SECTION 1: DNA EVIDENCE
(EXECUTIVE SUMMARY)

Editor's Note: *This is a summary of the full paper,* Section 1: DNA Evidence, *available online at http://www.fairlds.org/DNA_Evidence_for_Book_of_Mormon_Geography/. This paper was last updated 3 September 2008.*

This document is an analysis of the scholarly merits of the theories proffered by Rodney Meldrum[1] in his firesides and DVD presentation, *DNA Evidence for Book of Mormon Geography*.[2] Neither FAIR nor this document take any position on the geographic location of Book of Mormon events.[3] It is important, however, that Meldrum's theories be analyzed according to the same standards by which other Book of Mormon geography theories are evaluated. (To avoid confusion, this paper refers to Meldrum's geographic model as the Limited North American Model, or LNAM.[4]) This document is just one in a series of such analytical documents.

LOOKING FOR ANSWERS

In the introduction to the DVD presentation it is explained that in the Spring of 2003 when the presenter first became aware of critical claims against the Church relative to DNA studies, he was "totally confident that the LDS scholarly community would find the

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[1] This paper follows the scholarly custom of referring to an individual, at first reference, by full name and then subsequently referring to the individual by last name only. We fully recognize Rodney as a brother in the gospel, but in discussing secular issues (such as scholarly research and geographic models) it was felt that continually prefacing his name or the name of any other referenced scholar or individual with "Brother" or "Sister," while accurate, would distract from the readability of the paper.

[2] Rodney Meldrum, *DNA Evidence for Book of Mormon Geography: New scientific support for the truthfulness of the Book of Mormon; Correlation and Verification through DNA, Prophetic, Scriptural, Historical, Climatological, Archaeological, Social, and Cultural Evidence* (Rodney Meldrum, 2008). The DVD is in sections; citations in this paper reference the DVD's section number and title, followed by an approximate time stamp from the DVD.

[3] FAIR recognizes that faithful individuals and scholars can honestly disagree on where Book of Mormon events took place; there is no revealed or officially accepted geography. FAIR provides an online reference to over 60 different geographic models at http://en.fairmormon.org/Book_of_Mormon_geography (click on Book of Mormon Geographical Models). That being said, this paper may occasionally make reference to a Mesoamerican model for Book of Mormon geography. Such reference is not made to argue for that particular geographical model, but because (1) the presentation often criticizes Mesoamerican models through misrepresentation and (2) the presentation often makes a claim that is equally true of the Mesoamerican model. If both models make the same claims and meet the criteria necessary for those claims, it stands to reason that both models would be equally viable relative to such claims.

[4] Meldrum's model places Book of Mormon peoples in an area roughly covering the Atlantic seaboard to the Rocky Mountains. This name was chosen as descriptive of the general model. We recognize that Meldrum may pick a different name at some point and would invite him to do so.

answers."[5] Just a few moments later he indicated that "There were several LDS scholars who were attempting to address the issue, but didn't really have an answer to this."[6]

In 2003, when Meldrum first became aware of the Book of Mormon DNA problem, there were already several responses available online.[7] Before 2003 was out, there were other responses available online and in print.[8] In the subsequent years even more information has come forth, both from critics and the faithful alike.[9] Meldrum seems to have missed all of these articles in his research and his audiences do not hear about them.

MISTAKEN EXPECTATIONS

What does the presentation expect in the way of answers? Unfortunately, it begins with faulty expectations:

> Where did Lehi come from? Where did he leave from? From Jerusalem, that's right. Then he came to the Americas someplace. That would mean that he and his wife and Ishmael and his family would have come here and then, the Book of Mormon talks about how they covered the face of the land. That DNA would have to still be here someplace.[10]

The faulty expectation is that Lehi's DNA would still need to "be here someplace." Such statements are reminiscent of the expectations of critics, who argue that if Lehi and his party lived here and covered the Americas, then their DNA must be someplace. The majority of LDS researchers have also considered this very expectation and concluded that

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[5] Meldrum, *DNA Evidence,* Introduction, 1:08.

[6] *Ibid.,* 2:13.

[7] See, for instance, a 2001 presentation by Dr. Scott Woodward posted on FAIR's website (http://www.fairlds.org/pubs/woodward01/) on 24 December 2002. Also see "The Tempest in a Teapot: DNA Studies and the Book of Mormon" (http://www.fairlds.org/Book_of_Mormon/DNA_Studies_and_the_Book_of_Mormon.html) posted 20 January 2003. Also see "A Brief Review of Murphy and Southerton's 'Galileo Event'" (http://www.fairlds.org/Book_of_Mormon/Brief_Review_of_Murphy_and_Southerton_Galileo_Event.html) posted on 25 February 2003.

[8] See, for instance, John L. Sorenson, "The Problematic Role of DNA Testing in Unraveling Human History," *Journal of Book of Mormon Studies* 9:2 (2000), 66-74; John L. Sorenson and Matthew Roper, "Before DNA," *Journal of Book of Mormon Studies* 12:1 (2003), 6-23; Michael F. Whiting, "DNA and the Book of Mormon: A Phylogenetic Perspective," *Journal of Book of Mormon Studies* 12:1 (2003), 24-35; John M. Butler, "A Few Thoughts from a Believing DNA Scientist," *Journal of Book of Mormon Studies* 12:1 (2003), 36-37; and D. Jeffrey Meldrum and Trent D. Stephens, "Who Are the Children of Lehi," *Journal of Book of Mormon Studies* 12:1 (2003), 38-51; D. Jeffrey Meldrum, "The Children of Lehi: DNA and the Book of Mormon," August 2003 FAIR Conference presentation (http://www.fairlds.org/FAIR_Conferences/2003_Children_of_Lehi_DNA_and_the_Book_of_Mormon.html); David A. McClellan, "Detecting Lehi's Genetic Signature: Possible, Probable, or Not?," *The FARMS Review* 15:2 (2003), 35-90; Matthew Roper, "Nephi's Neighbors: Book of Mormon Peoples and Pre-Columbian Populations," *The FARMS Review* 15:2 (2003), 91-128; Matthew Roper, "Swimming in the Gene Pool: Israelite Kinship Relations, Genes, and Genealogy," *The FARMS Review* 15:2 (2003), 129-164; and Brian D. Stubbs, "Elusive Israel and the Numerical Dynamics of Population Mixing," *The FARMS Review* 15:2 (2003), 165-182.

[9] The Neal A. Maxwell Institute for Religious Studies has collected several responses together in *The Book of Mormon and DNA Research: Essays from the FARMS Review and the Journal of Book of Mormon Studies* (Provo, Utah: Maxwell Institute for Religious Studies, 2008).

[10] Meldrum, *DNA Evidence*, Introduction, 3:00.

it would be overwhelmingly unlikely to find DNA from Lehi's party.[11] If they don't share the presentation's faulty expectation about finding Lehi's DNA, is such an expectation reasonable?

GETTING THE SCIENCE WRONG

Scientists use DNA to understand human relationships by examining the way in which changes occur, over time, in DNA structure. When a cell divides, DNA is passed on to the new cell, but sometimes there is an error in what it passes on—the copy is not always perfect. Sometimes the error in the DNA is fatal to the cell, but most of the time it is not; it is just an error that is passed on to the new cell.[12]

All humans are related to each other somewhere, but some humans are more closely related than others. It is the genetic differences in our DNA that set us apart from each other. By examining the differences in human DNA, we can discover where, in our genetic history, the changes occurred that resulted in the differences. When DNA error patterns are studied, scientists can be very confident about how closely related two people—or groups of people—are.

Further, scientists understand that if we know how often DNA errors occur and if those occurrences happen at a constant rate, we can compare two living people and estimate how much time has passed since those people had a common ancestor. This leads to the concept of a "DNA clock" or a "mitochondrial clock," which is integral to genetics. Unfortunately, the presentation's conclusions about such clocks are entirely wrong:

> This led to, in the journal *Science* 1998 in an article called "Calibrating the Mitochondrial Clock" it said, "...researchers have calculated that 'mitochondrial Eve'—the woman whose mtDNA was ancestral to that of all living people—lived [100,000 to] 200,000 years ago in Africa. Using this new clock (this new calibration), she would be a mere 6,000 years old."
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> Brothers and sisters, how close is that to what we understand from the scriptures? This is DNA showing at least the preponderance of an Eve that lived 6,000 years ago. But then, I love this next sentence here: "No one thinks that's the case."[13]

Science is a prestigious journal, and the evidence in the presentation relies on a news article summarizing some then-recent research.[14] Meldrum has apparently not read the original article upon which this news article is based. He conveys incredulity concerning

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[11] See, for example, statements in Michael F. Whiting, "DNA and the Book of Mormon: A Phylogenetic Perspective," *Journal of Book of Mormon Studies* 12:1 (2003), 27, 35; John M. Butler, "Addressing Questions Surrounding the Book of Mormon and DNA Research," *The FARMS Review* 18:1 (2006), 105-106; and David A. McClellan, "Detecting Lehi's Genetic Signature: Possible, Probable, or Not?," *The FARMS Review* 15:2 (2003), 86-87.

[12] A detailed discussion of basic genetic principles for non-experts can be found in David A. McClellan, "Detecting Lehi's Genetic Signature: Possible, Probable, or Not?," *The FARMS Review* 15:2 (2003), 35-90.

[13] Meldrum, *DNA Evidence*, section 1, "DNA Evidence," 5:50.

[14] Ann Gibbons, "Calibrating the Mitochondrial Clock," *Science* 279:5347 (1998), 28-29.

the line that says, "No one thinks this is the case," but he stops there. He doesn't tell his audience *why* no one thinks that it's the case. And, it has nothing to do with refusing to accept that Adam and Eve only lived 6,000 years ago, as he concludes.

The original news article points out at least two possible options: "[1] if the noncoding DNA in the control region is not entirely immune to selection" (which ultimately turned out to be the case) then the clock is based on faulty assumptions. A second option for the rejection of the 6,000 year figure is that "[2] the oldest non-controversial archaeological sites [in the Americas] are 12,500 years old."[15] The mtDNA clock is not the only measure of time and if the mtDNA is getting an answer that is wildly different from the other methods, then the problem is probably with the mtDNA clock.

Once the scientists realized something was going on, they checked a variety of other mammals' mtDNA. They found that one spot in the control region was identical in all the species they checked. This suggests that the control region is not free to have any sort of error and therefore not suitable for use as a clock. As they point out, "the [control] region has crucial regulatory functions and internal sub-regions display quite different levels of variation, both within and between species."[16] Scientists were now aware that the control region was perhaps not a good region for a clock. They set out to find out why.

Within a few years researchers presented evidence about the mtDNA clock. The researchers found that "the [control region of mtDNA] has not [changed] at a constant rate across all human lineages…and is consequently less suitable for dating…" In contrast, the areas "*outside* of the [control region change] in a roughly 'clock-like' manner, enabling a more accurate measurement of mutation rate, and therefore improved estimates of times to evolutionary events."[17]

So, within a few years of the article used in the DVD presentation, the problem had been defined and a solution found. Meldrum must have been unaware of this updated information because his assumptions and conclusions are based on a misreading of the outdated data presented in the *Science* news summary.

WHAT IS MTDNA GOOD FOR?

There are several scientific papers cited in the DVD presentation relative to mtDNA. Unfortunately, the papers are cited incompletely and their implications are not engaged at all. Meldrum states:

> In fact this is from *Annual Views of Genomics and Human Genetics*, 2005 article. It said that they showed "a model that includes a rate variation in mitochondrial control region that gave an estimate for the age of the human

[15] *Ibid.*

[16] T.J. Parsons, *et al.*, "A High Observed Substitution Rate," 365.

[17] M. Ingman, *et al.,* "Mitochondrial Genome Variation and the Origin of Modern Humans," *Nature* 408:6813 (2000), 708, 712, emphasis added.

> mitochondrial DNA ancestry that was **half** of that that was obtained from a single mutation rate when that was assumed."
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> I know that's a lot of scientific mumbo-jumbo maybe. But what that's basically saying is that when they checked one individual and then checked it against the population, the individual was, or that the population ends up being half of what the original individual person's dating was. Well, how can that be happening? Half—that's a huge difference, OK?[18]

In 2005, however, it was well known that the mitochondrial DNA control region is not the best place to use as a clock, as mentioned above. Since Meldrum appears to be unaware of this updated information, these important details are not passed on to his audience. He concludes that the implications of the paper are that mtDNA should be used "for establishing relationships, but not for establishing dating"[19] and that "It's great for current day stuff but not for old things. You can't use it for dating."[20]

This interpretation is completely wrong. The authors are not saying mtDNA is good for establishing relationships but not dating; they are saying that average rates of mtDNA change are misleading. But, if the short- and long-term rates of error are known, then we can use them, provided we know the timeframe in which we are interested.[21] It is erroneous to claim that these authors do not think that DNA can be used to date "old things."

Understanding the DNA science can be tricky and it's easy for an amateur to become confused. We see this confusion in the presentation's misinterpretation of the scientific literature. It is lamentable that Meldrum has misunderstood and misapplied this specialized science to Book of Mormon research.

EXAMINING HAPLOGROUP X

A haplotype is a set of DNA changes ("errors," if you like) that are statistically associated.[22] In simple language, it is a group of differences in the DNA code that usually go together. A haplogroup is a group of humans that share related haplotypes—they all have similar differences in their DNA when compared to the rest of humanity. Haplogroups are useful in population genetics because they allow scientists to determine which human groups are more closely related.

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[18] Meldrum, *DNA Evidence*, section 1, "DNA Evidence," 35:50. Underlining and bolding are in the PowerPoint slide used in the presentation.

[19] Meldrum, *DNA Evidence*, section 1, "DNA Evidence," 36:28.

[20] Meldrum, *DNA Evidence*, section 1, "DNA Evidence," 37:18.

[21] See B. Pakendorf and M. Stoneking, "Mitochondrial DNA and Human Evolution," *Annual Review of Genomics and Human Genetics* 6 (2005), 169.

[22] A haplotype can also refer to a combination of alleles that are transmitted together through gene linkage, but that is a separate topic.

Native American groups[23] consist almost completely of five haplotypes: A, B, C, D, and X. Haplogroup X is the least common haplotype in the Americas. It consists of a group of humans that share a common female ancestor who had a single mtDNA error and passed it to her descendants. As Meldrum demonstrates there has been considerable debate about where haplogroup X comes from and to which human group the American haplogroup X is most closely related.

Meldrum hopes to show that there is a high likelihood that haplogroup X came from Lehi's party[24]—he wants haplogroup X to be traceable to Europe or the Middle East. And, he must show that American haplogroup X split off from its closest ancestors around the time of Lehi's departure from the Middle East, approximately 2,600 years ago.

> That brings us to this, which is really a critical article. This is from the *American Journal of Human Genetics* 2003, called "Origin and Diffusion of Mitochondrial DNA Haplogroup X."[25]

Meldrum is correct—this is a vital article. It is vital because it provides a detailed look at haplogroup X and, unfortunately, it is fatal for his theory. Yet, he quotes only those parts of the article that support his theory and ignores those that refute his theory.[26]

The presentation correctly notes that haplotype X is divided into two subgroups: X1 and X2. It tells us that a study states "X1 is largely restricted to North and East Africa, whereas X2 is widely spread throughout Western Eurasia."[27] Meldrum immediately comments on the study, asking, "Where is Western Eurasia? The Levant area, or Jerusalem—the Holy Land, let's put it that way."[28]

The problem is that the presentation omits a crucial detail from the study cited. Meldrum does not tell his audience that X1 is "restricted to populations of North and East Africa *and the Near East.*"[29] Thus, the area of interest for Book of Mormon studies—the Near East—contains *both* X1 and X2. Meldrum is eager to have a clear marker restricted to the Holy Land in X2, but he is apparently unaware that his argument is actually weakened by the evidence presented in those articles to which he refers.

Meldrum's theory allows him to overlook information that challenges his conclusions. He states:

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[23] Don't make the error of thinking that "American Indian" refers solely to natives living within the boundaries of the present-day United States of America. American Indians (Amerindians or Native Americans) are any group indigenous to North, Central, or South America.

[24] Since haplotype X is based upon an error in mtDNA, it cannot come from Lehi. Genetics dictates that it must come from a female in Lehi's party.

[25] Meldrum, *DNA Evidence*, section 1, "DNA Evidence," 40:40.

[26] In academic circles, the tendency to present only favorable data and ignore contrary data is referred to as "cherry picking." See http://en.wikipedia.org/wiki/Cherry_picking

[27] M. Reidla, *et al.,* "Origin and Diffusion of mtDNA Haplogroup X," *American Journal of Human Genetics* 73:5 (2003), 1188.

[28] Meldrum, *DNA Evidence*, section 1, "DNA Evidence," 41:10.

[29] M. Reidla, *et al.,* "Origin and Diffusion of mtDNA Haplogroup X," 1178, emphasis added.

> But the final is really where it gets exciting, brothers and sisters. "Finally, phylogeography of the subclades of haplogroup X suggests that the Near East is the likely geographical source for the spread of sub-haplogroup X2…The presence of a daughter clade [evolutionary group] in Northern Native Americans testifies to the range of this population's expansion. It is notable that X2 includes the two complete Native American X sequences."[30]

Note the use of ellipses (...) in the quote he reads. Obviously the ellipses aren't in what someone would be verbally saying (the presentation is oral), but they are in the PowerPoint slide used in the presentation. Ellipses indicate that material has been omitted from the original source. What did Meldrum leave out of the original? Here is the full quote, with the omitted material in bold type:

> Finally, phylogeography of the subclades of haplogroup X suggests that the Near East is the likely geographical source for the spread of sub-haplogroup X2, **and the associated population dispersal occurred around, or after, the LGM [Last Glacial Maximum] when the climate ameliorated [improved].** The presence of a daughter clade [evolutionary group] in northern Native Americans testifies to the range of this population expansion.[31]

It is true that the American subgroup of X2 *is* related to the Middle East. But it is also clear that the American group broke off from that Middle East group around the time of the "Last Glacial Maximum"—the point where the last ice age's glaciers reached their furthest southern extent about 18,000 years ago. This clearly means that the X2 haplogroup is unrelated to Lehi's group.

There is further evidence that the American branch of X2 split off from the others early because X2a has had time to begin to develop its *own* DNA errors. The same paper also points out that when the branch of X2 in the Navajo and Ojibwa[32] is examined, we see that "it began to diverge *while their common ancestor was already in the Americas*…we obtain a…time of 18,000 ± 6,800 YBP, implying an arrival time [in the Americas] not later than 11,000 YBP."[33] These numbers complement the numbers calculated for the initial spread of X2 from the Middle East area. The authors use mtDNA dating by checking *both* the control region and the rest of the mtDNA, as they should.

This particular example is not singular in nature; the presentation's own evidence, if examined fully, impeaches the use to which that evidence is put. There are multiple instances of this throughout the presentation—too many to list in this executive summary.[34]

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[30] Meldrum, *DNA Evidence*, section 1, "DNA Evidence," 42:11-42:47.

[31] M. Reidla, *et al.,* "Origin and Diffusion of mtDNA Haplogroup X," 1188.

[32] It should be noted that in the LNAM both the Navajo and Ojibwa are candidates for the Lamanites of the Book of Mormon.

[33] M. Reidla, *et al.,* "Origin and Diffusion of mtDNA Haplogroup X," 1188, emphasis added. YBP is an acronym meaning *years before present,* a common dating reference used in the sciences. In common vernacular you could replace YBP with "years ago."

[34] For a more detailed discussion of how evidence is used in the presentation, see the full *Section 1: DNA Evidence,* available online at http://www.fairlds.org/ DNA_Evidence_for_Book_of_Mormon_Geography/.

Meldrum summarizes his DNA presentation with this statement:

> So what we have, brothers and sisters, is we have European DNA which is found right in this general area, which matches up with DNA of modern Native Americans in this area. And they have no understanding of how it got there, you see, because it couldn't have come over through Asia.[35]

This is a faulty conclusion based upon faulty data. A full examination of the evidence clearly shows that the X2a subfamily in America is *not* the same as the X2 subfamilies in Europe or the Middle East. They are separate lines, with scientific evidence of separation much earlier than Lehi's migration.

CONCLUSION

The DVD presentation exhibits a consistent pattern of selective citation. Meldrum does not present information that is harmful to his case, nor does he engage it. DNA science can be difficult to navigate and Meldrum is not the first researcher to misunderstand and misinterpret the data. He, like so many others, shows little understanding of the underlying principles of the science he attempts to rally to his cause. While he is likely sincere in his attempt to bolster the Book of Mormon, his incorrect assumptions cause both him and his audience to draw conclusions that are false and contrary to the science he purports to present.

A review of the research cited by Meldrum cannot recommend his theories. While *DNA Evidence for Book of Mormon Geography* may tickle the ears of an audience that only sees the evidence through the lens Meldrum provides them, it doesn't stand up to a full examination in the light of day.

Again, this paper is a summary of information presented in the full paper, *Section 1: DNA Evidence.* If you are interested in a longer exposition on the matters covered here, please see the full paper. The full paper also provides additional points at which the theories in *DNA Evidence for Book of Mormon Geography* should be rejected.

[35] Meldrum, *DNA Evidence*, section 1, "DNA Evidence," 42:40-43:00.