

# 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.<sup>1</sup>

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.<sup>2</sup>

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.<sup>3</sup> 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.<sup>4</sup> These people, scientists say, spread rapidly to fill North and South America and were likely the primary ancestors of modern American Indians.<sup>5</sup>

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.<sup>6</sup> 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."<sup>7</sup>

Joseph Smith appears to have been open to the idea of migrations other than those described in the Book of Mormon,<sup>8</sup> 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.<sup>9</sup> 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.”<sup>10</sup>

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.<sup>11</sup> 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% 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.<sup>12</sup> Scientists designate these haplogroups with letters of the alphabet.<sup>13</sup>

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<sup>14</sup> and the mitochondrial DNA haplogroups A, B, C, D, and X, all of which are predominantly East Asian.<sup>15</sup> But the picture is not entirely clear. Continuing studies provide new insights, and some challenge previous conclusions. For example, a 2013 study states that as much as one-third of Native American DNA originated anciently in Europe or West Asia and was likely introduced into the gene pool before the earliest migration to the

Americas.<sup>16</sup> This study paints a more complex picture than is suggested by the prevailing opinion that all Native American DNA is essentially East Asian.

While Near Eastern DNA markers do exist in the DNA of modern native populations, 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 the appearance of genetic markers is not always accurate enough to pinpoint the timing of migrations that occurred as recently as a few hundred or even a few thousand years ago.<sup>17</sup>

Scientists do not rule out the possibility of additional, small-scale migrations to the Americas.<sup>18</sup> 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.<sup>19</sup> 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.”<sup>20</sup>

## 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.<sup>21</sup> 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.

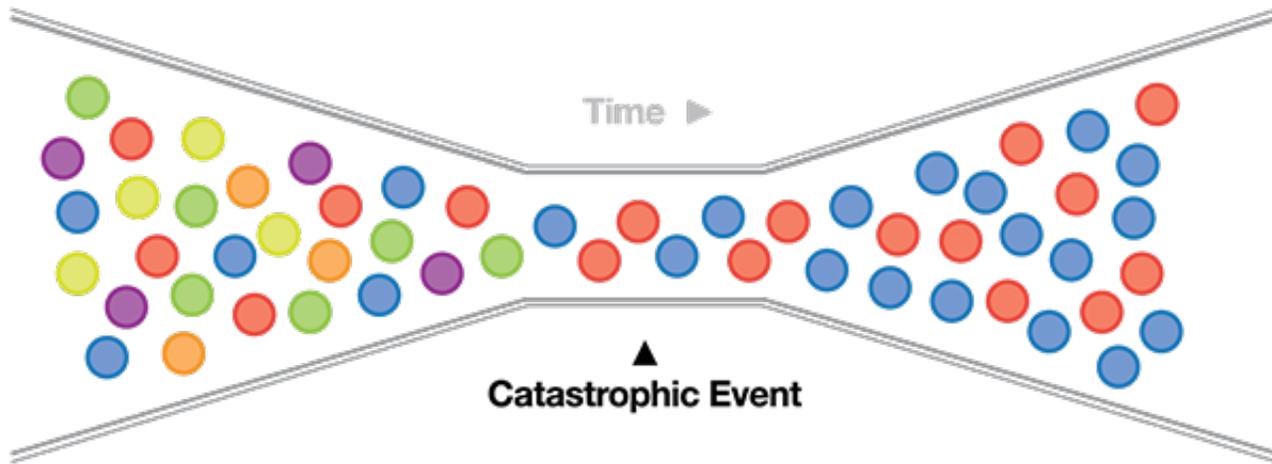


Illustration of population bottleneck. Due to a dramatic reduction in population, some genetic profiles (represented here by the yellow, orange, green, and purple circles), are lost. Subsequent generations inherit only the DNA of the survivors.

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.<sup>22</sup> 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.”<sup>23</sup>

## 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.

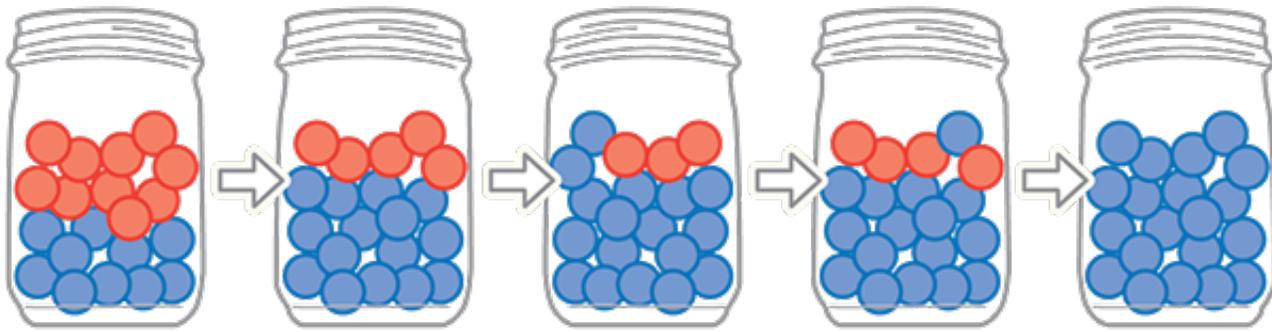


Illustration of genetic drift using colored marbles.

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.<sup>24</sup> 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."<sup>25</sup> 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.<sup>26</sup>

## 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.”<sup>27</sup>

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.”<sup>28</sup> 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.

## Resources

1. See introduction to the Book of Mormon.
2. This article uses the terms *Native American* and *American Indian* to refer to all the indigenous peoples of both North and South America. For more on the relationship of DNA studies and the Book of Mormon generally see Ugo A. Perego, “The Book of Mormon and the Origin of Native Americans from a Maternally Inherited DNA Standpoint,” in Robert L. Millet, ed., *No Weapon Shall Prosper: New Light on Sensitive Issues* (Provo, UT: Brigham Young University Religious Studies Center, 2011), 171–216; Michael F. Whiting, “DNA and the Book of Mormon: A Phylogenetic Perspective,” *Journal of Book of Mormon Studies* 12, no. 1 (2003), 24–35; Daniel C. Peterson, ed., *The Book of Mormon and DNA Research* (Provo, UT: Neal A. Maxwell Institute, 2008).
3. Antonio Torroni and others, “Asian Affinities and Continental Radiation of the Four Founding Native American mtDNAs,” *American Journal of Human Genetics* 53 (1993), 563–90; Alessandro Achilli and others, “The Phylogeny of the Four Pan-American MtDNA Haplogroups: Implications for Evolutionary and Disease Studies,” *PloS ONE* 3, no. 3 (Mar. 2008), e1764.
4. Ugo A. Perego and others, “Distinctive Paleo-Indian Migration Routes from Beringia Marked by Two Rare mtDNA Haplogroups,” *Current Biology* 19 (2009), 1–8.
5. Martin Bodner and others, “Rapid Coastal Spread of First Americans: Novel Insights from South America's Southern Cone Mitochondrial Genomes,” *Genome Research* 22 (2012), 811–20.
6. John L. Sorenson, “When Lehi’s Party Arrived in the Land, Did They Find Others There?” *Journal of Book of Mormon Studies* 1, no. 1 (Fall 1992), 1–34. These arguments were summarized more recently in John L. Sorenson, *Mormon’s Codex: An Ancient American Book* (Provo, UT: Neal A. Maxwell Institute, 2013). Sorenson suggests that indicators in book’s text makes it “inescapable that there were substantial populations in the ‘promised land’ throughout the period of the Nephite record, and probably in the Jaredite era also.” (“When Lehi’s Party Arrived,” 34).
7. Anthony W. Ivins, in Conference Report, Apr. 1929, 15.
8. “Facts Are Stubborn Things,” *Times and Seasons* 3 (Sept. 15, 1842): 922. This article is unattributed but was published under Joseph Smith’s editorship. See also Hugh Nibley, *Lehi in the Desert, The World of the Jaredites, There Were Jaredites* (Salt Lake City and Provo, UT: Deseret Book and Foundation for Ancient Research and Mormon Studies, 1988), 250.

9. For a review of statements on this subject, see Matthew Roper, "Nephi's Neighbors: Book of Mormon Peoples and Pre-Columbian Populations," *FARMS Review* 15, no. 2 (2003), 91–128.
10. Introduction to the Book of Mormon, rev. ed. (New York: Doubleday, 2006). The introduction, which is not part of the text of the Book of Mormon, previously stated that the Lamanites were the "principal ancestors of the American Indians." Even this statement, first published in 1981, implies the presence of others. (Introduction to the Book of Mormon, 1981 ed.)
11. John L. Sorenson, "When Lehi's Party Arrived," 5–12.
12. Peter A. Underhill and Toomas Kivisild, "Use of Y Chromosome and Mitochondrial DNA Population Structure in Tracing Human Migrations," *Annual Review of Genetics* 41 (2007), 539–64.
13. Haplogroup names follow a standardized nomenclature of alternated letters of the alphabet and numbers. See International Society of Genetic Genealogy, "Y-DNA Haplogroup Tree 2014"; Mannis van Oven and Manfred Kayser M., "Updated Comprehensive Phylogenetic Tree of Global Human Mitochondrial DNA Variation," *Human Mutation* 30 (2009), E386-E394.

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14. Vincenza Battaglia and others, "The First Peopling of South America: New Evidence from Y-Chromosome Haplogroup Q," *PLoS ONE* 8, no. 8 (Aug. 2013), e71390.
15. Ugo A. Perego and others, "The Initial Peopling of the Americas: A Growing Number of Founding Mitochondrial Genomes from Beringia," *Genome Research* 20 (2010), 1174–79.
16. Maanasa Raghavan and others, "Upper Palaeolithic Siberian Genome Reveals Dual Ancestry of Native Americans," *Nature*, Nov. 20, 2013.
17. This "clock" is based on the observed rate at which random mutations occur in DNA over time. For an example of a proposed mitochondrial DNA molecular clock see Pedro Soares and others, "Correcting for Purifying Selection: An Improved Human Mitochondrial Molecular Clock," *American Journal of Human Genetics* 84 (2009), 740–59.
18. Alessandro Achilli and others, "Reconciling Migration Models to the Americas with the Variation of North American Native Mitogenomes," *Proceedings of the National Academy of Sciences* 110, no. 35 (2013), 14308–13.
19. Morten Rasmussen and others, "Ancient Human Genome Sequence of an Extinct Palaeo-Eskimo," *Nature*, Feb. 11, 2010, 757–62. This hypothetical migration would have been separated by approximately 200 generations from early migrations to the Americas.

20. Quoted in Cassandra Brooks, “First Ancient Human Sequenced,” *Scientist*, Feb. 10, 2010, [www.thescientist.com/blog/display/57140](http://www.thescientist.com/blog/display/57140). Michael H. Crawford, molecular anthropologist at the University of Kansas, noted similarly that the “evidence does not preclude the possibility of some small-scale cultural contacts between specific Amerindian societies and Asian or Oceanic seafarers.” (Michael H. Crawford, *The Origins of Native Americans: Evidence from Anthropological Genetics* [Cambridge: Cambridge University Press, 1998], 4).
21. Ugo A. Perego, “Origin of Native Americans,” 186–87.
22. Native populations were reduced by as much as 95 percent. See David S. Jones, “Virgin Soils Revisited,” *William and Mary Quarterly*, Third Series, vol. 60, no. 4 (Oct. 2003), 703–42.
23. Michael H. Crawford, *Origins of Native Americans*, 49–51, 239–41, 260–61.
24. Agnar Helgason and others, “A Populationwide Coalescent Analysis of Icelandic Matrilineal and Patrilineal Genealogies: Evidence for a Faster Evolutionary Rate of mtDNA Lineages than Y Chromosomes,” *American Journal of Human Genetics* 72 (2003), 1370–88.
25. Beth Alison Schultz Shook and David Glenn Smith, “Using Ancient MtDNA to Reconstruct the Population History of Northeastern North America,” *American Journal of Physical Anthropology* 137 (2008), 14.
26. See “How Many Genetic Ancestors Do I Have?” Co-op Lab, Population and Evolutionary Genetics, UC Davis.

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27. Dallin H. Oaks, “The Historicity of the Book of Mormon,” in Paul Y. Hoskisson, ed., *Historicity and the Latter-day Saint Scriptures*, (Provo, UT: Brigham Young University Religious Studies Center, 2001), 239.
28. Moroni 10:4.

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