WHY DID GOD CREATE POISONS AND TOXINS?

JERRY BERGMAN*

Received 5 January 1994; Revised 6 August 1994

Abstract

The problem of toxicity is considered. It is concluded that many myths exist about the subject of poisons and toxins. A major one is that a dichotomy exists between poisonous and nonpoisonous chemicals when in actuality nothing is toxic in small levels, and all chemicals are toxic in high amounts. Further, most all chemicals which have a high level of toxicity have an important function in life, and because compounds can be used in a harmful way does not negate their importance when used appropriately. It is not the compound that is the problem, but the use.

When reading about cases of children dying from mercury or lead poisoning (or murders in which someone used the deadly poison arsenic) some may ask, "Why did God make poisons? Why would He create chemicals that serve to harm people? Would not such harm be contrary to His plan?" A commonly used argument by atheists is: Would a loving God make deadly chemicals which have served to kill millions of people?

The terms "poison," "toxic," "pesticide," "herbicide," and "preservative" all imply that, because some chemicals may function in this role, they must always be detrimental to humans. The implied dichotomy between the words toxic and non-toxic, or "poison" and "non-poison," is wholly artificial and impedes understanding of the toxicity problem (Woods, 1991). Chemicals are not toxic or poisonous, only amounts are: No chemical is toxic in small levels, and all chemicals are toxic in large amounts (Bergman, 1992). In Stevens' words, "Anything in a large enough dose can prove toxic" (1990, p. 1). Even water is toxic if a certain amount is ingested, and can cause a coma or is even fatal if ingested in high levels during a short period of time (Christian, 1992). Oxygen is also necessary for life, but as every nurse knows, excess amounts are lethal. A poison is only too much of a certain chemical in the wrong place. Lower amounts of many "poisons" in the right cells are actually necessary for life. For example, vitamins A and E are critical for life, but are toxic if taken in high dosages. All vitamins and minerals cause toxicity at certain levels. We are discovering that many chemicals found in nature have important uses (Griffith, 1988). Fire has caused the loss of an enormous number of lives, yet it has also saved countless lives and still serves us well by heating our homes, cooking our food, sterilizing medical equipment and other uses.

A good example of the time and place concern is the drug thalidomide. It became infamous for causing a large number of birth defects, primarily if taken during pregnancy at a certain time. This teratogenic agent caused children to be born with missing or misshapen limbs (Fine, 1972; Knightley et al., 1979). Unfortunately, the image of this drug has caused researchers to avoid exploring its potential uses. Recent studies, though, have found that it is among the most effective existing treatments for leprosy, and can improve the survival rate enormously of patients who receive bone-marrow transplants. It has also been used to successfully treat other potentially fatal disorders which include aplastic anemia and certain kinds of bone cancers. Aplastic anemia is anemia caused by aplasia, a failure of an organ to develop; thus in this disease the bone marrow—where most of the blood cells are produced—fails to develop or becomes diseased. Another use of thalidomide is to reduce the graft-vs.-host disease problem by reducing the voraciousness with which grafted foreign tissue attempts to reject its new home.

An excellent example of the fact that all substances are toxic in large amounts is water intoxication, described by Tisdale:

> The volume of water both inside and outside the cells increases, but the salt does not, and brain cells swell, then shrink. . . . Water intoxication can occur accidentally, especially in the medical treatment of a dehydrated person. But it happens most frequently among schizophrenics. For reasons as mysterious as any other in the realm of psychosis, schizophrenics sometimes have a compulsive need to drink water. Compulsions are exactly that, impossible to overcome, demanding in the most lordly and imperative of voices (1988, p. 27).

And an FDA report stated:

> FDA has recently received five reports of hospitalizations involving water intoxication of young infants. Preliminary reports indicate that three infants were admitted to the hospital with seizures and hyponatremia apparently associated with relatively large intakes of free water. The other two infants were reported to have low blood sodium levels on admission that were believed to be related to water ingestion (FDA Medical Bulletin, May, 1994, p. 5).

The Case of Arsenic

Probably the most famous of all poisons, arsenic, is actually a vital mineral for many animal metabolic systems. It is commonly used as an insecticide or rodenticide, and most arsenic based pest control products contain copper acetoarsenate, or calcium or lead arsenate (Stevens, 1990). Arsenic compounds cause death by their ability to interfere with the body's energy producing processes in the mitochondria found within the cell. The specific mechanism of arsenic poisoning is usually due to its inhibition of pyruvate dehydrogenase, the enzyme that breaks pyruvate down in the mitochondria so it can be processed for energy production. Arsenic also causes glucose stores to be decreased and inhibits glucose production (Reichl et al., 1989). It is also carcinogenic and teratogenic.

Conversely, as Lederer and Fensterheim (1983, p. 185) note, the research data indicate that "arsenic is an essential element for several animal species." One vital

*Jerry Bergman, Ph.D., Northwest State College, Archbold, OH 43502-9542

role that arsenic plays in many animals is as an enzyme component to metabolize protein and certain amino acids, including methionine, arginine and taurine. Wardlaw and Insel (1990, p. 437) note that "adults need about 12 to 25 micrograms per day." The most common ways of measuring body arsenic levels are hair and fingernail sample analysis and urinalysis (Poskanzer, 1980). Normal persons have an average concentration of 0.005 mg of arsenic per hundred grams of hair, and excrete between 0.01 and 0.06 mg arsenic per liter of urine.

The Botulinum Toxin

In evaluating toxins, it is imperative to discuss the most poisonous substance in the world—botulin, the neurotoxin produced by the single-celled bacterium *Clostridium botulinum* (Jankovic and Brin, 1991). Botulin is "six-million times more toxic than rattle snake venom" and a lethal dose for humans is a mere 1/10,000th of a milligram (Waters, 1992, p. 30). Botulin poisoning usually results from eating improperly canned or contaminated food, and results in muscle paralysis (Lundberg, 1990). It does this by permanently attaching itself to nerve endings and blocking neurotransmitters—chemicals which cause the nerve impulse to travel from one nerve to another at the synapse junction. By binding to nerve endings, the toxin prevents the release of the acetylcholine neurotransmitter. Similar to permanently jamming a light switch so that it cannot be turned on, it blocks the nerves so that the brain's signals cannot reach a muscle, and as a result the muscle becomes severely weakened or paralyzed if enough nerves are blocked. It causes death because the chest muscles are not able to perform their breathing function, consequently the person suffocates.

Yet, this most dreaded of all toxins is a miracle drug for people suffering from conditions such as dystonias—involuntary muscle spasms which cause eyelids to blink or clamp shut, the neck to twist into painful contortions, writer's cramps and loss of voice (Heneson, 1990). The dystonias in general result from too many nerve signals to the muscles, causing them to overreact. This uncontrolled muscle spasm can result from both voluntary and involuntary excessive electrical-brain impulses. In the area of cerebral palsy treatment, botulin holds enormous promise for millions of Americans in helping to control sposticity and tics (Chen, 1991; Rodman, 1991; Talan, 1990; Hussar, 1990). Success has also been achieved with severe stuttering by injecting the toxin into the vocal cords—providing potential relief for millions of sufferers.

Botulin therapy is a major breakthrough for blepharospasm, an uncontrollable eye blinking that sometimes involves other facial throat and neck muscles. It is also effective for both chronic writer's and musician's cramps—an especially severe problem for students who must write extensively, and for violinists and even pianists. It is also effective for spasmodic dysphonia, a muscle spasm which effects the pharynx, resulting in an extremely strained voice (Ludlow, 1990). The treatment is injection of botulinum into the thyroarytenoid muscles that control the vocal cords. One of the most useful areas is for the treatment of spasmodic torticollis, an extremely painful, debilitating neck spasm which causes the head to thrust about uncontrollably (D'Costa, 1992).

Botulinum treatment is also highly effective in about eighty-five percent of all cases of strabismus, the general cross-eye, or wall-eye condition. This malady is usually outgrown by about age six months, but if it persists, surgery was often the only alternative until the development of botulin treatment. Strabismus is caused by an over active eye muscle on one side, and a weak muscle on the other. The brain processes light information picked up by the retina by combining both the left and right signals, and if the weak eye is too much out of alignment with the dominant one, the brain will rely solely upon the stronger eye signals. If this continues for too long a period of time, the brain will become unable to interpret images from the weaker eye, thus it will let it drift—a condition called amblyopia or lazy eye. The result is that the person can use only one eye, and consequently has little depth of field and experiences much difficulty in judging distances. Amblyopia carries a considerable social stigma and often results in major psychological and social adjustment problems.

The surgical treatment involves cutting away a portion of the hyperactive muscle to weaken it and allow the eye to line up properly. The new treatment is to use precisely targeted injections of botulin to inactivate the spastic or hyperactive muscle. In most cases, this technique restores normal control to the patient without the need for invasive surgery. Botulin weakens the spastic or over developed eye muscles in the same way that it weakens the muscle pull of persons suffering from botulism toxin. Unfortunately, the results are not permanent—new nerve endings eventually replace those blocked by the drug. Nonetheless, it is now the most effective treatment for amblyopia and is regarded as established medical practice.

Other uses include treatment of oromandibular dystonia (involuntary movements of the jaw, lower facial, and tongue muscles), laryngeal dystonia (larynx muscle spasms which cause speech difficulties), and other movement disorders, and even tremors such as hemifacial spasm, an involuntary twitching or contraction of the muscles on one side of the face (Jonkovic and Brin, 1991). The incidence of the dystonia family of diseases is about 390 cases per million population. Before the botulin treatment, few effective means existed to help the large number of people afflicted with these problems. One study found its success rate was 85% in long term follow-up (Jankovic and Brin, 1991). Many persons in the past assumed that these diseases were psychosomatic—and the discovery that they are not has both relieved sufferers and helped to reassure physicians that these patients are not untreatable.

Botulin is an extremely complex molecule—its molecular weight is a whopping 80 times that of insulin. Its large number of atoms must be assembled with the precision of a fine watch. Its commercial and laboratory production is a complex specialty which still is more an art than a science, and is primarily directed by investigator Ed Schantz. Schantz has been researching growing the bacteria to effectively extract the toxin for about fifty years. His lifetime experience was required to achieve the skill needed to effectively isolate it from the bacteria for therapy use. Fortunately, because it is so lethal, an effective dose is usually only about one-millionth of a milligram (Waters, 1992, p. 32).

Ironically, the usefulness of botulin to the bacterium itself is not yet known. It is an anaerobic organism, once common when home canning and other means of preserving food was done improperly. Although one occasionally reads about cases, it is a rare concern today because commercial canners must by law heat their products up to temperatures and pressures high enough to kill not just the bacterium, but also the botulism spores. The bacteria that causes it is an extremely common soil and water bacteria spore. The proper conditions cause the spore to develop into the rod-shaped bacterium *Clostridium botulinum.*

Other Toxins

Whitney et al. (1990) summarize some of the evidence that indicates many other well-known toxins, including mercury, lead, silver, barium, and even cadmium, all play key roles in nutrition and health. Research is currently being completed to specify in more detail what these uses are. It is now well established that barium, a poison rated "5" on a scale of 1-6 (thus extremely toxic), which even in low levels can severely irritate the eyes, nose, throat and skin, is vital for proper growth. Even medium toxic levels of it cause cardiac irregularities, convulsions, and death from cardiac and respiratory failure (Stevens, 1990). Other highly toxic vital minerals include iodine, also with a toxicity rating of 5, which is needed for the synthesis of thyroid hormones. Vanadium is necessary for bone development and normal reproduction, cobalt is an essential part of vitamin B_{12} molecules, silicon is involved in bone calcification, and nickel is critical for the activity of certain enzymes and evidently also for iron metabolism (Wardlaw and Insel, 1990).

Many other trace minerals that are necessary for proper health are also toxic in relatively low amounts (Spallholz, 1981). Selenium is extremely poisonous (toxic at 0.2 mg/m^3) and if inhaled in sufficient amounts causes skin lesions, nervous system disorders, damage to the teeth and Lou Gehrig's disease. It is also an essential element, needed as part of enzymes that work as antioxidants. These compounds reduce the level of polyunsaturated acid oxidation, now considered by many researchers to be a major cause of arteriosclerosis (Spallholz, 1981). Selenium's role as an antioxidant is also complementary to that of vitamin E, and neither can replace the other. The recommended intake for adults is .05 to .2 mg daily (Christian, 1992).

According to several studies, selenium also has a protective effect against certain cancers, although probably its most important biological function is part of the enzyme glutathione peroxidase. This compound helps to minimize the cellular structure damage called peroxidation which, regardless of whether it is produced naturally or is chemically induced, can lead to cancer. The glutathione peroxidase enzyme destroys oxidative compounds that would otherwise oxidize chemicals in the cell, consequently destroying some organelles and eventually the cell. A number of studies have also indicated that selenium is extremely important in bolstering the body's immune system. The indications are now that its ability to reduce cancer is so dramatic that some researchers recommend daily supplements for the population in general.

It was determined that a past outbreak of heart disease in hundreds of thousands of children in certain parts of China in the 1970s was due to selenium deficiency. Correction of this diet deficiency has now almost totally eliminated the problem called Keshan disease (Christian and Greger, 1992, p. 456). The cause of the deficiency was because the soil in these areas was selenium poor, a condition that also correlates with certain kinds of cancer. Most Westerners are largely protected from such severe selenium deficiencies because their food is generally obtained from a wide variety of areas around the country (Spallholz, et al., 1981, p. 172). Also, meat and animal products, which are a major part of the Western diet, tend to be good sources of selenium.

The Case of Chromium

Chromium, which causes cancer, corrodes skin and nasal membranes, and can damage the kidneys and even the body's immune response system (toxic at 0.1 mg/m^3 or less) has also been shown to be an essential trace element (Fisher, 1990). Studies of patients for whom prolonged intravenous feeding was the sole source of nutrition has vividly demonstrated the importance of chromium for the normal metabolism of glucose. It interacts with insulin to aid the entry of glucose into the cell at the cell membrane entry port, and consequently it controls the energy supply for cell use. When chromium is lacking, the effectiveness of insulin is also impaired.

Because chromium tissue concentration typically declines with advancing age, and its deficiency may contribute to the development of adult-onset diabetes, many nutritionists recommend chromium supplements. Studies of diets which include chromium supplements have found that the element . . . can help control blood pressure, increase stamina, help firm up the body and build muscle (Fisher, 1990). Its absorption level depends upon the ion ingested, and the Cr^{+++} ion seems to be the form best absorbed and is most effective in living systems. The dietary supplement that is most effective is a preparation called chromium picolinate. The body also has a natural protective mechanism to prevent over absorption by causing absorption to increase with low dietary intake and decrease with high dietary intake.

Chromium is also an essential mineral that participates in carbohydrate and lipid (fat) metabolism. Chromium supplements can help to correct glucose imbalances by lowering high blood glucose concentration in people with diabetes, and raise low blood glucose concentrations as found in patient's with hypoglycemia. Since chromium deficiency can also raise serum cholesterol and LDL concentration, and lower HDL concentration, chromium supplements can help prevent coronary artery disease. Unfortunately, the more refined the food, typically the less chromium that it contains. For this reason, some researcher's estimate that a high level of the population does not ingest enough dietary chromium. Fisher (1990) concludes that up to 90% of us do not ingest enough of this vital nutrient" Chromium is particularly high in vegetable oils, brewer's yeast, whole grains, nuts, egg yolks, meats, and certain kinds of cheeses, but is often poorly absorbed, thus supplements are often recommended.

One of the better well-known examples of the need for balance is in vitamin use. Most every school child knows that vitamins are necessary for good health. Unfortunately though, many people believe that since small amounts of vitamins are essential, larger amounts are better and megadoses are better yet. Thus, overdosing on vitamins is now a major problem. Called hypervitaminosis, the most common symptoms include nausea, diarrhea, rashes, fatigue, and eventually death. Especially of concern are the fat soluble vitamins (A, D, E and K), and the most common vitamin for which overdose is a problem is vitamin A (Whitney and Sizer, 1994). Although necessary for the maintenance of skin, hair and mucous membranes, as well as vision and bone and tooth growth, high doses of vitamin A can cause serious health problems, and not uncommonly death. For this reason, many health experts recommend that supplementary vitamins should be taken only under the advice of a physician.

Natural versus Synthetic

Much of the concern over toxicity relates to the labels synthetic versus natural, a chemical division that is artificial and in many cases meaningless. The assumption that compounds made by nature are good, and those made by humans are bad (or at least have a far greater chance of being bad) is not valid. Although some have attempted to develop legal definitions, most all synthetic chemicals are nothing more than modified, and sometimes not greatly so, natural chemicals. Each chemical also has to be evaluated separately for toxicity concerns regardless of its source. Because this is true for all of the ten million chemical substances listed in the 1990 Chemical Abstracts shows that scientists have a lot of work to do.

Many persons tend to think of natural compounds as non-poisonous, and human-made ones as more likely to be harmful. This is not a valid generalization: All plants, including those used by us for food, produce their own specific natural compounds which were designed to be toxic as a means of protection against pests, including insects, fungi, and animals (Woods, 1991a). Humans are generally safe if they eat a balanced diet consisting of small amounts of a wide variety of foods. Since all foods contain toxins, the only concern should be the level that we are exposed to of each type of compound, and whether or not our liver can adequately detoxify the level of the compound ingested. This organ is marvelously efficient at rendering excess amounts of potentially lethal compounds harmless. Our body, if healthy and not overburdened, is actually extremely effective in rendering normally encountered levels of most toxins inert.

We should also be very cautious, but not paranoid, about utilizing chemicals which have not yet been adequately tested. On the other hand, many chemicals exist which we know are extremely highly toxic to humans, and yet many people do not seem very concerned about them (Woods, 1991). An example is hundreds of the over four thousand chemicals commonly found in cigarette smoke are extremely toxic to humans. One, radioactive polonium-210 (half-life = 138.4 days) is one of the most toxic substances known to mankind, yet we tend to worry more about Aspartame® which has a toxicity of something like a millionth of polonium-210 (Bergman, 1992). This information is thus not just useful, but could also mean saving lives if applied to reduce toxins in one's environment.

Some Conclusions

Compounds are not poisonous or toxic, the problem with poisons and toxins is a matter of excess and how a compound is used. Compounds which are highly toxic in some situations can be life-saving in other situations. The toxicity problem is solely a matter of degree, i.e., all compounds are toxic in high levels, and no compound is toxic in low levels. The toxicity concern is best described as one of fit, i.e., in one situation a compound is functional in another situation the same level is dysfunctional. The fact that some compounds are dysfunctional in certain situations in low levels does not support the common conclusion that some compounds are not dangerous and others are dangerous or toxic. The focus should be on the proper use of a compound in a given situation, and that all compounds and elements can be either beneficial, neutral or harmful, depending upon the situation. A review of selected common examples of poisons and toxins shows that they serve very specific roles in health, and even though research on some of these elements such as arsenic and botulism toxins has only just begun.

References

Bergman, Jerry. 1992. Toxicity. *Chemecology* 21(1):12.

Chen, Ingfei. 1991. Toxin to the rescue: Tapping a deadly botulinum protein to treat neuromuscular disorders. *Science News* 139: 42-43.

Christian, Janet L. and Greger, J. L. 1992. Nutrition for living. Benjamin/Cummings Publishing Company. Redwood City, CA.

D'Costa. D. F. 1992. Low dose botulinum toxin in spasmodic torticollis. *The Journal of The American Medical Association* 267 (5):646.

FDA Medical Bulletin. 1994/5. Water intoxication of infants. May, p. 5-6.

Fine, Ralph Adam. 1972. The great drug deception; the shocking story of MER/29 and the folks who gave you thalidomide. Stein and Day Publishers. New York.

Fisher, Jeffery A. 1990. The chromium program. Harper and Row Publishers. New York.

Griffith, H. Winter. 1988. Complete guide to vitamins, minerals and supplements. Fisher Books. Tucson, AZ.

Heneson, Nancy. 1990. Deadly toxin calms excited muscles. *New Scientist* 128(1746):24-25.

Hussar, Daniel A. 1990. New drugs. *Nursing* 20(12):41-51.

Jankovic, Joseph and Mitchell F. Brin. 1991. Therapeutic uses of botulinum toxin. *The New England Journal of Medicine* 324: 1186-1194.

Knightley, Phillip, Harold Evens, Elaine Potter and Marjorie Wallace. 1979. Suffer the children: the story of thalidomide. Viking Press. New York.

Lederer, William and Robert J. Fersterheim. 1983. Arsenic, industrial, biomedical, environmental perspectives. Van Nostrand Reinhold Co. New York.

Ludlow, Christy L. 1990. Treatment of speech and voice disorders with botulinum toxin. *The Journal of The American Medical Association* 264(26):2671-2676.

Lundberg, George D. 1991. Fish botulism—Hawaii, 1990. *The Journal of The American Medical Association* 266(3):324, 325.

Poskanzer, David C. 1980. Heavy metals. Chapter 225 in K. J. Isselbacher, Editor. Principles of internal medicine, ninth Edition. McGraw-Hill Book Company. New York.

Reichl, Franz-Xaver, Ladislaus Szinica, Helmut Kreppel and Wolfgang Forth. 1989. Effects on mitochondrial metabolism in livers of guinea pigs after a single or repeated injection of as-sub-20-sub-3 (arsenic). *Archives of Toxicology* 63(4):419-422.

Rodman, Morton J. 1991. FDA approvals: new drugs, new uses. NR 54(3):61-67.

Spallholz, Julian, John L. Martin and Howard E. Ganther. 1981. Selenium in biology and medicine. AVI Publishing Company, Inc. Westport, CT

Stevens, Serita Deborah and Anne Klarner. 1990. Deadly doses; a writer's guide to poisons. *Writer's Digest.* Cincinnati.

Talan, Jamie. 1990. Treating spasms with spoiled food. Reader's *Digest* 137(823):139-140.

Tisdale, Sallie. 1988. Lot's wife; salt and the human condition. Henry Holt and Company. New York.

Wardlaw, Gordon M. and Paul M. Insel. 1990. Perspectives in nutrition. Times Mirror / Mosby College Publishing. St. Louis.

Waters, Tom. 1992. The fine art of making poison. *Discover* 13(8): 30-33.

Whitney, N., Eleanor and Frances S. Sizer. 1994. Nutrition concepts and controversies. sixth edition. West Publishing Company. Minneapolis / St Paul.

Woods, Michael. 1991. Chemophobia—scientists and public clash over assessment of risk. *Chemecology* 20(4):18-19.

_____ 1991a. Nature makes its own toxins. *Chemecology* 20(5):12-13.

LETTERS TO THE EDITOR

Some Initial Thoughts Regarding Catastrophic Plate Tectonics

The last thirty to forty years have witnessed a revolution in the earth sciences with the general acceptance and application of plate tectonics. A significant, but largely unnoticed, part of the revolution has been the ability to reconcile the heritage of a strict nineteenth century uniformitarianism with singular; discontinuous events such as continents colliding, new crust forming along vast rifts at the midoceanic ridges, and the plunge of cold crust into the depths of the mantle. Plate tectonics has also been popularized with great success in many media, and its simplicity has facilitated its use in education at all levels Lowman, 1992). While these developments within uniformitarian geology are interesting in and of themselves, and deserve attention from the CRSQ readership, creationist questions surrounding plate tectonics have now moved into sharper focus with the publication of a plate tectonics interpretation of the Genesis flood (Austin, Baumgardner, Humphreys, Snelling, Vardiman, and Wise, 1994).

These authors, who possess significant creationist geologic expertise, posit the rapid subduction of the pre-flood ocean floor at the onset of the Flood event, and the subsequent development of new oceanic crust. Their paper should be welcomed as a serious discussion of the geological implications of the biblical record, but should also be critically evaluated. One path for such an evaluation would be to compare similarities between catastrophic and uniformitarian plate tectonics proposals. This would allow a parallel path of critical thought in areas where the distinctions between the catastrophic and uniformitarian versions are not explicitly stated or logically inferred. In addition, differences between the two should be examined to see whether or not they solve existing problems in uniformitarian plate tectonics and / or raise new difficulties. We intend to offer a brief introduction to both uniformitarian and catastrophic tectonic constructs in a short paper to be submitted soon. In it we will introduce several issues raised by the catastrophic plate tectonic proposal of Austin et al. (1994).

One area worth examination is philosophical rather than strictly scientific. It would be aided by insights from philosophers, especially philosophers of science. In the complex classification of ideas, what is the concept of plate tectonics? Is it a theory, a model, a new discipline, or something else? Scientists tend towards careless usage of such terms, and to our knowledge the interrelationships between observed data and intellectual constructs in plate tectonics thought has not been rigorously addressed on the uniformitarian side, and is not addressed in Austin et al. (1994). An examination of the history of the plate tectonics revolution bears great similarity to Kuhn's earlier thought (1970), and might lead to the conclusion that plate tectonics is a *paradigm* (perhaps not in the Kuhnian sense of "exemplary problem solutions"; 1977; pp. xix-xx, but in a broader sense). If so, what is its relationship to other paradigms of modern geology such as uniformitarianism?

This concern for philosophical insight raises the question of how historical research ought to be performed in a creationist framework. This issue is discussed in a series recently submitted to CRSQ (Reed and Froede, in preparation). We submit that geological models of earth history are mixed questions,* and should be constrained from the top down, but developed from the bottom up. In other words, geological models of young-earth creationists will be outlined before field evidence is encountered, simply because the questions of earth history are not the exclusive domain of geology. However, those models will be only skeletons until they are tested and refined in the field. Any catastrophist concept of plate tectonics must be constrained within a biblical-Christian philosophical framework by evidence from all relevant historical sources. We are certain that Austin et al. (1994) would agree that the primary historical source is the scriptural record. The interplay between the scriptural constraints that outline a model, and the physical data that develop a model, should be examined and clarified. For example, is it the scriptural phrase ". . . all the fountains of the great deep burst open . . ." (Genesis 7:11, NASB) or geophysical datasets that require events similar to those described by plate tectonics? Clearly, whether the answer is "Genesis" or "geophysics," the specifics of evidence and analysis remain undefined. Therefore, in the context of a mixed question approach, the distinctions between constraining a model and developing it must be cited with precision to enable the reader to exercise critical thought with the same precision.

Catastrophic and uniformitarian plate tectonic concepts share assertions, inviting comparisons both supportive and critical. A wide variety of evidence has historically been submitted to demonstrate uniformitarian plate tectonics. A recent summary by Cronin (1992, pp. 13-14) would probably be accepted by a majority of geologists:

*The mixed question approach as defined by Adler (1965) recognizes that each intellectual discipline is based on its own special methods and special questions. When questions arise that cross disciplinary lines, they are addressed by a combination of disciplines (e. g., science and philosophy), and are considered mixed questions because they are not exclusively within the domain of any single discipline.