Book of Mormon and DNA Studies

The Church of Jesus Christ of Latter-day Saints affirms that the Book of Mormon is a volume of sacred scripture comparable to the Bible. It contains a record of God's dealings with three groups of people who migrated from the Near East or West Asia to the Americas hundreds of years before the arrival of Europeans.

Although the primary purpose of the Book of Mormon is more spiritual than historical, some people have wondered whether the migrations it describes are compatible with scientific studies of ancient America. The discussion has centered on the field of population genetics and developments in DNA science. Some have contended that the migrations mentioned in the Book of Mormon did not occur because the majority of DNA identified to date in modern native peoples most closely resembles that of eastern Asian populations.

Basic principles of population genetics suggest the need for a more careful approach to the data. The conclusions of genetics, like those of any science, are tentative, and much work remains to be done to fully understand the origins of the native populations of the Americas. Nothing is known about the DNA of Book of Mormon peoples, and even if their genetic profile were known, there are sound scientific reasons that it might remain undetected. For these same reasons, arguments that some defenders of the Book of Mormon make based on DNA studies are also speculative. In short, DNA studies cannot be used decisively to either affirm or reject the historical authenticity of the Book of Mormon.

The Ancestors of the American Indians

The evidence assembled to date suggests that the majority of Native Americans carry largely Asian DNA. Scientists theorize that in an era that predated Book of Mormon accounts, a relatively small group of people migrated from northeast Asia to the Americas by way of a land bridge that connected Siberia to Alaska. These people, scientists say, spread rapidly to fill North and South America and were likely the primary ancestors of modern American Indians.

The Book of Mormon provides little direct information about cultural contact between the peoples it describes and others who may have lived nearby. Consequently, most early Latter-day Saints assumed that Near Easterners or West Asians like Jared, Lehi, Mulek, and their companions were the first or the largest or even the only groups to settle

the Americas. Building upon this assumption, critics insist that the Book of Mormon does not allow for the presence of other large populations in the Americas and that, therefore, Near Eastern DNA should be easily identifiable among modern native groups.

The Book of Mormon itself, however, does not claim that the peoples it describes were either the predominant or the exclusive inhabitants of the lands they occupied. In fact, cultural and demographic clues in its text hint at the presence of other groups. At the April 1929 general conference, President Anthony W. Ivins of the First Presidency cautioned: "We must be careful in the conclusions that we reach. The Book of Mormon … does not tell us that there was no one here before them [the peoples it describes]. It does not tell us that people did not come after."

Joseph Smith appears to have been open to the idea of migrations other than those described in the Book of Mormon, and many Latter-day Saint leaders and scholars over the past century have found the Book of Mormon account to be fully consistent with the presence of other established populations. The 2006 update to the introduction of the Book of Mormon reflects this understanding by stating that Book of Mormon peoples were "among the ancestors of the American Indians."

Nothing is known about the extent of intermarriage and genetic mixing between Book of Mormon peoples or their descendants and other inhabitants of the Americas, though some mixing appears evident, even during the period covered by the book's text. What seems clear is that the DNA of Book of Mormon peoples likely represented only a fraction of all DNA in ancient America. Finding and clearly identifying their DNA today may be asking more of the science of population genetics than it is capable of providing.

Understanding the Genetic Evidence

A brief review of the basic principles of genetics will help explain how scientists use DNA to study ancient populations. It will also highlight the difficulty of drawing conclusions about the Book of Mormon from the study of genetics.

DNA—the set of instructions for building and sustaining life—is found in the nucleus of almost every human cell. It is organized in 46 units called chromosomes—23 received from each parent. These chromosomes contain about 3.2 billion instructions. Any two individuals share approximately 99.9 percent of their genetic arrangement, but the thousands of small differences account for the tremendous variation between people.

Genetic variations are introduced through what geneticists call random mutation. Mutations are errors that occur as DNA is copied during the formation of reproductive cells. These mutations accumulate over time as they are passed from generation to generation, resulting in unique genetic profiles. The inheritance pattern of the first 22 pairs of chromosomes (called autosomes) is characterized by continuous shuffling: half of the DNA from both the father and the mother recombine to form the DNA of their children. The 23rd pair of chromosomes determines the gender of a child (XY for a male, XX for a female). Because only males have the Y chromosome, a son inherits this chromosome mostly intact from his father.

Human cells also have DNA in a series of cell components called the mitochondria. Mitochondrial DNA is relatively small—containing approximately 17,000 instructions—and is inherited largely intact from the mother. A mother's mitochondrial DNA is passed to all of her children, but only her daughters will pass their mitochondrial DNA to the next generation.

Mitochondrial DNA was the first type of DNA to be sequenced and was thus the first that geneticists used to study populations. As technology has improved, analysis of autosomal DNA has allowed geneticists to conduct sophisticated studies involving combinations of multiple genetic markers.

Population geneticists attempt to reconstruct the origins, migrations, and relationships of populations using modern and ancient DNA samples. Examining available data, scientists have identified combinations of mutations that are distinctive of populations in different regions of the world. Unique mitochondrial DNA and Y-chromosome profiles are called haplogroups. Scientists designate these haplogroups with letters of the alphabet.

At the present time, scientific consensus holds that the vast majority of Native Americans belong to sub-branches of the Y-chromosome haplogroups C and Q and the mitochondrial DNA haplogroups A, B, C, D, and X, all of which appear to have come to the Americas via migrations from East Asia. Ongoing studies continue to provide new insights that both challenge and confirm previous conclusions. For example, a 2014 study indicates that as much as one-third of Native American DNA may have originated anciently in Europe or West Asia. From this evidence, scientists conclude that some Europeans or West Asians migrated eastward across Asia, mixing with a group that eventually migrated to the Americas millennia before the events described in the Book of Mormon.

Additional DNA markers from Europe, West Asia, and Africa exist in the DNA of modern native populations, but it is difficult to determine

whether they are the result of migrations that predated Columbus, such as those described in the Book of Mormon, or whether they stem from genetic mixing that occurred after the European conquest. This is due in part to the fact that the "molecular clock" used by scientists to date Y-chromosome and mitochondrial DNA markers is not sufficiently sensitive to pinpoint the timing of migrations that occurred as recently as a few hundred or even a few thousand years ago. Moreover, no molecular clock is currently available for complete genomes.

Scientists do not rule out the possibility of additional, small-scale migrations to the Americas. For example, a 2010 genetic analysis of a well-preserved 4,000-year-old Paleo-Eskimo in Greenland led scientists to hypothesize that a group of people besides those from East Asia had migrated to the Americas. Commenting on this study, population geneticist Marcus Feldman of Stanford University said: "Models that suggest a single one-time migration are generally regarded as idealized systems. … There may have been small amounts of migrations going on for millennia."

The Founder Effect

One reason it is difficult to use DNA evidence to draw definite conclusions about Book of Mormon peoples is that nothing is known about the DNA that Lehi, Sariah, Ishmael, and others brought to the Americas. Even if geneticists had a database of the DNA that now exists among all modern American Indian groups, it would be impossible to know exactly what to search for. It is possible that each member of the emigrating parties described in the Book of Mormon had DNA typical of the Near East, but it is likewise possible that some of them carried DNA more typical of other regions. In this case, their descendants might inherit a genetic profile that would be unexpected given their family's place of origin. This phenomenon is called the founder effect.

Consider the case of Dr. Ugo A. Perego, a Latter-day Saint population geneticist. His genealogy confirms that he is a multigeneration Italian, but the DNA of his paternal genetic lineage is from a branch of the Asian/Native American haplogroup C. This likely means that, somewhere along the line, a migratory event from Asia to Europe led to the introduction of DNA atypical of Perego's place of origin. If Perego and his family were to colonize an isolated landmass, future geneticists conducting a study of his descendants' Y chromosomes might conclude that the original settlers of that landmass were from Asia rather than Italy. This hypothetical story shows that conclusions about the genetics of a population must be informed by a clear understanding of the DNA

of the population's founders. In the case of the Book of Mormon, clear information of that kind is unavailable.

Population Bottleneck and Genetic Drift

The difficulties do not end with the founder effect. Even if it were known with a high degree of certainty that the emigrants described in the Book of Mormon had what might be considered typically Near Eastern DNA, it is quite possible that their DNA markers did not survive the intervening centuries. Principles well known to scientists, including population bottleneck and genetic drift, often lead to the loss of genetic markers or make those markers nearly impossible to detect.

Population Bottleneck

Population bottleneck is the loss of genetic variation that occurs when a natural disaster, epidemic disease, massive war, or other calamity results in the death of a substantial part of a population. These events may severely reduce or totally eliminate certain genetic profiles. In such cases, a population may regain genetic diversity over time through mutation, but much of the diversity that previously existed is irretrievably lost.

In addition to the catastrophic war at the end of the Book of Mormon, the European conquest of the Americas in the 15th and 16th centuries touched off just such a cataclysmic chain of events. As a result of war and the spread of disease, many Native American groups experienced devastating population losses. One molecular anthropologist observed that the conquest "squeezed the entire Amerindian population through a genetic bottleneck." He concluded, "This population reduction has forever altered the genetics of the surviving groups, thus complicating any attempts at reconstructing the pre-Columbian genetic structure of most New World groups."

Genetic Drift

Genetic drift is the gradual loss of genetic markers in small populations due to random events. A simple illustration is often used to teach this concept:

Fill a jar with 20 marbles—10 red, 10 blue. The jar represents a population, and the marbles represent people with different genetic profiles. Draw a marble at random from this population, record its color, and place it back in the jar. Each draw represents the birth of a child. Draw 20 times to simulate a new generation within the population. The second generation could have an equal number of each color, but more likely it will have an uneven number of the two colors.

Before you draw a third generation, adjust the proportion of each color in the jar to reflect the new mix of genetic profiles in the gene pool. As you continue drawing, the now-uneven mix will lead to ever more frequent draws of the dominant color. Over several generations, this "drift" toward one color will almost certainly result in the disappearance of the other color.

This exercise illustrates the inheritance pattern of genetic material over the course of several generations and shows how drift can result in the loss of genetic profiles. The effect of drift is especially pronounced in small, isolated populations or in cases where a small group carrying a distinct genetic profile intermingles with a much larger population of a different lineage.

A study in Iceland combining both genetic and genealogical data demonstrates that the majority of people living in that country today inherited mitochondrial DNA from just a small percentage of the people who lived there only 300 years ago. The mitochondrial DNA of the majority of Icelanders living at that time simply did not survive the random effects of drift. It is conceivable that much of the DNA of Book of Mormon peoples did not survive for the same reason.

Genetic drift particularly affects mitochondrial DNA and Y-chromosome DNA, but it also leads to the loss of variation in autosomal DNA. When a small population mixes with a large one, combinations of autosomal markers typical of the smaller group become rapidly overwhelmed or swamped by those of the larger. The smaller group's markers soon become rare in the combined population and may go extinct due to the effects of genetic drift and bottlenecks as described above. Moreover, the shuffling and recombination of autosomal DNA from generation to generation produces new combinations of markers in which the predominant genetic signal comes from the larger original population. This can make the combinations of markers characteristic of the smaller group so diluted that they cannot be reliably identified.

The authors of a 2008 paper in the *American Journal of Physical Anthropology* summarized the impact of these forces succinctly: "Genetic drift has been a significant force [on Native American genetics], and together with a major population crash after European contact, has altered haplogroup frequencies and caused the loss of many haplotypes." Genetic profiles may be entirely lost, and combinations that once existed may become so diluted that they are difficult to detect. Thus, portions of a population may in fact be related genealogically to an individual or group but not have DNA that can be identified as belonging to those ancestors. In other words, Native Americans whose ancestors include Book of Mormon peoples may not be able to confirm that relationship using their DNA.

Conclusion

Much as critics and defenders of the Book of Mormon would like to use DNA studies to support their views, the evidence is simply inconclusive. Nothing is known about the DNA of Book of Mormon peoples. Even if such information were known, processes such as population bottleneck, genetic drift, and post-Columbian immigration from West Eurasia make it unlikely that their DNA could be detected today. As Elder Dallin H. Oaks of the Quorum of the Twelve Apostles observed, “It is our position that secular evidence can neither prove nor disprove the authenticity of the Book of Mormon.”

Book of Mormon record keepers were primarily concerned with conveying religious truths and preserving the spiritual heritage of their people. They prayed that, in spite of the prophesied destruction of most of their people, their record would be preserved and one day help restore a knowledge of the fulness of the gospel of Jesus Christ. Their promise to all who study the book “with a sincere heart, with real intent, having faith in Christ,” is that God “will manifest the truth of it unto you, by the power of the Holy Ghost.” For countless individuals who have applied this test of the book’s authenticity, the Book of Mormon stands as a volume of sacred scripture with the power to bring them closer to Jesus Christ.

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