and the subject of "mixed questions," in which more than one discipline or method is required to provide an answer. The philosophy of science will be applied to geology in general and stratigraphy in particular. A summary of stratigraphic methods, themselves outgrowths of the historic contexts intimated in Table I, is then examined in the light of essential philosophic principles.

Some readers lacking a background in the philosophy of science will probably wish to jump right to the application of stratigraphy (Part II) or sequence stratigraphy (Part III) within the Biblical worldview. This would be disastrous! Merely rehashing various examples would serve only to reinforce existing biases, accomplishing nothing constructive. Thus, it is only after understanding the philosophic basis (Part I) that sequence stratigraphy can be analyzed in relation to other stratigraphic principles and methods to determine its suitability and utility for use by creationist geologists.

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Table I. Historic schools of stratigraphic thought.

System	Dates[1]	Description
Diluvial	1550–1850	Emphasis on local geology and general explanation; belief that the Deluge was primarily responsible for sedimentary rocks (notable opposition from rationalists and deists; Arduino introduced terminology *Primary*, *Secondary*, and *Tertiary*)
Wernerian	1780–1840	Emphasis on lithostratigraphy; belief in successive worldwide lithologies (e.g. *Carboniferous*, *Cretaceous*)
Cuvierist	1810–1850	Emphasis on biostratigraphy and unconformities; belief in successive regional or global catastrophes (Deluge being most recent)
Lyellian[2]	1830–1980	Emphasis on biostratigraphy; belief in successive worldwide ages characterized by fossil assemblages (e.g. *Cambrian*, *Devonian*, *Permian*)
Neocatastrophist[3]	1970–present	Emphasis on unconformities; belief in successive regional or global catastrophes separated by long periods of quietude (uniformitarianism interrupted by catastrophes)[4]
Sequence Stratigraphy	1980–present	Emphasis on unconformity-bounded sequences (or flooding surface or physical boundaries); belief in eustatic cyclicity

[1]Approximate period of popularity, recognizing that individuals holding more or less to a particular perspective on stratigraphy may be found before or after the indicated dates.
[2]Also called *Gradualist*, *Quietist*, or *Classical Uniformitarian*.
[3]Many creationists of this century have much in common with mainstream neocatastrophism; howevever, this table is a simplification and meant to represent only the scientific mainstream.
[4]Creationists who believe in multiple regional or global catastrophes (only one of which was the Biblical Deluge) are sometimes referred to as "Neo-cuvierists" (or neocuvierists); their view differs from that of Cuvier in that one or more of these catastrophes are postdiluvial.

For many, philosophy is an endless maze of useless mind games far removed from science. To be sure, as many philosophies can be generated as there are people to philosophize. But science is itself a branch of philosophy, formerly called "natural philosophy," and wholly dependent upon such branches of philosophy as logic (what is proper reasoning?) and metaphysics (what is the nature of reality?). To neglect the question "What is proper reasoning?" before attempting to practice science is to prepare for failure. Several notable examples may be readily found of geologists who turned their backs on the biblical worldview, to some extent at least on the basis of stratigraphy. Some of them even wrote for this journal. To ignore the philosophic underpinnings of this issue is a dangerous mistake.

It is my objective to assemble the fragments of stratigraphic method and application presented over the past three-and-a-half decades into an understandable mosaic that will assist the reader in comprehending sequence stratigraphy—and stratigraphy in general—within the overall philosophic context in which it necessarily functions. In Part I of this series, the relationship between philosophy and stratigraphy is examined. In Part II, the scientific veracity of various stratigraphic methods will be evaluated. In Part III, a more detailed examination will be made of sequence stratigraphy due to its increasing dominance and potential importance. I have attempted to provide a representative sample of citations to assist readers in studying particular issues in greater depth. The reader unfamiliar with geological and philosophical terminology may wish to consult the glossary at the end of this paper.

The Philosophy of Science

Much has been written on the philosophy of science, some of it from a Christian perspective (Ancil, 1983, 1985; Bartz, 1987, 1989, 1992; Bergman, 1982; Brand, 1985, 1996; Brown, 1994; J. Clark, 1976; Frangos, 1991; Hoffman, 1993; Hull, 1989a, 1989b; Johnson, 1991, 1993, 1995; Kofahl, 1986, 1989; Lillo, 1987; Lumsden, 1992; Malcolm, 1997; McGhee, 1987; Middelmann and Wilder-Smith, 1980; Moreland, 1989; Pearcey, 1987; Plantinga, 1990, 1997a, 1997b; Renard, 1993; Riemen, 1987; Schaeffer, 1968a, 1968b, 1972, 1976; Sproul et al., 1984; Sire, 1988; Verbrugge, 1985; Øhrstrøm, 1990). Some have attempted to provide a Biblical approach in

applying the philosophy of science to geology (Brand, 1974; Howe and Williams, 1994; Reed, 1996a, 1996b; Reed and Froede, 1996; Reed et al., 1996; Williams, 1992). Many of these authors have pointed out the dependence of the scientific enterprise on the following presuppositions:

- A reality exists external to man.
- This external reality is ordered and causal.
- Our senses can provide reliable information about the external world.
- Man has the mental capacity to comprehend this ordered reality through induction and the laws of logic, epistemology, ontology, and truth (and, by extension, moral values).
- Natural laws are unifiable and isotropic.
- Parsimony is desirable ("elegance" or "Occam's Razor").

It is evident that the scientific method (described below) could not have arisen from the nonchristian worldviews of current society, and it is not surprising that the science of postchristian occidental society increasingly resembles the "armchair" science of the ancient Greeks and other pagan cultures (Middelmann and Wilder-Smith, 1980; Schaeffer, 1976). Nor is it coincidental that empirical science arose within the Reformation culture (Middelmann and Wilder-Smith, 1980; Morris, 1984; Titus et al., 1979, p. 220; Schaeffer, 1976; Sire, 1988). Today, the geologic establishment largely operates within the confines of the uniformitarian-naturalist worldview (Johnson, 1991, 1993, 1995; Reed, 1996a), a worldview which is logically incoherent (G. Clark, 1978; Schaeffer, 1968a, 1968b, 1972, 1976; Sire, 1988), and which seeks knowledge, causality and order where none is assured (Sire, 1988; Zeller, 1964). Reed (1996a, p. 12) summarized this in a recent article in the *Quarterly*:

> In summary, *the naturalist-uniformitarian system fails the formal comparison of its conclusions and methods with its axioms*. Ironically, axioms that are crucial to its very existence are shown to be theological conclusions derived from the Biblical doctrine of creation, and derivative God-man-nature relationships. Naturalists have not, and probably logically cannot provide a non-theistic formulation that would justify those axioms foundational to modern science (emphasis mine).

Although no precise definition of natural science is universally accepted (Moreland, 1989; Plantinga, 1997b; Schoepflin, 1982), the problem is not intractable, as evidenced in the similarity of various descriptions of the scientific method. One is given by Copi (1982, pp. 468–475), summarized by the following five points:

- *Relevance*: the phenomenon of interest must be deducible from the proposed hypothesis.
- *Testability*: a proposed explanation must be testable (verifiable/falsifiable).
- *Compatibility with Previously Well-Established Hypotheses*: it must exhibit logical coherence.
- *Predictive or Explanatory Power*: the greater the number and range of deductions that follow from the hypothesis, the greater its predictive power.
- *Simplicity*: a bias is encouraged for the acceptance of the least complicated explanation; this is also known as parsimony, elegance, and "Occam's Razor."

The scientific method is essentially inductive, using deductive reasoning to test hypotheses and direct research. Although induction has been criticized by some, including Karl Popper, it remains an essential component of the scientific process (Copi, 1982; Lillo, 1987; Malcolm, 1997, p. 174; Titus et al., 1979). The differences between inductive and deductive reasoning are illustrated in Table II.

Empirical science, occupied with the analysis of data collected from the natural world, deals with probabilities. Hence, "scientific proof" is an oxymoron. Hypotheses may be deduced from an extrascientific philosophical

Table II. Induction versus deduction.

Inductive Reasoning	Deductive Reasoning
The conclusion probably follows from the premises. Often comes to general conclusions from particular cases. Conclusion is more probable with more substantiating data.	The conclusion *necessarily* follows from the premises. A general principle is applied to a particular case. Can be disproved with a single contradictory case.
One strengthens one's case by collecting more supporting evidence. An inductive argument cannot be proved or disproved, but can be arguably more or less likely (verifiability). This is the traditional hypothesis or "scientific argument."	Supporting evidence (verifiability) does not "prove" one's argument, though the conclusion can be disproved (falsifiability). "Natural laws" and paradigms are deductive arguments and reflect imposition of one's worldview upon the data.

viewpoint or arrived at intuitively or inductively using various models or statistical techniques. However, all models, including mathematical (statistical) ones, are still mental constructs and are only as good as their underlying presuppositions (Baker, 1996; Molnia, 1996; Pilkey, 1996; Rojstaczer, 1996). They must be testable, by both verification and falsification criteria (Copi, 1982; Frangos, 1991; Johnson, 1991, p. 71; Malcolm, 1997, p. 174; McCluskey, 1995). The strength of the scientific method (as codified by Francis Bacon et al.) is its limitation to empirical data, i.e. what can be directly observed and measured. *Science is that branch of philosophy which limits itself to the empirical.*[1]

This has direct application to geology, as asserted by Koch and Link (1970, p. 8):

> The sampling results—raw data, derived observations, and conclusions—should be verified before being accepted as valid information on which to base an analysis. Verification, an essential requirement of the scientific method, is too often done informally or not at all in geology.

- Titus et al. (1979, pp. 201-208) divide the scientific method into two components: logical methods and technical methods. Technical methods would include means of observing or measuring the natural world, and are often matters of agreement between creationists and evolutionists. Logical methods would include direct inferences, models, and paradigms derived from worldviews. These are often matters of disagreement between creationists and evolutionists. Both types of methods within natural science are subject to three tests for truth:
- *Correspondence*: the idea fits with data obtained from nature
- *Coherence*: it is logically consistent
- *Utility*: it is practical and "useful"

Scientific Models

The relationship between empirical science, worldview, and scientific models can be conceived as illustrated in Figure 1. As used in this figure, *worldview* refers to how one views reality based on a set of presuppositions one holds. Because no one can exist without a worldview, such presuppositions are often reflective of the culture into which one is born; hence, a given worldview is often shared by members of a particular society and defines their culture. *Paradigm* refers to a belief system derived from that worldview relative to a particular field of inquiry, e.g. ethics or politics. Inferences and hypotheses are attempts to correlate data (measurements of natural phenomena) or interpret their relationships. Hypotheses about specific phenomena are inevitably integrated with inferences from other sources when they encounter a researcher's paradigm, resulting in the birth of a *model*. The model is the interface between the metaphysical worldview and the empirical scientific research enterprise. It is here that the researcher seeks—as he must—to reconcile what he believes and what he observes. This is not, however, an essentially objective process. As indicated in Figure 1, the researcher's worldview, expressed through a particular paradigm (usually shared with other researchers), influences his choices in phenomena to be investigated and data to be acquired.

According to Koch and Link (1970, p. 18), "A model is a representation of a natural phenomenon or process." Geologic models may be grouped using their classification scheme as:

- physical (e.g. sedimentation in a flume)
- geological (e.g. a molasse basin)
- mathematical (deterministic or stochastic)

"In choosing between a deterministic or a statistical model for a mathematical study of a geological problem, one relies on taste and judgment, influenced above all by one's view of the real nature of the world (Koch and Link, 1970, p. 24)"

Mixed Questions

Clearly, the criteria of Copi, especially testability and predictive power, are not applicable to all fields of knowledge or endeavor. They are not, for example, relevant to fine art or jurisprudence. Nor are they applicable to the study of history. However, scientific methods can have some applicability as adjuncts to historical study, for example in the fields of forensic science, archaeology, and historical geology. Here we concern ourselves

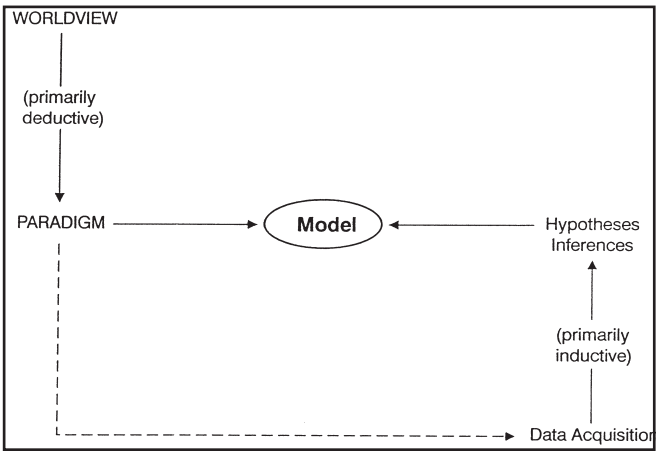

Figure 1. Construction of a scientific model.

[1]This definition is consistent with the idea of "Duhemian science" (Plantinga, 1997b).

Table III. Science versus history.

Science	History
ongoing	unique
repeatable	unrepeatable
directly observable	not directly observable
primarily inductive reasoning	primarily deductive reasoning
relies principally on measurement/observation	relies principally on testimony/observer
Failure to recognize the limitations of science leads to distortion of science and produces faulty conclusions.	Failure to recognize the limitations of historical methods leads to distortion of history and produces faulty conclusions.

with historical geology. Fields in which knowledge may be properly acquired from more than one source or using more than one method require proper attention to their differences lest false conclusions be reached (Ancil, 1985; Brand, 1985; Frangos, 1991; Plantinga, 1997a, p. 23). These interdisciplinary questions are sometimes termed "mixed questions" (Adler, 1965). (Readers unfamiliar with the "mixed question" concept may see the appendix for a more detailed explanation.) Any geologic research which involves the past—and a great deal of activity in geology does—is a mixed question. Mixed questions require input from a plurality of disciplines and methods.

Mixed Questions and Stratigraphy

Stratigraphy could avoid the mixed question problem if it were limited to strictly empirical methods. This would require that the discipline be limited solely to a descriptive function, describing the spatial arrangements of various rock bodies defined on purely empirical grounds. However, stratigraphers have always insisted on meddling in natural *history*, thus introducing nonempirical elements into stratigraphy. Reed (1996a, p. 8) suggests some "ground rules for the interpretation of earth history":

> *The first step in such a critique is the recognition that historical analysis is a much larger and more complex question than is commonly presented in geologic interpretations*. Key issues to be addressed prior to developing any model are: (1) the severely limited potential for human neutrality in historical analysis; (2) the proper domains and relationships of the various areas of human knowledge; and (3) the criteria for establishing a critical framework within which competing models can be evaluated (emphasis mine).

The differences between the historical and scientific methods are illustrated in Table III. Naturalistic science (the "modern modern science" of Schaeffer[2]) has not only failed to observe these differences, but has actively subsumed other fields of knowledge into "science," scorning any method as "unscientific" that differs with empiricism (Becker, 1932; Johnson, 1995; Plantinga, 1990; Schaeffer, 1968a, 1968b; Sire, 1988). "Social science" fails by *a priori* rejecting the possibility of the human soul and ignoring man's spiritual capacities. "Historical science" fails by *a priori* assuming a positivist viewpoint, confusing imagination with evidence, and being unwilling to admit that in many cases we simply cannot know (aside from divine revelation). This is the fallacy of reductionism, looking for truth *within* the scientific enterprise instead of using the scientific method as *one means among several* to arrive at truth.

Historically, this fallacy has resided in geologic circles in the form of uniformitarianism, a paradigm now being challenged. But the worldview behind it remains entrenched, as Bartlett (1997, p. 13) describes:

> Secularists agree that uniformitarianism is false and stifling to hypothesis construction as well as scholarly discussion. In the past, the issue was the burial of the question of divine intervention. The whole issue involves recognition of and submission to the Christian God—Jesus Christ. 'We will not have this *man* to reign over us' (Luke 19:14c) was the clarion battle cry of Enlightenment scientism (emphasis his).

This reveals the true motivation behind the naturalist/secularist worldview. This was the worldview that gave birth to the traditional geologic column. This is the

[2]Schaeffer coined the term "modern modern science," in contrast with "modern science," to point out the fundamental transformation that occurred when the idea of uniformity in nature based on the immutability of God was replaced by the idea of uniformity in nature *a priori* without God. Schaeffer's analysis is profound and very readable. Those of you who are not familiar with his works would do well to read them.

worldview from which some suggest sequence stratigraphy may deliver us (Bartlett, 1997). Can it?

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Appendix

With a little thought, one can quickly see that we are faced daily with a myriad of mixed questions. Most of our decisions are attempts to reconcile several competing factors, a fact easily discerned in maintaining a budget. Abortion can be thought of as a mixed question, since it involves moral, political and scientific issues. However, Scripture rather clearly indicates that the unborn are individuals created in the image of God (Psalm 51:5, 139: 13; Jeremiah 1:5; Luke 1:15) and that murder is sin (Genesis 9:5,6; Exodus 20:13; Psalm 106:36-40; Proverbs 24: 11,12). Thus, this is really more of an example of sin than of a mixed question. Similarly, denying the authority of Scripture by interpreting it based on current "science" or some other human basis more closely resembles sin than a "mixed" theological and scientific question (Exodus 20:1,2; Psalm 118:8,9; II Timothy 3:16,17; II Peter 1:19-21). In contrast, many of the questions that arise in geology must be addressed *within the framework* of a Biblical worldview, since the Scripture does not give us these details. Where these questions involve earth history, they are mixed questions.

Consider the following example of a mixed question. The United States government is considering whether to provide financial assistance to the government of a developing nation. At a minimum, this decision involves the following factors:

1. The political effects on the United States
2. The political effects on the developing nation
3. Potential impacts on political power balances in the region
4. The motives and character of those in both governments who are responsible for overseeing the program
5. Ethical/moral questions about the process itself
6. Ethical/moral questions about this specific application of principle
7. The sociological impacts on the citizens of the U.S. from sending tax monies overseas
8. The sociological impacts on the citizens of the developing nation
9. The economic impacts on the citizens of the U.S. from sending tax monies overseas
10. The economic impacts on the citizens of the developing nation

Clearly, the first three factors are political. In analyzing the political factors, however, elements of sociology, psychology, and history will be prominent. Factors 4–6 are clearly ethical or moral. Factors 7 and 8, though obviously sociological, will incorporate elements of psychology and economics. Factors 9 and 10, clearly economic in nature, are closely related but not identical to Factors 7 and 8. Obviously, these various factors and the fields of knowledge upon which they impinge are interrelated, but just as clearly, different methods must be used for each. Principles of macroeconomics must be used, but can only address a portion of the questions raised in considering the foreign aid issue. The sociological impacts will be closely linked to the political and economic effects, but neither economics nor politics will be adequate to describe the sociological impacts. The ethical/moral questions leave relativistic cultures in a quandary[3]. As this example illustrates, mixed questions require input from a plurality of disciplines and methods.

Glossary

axiom: an assumed or accepted principle, often regarded as self-evident

biostratigraphy: correlation of rock units based on fossil content

causality: the relation between effects and their causes ("cause and effect")

Cuvierist: one holding to the view that Earth history has been dominated by several global or near-global catastrophes, the Deluge being the most recent

deduction: a form of logic in which the conclusion necessarily follows from the premises (cf. Table II)

Deluge: the global water cataclysm described in Genesis

deterministic: a constrained process generating a certain outcome

empirical: capable of physical observation or measurement

epistemology: discipline concerned with the theory of knowledge or how one can know

eustasy: global sea level and its fluctuations in time

induction: a form of logic in which the conclusion probably follows from the premises (cf. Table II)

isotropic: having uniform properties throughout space; the assumption that space is uniform

[3]These questions can only be properly answered from the Bible, which must govern research in the other fields as well lest false conclusions be reached (Psalms 36:9; 119: 89–91, 130. Proverbs 2:1–6)

jurisprudence: the body, system, or philosophy of law and its application
lithostratigraphy: correlation of rock units based on lithology (rock type)
macro/microeconomics: economics on the national/global scale and business enterprise/individual scale, respectively
metaphysics: study of the nature of ultimate reality
neocatastrophist: one who stresses the importance of catastrophic or episodic geologic events
Neocuvierist: a term loosely applied to neocatastrophists who envision large scale catastrophes and hold to periodicity (secular) or accord great importance to presumed postdiluvian catastrophes (creationist)
Occam's Razor: the principle, attributed to William of Occam, that the simpler of competing views is more likely to be correct
ontology: study of the nature of being
oxymoron: a self-contradictory term (e.g. compassionate cruelty)
paradigm: a mental framework for integration of particular data (cf. Figure 1)
parsimony: stinginess or thriftiness; in philosophy, avoidance of superfluous premises
positivism: the belief that only empirical propositions are meaningful and that metaphysics is impossible
quietism: the belief that Earth history has been free of major (inter-regional or global) catastrophes
scientism: idolization of science; the view that true knowledge comes only via natural science
stochastic: an unconstrained (random) process generating an uncertain outcome
stratigraphic sequence: a package of conformable strata, often cyclic; in sequence stratigraphy, the term is applied at a regional scale, usually comparable to a group; otherwise, it is usually a smaller sedimentary package of formation or lesser rank
unconformity: a contact between rock units that does not conform to the geometry or fabric of the adjacent beds; it often represents an erosion surface
unifiable: the idea that natural phenomena are capable of being related logically (often mathematically) to each other
uniformitarianism: the doctrine that geologic processes in the past did not differ substantially from those observed in the present
Wernerian: the stratigraphic school of thought that taught that successive ages were characterized by predominant lithologies (e.g. Carboniferous, Cretaceous)
worldview: a person's (or group's) view of reality, sum of beliefs, philosophy of life

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AAPG: American Association of Petroleum Geologists Bulletin
BSN: Bible-Science Newsletter/Bible-Science News
CENTJ: Creation Ex Nihilo Technical Journal
CRSQ: Creation Research Society Quarterly
JSP: Journal of Sedimentary Petrology
N: Nature
O: Origins
O&D: Origins & Design
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Unfortunately, 19th-century scientists were just as ready to jump to the conclusion that any guess about nature was an obvious fact, as were 17th-century sectarians to jump to the conclusion that any guess about Scripture was the obvious explanation . . . . and this clumsy collision of two very impatient forms of ignorance was known as the quarrel of Science and Religion.

Thomas Aquinas