DATA VERSUS INTERPRETATION

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INTRODUCTION

To work in science, it is necessary to develop some basic concepts in order to process the variety of information that is obtained from research. What is thought to be knowledge or information can usually be divided into two separate concepts: data and interpretation. Since data is subject to alternative interpretations, researchers must carefully distinguish between the information that constitutes the collected data and the "information" derived from the data that is presented as evidence in support of a hypothesis. Scientists endeavor to be objective as much as is possible in this regard but several factors (biases) influence the selection and interpretation of the data.

This differentiation is no less important in the science classroom than it is in the science laboratory. The greatest difficulty with this process of separating data from interpretation lies within the context of textbook assignments. Textbooks are the prime sources for information in any classroom; however, in the science classroom the information that is provided is often more interpretation than data. Students need early training with respect to identification of data in exercises using the textbook. The development of such exercises will require additional effort on the part of the teacher but should yield more analysis on the part of the students and less explanation on the part of the teacher as the class progresses.

DATA AND INTERPRETATION

What is data? What is the difference between data and interpretation? Data consist of measurements, observations or statistics used as a basis for reasoning, discussion or calculation.[1] Data are usually regarded as unalterable facts but may or may not be true. As technology and science progress, "facts" will be discarded, modified or replaced with new data. For example, measurements may form a basis for identification of an object or phenomenon. Fossils of extinct organisms are often identified based on measurements of various structures on the body parts that have been preserved. This makes accurate identification difficult because with many of the extinct shelly fauna scientists do not know whether or not large organisms that have similar structure to small organisms represent different species, gender or developmental stage. The actual identifications or calculations are not data; they are interpretations. Much of the controversy that exists in the scientific literature is generated by a rather significant problem: interpretations drawn from limited databases. This point needs to be emphasized in every unit that is studied in any science classroom.

The Complexity of Data and Interpretations

The interplay between the data and interpretations can be illustrated by the microscopic examination of a very thin slice of rock (commonly referred to as a "thin section"). Polarized light (light that passes through the sample in only two directions) is used to conduct a series of tests on the light properties of the rock. The tests provide a database of light-transmission patterns that can be used by mineralogists to determine the mineral composition of the sample. The identification of the minerals is an interpretation that is based on the light property data. By examining the contact of one mineral with another and measuring how much of each mineral is

[1]Costello, Robert B. 1991. Webster's College Dictionary: Random House, p. 346.

present, the rock type can be determined. The geologist who identifies the rock considers the mineral identifications "data" even though the rock identification is actually an interpretation of an interpretation. (The mineralogical "data" was determined originally from the light property data.) The point is that the scope of what constitutes data is actually quite narrow.

Just how valid is identification? Identifications can be made using comparisons with standards. For example, three thin sections may have the same mineral composition but the mineral contacts may be very different. If the mineral grains are interlocking, the rock is an igneous rock. If the mineral grains are interlocking, elongated and aligned, it is a metamorphic rock, but if the minerals are cemented together, it is a sedimentary rock. If our terms are well defined, identification is fairly easy and relatively reliable.

Since data is limited to what we can measure or directly observe, we need to develop our ability to interpret the data so that we can develop reliable conclusions. An interpretation is an explanation, a means of presenting information in understandable terms.[2] Interpretations are limited by the availability of data and by the bias of the observer. In addition, there are several levels of interpretation. For example, a thin section made of round, beadlike rocks all cemented together must first be identified as some type of structure. So the first level of interpretation is to identify the little beads as oolites. A second level of interpretation is to explain how they were formed. From observations in modern environments geologists know that oolites are typically found near a shore where they are formed by the agitation of warm, shallow, saline waters. A third level of interpretation would be to apply this knowledge to oolites found in rocks on a

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[2]Ibid., p. 705.

mountainside. In other words, geologists take what they know about the modern setting and interpret the ancient setting accordingly. They assume that the oolites on the mountain formed at that sometime in the past in the same way that oolites form in the ocean or Great Salt Lake, Utah, U.S.A. That interpretation implies that oolites do not form in any other way; however, this implication may not be true. Another example is the patterns of sandstone that are called cross bedding. Typically, cross-beds are formed as currents (wind and/or water) deposit sand and silt on the lee slope of dunes. By integrating a broad range of data and interpretations (the minerals, rocks, oolites, and cross-bedding) geologists can now develop a fourth level of interpretation: modeling. Models provide scientists with a generalized framework for developing predictions and assessing events that may have occurred in the past.[3]

There is a distinct difference between data and interpretation that must be utilized when evaluating research. Data are actual measurements and observations. Interpretations try to explain what is measured and observed. The validity of an interpretation is based on how well the interpretation accommodates the available data. Interpretations change as the database changes. This is how science progresses.

THE PROBLEM OF BIAS

Scientists are painfully aware that some room for improvement exists since they are subject to error and misconception. They endeavor to maintain an attitude of objectivity with

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[3]Andrew D. Miall. 1984. Principles of Sedimentary Basin Analysis: Springer-Verlog, New York, p. 3.

respect to research.[4] This commitment to objectivity has created a sort of aura around scientists and, unfortunately, science has developed a popular image of "infallibility." People often prefer to believe that scientists are objective and deal with absolutes. In addition, some people think that when a scientist draws a conclusion, this indicates that all competing theories have been refuted and other questions have been resolved. A false sense of security has developed that scientists have defined immutable scientific laws that explain most observations. Some scientists do little to dispel this image. To complicate matters, the scientific community has adopted the position that any researcher having a religious bias is nonscientific; therefore, by definition, creation-science cannot be science. Such an attitude fails to recognize its own bias.[5]

TECHNICAL BIAS

There are some serious problems that are inherent in science. Scientists have both "technical" biases to overcome as well as the more subtle, even unconscious factors that influence them.

Sampling Constraints

As scientists grapple with technical problems, they may ask, "how can I acquire the data in a way that will minimize bias?" They ask that question because the first problem in gathering data is sampling bias. Every scientist has some preconceived ideas about the research that

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[4]Francisco Ayala, Robert McCormick Adams, Mary-Dell Chilton, Gerald Holton, Kumar Patel, Frank Press, Michael Ruse, and Philip Sharp. 1989. On Being a Scientist: National Academy of Sciences Press, Washington, D.C., p. 1.

[5]Del Ratzsch. 1996. The Battle of Beginnings: Why Neither Side Is Winning the Creation – Evolution Debate: InterVarsity Press, Downers Grove, Illinois, p. 158 – 179. See also: Philip E. Johnson. 1991. Darwin on Trial: InterVarsity Press, Downers Grove, Illinois, p. 6 – 12.

influences the selection of data. Random sampling helps minimize problems[6] but even then, there are choices made that favor a particular hypothesis. When I was an undergraduate student we were assigned a lab exercise that required us to conduct grain size analyses from a flood plain deposit. We worked in pairs as we collected our samples from within a grid, sieved each sample and plotted the grain size information. We knew from our textbooks what the graphs should look like for a flood plain deposit and we were plotting similar graphs. However, two men were having problems. They had picked up an oversized pebble that was skewing their graph. The discussion that ensued resulted in the removal of the "errata." Knowledge of the expected conclusion dictated the data that was accepted despite the use of a random sample.

Systematic Errors

A scientist may also have a blind spot: a failure to recognize data. It is common for a paleontologist who specializes in fossil snails to collect a wider variety of snails than anyone else on the mountainside. However, that same individual will have fewer clams and corals than other fossil collectors. It is even possible for that individual to find no clams or corals at that location. Why? That person has a built-in collecting bias. The collector was trained to find fossil snails and will mentally shut out all other fossil forms. These other fossils can have a significant impact on the interpretation of that site but the bias of the researcher eliminates that input.

Besides the problems involved with the acquisition of data, the processing of the data can introduce technical bias.[7] A researcher who consistently misidentifies a particular mineral

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[6]Ayala, et al., p. 5.

[7]Ibid. p. 5 – 6.

introduces a systematic error or bias into the results. Systematic errors are difficult to overcome and can cause serious problems in the process of theory development.

Technological Constraints

One example that best illustrates theory development and technical bias is the paleoenvironmental interpretations of the upright stumps in Yellowstone National Park, Wyoming, U.S.A.[8] For many years, there were six pieces of evidence advanced to "prove" that the stumps represented successive fossil forests. Each level of stumps was thought to represent a forest that had grown right in that area died, and was covered by dirt. Subsequently, a new forest had grown over the same region so that ultimately 48 or more forests were stacked one on top of the other. This region was later eroded to form the mountains we see in Yellowstone today. Today there is a total of 18 pieces of evidence that indicate that the "forests" are actually stumps that were catastrophically transported to the area during a series of volcanic eruptions from three, possibly four, different volcanoes. At one time the weight of evidence favored the forest interpretation; however, the weight of evidence now favors transport. The change in the database can be attributed partly to the use of available technology. Because interpretations are based on assumptions and available data, the available technology naturally contributes to the amount of available data.[9] The use of sonograms to detect upright stumps on the bottom of Spirit Lake for comparison to the Yellowstone stumps and x-ray fluorescence spectrometry of the volcanic ash

[8]Harold G. Coffin. 1997. They Yellowstone Petrified "Forests": Origins 24 (1): 5 – 44. See also: Harold G. Coffin. 1993. The Yellowstone Petrified Forest: Geoscience Research Institute File Paper, 9p.

[9]Harold L. Levin, 1978. The Earth Through Time: WB Saunders Company, Philadelphia, Pennsylvania, p. 17.

beds in Yellowstone greatly enhanced the ability of scientists to interpret the depositional environment for the petrified stumps found in the park. In addition, the quality of the data can be a limitation. For example, root systems broken by transport can be difficult to identify because the petrification process also results in breakage. Therefore, it was important that the cause of breakage be clearly determined. Some isolated specimens with roots broken during transport were identified but that evidence did not provide sufficient support for a transport model. Years of diligent work were required to establish a good quality database for the Yellowstone research.

Interpreting data can be very complex as seen in the Yellowstone deposit. However, the simplest scenario is usually preferred to the more complex in the development of theories. The development of simplified models with computer-generated systems produces technical bias because the simplified parameters place limits on the application of the model to real systems.[10]

Certainly, the analysis of the data introduces bias through the qualitative or subjective data that is included. Even the quantitative data is not always as objective as we would like to believe. For example, in the theory of plate tectonics the rate of spreading between two continents is calculated by averaging the rate of movement over a period of years because the margin of error for any given measurement is greater than the distances scientists are trying to measure.[11]

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[10]Ayala, et al., p. 6.

[11]Richard Monastersky. 1992. Satellites Catches Earthquake in Act: Science News (December 19 and 26), p. 429. Note: satellite resolution is 10 meters. Plate movement is estimated in centimeters per year. There are recent advertisements for positioning devices that can identify a site within one meter; however, margin of error is still greater than the distance being measured.

Rigorous testing is required by the scientific method before any theory can be accepted. Today, scientists live in a "publish or perish" environment. Time and monetary constraints limit this crucial testing process. New data is incorporated into current theory because it is easier to get material published if it is generally accepted by the scientific community. In 1986, "Science" magazine issued this statement, "it appears to be customary under the modern peer review system to categorically reject papers for publication that do not support the accepted dogma, irrespective of whether the dogma is fact or supposition." The funding process has an incredible influence on research today.[12] No papers, no money. It's that simple. The rigorous testing proposed by the scientific method is not cost-effective; so ideas and concepts are rushed into print and cited in subsequent publications. The monetary pressures are increasing the technical bias by limiting the experimental process. Students should be aware that research funding has significant control over published research. They need to know how science really works in the practical day-to-day system.

PARADIGM BIAS

Modern Analogs

In addition to the technical problems there are several unconscious influences at work among scientists.[13] All scientists have some basic assumptions. Basic assumptions are not provable. A typical example is the assumption that modern environments explain past deposition. These modern analogs are very popular in theory development but there are ancient

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[12]Francisco J. Ayala and Bert Black. 1993. Science and the Courts: American Scientist 81: 230 – 239.

[13]Ayala, et al. p. 6 – 9.

widespread deposits that are unlike anything being deposited in our modern settings. Scientists assume that processes similar to modern processes created these paleoenvironments. They also assume that the ancient rates of deposition and erosion were similar to the rates at which these processes occur today.[14] Modern analogs are used to imply that slow, gradual depositional and erosional processes were responsible for some very unique deposits, such as the Shinarump Formation. The Shinarump is a deposit that covers 260,000 square kilometers (100,000 square miles) and has a relatively uniform thickness of about 29 meters (90 feet).[15] To state that the deposition of this unit was slow, when there is evidence for rapid, high-energy deposition is ludicrous. (The unit is a coarse-grained sandstone/conglomerate deposit.) The grain-size alone requires considerable energy for transport. To attribute the deposition of such a widespread unit to hundreds of streams is equally ridiculous. There is no modern analog for such widespread, uniform deposits. Based on the lateral distribution, the best analog would have to be a large body of water but the Shinarump has been interpreted as a freshwater stream deposit. Using the present as "the key to the past" introduces bias and such assumptions may introduce a pervasive bias.

Training Biases

Each scientist also has some personal paradigm biases.[16] The influence of an individual's

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[14]Frank Press and Raymond Siever. 1986. Earth: W. H. Freeman & Co., New York, NY, 4th addition, p. 28 – 38.

[15]Larry T. Middleton, Ronald C. Blakey, Mary J. Kraus and Thomas M. Brown. 1985. Triassic-Jurassic Fluvial Systems, Northeastern Arizona: Guidebook for SEPM Field Trip Number 8, p. 95.

[16]Ayala, et al., p. 8.

training has enormous impact on that person's approach to science. Many schools pride themselves on the "mind set" of their graduates. Personal religious beliefs also make an impact. A naturalistic evolutionist will never look at a fossil and say, "this animal died in the Genesis flood." The thought that the Genesis flood may be responsible for the death of that life form will never cross that person's mind. Why? Because that individual does not even believe there was a worldwide flood. That's personal bias. In the same way, a creationist does not look at a fossil and say, "here is evidence for millions of years of evolution." Does that make them poor scientists? No. It shows that all scientists have a world view that governs their interpretations.

Peer Pressure: Reputation

Community paradigm biases include the pressure of reputation. Before unmanned probes went into space, the astronomers thought that Mercury's period of rotation required 88 days. Students conducted laboratory exercises to determine Mercury's period of rotation and they all concluded for decades that a single rotation occurred in 88 days. Then a rocket was launched and we discovered that Mercury's period of rotation is 59 days.[17] How could this happen? The man that first determine the period of rotation for Mercury was a very well respected astronomer, a meticulous researcher, and no one believed he could have made such a mistake.[18] His reputation introduced bias into the scientific community.

Peer Pressure: Traditional Interpretations

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[17]Theodore P. Snow. 1991. The Dynamic Universe: West Publishing Company, St. Paul, Minnesota, p. 223.

[18]Isaac Asimov. 1982. Asimov's Biographical Encyclopedia of Science and Technology: Doubleday, New York, NY, p. 386.

It is difficult to break with traditional interpretations. Scientists tend to find new things within a framework defined by the scientific community.[19] J. Harlen Bretz working in eastern Washington and Western Montana, U.S.A., discovered deposits that he thought could only be interpreted as a gigantic flood.[20] He was derided at professional meetings because everyone knew that such large-scale structures and erosion took a long time to form. A catastrophic flood was unreasonable. It took four decades of hard work and a lot of courage to prove that he was correct.

Peer Pressure: Popular Ideas

Another community bias comes from the "bandwagon philosophy." The extrapolation of glacial criteria that may or may not be due to glaciation throughout the geologic column worldwide is an example of this pressure. Once criteria were developed to identify glaciation, geologists were finding evidence for glaciation everywhere. Unfortunately, in most places they used only one or two criteria as evidence for glaciation. For example, debris flows are structurally very similar to glacial till. Both debris flows and glacial till consist of unsorted, somewhat angular sand, pebbles, cobbles, and boulders. Typically, glacial till has been differentiated from debris flows by the occurrence of faceted boulders within the deposit; however, the physical processes responsible for the faceting of the boulders occur in debris flows as well as in glacial till. In addition, the movement of debris flows may scour the underlying rock leaving a polished surface and/or a striated surface, i.e., extended linear gouges. All of these

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[19]Ayala and Black, p. 239.

[20]John Eliot Allen and Marjorie Burns.1986. Cataclysms on the Columbia: Timber Press, Portland, Oregon, 213p.

features were used in the 1960s as criteria to identify glaciated regions. Since such an interpretation requires multiple lines of evidence in a single locality, some of the work that was done during the glaciation bandwagon of the 1960s has been reinterpreted.[21] Today, land forms are considered more reliable criteria for determining glaciated regions but even land forms are subject to interpretation. Interpretations are very complex and scientists must be very careful when developing their conclusions.

Peer Pressure: Reviewed Publications

Science does have a mechanism for some self-correction and it is called the peer review process. Researchers submit their work and ideas to the scientific community in published reports. Professional journal editors send the papers to colleagues who have expertise in the same field to critique the papers. This approach has been very helpful to researchers since problematic material is often identified by the reviewers who then offer suggestions for additional research and/or improvement. Unfortunately, this self-correction occurs only within the major paradigms of the scientific community and is not applicable to those concepts advanced outside the current views.

IMPLICATIONS FOR SCIENCE AND RELIGION

Several points need to be considered with regard to the interface between science and

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[21]V. R. Oberbeck, J. R. Marshall and H. Aggarwal. 1993. Impacts, Tillites, and the Breakup of Gondwanaland: Journal of Geology 101: 1 – 19. See also: Jeffrey P. Schaffer. 1991. A Reinterpretation of the Effectiveness of Glaciers in Yosemite Valley, Sierra Nevada, CA: Geological Society of America, Abstracts with Program, p. A 255. Carolyn H. Eyles and Nicholas Eyles. 1989. The Upper Cenozoic White River "Tillites" of Southern Alaska: Sub-aerial Slope and Fan-delta Deposits in a Strike-Slip Setting: Geological Society of America Bulletin 101: 1091 – 1102.

religion. First, not all data are accurately measured and sometimes it is difficult to differentiate between data and interpretation. (Data is an actual observation, whereas interpretation is an explanation.) Certainly, multiple, alternative interpretations of any database are not only possible but probable. Second, bias is present in any interpretation because all scientific interpretations are subjective. (It is encouraging to know that most creation scientists openly acknowledge their bias.) Third, people need to understand the nature of science and how scientists work. People get discouraged because scientific interpretations are changing constantly and they don't know what to believe. However, that is the nature of science; that is how it advances. Once one truly grasps this aspect of science, one is reluctant to base theological beliefs on specific data or scientific concepts. Fourth, while science may be useful and provide relevant information, science should not dictate anyone's theology. If people allow science to dictate their theology, then every time scientific interpretations change, their theology must be altered whether that alteration is consistent with their personal experiences or not. On the other hand, theologies should not dictate anyone's science. Concepts such as "fixity of species" and "flat earth" came from theological positions based on a too literal interpretation of the Bible.[22] Scripture can supply legitimate working hypotheses and constraints for science. In fact, Scripture as an information source suggests avenues of investigation that would not be considered by most nonreligious persons. Such research should acknowledge any scriptural bias that may be present and all of the data must be fairly evaluated.

CONCLUSIONS

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[22]Personal communication/unpublished lecture information from Ben Clausen, Ph.D.

Scientists are fairly confident that they know what they are doing. However, science alone cannot assess the complete database because the scientific approach does not consider the possibility of supernatural involvement in nature and in the history of our earth. Most scientists believe there are irreconcilable conflicts between science and Scripture.[23] Francisco Ayala stated, "To claim that the statements of Genesis are scientific truth is to deny all the evidence.[24] The evidence does not prove either a long or short history for life. The evidence available provides very limited information. The data are not the problem in reconciling science and Scripture. It is the interpretation of the data that presents conflicts. It has also been said, "Not only is the present the key to the past, but the present is the key to the future."[25] Both the historical accounts of a worldwide flood and the prophetic accounts of Christ's second coming proclaim the falsity of that concept.[26] For Christians, the Bible provides a source of information that suggests there is a better way to approach science. From this perspective, harmony between science and Scripture can be recognized. In fact, Christians expect harmony because they recognize God as the Creator of nature and its scientific "laws."

[23]Colin Norman. 1986. Nobelists Unite Against "Creation Science": Science 233:935.

[24]Ibid., p. 935.

[25]Alan Baharlou. 1978. Personal communication that echoes sentiment of James Hutton in 1788, "The results, therefore, of our present inquiry is, that we find no vestige of a beginning – no prospect of an end." from Transactions of the Royal Society of Edinburgh.

[26]II Peter 3: 3 – 10.