THE MUMMA SURNAME DNA PROJECT

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This report describes the Mumma Surname DNA Project from its inception in April of 2000 to the current time. All spelling variations of the MUMMA surname have been included in this study. The Y-chromosome data from 55 participants is presented and a method described for its interpretation. A modal haplotype unique to the MUMMA family was determined from the analysis of 25 marker locations from which 15 haplotypes were observed. A Mumma surname mutation rate of 0.039 was determined from 20 known descendants of the immigrant, Leonard Mumma. Comparing the MUMMA modal haplotype within the participant group confirmed family traditions that most males with the Mumma surname, or variant spellings, share a common ancestry that extends to the Momma families of Germany. Several similar name spellings were also shown that they do not share a common Mumma ancestry, suggesting they descend from a quite different male lineage. These results have proved valuable for determining whether or not the men share a recent common ancestor and for identifying unique haplotypes specific to particular branches. It is also estimated from comparison results that the Momma surname family originates from the early human migration group known as haplogroup R1b, the most common haplogroup in European populations. The project's overall results exceeded the original goals and have created a data bank of information that will help guide future genealogical research seeking the specific connection of the American Mumma families with the Momma families of Germany in addition to identifying interrelationships within the MUMMA family.

INTRODUCTION AND BACKGROUND

From elementary genetics we learn that the 23rd chromosome is the "sex" determining chromosome. Males have both "X" and "Y" 23rd chromosomes, while females have two "X's" for their 23rd chromosomes. The human egg becomes a female embryo if the male sperm carries an X-chromosome and a male embryo when the sperm has a Y-chromosome. Thus the Y-chromosome is passed down from generation to generation, but only through the male line, essentially unchanged.

Using a Single Nucleotide Polymorphisms (SNP) analysis of the Y-chromosome, anthropologists have categorized the early migrations of man into 18 major groupings and they are known as haplogroups. SNP results change or "mutate" so slowly over time (tens of thousands of years) that they are of little value to the genealogist who is more interested in hundreds of years to maybe a thousand years in the past. An examination of the STRs (Short-Tandem Repeats) on the Y-chromosome, however, are shown to change and mutate on a much quicker time scale (hundreds of years), thus allowing identification of specific families and surnames. Therefore, this study primarily uses the results of STR data and analysis.

You might want to read an excellent article about the Y-chromosome written by Dr. Mark Jobling of Leicester University entitled "The Y chromosome as a marker for the history and structure of human populations" A well publicized case involved the question as to whether or not President Thomas Jefferson fathered any children with Sally Hemings. The DNA results from the descendants of one of her sons showed a DNA pattern similar to that of the unusual "Jefferson" Y-chromosome pattern, strongly suggesting either Thomas, or one of his relatives living nearby, fathered one of the sons of Sally. Reuters issued a news release in early 2000 entitled, "Gene test helps scientist trace family names". In this article, Dr. Bryan Sykes of Oxford University was able to demonstrate, using DNA test results from a random sampling of 250 men with the Sykes surname, that they descended from a common ancestor. This article also reported that an Oxford University startup company would soon be commercially offering Y-chromosome testing. The suggestion that DNA testing would soon become commercially available was personally very intriguing to me. A third study involved Jewish men who are *Cohanim*, a Hebrew word literally meaning "priests". During the time of the First and Second Temples and up until the latter's destruction in 70 AD, the Cohanim were responsible for performing elaborate rituals of animal sacrifices and grain offerings. Based on a study of 306 Jewish men in Israel, Canada and England, the researchers discovered that the 106 Jews who had identified themselves as Cohanim shared genetic markers in

their Y-chromosomes that members of the general Jewish population did not. Many other articles such as "The Y-Chromosome in the Study of Human Evolution, Migration and Prehistory" by Dr. Neil Bradman and Dr. Mark Thomas as well as a review article by Dr. Mark Jobling entitled "In the Name of the father: surname and genetics", volume 17 of *Trends in Genetics* are worth reading for background information as they deal with this specific subject. There are now many web sites dedicated to this subject which provide links to many excellent articles and web sites which present results of other surname projects.

Thus in early 2000, it was demonstrated through university research that STR analysis of the male Y-chromosome could be used to help identify the male descendants of a single progenitor.

HISTORY OF THE MUMMA SURNAME DNA PROJECT

There were many Mumma surname branches in the United States that could not be connected together through civil or church records. For example, we did not know whether or not the immigrants, Jacob, Leonard and Peter Mumma were brothers, cousins or not related at all. We were not sure from which immigrant various "unconnected" branches descended. There were questions as to whether individuals with the Mummey, Moomey surname or the Canadian Mumas descend from a common Mumma ancestor. In addition, the Mumma surname does not exist outside the United States, except for a small isolated group in Estonia. Family legends suggest that the family originated as Swiss Mennonites, or from the Alsace-Lorraine region of France and were Huguenots. There are even claims that the Mumma family descends from Lucium Mummius, the Roman General who destroyed Corinth in 146 BC. These are all very interesting and colorful family stories and legends that have been handed down through the generations, but without any supporting evidence. Still other research suggested that the MUMMA spelling is a variation of the surname, MOMMA, which can still be found in Germany today. The Momma family has been documented as living in the Aachen-Stolberg area of Holy Roman Empire (near the intersection of the current German-Belgium-Dutch boarder) since the 1500's and descendants of this family reside there to this day. Thus, there were, and still are, many unanswered genealogical questions and it was hoped that analysis of the Y-chromosome from Mumma descendants might provide direction and guidance for future genealogical research.

While researching my own family genealogy, many roadblocks were encountered which prevented identification of many ancestors. As an attempt circumvent these obstacles, I began collecting a massive amount of family records which were entered into an on-line, searchable database, now containing over 58,000 Mumma descendants. There are still many "unconnected" branches or small twigs in the database and this new technology piqued my curiosity as to whether it might be a possible tool to determine family connections and guide traditional research. Thus the Mumma Surname DNA Project was conceived. The specific goals for the project were to determine whether or not the various Mumma branches were related and to provide a bank of data that could be used to identify specific branches within a given tree. With the goals established, a testing laboratory capable of performing DNA analyses was needed in pursuit of these goals.

My initial search led me to GeneTree, Inc., a company primarily performing DNA testing for paternity cases, but they were expanding their business into DNA testing for genealogical purposes. Because of the embryonic state of genealogical DNA testing, it quickly became apparent for the desirability to use a testing laboratory associated with a qualified and recognized genetic research team. Data interpretation would obviously need assistance and guidance from the genetic scientists. I felt that GeneTree, working in close cooperation with Dr. Scott Woodward at BYU, should be qualified.

I also found a new startup company by the name of Family Tree DNA, Inc. (FTDNA). This company was founded strictly for the purpose of performing genealogical DNA testing and analysis. They were working closely with Dr. Michael Hammer of the University of Arizona. Dr. Hammer was a highly respected and well published geneticist who had done much research on a variety of Y-chromosome projects. Contact was also attempted with another new company called "Oxford Ancestors", a British startup company associated with Dr. Bryan Sykes. Dr. Sykes was also investigating the application of DNA testing for genealogical purposes. While Oxford Ancestors described Y-chromosome testing, they were not offering the service at that time this project was launched. Web site addresses and additional information about these and other current companies offering DNA testing services can be found on Kevin Duerinck's web site - http://www.duerinck.com/dnalabs.html or by performing a search of the Internet.

After discussions with all of these companies, Family Tree DNA was selected as the organization to perform the DNA extraction and analysis for the Mumma Surname Project. This selection was based on a number of factors including, price, the number of "markers" measured (eleven at that time) and the excellent reputation of Dr. Michael Hammer as a respected genetic researcher and scientist.

After the company was selected to perform the DNA analyses, the project goals were refined and e-mail invitations sent to a distribution list of over 500 people associated with the Mumma surname, to encourage men with the Mumma surname (or alternate spelling) to participate. The response was extremely positive and the project proceeded swiftly, the details of which are the subject of the remainder of this report.

All that is required to participate in the project is to be a male (the male Y-chromosome is needed), to have the Mumma surname (or alternate spelling) and provide a small sample of DNA for analysis. The sampling technique is painless and only involves the use of a swab to collect a small amount of buccal cells containing DNA from the inside of a person's cheek. The participant self-administers a test kit to collect the sample. Instead of brushing your teeth, you brush the inside of your mouth and cheek which painlessly scrapes and collects a sufficient sample of DNA for analysis. The sample collection kit used by FTDNA can be viewed at http://www.familytreedna.com/kit.html. An excellent NBC news story showing the collection of a DNA sample can be viewed at http://www.msnbc.com/news/682153.asp?pne=msn. For those who have an interest in determining whether or not their particular "ancestral twig" might connect to one of the main branches of the MUMMA family, simply click on the "DNA testing sign-up" button at the beginning of this report or go to http://www.mumma.org/sign_up.htm. In addition, you can visit the Family Tree DNA web site at http://www.familytreedna.com where you can also sign-up. The Mumma project is still actively gathering additional information with new participants submitting samples for analysis on a regular basis.

PROJECT HISTORICAL TIMELINE

This project has had an interesting journey since its inception and infancy to the present time. Many technical changes and improvements have occurred during the three year time span, all of which have proved to increase the ability to discriminate between various family branches.

15 Nov 1998 - E-mail messages were exchanged with Udo Momma of Germany discussing the viability of using DNA analysis to trace ancestors and the possibility of using this technique to verify the Mumma/Momma family connection. No commercial laboratories could be found at that time to perform DNA analysis for private individuals.

10 April, 2000 - Contact was made with David Roper regarding a DNA testing program he was proposing to conduct. He was not aware of any commercial testing companies available at that time who offered Y-chromosome analysis for surname investigations. Most companies only performed DNA analyses for paternity determination and civil cases.

10-17 April, 2000 - Internet searches were conducted to locate companies offering DNA testing services. Contact was made with FTDNA and GeneTree and it was determined they were prepared to commercially offer STR analysis of the Y-chromosome. Discussions were held with both companies regarding the analysis of a large number of DNA samples for a proposed group of Mumma participants.

April 17, 2000 - The Mumma DNA surname project was formally launched and males with the Mumma surname (or spelling variants) were actively solicited by letter, e-mail and telephone calls.

June 2000 - 27 men volunteered to participate in this project with most funding their own analytical costs. Test kits were distributed to the men living in America, Canada, Germany and Estonia.

7 July 2000 - 26 DNA samples were returned and sent as a group to FTDNA for DNA extraction and analysis. This was the largest group of samples processed by FTDNA, at that time, from a single surname project.

20 Sept 2000 - The initial results were received and in the short span of 6 months, the project progressed from a concept and dream to the receipt of analytical results for the 26 participants.

February 2001 - Because few mutations were observed in the results, it was decided to test additional loci which might provide assistance in identifying specific family branches. Testing services were solicited from several DNA laboratories to provide measurements at additional markers.

July 2001 - Dr. Mark Jobling's laboratory at the University of Leicester in England completed an analysis of 19 loci for four Mumma participants. A meeting was held with Dr. Jobling in England to receive and discuss the results.

October 2001 - FTDNA completed their analysis of 13 additional markers.

December 2001 - A contract with Dr. Woodward at BYU was cancelled due to lack of performance on their part. They were unable to provide the DNA analysis requested.

March 2002 - FTDNA expanded the number of markers they were measuring to 25.

April 2002 - FTDNA revealed the DYS nomenclature for all of the loci they measure and the data was now reported in allele/repeat values. Full disclosure was finally achieved.

January 2004 - Since the initial project was launched in April of 2000, 55 men have submitted DNA samples for the Mumma Surname DNA Project and their results have been received and analyzed.

PROJECT RESULTS

The following summary table contains the Y-STR data obtained from the MUMMA Surname DNA Project. The first column, "M#", is a unique number that was assigned to each participant, based on the date their sample was received. The next column, "Surname", is the surname used by each participant. The next thirty-three columns, marked 1 to 33, represent an arbitrary identification number assigned to the various loci where STR repeat values were measured and alleles values determined. The DYS number is a specific identification number assigned by the HUGO Gene Nomenclature Committee to specific locations along the Y-chromosome. These DYS number's allow results determined from one laboratory to be compared with those derived from another laboratory. Besides the testing conducted by FTDNA, four samples were analyzed by Dr. Mark Jobling at the University of Leicester are reported in last seven columns as well as other confirming measurements made at twelve locations duplicating the measurements by FTDNA.

The far right hand column is a "Henry" reference number that has been assigned to all Mumma descendents listed in the Mumma surname database containing over 58,000 Mumma descendants. This generation identification number uniquely codes each person based on the number of generations they are removed from the progenitor of a group. Each number represents his ancestors birth order at that generation. These numbers are further explained and identified beneath Table 1. The results in this table have been arranged by ascending Henry number for known Mumma descendants and then unconnected individuals are assigned a "U" number. Similar U numbers share a common ancestor, but they have not been connected to one of the original immigrants. In addition, a number of individuals were included in the study whose surname spellings were sufficiently close that it was desired to clearly determine whether that surname or branch shared a common Mumma ancestry. The participants near the bottom of the table were not considered to be likely Mumma descendants from all documentary evidence, but included to confirm this supposition.

The values shown for each participant at specific DYS locus are listed as the *allele* at that location in the marker columns listed as 1 to 33. The alleles listed for DYS464 have been adjusted per the FTDNA nomenclature announcement message of 19 May, 2003. Whereas most participants only had four copies of DYS464 recorded, one participant had five copies, so an extra column has been added and named DYS464e. An explanation about this issue will be discussed later. Any blank cells in the table means that a measurement was not made at that specific locus.

Table 1 - Summary of MUMMA Surname STR Y-Chromosome Results (Alleles)

	Marker #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
	DYS # =>	393	390	19	391	385a	385b	426	388	439	389i	392	389ii	458	459a	459b	455	454	447	437	448	449	464a	464b	464c	464d	464e	434	435	436	438	460	461	462	
M#	**Surname**	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	9	11	12	12	10	10	11	**Henry Ref#**
7	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	18	9	10	11	11	24	15	19	30	14	17	17	17	0	9	11	12	12	10	10	12	111811411
19	Mummau	13	25	14	11	11	14	12	12	12	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	18	0								117231401
4	Mummau	13	25	14	11	11	14	12	12	12	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	18	0								1172314012
45	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								13311917
2	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								2105141911
36	Moomaw	13	25	14	11	11	14	12	12	12	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								217415742
3	Moomaw	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								217415a11
31	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								217514173
21	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	29	14	17	17	17	0								217514644
18	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								217514647
37	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								217587411
34	Mumaw	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								21765858
5	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								218333122
1	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	9	11	12	12	10	10	11	21837023
16	Moomaw	13	25	14	10	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	16	17	17	0								221105511
6	Moomaw	13	25	14	10	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								22119362
11	Moomaw	13	25	14	10	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								22193612
50	Mumma	13	25	14	11	11	13	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	14	17	17	17								2523137411
49	Mumma	13	24	17	10	13	15	11	13	13	12	11	28	16	8	10	10	12	25	15	21	28	14	14	15	15	0								252742111
29	Mumaugh	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								274511141
54	Mumma	13	25	14	11	11	14	12	12	12	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								27712124
40	Moomaw	14	22	14	10	13	13	11	14	12	13	11	29	15	8	9	8	11	22	16	20	29	12	14	15	15	0								292481221
14	Moomaw	13	25	14	11	11	14	12	12	14	13	13	29	17	9	10	11	11	24	15	19	31	14	17	17	17	0								292713131
15	Moomaw	13	25	14	11	11	14	12	12	13	13	13	29	17	9	9	11	11	24	15	19	30	14	17	17	17	0								29271553
25	Mummah	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								29627222
9	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	18	9	10	11	11	24	15	19	30	14	17	17	17	0								298221262
46	Mumma	13	25	14	11	11	14	12	13	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								4249121
26	Muma	13	25	14	11	11	14	12	13	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								U08-111114
27	Mumma	13	25	14	11	11	14	12	13	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								U08-12642
52	Mumma	13	25	14	11	11	14	12	13	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								U28-1403
32	Mumah	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								43242352
30	Reenstjerna	13	25	14	11	11	14	12	12	12	13	13	29	16	9	10	11	11	24	15	19	30	14	17	17	17	0	9	11	-	12	10	10	11	E-143143311151
10	Momma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								E-1458353211114
12	Momma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	9	11	12	12	10	10	11	E-1458353413231
43	Mewmaw	13	25	14	11	11	14	12	12	12	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								U07-133352
51	Moomau	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								U45-137537
8	Moomau	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								U45-1387411
35	Mumma	13	25	14	11	11	14	12	12	12	13	13	29	18	9	10	11	11	24	15	19	31	14	17	17	17	0								U46-113833
39	Mumma	13	25	14	11	11	14	12	12	12	13	13	29	18	9	10	11	11	24	15	19	31	14	17	17	17	0								U46-1128121
44	Stevenson	13	25	14	10	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								U62-1472152
48	Mummaugh	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	29	14	17	17	17	0								U51-133122
55	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	29	14	17	17	17	0								U69-153
53	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								U30-112542
17	Muma	13	26	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								U21-1334663
22	Muma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	28	14	17	17	17	0								U21-13346792
13	Muma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								U21-1492712
20	Muma	13	24	14	11	11	14	12	12	12	11	13	27																						U21-148XXXX
23	Mumma	13	22	14	10	14	14	11	14	11	12	11	28																						Mumma-Estonia
28	Moomey	13	24	13	11	11	15	12	12	11	13	13	29																						Moomey
42	Moomey	13	24	13	11	11	15	12	12	11	13	13	29	17	9	9	11	11	25	15	19	30	15	15	17	17	0								Moomey
33	Mummey	13	24	14	10	11	14	12	12	13	13	13	30																						Mummey
47	Mummey	13	22	15	9	13	14	11	13	11	12	11	29																						Mummey
24	Mumme	13	24	14	11	11	13	12	12	12	13	13	29	18	9	10	11	11	26	15	19	28	15	15	16	17	0								Mumme
38	Webb	14	22	14	10	13	13	11	14	12	13	11	29																						Webb
41	Webb	14	22	14	10	13	13	11	14	12	13	11	29																						Webb

(Note: A special modified Henry numbering system is used to identify each individual in the chart. The top individual in a particular genealogical tree is given an identifying number. At each new generation an additional digit is added to each descendant and the numeric value added is typically the child's order of birth. 1st child = #1, 2nd child = #2, ...9th child = #9, 10th child = #0, 11th child = #a, 12th child = #b, etc. Therefore, a seven digit number means that the person is the sixth generation down from the top individual. If a group of individuals cannot be linked to one of the known Mumma immigrant trees, then that group is assigned a unique "U" number at the beginning of their Henry number. Individuals not listed in the Mumma database have only their surname listed.)

Henry Ref# beginning with 1 = Descendants of Jacob Mumma - arrived America in 1731 & were primarily Mennonite.
Henry Ref# beginning with 2 = Descendants of Leonard Mumma - arrived America in 1732 & were primarily Lutheran/Reformed.
Henry Ref# beginning with 4 = Descendants of Peter Mumma - arrived America in 1748 & were primarily Reformed.
Henry Ref# beginning with E1 = Descendants of Wilhelm Momma - b. ~1543 in Germany where the family remains today.
Henry Ref# beginning with U07 = Descendants of David Muma - b. 1760 in PA, appears in Page Co., VA ~1810.
Henry Ref# beginning with U08 = Descendants of Christian Mumma - b. 1791 PA, migrated from Lancaster Co., PA to Springfield, OH.
Henry Ref# beginning with U21 = Descendants of Jacob Muma - b. ~1750 migrated to Canada ~1800. Known as the Canadian Mumas.
Henry Ref# beginning with U28 = Descendants of John Mumma - b. ~1790 migrated to Hanover township of Dauphin County ~1830.
Henry Ref# beginning with U30 = Descendants of John Mumma - b.bef 1750 John Mumma. Found in Cumberland County, PA .
Henry Ref# beginning with U45 = Descendants of Christian Mummer - b. ~1768 appears in Botetourt Co., VA.
Henry Ref# beginning with U46 = Descendants of David Mumma - b. ~1790 appears Franklin Co., PA ~1810.
Henry Ref# beginning with U51 = Descendants of George Mummaugh - b. ~1809 appears in Carroll Co., MD in the 1840 census.
Henry Ref# beginning with U62 = Descendants of John Mumma - b. ~1750 in Lancaster Co. PA, migrated to York Co., ~1780.
Henry Ref# beginning with U69 = Descendants of William H. Mumma - b. ~1876 in Ohio appears in Columbus, Ohio - 1900 census
Several unusual surnames appear in the table and the reason they were included in the study will be explained later.

DATA INTERPRETATION

Mumma Modal Haplotype - The alleles shown in the table are simply a series of numbers that represent the number of times a specific repeating pattern was observed at each specific DYS marker location. A initial examination of the alleles reveals a generally consistent pattern of similar values being recorded at each locus or marker position. A haplotype is simply defined as any series of alleles or repeat values and therefore, each person has their own haplotype or Y- chromosome "fingerprint". There is no specific order to the numbers nor is there a specific set of locations on the Y-chromosome. When a consistent pattern of alleles is observed and shared by a majority of men, it called a *modal haplotype*. In this case, one unique sequence of alleles is shared by 18 Mumma participants at 25 marker locations and this has been defined as the "***MUMMA modal haplotype***", representing a specific haplotype for the Mumma surname. Anytime in this report the term, MUMMA modal haplotype is used, it refers to this haplotype sequence which is shown in the box beneath the DYS identification numbers and is shaded yellow. It is this haplotype by which all other haplotypes measured in the MUMMA study are compared. The boxes containing alleles which differ from the MUMMA modal haplotype by +/- one or more values (mutations) are shaded a salmon color to provide a visual discrimination. This makes it easier to observe whether or not an individual's haplotype matches the MUMMA modal haplotype or is different. The more boxes with a salmon color, the greater number of mutations in that person's haplotype as compared to the MUMMA modal haplotype. A "mutation" simply represents any allele that has changed. So, by simple observation of the consistent allele values, we can conclude there is one unique haplotype common to the majority of the Mumma participants.

The 26th column, DYS 464e, needs further explanation. DYS 464 is a highly polymorphic marker and shows the most variability in the FTDNA database. Polymorphic means rapidly changing! The repeats at markers 464a-d are copies found at different locations on the Y chromosome. In about 1.5% of the analyses, more than 4 copies will be present, represented by markers 464e, 464f and 464g, if additional copies are present. This was the case for one of the Mumma participants, #50. As a result, special care is required for the interpretation of the number of mutations recorded for DYS 464. FTDNA always reports the allele results from low to high, starting with 464a. When a mismatch occurs, i.e. different values within 464a-d or an extra copy is observed, consideration must be made whether the number of apparent mismatches are a result of the order of presentation of the markers. The order of the results for these markers may make it appear as if there are more mismatches than are actually present. Therefore, when comparing and reordering the alleles observed for the DYS 464 markers for participant #50 we see he has an extra copy of DYS 464 with 14 alleles in addition to the four copies found in the Mumma modal haplotype (14, 17, 17, 17).

To further help interpret the data, it is useful to separate it into various groups which share a known common ancestor or are connected by some other common characteristic. The first group we will examine are the results

shown below in Table 2, from the 22 documented descendants of Leonard Mumma who arrived in America in 1732. We don't know the exact location or region from which he and his family emigrated, but research suggests that the family may have lived in the village of Großkarlbach in the Palatinate region of the Holy Roman Empire, now known as Germany.

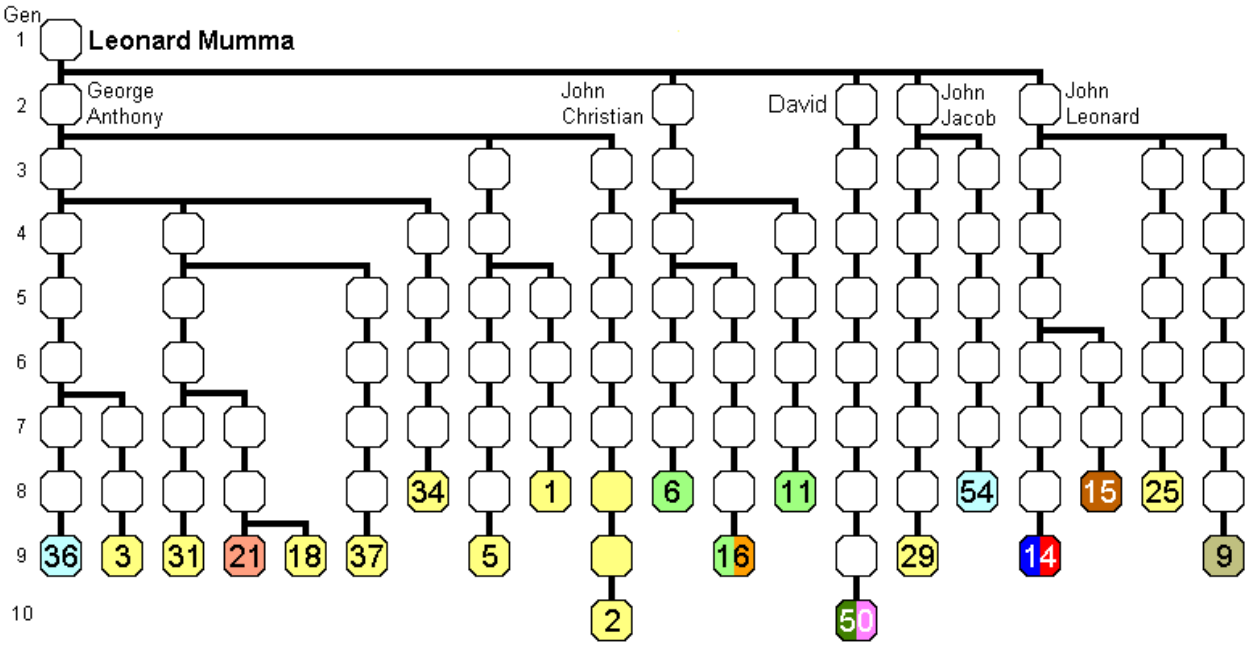
Table 2 - Summary of MUMMA Surname STR Y-Chromosome Results (Alleles)

	Marker #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
	DYS # >	393	390	19	391	385a	385b	426	388	439	389i	392	389ii	458	459a	459b	455	454	447	437	448	449	464a	464b	464c	464d	464e	
M#	Surname	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	Henry Ref#
2	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	2105141911
36	Moomaw	13	25	14	11	11	14	12	12	12	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	217415742
3	Moomaw	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	217415a11
31	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	217514173
21	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	29	14	17	17	17	0	217514644
18	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	217514647
37	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	217587411
34	Mumaw	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	21765858
5	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	218333122
1	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	21837023
16	Moomaw	13	25	14	10	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	16	17	17	0	221105511
6	Moomaw	13	25	14	10	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	22119362
11	Moomaw	13	25	14	10	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	22193612
50	Mumma	13	25	14	11	11	13	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	14	17	17	17	2523137411
49	Mumma	13	24	17	10	13	15	11	13	13	12	11	28	16	8	10	10	12	25	15	21	28	14	14	15	15	0	252742111
29	Mumaugh	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	274511141
54	Mumma	13	25	14	11	11	14	12	12	12	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	27712124
40	Moomaw	14	22	14	10	13	13	11	14	12	13	11	29	15	8	9	8	11	22	16	20	29	12	14	15	15	0	292481221
14	Moomaw	13	25	14	11	11	14	12	12	14	13	13	29	17	9	10	11	11	24	15	19	31	14	17	17	17	0	292713131
15	Moomaw	13	25	14	11	11	14	12	12	13	13	13	29	17	9	9	11	11	24	15	19	30	14	17	17	17	0	29271553
25	Mummah	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	29627222
9	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	18	9	10	11	11	24	15	19	30	14	17	17	17	0	298221262

The DNA samples from these men were initially analyzed at 12 markers, but later expanded to 25 markers when the extended analysis became available. The haplotypes recorded for #40 and #49 stand out as being distinctly different from all of the other results. Because of their unique differences, the results of #40 and #49 will be ignored for the present and discussed later. Ten men in this group share the MUMMA modal haplotype and those that don't only differ by 1 repeat at 1 or 2 marker locations. From civil and religions records we know all of these men share a common ancestor, Leonard Mumma, so these data provide insight about mutations within a group of men with proven relationships.

To visualize the relationships between these participants, a pedigree chart is shown in Figure 1 with the progenitor of the group, Leonard Mumma, appearing as the top generation 1 (Gen 1). Below him at the generation 2 level are five sons, George Anthony Mumma, John Christian Mumma, John Jacob Mumma and John Leonard Mumma. Their sons appear below them as generation 3 and so on until each participant in this study appears as the last person in his line. Each participant's box has been shaded with different colors to represent their unique haplotype. The legend shown below Figure 1 describes the color scheme used to represent the mutations observed at a specific locus. If a haplotype showed two mutations, then the respective box is shaded with two colors, each representing a different marker that mutated. Boxes shaded yellow represent the MUMMA modal haplotype and all mutations are compared to this pattern of alleles.

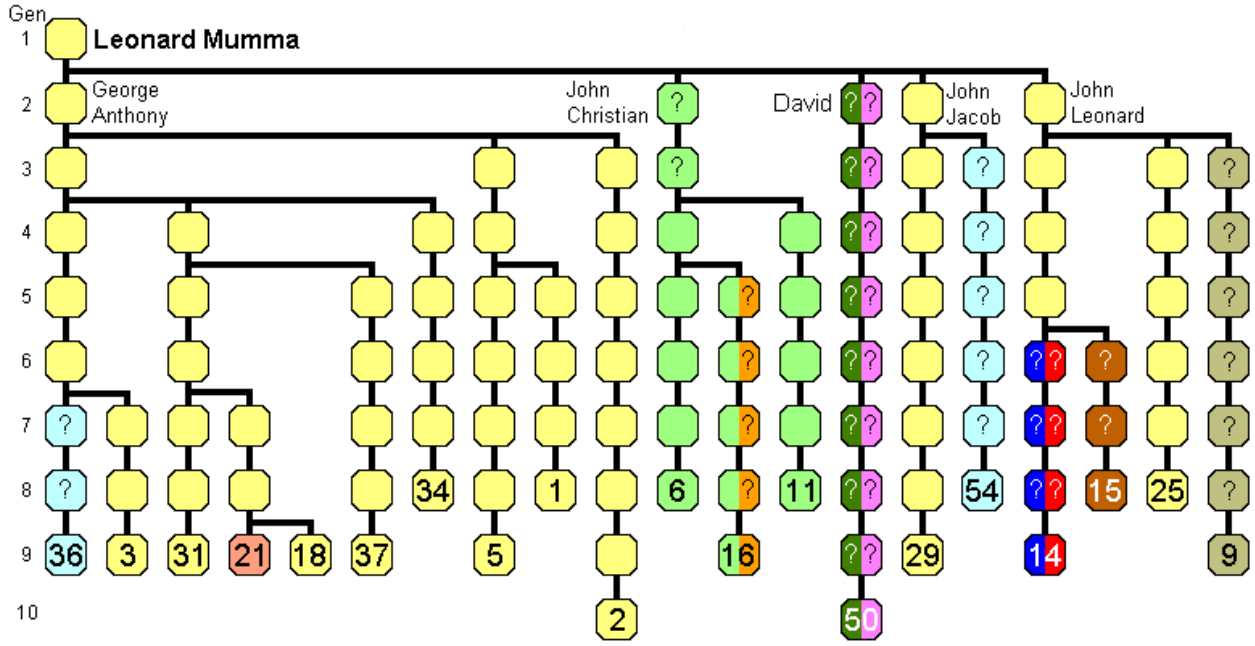
Figure 1



Mutation Color Legend				
Participant #		Box color	Observed mutations	Allele change
all others		Yellow	MUMMA modal haplotype	none
#50		Dark Green	-1 repeat at DYS 385b	14 ==> 13
#6, #16, & #11		Green	-1 repeat at DYS 391	11 ==> 10
#36 & #54		Light blue	-1 repeat at DYS 439	13 ==> 12
#14		Dark blue	+1 repeat at DYS 439	13 ==> 14
#21		Salmon	-1 repeat at DYS 449	30 ==> 29
#14		Red	+1 repeat at DYS 449	30 ==> 31
#9		Olive	+1 repeat at DYS 458	12 ==> 13
#15		Brown	-1 repeat at DYS 459b	10 ==> 9
#16		Orange	-1 repeat at DYS 464b	17 ==> 16
#50		Purple	+14 repeats at DYS 464	extra allele 14

The probable haplotype for each participant's ancestors was determined using deductive reasoning, the principle of parsimony (using a minimum number of mutational events) and the genetic fact that if two or more descendants share the same haplotype, then their common ancestor must have also had that same haplotype. Following these principals, a "reconstruction" of the likely haplotype of each ancestor is shown in Figure 2. If we look at #1 and #5 (about in the middle of Figure 1), we see that both men had no mutations and match the MUMMA modal haplotype, so they are colored yellow. Therefore, their common ancestor 4 / 5 generations prior must have also had the MUMMA modal haplotype using the principle of parsimony. The principle of parsimony precludes a mutation to occur at a marker and then mutate back to the original value in a subsequent generation. Hence, it is reasonable to expect that all ancestors between #1 and #5 and their common ancestor share the same haplotype. All of the ancestor boxes between them and their common ancestor are shaded yellow, the same color as that of #1 & #5. Using this thought process, all of the ancestors above each individual with the MUMMA modal haplotype are colored yellow, all the way up until Leonard Mumma is reached.

Figure 2



Next, the ancestors of the men who show mutations are also identified with their respective mutation colors using this same process. The color representing a particular mutation is extended to previous generations until a yellow colored generation box is reached, representing the MUMMA modal haplotype. Without further testing, it is impossible to determine at which specific generation the mutation took place, so a question mark appears at each generation indicating the uncertainty of the correct haplotype for that generation. The mutation could have occurred at any generation where a question mark is shown.

The results from the descendants of John Christian Mumma (the second son) are interesting since the entire branch is colored green. We don't know whether the initial mutation occurred with John Christian himself or his son, but it must have occurred at one of these two generations. Then in the case of John Christian's descendant, #16, two mutations were observed and there is uncertainty as to the precise generation where the two mutations of DYS459b occurred, as noted with the question marks. It is interesting to further observe that two brothers, #21 and #18, show different haplotypes. Thus in this case, the mutation of DYS449 must have occurred with the conception of #21. The result of this activity allows us to "reconstruct" a descendant chart for Leonard Mumma which shows the mutations observed from the DNA of his descendant participants and plausible haplotypes for all of their ancestors. An extremely beneficial aspect of this analysis is it shows how a family branch can be identified as having a unique haplotype "fingerprint", as in the case of participants #6, #16 and #11 which are all colored green because of a mutation of DYS391. If the DNA analysis of a new participant with an uncertain Mumma ancestry does not show this same mutation at DYS391, then it is extremely unlikely that he is a descendant of this branch.

The unusual haplotypes of #40 and #49 needs explanation. While assisting other researchers tracing the ancestry of participant #40, it was discovered that the likely link of this branch to the main Mumma tree was through a female whose maiden name was Mumaw, but for which no husband could be identified. It was not clear whether this was a case of she and a cousin marrying or possibly a case of an illegitimate birth. To better understand the connection, a descendant of this branch was sought, found and a sample of his DNA analyzed. The lack of similarity between his haplotype and that of the MUMMA modal haplotype was striking and clearly showed one of his ancestors was not fathered by a male with the Mumma/Mumaw/Moomaw haplotype. Subsequent record searches revealed one entry in the 1850 census of Virginia where a child closely matched his age and and the mother's age was correct, but the child's surname was listed as "Webb" and the mother's name was Fadeley. Further detective work revealed that the maiden name of the female married to Mr. Fadeley was "Mumaw". Speculation was that a man with the Webb surname may have been the child's father. Further record searches and Internet queries revealed that a Will written by a Mr. Webb left substantial money to his

housekeeper, a Mumaw female, if she "continued to serve him as she had in the past". This was an unusual bequeath since this represented a large amount of money to leave to a housekeeper while his wife was still living, but they were separated. Mr. Webb died just prior to the 1850 census. Now there were strong clues and evidence as to the likely male ancestor of participant #40, a Mr. Webb. Two male descendants of Mr. Webb were located and their DNA tested. Since we only wanted to determine whether the haplotype of the Webb men matched participant #40, a simple 12 marker test was used. The results of the analysis are compared in Table 3 and are conclusive. Participant #40 clearly shares the same haplotype as the Webb participants and must have been fathered by a Webb. This excellent example demonstrates the power of Y-chromosome testing to confirm or deny genealogical relationships. Since the mother was a Mumaw descendant, the descendants of this branch still share a Mumma ancestry, but through the maternal side. The male descendants share the WEBB modal haplotype, not the MUMMA modal haplotype.

Table 3 - Comparison of Webb/Mumaw/Moomaw Surname Results

	Marker #	1	2	3	4	5	6	7	8	9	10	11	12
M#	DYS # =>	393	390	19	391	385a	385b	426	388	439	389i	392	389ii
-	Mumma modal haplotype	13	25	14	11	11	14	12	12	13	13	13	29
40	Moomaw/Mumaw	14	22	14	10	13	13	11	14	12	13	11	29
38	Webb	14	22	14	10	13	13	11	14	12	13	11	29
41	Webb	14	22	14	10	13	13	11	14	12	13	11	29

The unusual haplotype of #49 is simply that his father is known to have been adopted, but there was little discussion about the issue or knowledge about the circumstances. Since another child had been adopted within the family, but was a Mumma descendant, participant #49 wanted to verify whether or not his father's father was a Mumma descendant. The results clearly show that his father was not fathered by a Mumma. Further, he wanted to have detailed DNA results in case an exact 25 marker match is discovered someday as the number of haplotypes in the various DNA databases increase, however unlikely that might occur.

The next table shows the results from the descendants of another immigrant, Jacob Mumma, who arrived in America in 1731. Only four of his descendants participated, but one man matched the MUMMA modal haplotype exactly. No physical documentation has ever linked Jacob and Leonard as brothers or even cousins. From the results we can firmly conclude that both immigrants, Jacob and Leonard, shared a recent common ancestor, but that is the extent to which we can make claims. There is not sufficient precision in this technique currently to determinate whether the immigrants were brothers or close cousins. Participants #19 and #4 are father and son and their haplotypes matched each other exactly as expected, but with two, one step mutations from the Mumma Surname haplotype. We conclude this group belongs to the same general Mumma family.

Table 4 - STR Y-Chromosome Results Descendants of the Immigrant Jacob Mumma

	Marker #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
	DYS #	393	390	19	391	385a	385b	426	388	439	389i	392	389ii	458	459a	459b	455	454	447	437	448	449	464a	464b	464c	464d	464e	
M#	Surname	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	Henry Ref#
7	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	18	9	10	11	11	24	15	19	30	14	17	17	17	0	111811411
19	Mummau	13	25	14	11	11	14	12	12	12	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	18	0	117231401
4	Mummau	13	25	14	11	11	14	12	12	12	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	18	0	1172314012
45	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	13311917

The cases we have examined so far have been easy to evaluate because either the relationships were known, or there were dramatic differences in the recorded haplotypes. As we continue comparing the various groups we

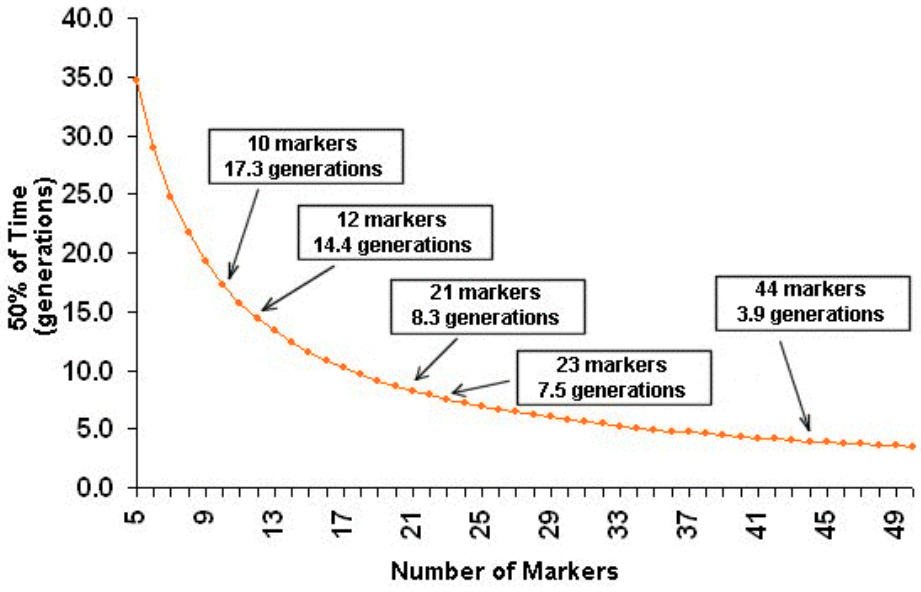
will find either the relationships are not precisely known or the haplotype differences are not as dramatic. Thus we need to establish criteria for judging the "relatedness" of the participants, i.e. whether or not they share a common Mumma ancestor in the recent past.

Mutation Rates - We now turn to statistics to for guidance. From genetics, we learn that mutations occur at random. As we have seen in Table 2 and Chart 2, very distant cousins may match each other exactly on all 25 markers while two brothers, such as #18 and #21, do not. Because of the random occurrence of mutations, probability theory is used to estimate the time in generations to the Most Recent Common Ancestor (MRCA), the time in which the ancestors of two men become the same ancestor. The actual calculations of MRCA are mathematically complex and for the highest accuracy, depend on knowing the rate of mutation for each locus. A research paper published in 2000 by Dr. Bruce Walsh of the University of Arizona "Estimating the Time to the Most Recent Common Ancestor for the Y-chromosome or Mitochondrial DNA for a pair of Individuals" addresses this subject. A more simplified discussion of this paper, MRCA and its implications written in layman terms can be viewed on this his web site at http://nitro.biosci.arizona.edu/ftdna/TMRCA.html. Behind his calculations are several variables, namely how fast the various loci mutate and any change in a marker is treated as a single mutation. A mutation rate of 0.002 (1 change in 500 opportunities) is typically used in most calculations. Walsh calculates probabilities shown below. This table simply lists the number of generations corresponding to the time, in generations, when 50%, 90% and 95% of all men sharing that exact haplotype would share a common ancestor. The effects of one or two mutations are also shown.

Match		50%	90%	95%
12-12	Match exactly at all 12 markers	14	48	62
11-12	11 exact matches + 1 mutation	37	85	103
25-25	Match exactly at all 25 markers	7	23	30
24-25	24 exact matches + 1 mutation	17	40	48
23-25	23 exact matches + 2 mutation	28	56	66

Even with an exact match of all 25 markers, it is not until the 30th generation that 95% of all the men would share a common ancestor. Graphically, the 50%, or a 50-50 probability that two people with identical haplotypes share a common ancestry within a given number of generations is shown in Figure 3 which was created by Dr. Walsh. As can be seen, the more markers that are measured, the more closely one can estimate at which generation two people may share a common ancestor.

Figure 3 Plot of MRCA time (50%) versus the number of markers measured



MUMMA Generation time span - So how long a time is a generation? Some geneticists and anthropologists suggest 15 to 25 years as the number of years per generation. I believe this substantially understates the value for modern times, i.e. in the last 500 years. First, this time appears to be the time for the "first birth" of females and not an average time for the birth all of her children. For example, if we simply assume a woman's child bearing period was typically from age 15 to 45, the median child would be born around 15 years after her marriage, suggesting an average generation time of 30 years, based on the mother's age. The second reason is the typical male married somewhat later than females, often around age 25, so the average time from the father's birth to the average time when all of the children were born would be longer. To verify this, I determined the average male generation time span all of the Mumma surname participants was about 33 years and for the Momma/Reenstjerna families of Europe it was 34 years, thus confirming a longer time than is normally quoted. It was brought to my attention by Ann Turner that a published paper by Tremby & Vézina, American Journal of Human Genetics 66:651-658, 2000 reached similar conclusions. In their study, they determined an "Intergenerational Interval" of 34.4 years for men from family reconstruction. Using a time of 33 years as the time per generation for Mumma males, a perfect match of 25 markers out of 25, 95% is not reached until around 1000 years. Even at 50% probability, the median time that two men share a common ancestor is about 231 years. This, of course, is with a match of 25 out of 25 markers so you can easily see these probabilities increase substantially if many mutations are observed. I don't find these numbers to be helpful in determining whether two men are related, other than it confirms that the haplotypes to two men must closely match as was observed from the results in Table 1.

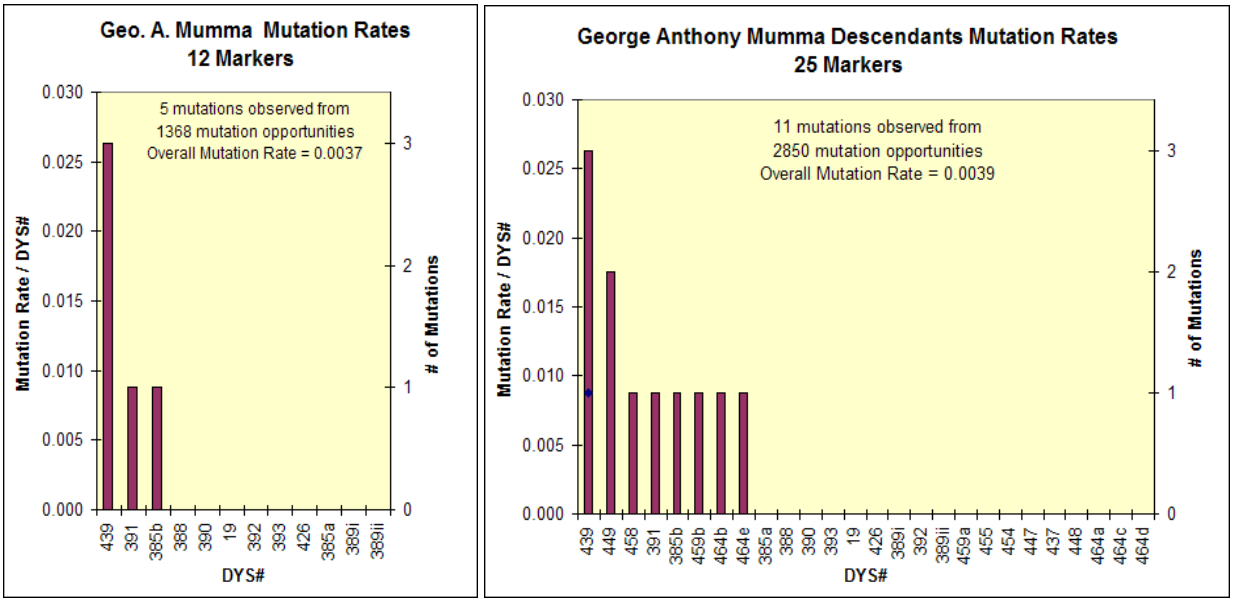
MUMMA Mutation rate - Most geneticists use a mutation rate of 0.002 as an average rate for all loci or markers. In the MUMMA study, accurate genealogies exist for the descendants of George Anthony Mumma which allow us to determine the exact number of conceptions and thus derive a mutation rate specific for the MUMMA surname. The reconstruction of the probable haplotypes for each ancestor in Chart 2 allows the precise determination of the number of conceptions that occurred for the descendants of Leonard Mumma that are shown. Each generation box represents a conception and is an "opportunity" for a mutation to occur at any of the 25 loci or markers measured. The 11 observed mutations resulted from 2850 mutation opportunities (114 conceptions and 25 measured loci). This yields a mutation rate of 0.0039 which is significantly higher than that rate used by geneticists from a mixture of surnames. A similar mutation rate was determined by combining the results of all men who appear to be Mumma descendants. While everyone cannot be connected together precisely using documented genealogies, rather good, conservative estimates can be made of their likely connections. A very similar mutation rate of about 0.0038 was computed for all likely related participants.

It is also instructive to plot the number of mutations observed as function of the DYS location for both the 12 and 25 marker analyses. The results are shown in Chart 4a and 4b. For the MUMMA modal haplotype, DYS439 exhibits the highest locus mutation rate of about 0.026 and it dominates the mutation rate calculations for this surname study. The number of mutations observed for DYS439 and DYS458 represent about 50% of the total mutations recorded. While the sample size is relatively small and includes the subjective connection of all the "unconnected" Mumma family branches into just one tree, I feel this is a more realistic mutation rate to use in calculations for the Mumma family. This value was derived from actual data representing mutations occurring over an 8 to 12 generation time span. I further believe, based upon my perceptions, that the mutation rates and volatility of these loci are specific to the MUMMA surname and should not be applied to other surnames without further verification. For interest, Ann Turner has created a handy "Mutation Rate" calculator program which is available for download at http://members.aol.com/dnafiler/MutationCalculator.exe. This program simply allows you to plug in various mutation rates and determine the number of mutations that will likely be observed. In the case of the descendants of George Anthony Mumma, using the classical rate of 0.002, the expected number of mutations would be 6, about half of the number that were observed. It is also interesting to note that FTDNA has concluded from an examination of their database that DYS464 shows the most mutation volatility. This has not been the case with the Mumma study suggesting different mutation rates and specific marker volatility will vary between specific surnames.

Another interesting observation is that all of the mutations occurred within a third of the markers measured. This would suggest that about two thirds of the markers, at least for the MUMMA surname, rarely mutate and could be thought of as the "core", non-mutating, MUMMA surname haplotype. The more volatile markers then become unique to identifying specific branches within the family. Of course this is purely speculative and

derived from an extremely small sample size, but it is an interesting observation. To further explore this thought, I asked FTDNA to examine their database for the number of men who exactly match this 16 marker "core" haplotype for which no mutations were observed for the Mumma men. Much to my surprise, of the 12,569 individuals listed in the FTDNA database, only 39 exhibit this specific 16 locus haplotype and of the 39 matches, 37 were from the MUMMA surname study. The 2 non-Mumma men who also matched the alleles of the 16 loci, however, only matched 20 of the 25 markers comprising the Mumma modal haplotype and are clearly not Mumma descendants. Whether this 16 marker core haplotype proves to be of any value or benefit when examining future results remains to be seen, but it was a curious observation.

Figures 4a & 4b - Mutation rates for specific loci



Using the observed mutation rate of 0.0039 and the MRCA calculator provided by Ann Turner (moderator of the Genealogy DNA list), new MRCA probabilities were generated for the MUMMA surname. Her PC based computer program is interesting to use as it allows one to vary not only the mutation rate, but the number of markers measured. The program is based on the formulas and criteria developed by Walsh as previously discussed and provides a reasonably good approximation. She freely shares this program and it can be downloaded from her site at http://members.aol.com/dnacousins/MRCA.exe. The results of these calculations, using the revised mutation rates for the MUMMA surname, yields the following revised MRCA probabilities. The higher mutation rate leads to interesting MRCA times when 32 markers are used as was the case for a small group of men who had additional markers tested. This clearly shows that additional markers will be helpful when trying to distinguish between various branches a surname who share a common progenitor.

Match	Description	50%	95% Confidence
25-25	Match exactly at all 25 markers	3.7	0.1 - 19.9
24-25	24 exact matches + 1 mutation	9.3	1.3 - 30.7
23-25	23 exact matches + 2 mutations	15.1	3.5 - 40.7
32-32	Match exactly at all 32 markers	2.9	0.1 - 15.6
31-32	31 exact matches + 1 mutation	7.2	1.0 - 23.9
30-32	32 exact matches + 2 mutations	11.7	2.7 - 31.5

Based on this experimentally derived mutation rate and observations of actual data, we are now in a better position to view the remaining haplotype comparisons where the exact connection and link to the MUMMA family was not certain, and in fact in some cases, was not expected. From the results of the first phase of the project where 12 markers were measured, a generalized criteria was established that a man's haplotype had to match the MUMMA modal haplotype exactly or not be different by more than 1 mutation. For the 25 marker test, the criteria was doubled to a maximum of 2 mutations to be considered as a possible Mumma descendant. The criteria was reduced to simply "3 strikes (mutations) and you're out (non-Mumma)".

"Unattached" MUMMA Participants -Table 5 shows the values obtained for the "unattached" Mumma trees. All of these participants are assumed to be descendants of one of the original MUMMA immigrants, but their ancestry and connection has not been determined using traditional documentary records, but is highly likely. We will examine the first four individual in this chart, but discuss them in the order the results were received. The results of #26 and #27 initially received. These are distant cousins whose descendancy splits immediately with the progenitor of their branch. The fact that their unique haplotypes matched exactly was confirmation of the validity of this technique and provided a haplotype identification for this branch. Census and other records strongly suggested that their connection was to Peter Mumma, the immigrant, but no documented proof exists. Then the results of #46 was received and he is a known descendant of the immigrant, Peter Mumma. Needless to say it was very exciting when the haplotype of #46 exactly matched the haplotype of #26 and #27. Now, in addition to strong circumstantial and family legend evidence, this scientific data essentially confirms that they share a common ancestor. The other revealing information came when the results of #52 was received. He descends from another "unconnected" branch for which there was also strong circumstantial evidence that this branch descended from Peter. Again the haplotype of #52 matched the haplotype of the known descendant of Peter Mumma (#46) and this almost becomes genetic "proof" of the connection. There is some documentation that #32 is also a descendant of Peter, but in this case, his haplotype does not match that of the other descendants of Peter. This may give rise to the possibility that #32 is not correctly attached to Peter. This participant is interesting, however because he has a maternal connection to the Mumma family.

Participant #44 uses the surname of Stevenson, but is a Mumma descendant. His surname was changed when he was being raised in the Stevenson household. He descends from one of the unattached lines and his mutation at DYS 391 may prove to be the identifying marker and haplotype for this branch.

The next two men, #8 and #51, use the Moomau surname spelling and documentation connects them together, but not to one of the main Mumma branches. They match the Mumma surname haplotype without any mutations, so we have little evidence to guide us in determining a potential connection to any specific branch.

The same conclusion is true for #53. He also matches the Mumma haplotype and uses the surname spelling of Mumma, so there is little to guide our investigations regarding his possible connection to one of the main branches. His ancestors lived in Cumberland Co., PA and his family legend suggests he is a descendant of immigrant Jacob.

Participant #43, a Mewmaw of undetermined connection matched the haplotypes of #36 and #54 who are known descendans of Leonard Mumma, but on slightly different branches. There is nothing in the genealogy of #43 that would suggests he might be closely connected to either #36 or #54. I conclude this is simply a coincidence of a mutation occurring at the most volatile marker measured for the Mumma surname.

The next two men, #48 a Mummaugh and #55, a Mumma, share the same haplotype with a mutation at DYS449, and they also share it with a #21. In the case of #21, his mutation occurred when he was conceived as is evidenced in Figure 2, where his brother shows no mutation. Obviously they don't share a close link with #21. Likewise, there is nothing in the genealogies of #48 and #55 that would suggest they share an obvious connection to the same branch or twig. The Mummaugh family has lived in Carroll County, MD for almost 200 years with almost no emigrations to other areas of the country and all descendants have been accounted for. It would appear that this is another coincidental mutation for two people on the second most volatile marker for the Mumma project.

The interpretation of the results of #35 and #39 has been perplexing. Using the previous criteria of *"3 strikes and you're out*", they would be rejected as not sharing a recent Mumma common ancestor. However, all documentation suggests that they are likely Mumma descendants. So, are they Mumma descendants or not?

The two men are documented, distant cousins who share a common ancestor 4 generations earlier. Their 3 mutations, however, occurred on the 3 most volatile markers observed in this study, namely DYS439, 449 & 458. Because the high mutation frequency of these loci, possibly the "*3 strikes and you're out*" model is to simplistic and stringent. While 3 mutations is unusual, it is statistically possible to have this many and still be a Mumma descendant. My initial reaction was to exclude them as not being Mumma descendants, but I now feel 3 mutations may be allowable and still be closely related, but with the added stipulation that the mutations must occur at the most volatile loci. The relatedness of these men to a common Mumma ancestor must remain somewhat questionable without additional documentary proof or new DNA tests.

The final grouping of four participants, #17, #22, #13 & #20, descend from an "unattached" branch who exclusively use the MUMA spelling and appeared in Canada shortly after the Revolutionary War. They were most likely "*loyalists*" wanting to remain under British rule. In the case of #13, he matches the MUMMA modal haplotype exactly while #17 and #22 both show single mutations, but at different markers. These three men meet the criteria as being Mumma descendants. The surprise occurs with the results of #20. His haplotype shows 4 mutations within the first 12 markers, a result that was unexpected. This many mutations appearing in the first 12 markers strongly suggests he is not a Mumma descendant. In addition, 2 of his mutations occurred on loci which showed no mutations for the other Mumma participants. Because he did not pass the initial criteria of no more than 1 mutation in 12 markers, his sample was not analyzed at the remaining 13 markers. We have insufficient knowledge to know what caused his haplotype to be different, but apparently a non-Mumma paternity event likely occurred as the result of an adoption, rape or infidelity. No further testing was pursued to try and identify at which generation this event possibly happened. It is because of these possible results that I strongly recommended an individual's identity remain private and confidential until "expected" results are obtained.

Table 5 - STR Y-Chromosome Results"Unattached" Mumma Branches

	Marker #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
	DYS # =>	393	390	19	391	385a	385b	426	388	439	389i	392	389ii	458	459a	459b	455	454	447	437	448	449	464a	464b	464c	464d	464e	
M#	Surname	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	Henry Ref#
26	Muma	13	25	14	11	11	14	12	13	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	U08-111114
27	Mumma	13	25	14	11	11	14	12	13	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	U08-12642
46	Mumma	13	25	14	11	11	14	12	13	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	4249121
52	Mumma	13	25	14	11	11	14	12	13	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	U28-1403
32	Mumah	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	43242352
44	Stevenson	13	25	14	10	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	U62-1472152
51	Moomau	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	U45-137537
8	Moomau	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	U45-1387411
53	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	U30-112542
43	Mewmaw	13	25	14	11	11	14	12	12	12	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	U7-133352
48	Mummaugh	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	29	14	17	17	17	0	U51-133122
55	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	29	14	17	17	17	0	U69-153
35	Mumma	13	25	14	11	11	14	12	12	12	13	13	29	18	9	10	11	11	24	15	19	31	14	17	17	17	0	U46-113833
39	Mumma	13	25	14	11	11	14	12	12	12	13	13	29	18	9	10	11	11	24	15	19	31	14	17	17	17	0	U46-1128121
17	Muma	13	26	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	U21-1334663
22	Muma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	28	14	17	17	17	0	U21-13346792
13	Muma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	U21-1492712
20	Muma	13	24	14	11	11	14	12	12	12	11	13	27															U21-148XXXX

Table 6 shows the data obtained for the "Miscellaneous" participants, most of whom were not expected to be Mumma descendants. While some of their surnames spellings are similar and are phonetically close to Mumma, no documented proof existed to either confirm or deny they shared a common Mumma ancestry. In such cases,

a simple 12 marker analysis appears to be sufficient to determine whether or not they are possibly Mumma descendants.

The first man, #23, with the Mumma surname was included to satisfy my curiosity. The Mumma surname spelling is rarely found outside the United States, where the spelling originated. However, after an extensive world wide search, I discovered a small family group living in Estonia who use the Mumma surname spelling. Participant #23 agreed to provide his DNA sample which was analyzed. The results show that in spite of sharing a common surname spelling, there is no close connection between Mumma family of Estonia and the Mumma families of America.

The Moomey spelling, represented by #28 and #42, showed they did not share a common ancestry with the Mumma family. I was initially convinced that the Moomey spelling was simply an alteration of the Moomaw surname, a well known variation of Mumma. Their matching haplotypes show they both share a common ancestry, but with such a large number of mutations, they don't share a common Mumma ancestry. The Mummey spelling was one for which there was little guidance whether men with this surname spelling were closely related with the Mumma family. Because of the large number of mutations, they too do not descend from the Mumma family and they don't even share a common ancestry between each other. The Mumme spelling is still found in Germany today and a representative was included to determine whether or not there was a possible relationship with the Momma family. Again the results show this family surname is likely not related. These were people whom we felt, before the testing began, did not likely share a common ancestry with the MOMMA/MUMMA families. The results confirm the supposition. In all cases, the number of multiple mutations recorded differed from the MOMMA/MUMMA modal haplotype by more than 3 mutations. Using the previously established criteria of only allowing a single step mutation at one loci in the 12 marker analysis, none of these men likely share a common ancestry with the MOMMA/MUMMA families.

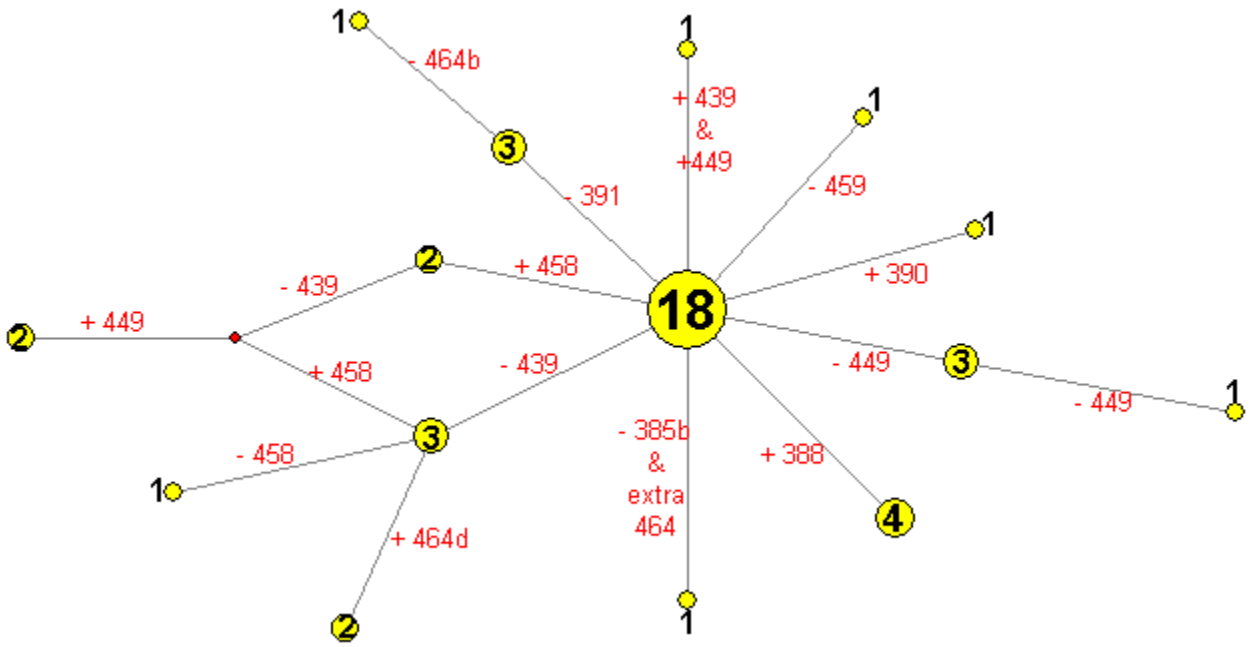
Table 6 - Miscellaneous Results

	Marker #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
	DYS # >	393	390	19	391	385a	385b	426	388	439	389i	392	389ii	458	459a	459b	455	454	447	437	448	449	464a	464b	464c	464d	464e	
M#	Surname	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	Henry Ref#
23	Mumma	13	22	14	10	14	14	11	14	11	12	11	28															Mumma-Estonia
28	Moomey	13	24	13	11	11	15	12	12	11	13	13	29															Moomey
42	Moomey	13	24	13	11	11	15	12	12	11	13	13	29	17	9	9	11	11	25	15	19	30	15	15	17	17	0	Moomey
33	Mummey	13	24	14	10	11	14	12	12	13	13	13	30															Mummey
47	Mummey	13	22	15	9	13	14	11	13	11	12	11	29															Mummey
24	Mumme	13	24	14	11	11	13	12	12	12	13	13	29	18	9	10	11	11	26	15	19	28	15	15	16	17	0	Mumme

Phylogenetic Network

Another way to view the haplotype data and mutations is in the form of a phylogenetic network chart where men with similar haplotypes are grouped together. Such a chart for the Mumma Surname DNA project is shown in Figure 5. The dominance of the 18 men with the MUMMA modal haplotype is represented by the large central circle. Only Mumma descendants, which all had 3 or fewer mutations, were included in the network. The nearest non-Mumma participant had 8 mutations and obviously does not share a common ancestry with the Mumma/Momma family. Therefore, only data from the 44 men who are likely Mumma descendants were included to minimize distortion of the network. The area of each circle is representative of the number of haplotypes observed which is listed as the number in black. A total of 15 unique haplotypes were observed. The loci DYS numbers which mutated and were different from the MUMMA modal haplotype are shown in red with a + or – sign signifying whether the allele increased or decreased. For the purposes of this network, the extra repeat of DYS464 for #50 was treated as a single mutation. The basic tree shape and information was created using network tree software provided free through the courtesy of Fluxus Technology, Ltd.

Figure 5 - Phylogenetic Network for 44 MUMMA participants



EXTENDED LOCUS TESTS

The next table shows the results obtained from two German Momma surname participants, #10 and #12, as well as a man with the surname of Reenstjerna, #30. A brief explanation for his unusual surname spelling and connection to Momma is appropriate. Several Momma families migrated from Aachen to Holland in the 1500's. Eventually several brothers moved to Sweden where they established large shipping and mining companies and contributed greatly to the economy of Sweden. Because of these contributions, they were *ennobled* by the King of Sweden in 1669 and were allowed, thereafter, to use the surname of *Reenstierna*, which literally translated means "reindeer star". Hence, anyone with this surname would be expected to carry the MOMMA haplotype. Because of their high status in finance and commerce, the genealogies of both the Momma and Reenstjerna families are well documented though court records. They are known to share a common ancestor 11-12 generations ago with the progenitor, Wilhelm Momma, who was born about 1550.

Again consistency is observed in the data and the two Momma men have matching marker MUMMA modal haplotypes. Obviously this suggests that one should say that the MUMMA families of America descend from the MOMMA family of Germany since the Momma family predates the Mumma families. While we can't determine at which specific generation the two families share a common ancestor, at least we know they link together in the not too distant past. The Reenstjerna haplotype is also very close to that of the Mumma modal haplotype, only showing 2 mutations in the 25 marker analysis. Thus we can conclude a highly probable connection between these families through the DNA analysis both by genetic and written documentation.

Additional data is also presented in Table 7 for markers numbered 27 to 33. At the completion of the the first phase of the project, only 12 markers were available for comparing the haplotypes of the participants. In that data, a majority of the Mumma participants shared the exact same haplotype. While it confirmed a common ancestry, it did not provide sufficient mutational variety that would allow an identification of specific branches. It was then decided to investigate whether other laboratories might be able to measure different loci. Several men were selected from the first phase of the testing for inclusion in this extended test group, eventually becoming known as the "gang of 4". The selected men shared were to have the MUMMA modal haplotype, but were to be from different Mumma branches. Since I met the criteria of having the MUMMA modal haplotype, my sample was included, representing the descendants of the immigrant, Leonard Mumma. Sample #7, a descendant of the immigrant, Jacob Mumma was included as he too matched the MUMMA modal haplotype. A descendant of the immigrant Peter was not available at that time. One of the Momma men, #12, was included as

he represented the European link and also matched the 12 marker MUMMA modal haplotype. The final selection was #30, the Reenstjerna, because he and #30 are known to be 11 & 12 generations from their common ancestor (23 generation events or conceptions have occurred between these two men). These samples provided a good representation of men from distinctly different family groups. Five laboratories were solicited to analyze loci that overlapped those that had been measured by FTDNA, as well as providing measurements of different loci. Eventually, only two laboratories proved to be capable at that time of performing the analysis and providing data. DNA samples were sent to Dr. Mark Jobling at the University of Leicester in England who graciously consented to perform the desired analysis. In addition, FTDNA/Dr. Hammer also agreed to include these four men in the research he was performing on additional markers. Samples were sent to BYU, but after six months of trying, they were unable to perform acceptable analyses and their contract was cancelled. Their suggestion to utilize the services of Relative Genetics, for whom they consulted, was rejected. Eventually BYU refunded all costs that were charged.

The Jobling analysis for the "Gang of 4" (#1, #7, #12 & #30) are also shown in table 7 as markers 27 through 33, representing loci that did not duplicate the measurements of FTDNA. The specific markers & loci that Dr. Jobling analyzed are shaded green along the top row of the chart. At all duplicate markers, identical alleles values were measured and reported. These results provided good confidence in the quality control measures employed by both laboratories.

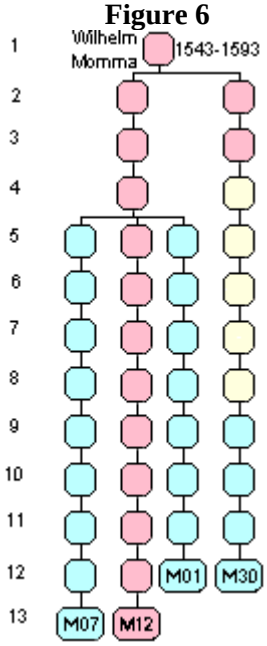
The results are extremely interesting and show that the 32 markers measured for me, #1, and #12, the German Momma participant, are identical. This was a surprising and unexpected result. Using the revised probability table calculated for the MUMMA surname, the median time for the occurrence of a common ancestor for us would be at 2.9 generations. A 95% confidence probability will occur between the 1st and 16th generation. I am a 7th generation American, the earliest that #12 and I could share a common ancestor is at the 8th or 9th generation. A descendant chart showing the progenitor, Wilhelm Momma, b. 1543 and the likely descendancy of the four participants is show in Figure 6. The boxes filled with a salmon color represent generations born in Germany, those in blue were born in America and the yellow colored boxes were generations born in Sweden.

Also, we find few mutations in the haplotypes of the other two men. The Reenstjerna, #30, showed no mutations for these additional 4 loci and only #7, the American descendant of Jacob Mumma showed a single mutation at DYS464. Because the sample size was so small, I am unable to conclude whether these extra loci will prove to be useful markers for branch identification within the Mumma trees. The data certainly suggests that it is important for a surname project to establish a baseline of information for men with known genealogies and to analyze the largest possible number of loci. These data further suggest that the MUMMA/MOMMA haplotype is very stable and predictable.

Table 7 - European and Extended Analysis Results

	Marker #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	
	DYS # =>	393	390	19	391	385a	385b	426	388	439	389i	392	389ii	458	459a	459b	455	454	447	437	448	449	464a	464b	464c	464d	464e	434	435	436	438	460	461	462	
M#	Surname	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	9	11	12	12	10	10	11	Henry Ref#
10	Momma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0								E-1458353211114
12	Momma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	9	11	12	12	10	10	11	E-1458353413231
30	Reenstjerna	13	25	14	11	11	14	12	12	12	13	13	29	16	9	10	11	11	24	15	19	30	14	17	17	17	0	9	11	-	12	10	10	11	E-143143311151
1	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	17	9	10	11	11	24	15	19	30	14	17	17	17	0	9	11	12	12	10	10	11	21837023
7	Mumma	13	25	14	11	11	14	12	12	13	13	13	29	18	9	10	11	11	24	15	19	30	14	17	17	17	0	9	11	12	12	10	10	12	111811411

Figure 6



MSY1 Data

In addition to the Y-STR data, Dr. Jobling and Ms. Turi King of the University of Leicester in England also performed an MSY1 analysis. I was interested in this because it was one of the analytical techniques used in the President Jefferson - Sally Hemings case . In that project, it was considered to be useful in uncovering small differences in similar samples.
The numeric MSY1 reported values are:
#1 No data obtained - (this was frustrating as these would be my results)
#7 (1)17 (3)41 (4)2 (3)2 (4)16 - (American MUMMA)
#12 (1)17 (3)41 (4)1 (3)3 (4)16 - (German MOMMA)
#30 (1)17 (3)41 (4)3 (3)1 (4)16 - (Swedish REENSTJERNA)

Figure 7 – Graphic display of MSY1 results

Since Dr. Jobling's laboratory is the only one which measures MSY1, there is little other data by which to compare these results and a technical description of the measurement is beyond the scope of this report. Dr. Jobling's comments were that the results show there is little variation of the Y-chromosome for these three DNA samples.

CONCLUSIONS

From the analysis of the Y-chromosome STR data obtained from 55 participants, the following observations and conclusions have been drawn:

1) A stable, slowly mutating, MUMMA/MOMMA surname modal haplotype has been identified from the DNA analyzed from 40 Mumma men. 18 men share the same identical haplotypes measured at 25 markers. These men are descendants from a broad and diverse representation of the MUMMA/MOMMA family, primarily descendants of immigrants Jacob, Leonard & Peter MUMMA who arrived in America in the early to mid 1700s. In addition, men from Germany with the MOMMA surname, a man with the REENSTJERNA surname originating in Sweden, members of the MUMA family of Canada and several "unconnected" lines also share this identical haplotype.

2) A 16 marker "core" haplotype shared by all of the Mumma descendants was identified and no mutations were observed . This "core" haplotype was compared with 12,569 haplotypes in the FTDNA database and only 39 identical matches were revealed. Of those 39 matches, 37 were men from the MUMMA surname project. This suggests there is a portion of the Y-chromosome that mutates extremely slowly, if at all, for the MUMMA surname.

3) A mutation rate of 0.0039 was determined for the Mumma surname from an analysis of 25 marker data using the DNA from men who have documented descendency from a single, common ancestor, Leonard Mumma. A rate of 0.0037 was determined from an analysis of just the 12 marker data of this same group. In addition, it was determined that 66% of the mutations occurred at DYS439, DYS458 and DYS449 for the MUMMA surname.

4) This technique has been demonstrated to be a reliable tool to distinguish whether men share a common ancestry. It is also showing great promise a a tool for identifying specific branches within a single surname family. A number of participants in the MUMMA Surname project were shown to not share a recent MUMMA ancestor, even though they use the MUMMA surname or close variant spellings. Proving the negative conclusion, that two men do not share a common ancestry, is probably the greatest power of this technique.

ACKNOWLEDGEMENTS

I would like to take this opportunity to acknowledge the support and assistance of various people and organizations who have greatly assisted the Mumma Surname Project successfully reach and exceed the original goals.

First, I would like to thank all of the men who have participated in this project providing samples of their DNA and money for its analysis. Without their support and help, both in spirit and financially, the project would never have been successfully launched.

I would like to thank Bennett Greenspan, president of Family Tree DNA, who has been a great assistance to this project. His door has always been "open". His patience and dedication in providing excellent DNA analytical service is outstanding and I feel he and FTDNA have made a positive contribution not only this project, but to the genealogical community as a whole. I would also like to thank Bennett and FTDNA for giving me permission to use various charts, figures and images used on their web site.

Dr. Mike Hammer and his staff at the University of Arizona have been superb in providing reliable and accurate analysis of the DNA samples. They have also provided me with answers to numerous technical questions.

Dr. Mark Jobling and his graduate student, Turi King, were most helpful with their generous analysis of the four special samples. This effort provided me with additional knowledge about different loci and confirmation of inter-laboratory accuracy at matching loci.

Thanks also to Ann Turner who unselfishly created and maintains the RootsWeb Genealogy-DNA discussion list as well as sharing her calculational tools for determining MCRA and Mutation Rates.

FUTURE PLANS

Continuing testing will be conducted to further expand the knowledge about the MUMMA haplotype. There are still many gaps in the knowledge base which will be filled with additional testing of the various "unattached" branches and our MOMMA families of Europe.

If you are a man with the Mumma surname (or alternate spelling) and would like to participate in this project and add your information to the database, please sign up at http://www.mumma.org/dna_signup.htm or e-mail Doug Mumma at doug@mumma.org. You may also contact Doug Mumma at 2123 Farmington Place, Livermore, CA 94550.
