ANTHR 1-L: Biological Anthropology
R. Mitchell, Instructor

Using Science to Think Anthropologically

Geoff Clark, a well-known expert on the Spanish Upper Paleolithic period, said to one of us recently, "I am a scientist first, an anthropologist second, and an archaeologist third." By using this order, he is stating that he thinks like a scientist first (method), like an anthropologist second (broad-based content), and like an archaeologist last (specific content). No matter what our specialization in anthropology, we must first and foremost think scientifically and as a student of anthropology, you must think scientifically too. How do we do this?

Science is a way of thinking about something. It is a method of seeking knowledge. It does not necessarily involve bubbling retorts or white lab coats. Because scientists believe there is an orderly world out there where events (past or present) can be explained if adequate observation or data are used properly, that world can be known. And it is **knowledge** that scientists are searching for. Science goes beyond data gathering and description to explain things and happenings.

For example, **biological anthropologists** do not just excavate and then describe fossils of our ancestors who lived before us; they attempt to explain why there has been change between then and now and, if there is a large enough sample, why one fossil looks different from one that is the same age. **Archaeologists** don't just describe the flint tools they excavate; they try to explain how those tools were used. And although it seems quite different, other anthropologists use what people do and say as the data they examine. A **cultural anthropologist** doing research in rural India might note that there is a widespread presence of cattle even in areas of malnutrition and wonder why people do not eat beef (Harris 1965). A specialist in **linguistics** in the same neighborhood would note the symbols for sounds in the language spoken by the people and then attempt to figure out how they can engage in trade with a neighboring group who speak a totally different language.

Scientists do not have to use statistics or do experiments to do science. All they have to do is think scientifically. To think scientifically is to do science, and doing science concerns its method. What scientists use is **the scientific method**. The scientific method begins with something worth investigating, some question for which we do not have an answer. If there is a question, there is probably more than one possible answer to it. When the question is stated with a possible answer, it becomes a **hypothesis**. Put another way, a hypothesis is a good guess about something. Here are some anthropological examples. "I hypothesize that modern humans were on Earth about 100,000 years ago." This is a good guess based on existing fossil finds and modern dating techniques. "He hypothesized that many more tools could be made from a flint nodule if the flint knapper made blades instead of flakes." This is a good guess based on previous flint knapping experiments by a flint knapper (Note: Flint knapping is making modern tools of flint using techniques deduced from observing marks on prehistoric tools). "I hypothesize that Indian farmers don't eat their cattle because they are more useful as plow animals, and if they eat them they won't be able to farm." This is a good guess based on observation and talking with the farmers. Finally, "I hypothesize that people in New Guinea highland can trade with neighbors who do not speak their language because what they are trading is very valuable to them, and they are able to do the actual trade through gestures." This is also a good guess based again on observation (the gestures) and talking to the people involved.

Whichever hypothesis you want to follow through on, the fossil, the artifact, the customs, or the language, the next step is to attempt to discover whether it is false or supported. Many interesting things cannot be falsified and therefore are not subject to scientific investigation. Some of us would like to know whether the Tooth Fairy exists, but hypothesizing that it does exist (or does not) is not scientific because the hypothesis cannot be falsified.

To **test** any of these hypotheses, the scientist-anthropologist would have to gather data pertinent to the question asked to falsify or support it. You can't gather and use data on penguins to answer a question about human burial rituals. The fossils, artifacts, observations on customs, and tape recordings of the spoken language are all considered **evidence** or **data** and are used to support or falsify a particular hypothesis. If the evidence supports the hypothesis, it is supported; if not, it is falsified.

What do we mean by evidence or data supporting or falsifying any hypothesis? For the hypothesis suggesting modern humans had evolved by 100,000 years ago, if a bioanthropologist finds a new complete fossil in Ethiopia that was securely dated at 140,000 years ago and showed traits that were 98% the same as contemporary humans, the hypothesis about the date would be supported. If, however, that well dated fossil showed numerous traits that linked t closer to previous species in our lineage, the hypothesis would be falsified, that is, not supported. To take one more example, if a modern flint knapper could make twice as many useable blades as flakes from the same size flint nodule, they hypothesis that claimed people changed their tool making because they could make more tools with the same amount of flint would e supported. But if a modern female flint knapper made fewer blades than flakes, the hypothesis would be falsified. We do not know if only one sex of our ancestors made tools but can assume that males have always had more upper arm strength than women. As the leading philosopher of science, Karl Popper, said many years ago, if a hypothesis cannot be falsified, it isn't science. We would add that if a hypothesis is falsified, it is "back to the drawing board."

Testing hypotheses is not the solitary job of a single scientist testing and retesting his or her own work. Other scientists take a skeptical position and retest the hypothesis to see whether they get the same results. If the same data and methods are used, **replication** can support or refute the hypothesis. Thus, science is a collective rather than an individual enterprise.

Hypotheses can be found to be false, but they **cannot be proved** because all of the data pertinent to answering the question are never available. We do not have the remains of all of the people who were alive 100,000 years ago, we do not have all of the flint blades and flakes ever made, we were not in India or New Guinea when most social customs originated, and we cannot watch every trading expedition. Scientists never use the terms "proof" or "prove" because they imply certainty. The same is true of the word "truth" because it implies certainty beyond a shadow of a doubt. Scientists know better than to even claim they search for truth because it is unattainable. They are content with finding **knowledge**, defined as a description of something that is probably correct, given the available data. But if truth and proof are finite and nonchanging, knowledge is changeable and fluid. Today's knowledge is yesterday's antiquated myth, and tomorrow's knowledge will show that half of what we think we know now is wrong. Scientists look for change in knowledge, and it is healthy to be skeptical about one's own work as well as that of others.

Some change in knowledge is slow in coming; some is very fast. As an example of slow change in knowledge, consider how biological traits are transmitted from one generation to another. For thousands of years, people have certainly noticed that children look more like their parents than they look like strangers. Until the nineteenth century, scientists thought traits were carried in the blood; then Gregor Mendel devised his Laws of Inheritance, with 34 years elapsing until his ideas became known and accepted. Finally, it was another 50 years before we could speak of the beginning of modern genetics in the 1950s.

Other changes in knowledge are remarkably speedy, such as the discovery of the Ice Man, a mummy found on the Austrian-Italian border in the Alps in 1991. When first discovered, it was thought to be a casualty of a previous year's bad storm, but the condition of the body tissue suggested it was old. At first, it was dated as perhaps 2,000 years old, but more recently, carbon 14 dated the mummy at 5,300 years ago. As to the cause of his death, early knowledge suggested that he froze to death, and then the ice and snow desiccated his tissue, mummifying it. Very recently, a computed axial tomography (CAT) scan discovered an arrow in his shoulder, and it is now believed that this caused his death, directly or indirectly (Bahn 2002; Fowler 2000). At any point in the past decade, our knowledge about the Ice Man was based on data we had at that time, but as additional evidence became available, our knowledge changed. And it will continue to change. It is a good thing that none of the scientists involved claimed to have "proved" anything!

There are two variations of the scientific method in terms of the order of steps taken to go from interesting findings to conclusions. If a hypothesis is generated about something interesting before any data are gathered (observations made, people talked to, languages heard), the type of science is called **deductive science**. That hypothesis could have come from someone else's previous work that the particular scientist did not agree with, or it could have come from a brainstorming session with other scientists over a beer at the end of a day, or it could have come in a dream. The point is that it is a good guess about something, as in "I bet they can trade with their neighbors through gesture even if they can't understand each other." In deductive science, the scientist then gathers appropriate data to see whether it supports that guess. If it does, it is supported; if not, it was a bad guess. The other variation is called **inductive science**. In inductive methods, data about a particular subject of interest are freely gathered, with no preconceived idea of whether they will answer any question or how they would answer any question. Out of the data gathering and analysis comes a tentative conclusion about that subject, and that conclusion becomes the hypothesis. Now different data must be gathered to test the hypothesis for support or falsification. So, regardless of where in the process one begins, the process is the same; hypothesis, data gathering, data analysis, conclusions.

Here are three examples of inductively and deductively generated research projects:

1) Everyone "knows" that 25,000-year-old Venus statuettes from the European Upper Paleolithic period and carved from ivory, bone, or precious stone were fertility dolls. Right? Not necessarily. A female anthropologist wondered whether the anthropologists who had studied Venus statuettes previously---all male---were biased by the obvious nakedness of the statuettes and attributed fertility to them because of it. She decided to look at every one of the 180 Venuses and assess each relative to its age (did the artist attempt to sculpt a young, middle-aged, or old woman?) and state of pregnancy (did the artist attempt to sculpt a pregnant woman?). After categorizing every possible Venus, the result was that only 17 percent of the statuettes were both in the right age category and obviously pregnant. Not only did this suggest that the fertility doll idea was incorrect, but the conclusions also led to a new hypothesis: women were sculpted because they provided most of the food eaten by the group, did become pregnant and have babies, and were the important focus of house and home (Rice 1981). New evidence was then gathered to support (or not) the new hypothesis. You should recognize this as **inductive** research because data were freely gathered, resulting in a hypothesis. It also suggests that male and female scientists observe the same things—in this case Venus statuettes—differently just because they are of different sexes.
2) A specialist in prehistoric art published research that concluded that a painting on the ceiling of the famous 18,000-year-old Altamira ceiling was a bison, not a wild boar, as previous experts believed. Another specialist in prehistoric art in turn questioned the bison identification of the animal and set out to find data to support the hypothesis that it was a boar after all. This specialist measured various points on the animals in question, other bison and boars in cave art, and live bison and boars and came up with four ratios that described the shape of the two animals (relative leg length and body shape). By comparing the ratios of all of the animals, the specialist found that the animal in question matched the boar, not the bison (Rice 1992). You should recognize this as **deductive** research because the researcher had already generated the hypothesis ("It is a boar") before collecting any data (the ratios).
3) If you wonder whether Maya women become farmers because there is increasing economic need where they live and decide to test this hypothesis by conducting research in southern Mexico, this is deductive science because your hypothesis, "Rural Maya women will enter farming because of economic need," precedes your trip to Mexico. You have already predicted a reason for the Maya women to become farmers. But when you arrive and discover that indeed there is economic need but that women are becoming commercial weavers, not farmers, your hypothesis is disproved or falsified. So, like any good researcher, you collect a lot of data about women weavers. You ask them about where they live, what they weave, and how they learned to weave, and about their friends, communities, religions, and families. This is inductive science because the data were gathered freely, with no assumed question asked. Although this sounds a good deal like plain conversation, and it is, it is also more evidence for other questions you might ask. When you return from your field work and analyze your evidence, if you discover that those Maya women who live in urban settings and are Protestant converts don't know how to weave and sell commercially made crafts, whereas rural women who still learn weaving from their mothers sell traditional hand-woven crafts, this becomes an inductive hypothesis ("Protestant women are less likely than Catholic women to know and use traditional weaving skills") that arose

after you collected your data (O'Brian 1994). You would probably return to collect new data, perhaps quantitative, to support or reject that hypothesis and then perhaps move into some of the "why" questions. Research generates further research.

The word **hypothesis** has another scientific meaning related to the **level of confidence** a scientist has about the results of an investigation. If a scientist has medium amount of confidence in a conclusion, perhaps because he or she did the actual work, the phrase "the hypothesis is supported" is appropriate. If that hypothesis is tested and retested by many different scientists over a period of years and it is still supported (not rejected or found to be false), its level of confidence raises it to the level of **a theory**. When a theory has been around for a hundred years or more and hundreds of scientists have tried to disprove it with no luck, its level of confidence is extremely high, and we call it a **law**. Any one of these---hypothesis, theory, or law---can still be found to be false, but the higher the confidence level, the less likely it is to be found false.

For example, when Charles Darwin came up with the idea of natural selection, it was a hypothesis. It explained some observable things in nature, such as the shape of tortoise shells in the Galapagos Islands, but there was a lot about nature that was still unknown, such as genetics. By the turn of the twentieth century, scientists knew about mutations and some genetic principles, and more of the biological world could be explain- ed by natural selection. At this point, natural selection became a theory because the original hypothesis had gained in its level of confidence. It has now been close to 150 years since the *Origin of Species* was published, with thousands of scientists attempting to disprove natural selection. It has been tweaked and changed in place, but in general Darwin's version of natural selection has not changed. Our level of confidence in it gives it law-like status. Thus hypothesis, theory, law are place on a continuum of scientific confidence. Not much knowledge is law-like, the term "theory" tends to be overused, and thus most of what knowledge we have is in the form of hypotheses, ready to move to a higher level of confidence, if merited or tested yet again to see whether it remains supported.

An example of a hypothesis in the bioarchaeological world of anthropology that is still being tested and retested concerns the role of Neandertal in modern human ancestry. The hypotheses could be stated either way. They were in our ancestry or they were not, and the hypothesis might be, "Neandertals were a separate species from *Homo sapiens* in Europe even though they overlapped there for perhaps 10,000 years." Some experts have tested the hypothesis by comparing fossils of the two populations, concluding that they differ in enough traits to call them different species and that they were not in our ancestry at all; some have tested it using mitochondrial DNA, concluding that there are too many differences for them to be a single species. These tests supported the hypotheses. But other experts point to a number of biological traits occurring in the vast majority of Neandertal fossils and subsequently in modern human invaders and claim that those traits have come about through interbreeding of the two populations. This rejects the hypothesis. The point here is that scientists keep testing and retesting hypotheses, and in some cases new research supports and in some cases it rejects that hypothesis. Sometimes falsification removes the hypothesis from further study, whereas in the case of the Neandertal hypotheses, sides are so entrenched that the testing on both sides will continue.

A cultural example of testing and retesting refers to how people rear and understand children and teenagers, something that is of fundamental interest to most people. In the 1920s, Margaret Mead hypothesized that raising children in the traditional Polynesian society of Samoa would produce relaxed, easygoing teenagers. She suggested that they differed dramatically from American teenagers, who seemed full of emotional turmoil. Mead concluded that the seeming difference between Samoan and American teenagers meant that adolescence was strongly shaped by culture, not biology (Mead 1928).

Much later, in the 1980s, another anthropologist, Derek Freeman, using data he had collected from elsewhere in Samoa in the 1940s, argued that Samoan teenagers had a good deal of anxiety and turmoil, although they expressed it differently from Americans. He argued that, contrary to Mead, adolescence probably was a biological state experienced by teenagers in all cultures (Freeman 1983). Freeman's work has been criticized by other anthropologists wanting to test his hypothesis. It appears that Mead and Freeman both were a little bit right and a little bit wrong and that at least some adolescent moodiness is biologically driven but that culture, the rules and ideas of a given society, shapes the way teenagers behave and express their emotions. The issue is not closed, and other cultural anthropologists will continue to test the biological and cultural hypotheses with data from groups they have studied.

What do scientists mean when they speak or write of **data** or **evidence**? How do they get it? What do they do with it? Anthropological data or evidence varies by subdiscipline. To a biological anthropologist, the data may come from excavating fossils, analyzing fossils found by others, or work on modern people. Some biological anthropologists, such as Meave Leakey, Alan Walker, or Don Johanson purposely look for fossils in our human lineage, Meave Leakey and Alan Walker at sites in Kenya looking for fossils that are in the neighborhood of 3 to 1 million years ago and Don Johanson in Ethiopia looking for fossils several million years older than this. Other biological anthropologists compare single anatomical features through time, such as evidence of bipedalism or brain capacities.

Archaeologists often use the physical **artifacts** such as tools as their data or evidence, but they can also use ecofacts such as pollen to indicate prehistoric diet or environmental context. Although tools are important because they tell archaeologists what people did for a living, often the nature of trade, and sometimes even social organization, other artifacts tell us even more: a bit of twine embossed in a chunk of clay tells us that 24,000 years ago, people were making twine and probably weaving cloth or making nets for fishing. Grains stuck in fired pottery can tell us what crops might have been domesticated. Cave paintings going back as early as 32,000 years ago and Venus figurines may tell us about social organization and the relative rank of the sexes in Paleolithic times (Rice and Paterson 1988). Finally, the finding of burials, shrines, or statuary may give us a glimpse of people's religion in prehistoric times. By definition, an artifact is any remains of something made by a human in the past such as a tool, a cave painting, or a burial. They normally don't "speak for them- selves," and have to be interpreted, but they are evidence nonetheless.

Culturally, evidence includes the tools modern people use, but it can also be people's behavior, their conversations and ideas, and their traditions and customs. For example, if an ethnographer visits people in a lowland Amazonian village and writes down whatever he observes them doing when he arrives and does this many times over the course of a number of months, he can discover, statistically, how people spend their days. Although the people may tell the ethnographer one thing—that men work harder than women, for example—the data from all of those visits might show that women work more because when families sit around and talk after a meal, women also busy themselves with tasks while men and children do not. Indeed, Allen Johnson (1975), working among the Machiguenga in Peru, found exactly that and showed how his careful collection of time allocation data provided results that surprised even him.

In this cultural example, all the simple things that people do in their daily lives have been transformed into evidence, and understanding its larger meaning depends on how the anthropologist collects and analyzes it. You can also see that the collection and analysis of data can show that what people say may not be accurate, and that in itself might suggest further questions to ask. In the example, you might want to ask why women's work seems less hard or why people seem to ignore it. This question, based on the analysis of your previous work, would lead you to more research.

CONCLUSION

Thinking scientifically will put you in the proper attitude for thinking anthropologically, which in turn will allow you to think human biology, archaeology, linguistics, or cultural anthropology. When you read about current evidence supporting a particular hypothesis, remember that it is not necessarily the last word. New evidence may be discovered that forces scientists to change their conclusions and perhaps ask new questions. That means that you should be skeptical and keep an open mind, realizing that there are different degrees of confidence given to each finding, and that science is self-correcting. Today's factoids may be tomorrow's corrected knowledge. And science continues, getting better and better at explaining that knowable world out there.

NOTE

1. Anthropologists do not all take the same approach to try to understand the world: humanistic anthropologists focus on cultural meaning, critical anthropologists focus on social evaluation and policy, and scientific anthropologists use the scientific method to explain what it is to be human. This chapter focuses on the scientific approach.