

A DNA Genealogy Primer

How to break genealogical brick walls with genetic science

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Presented for the Morgan County (Alabama) Genealogy Society

Outline

- DNA Basics
- Types of DNA Tests
 - Y-DNA
 - mtDNA
 - Autosomal DNA



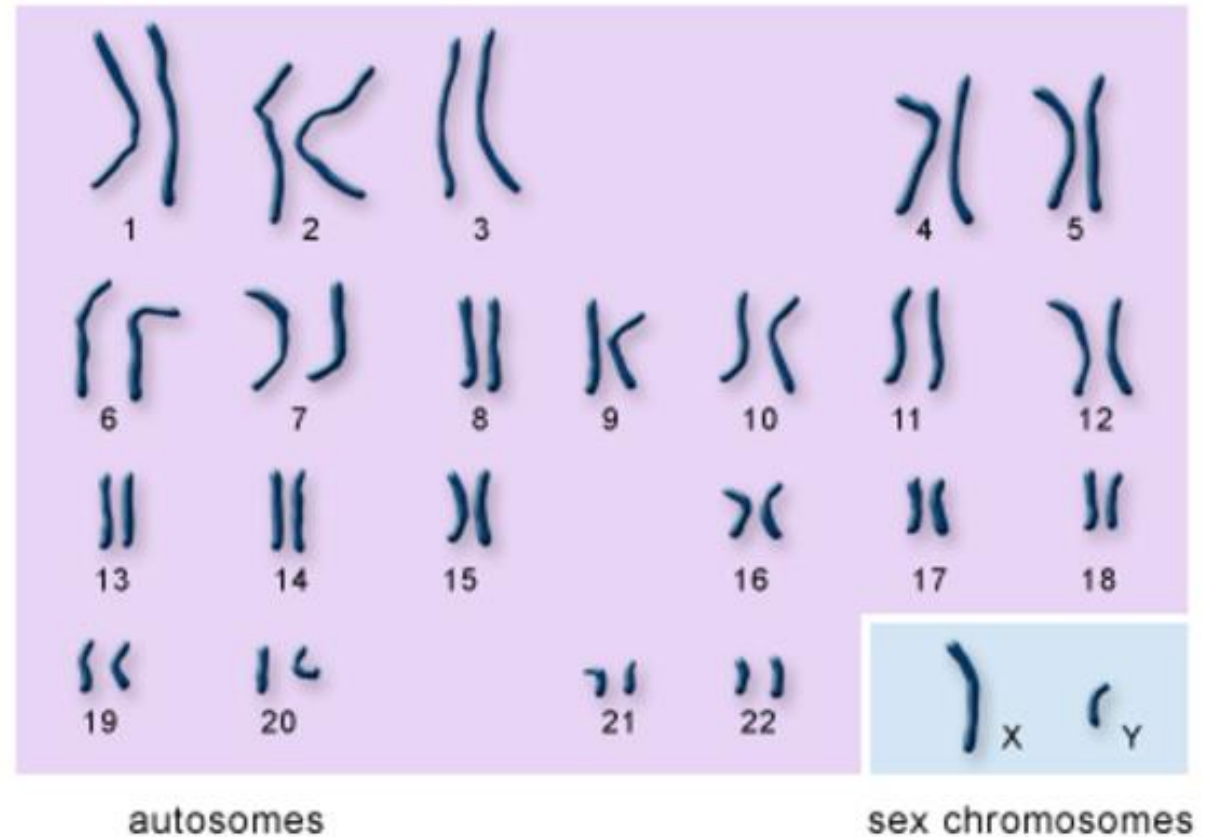


DNA Basics

- DNA (**D**eoxy-ribo**N**ucleic **A**cid): complex organic molecule that encodes sequences of proteins
- All living things have DNA
- Bundled into ***chromosomes***
- Humans generally have 23 pairs of chromosomes (46 in all)

Sex chromosomes and Autosomes

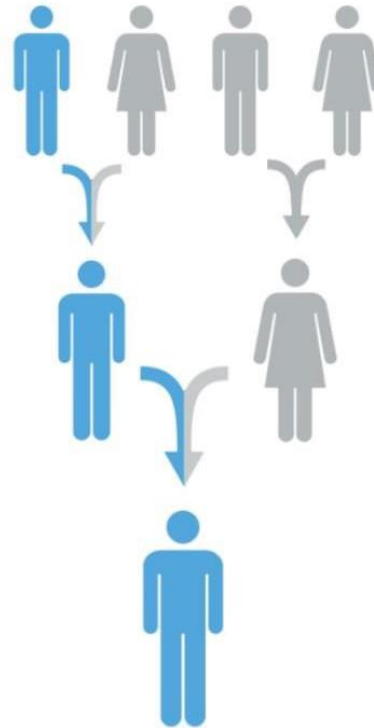
- One pair out of the 23 pair are called **sex chromosomes**
 - Sex chromosomes define male and female characteristics
 - Males: X from mother, Y from father (XY)
 - Females: X from mother, X from father (XX)
- Remaining 22 pair: **autosomes**



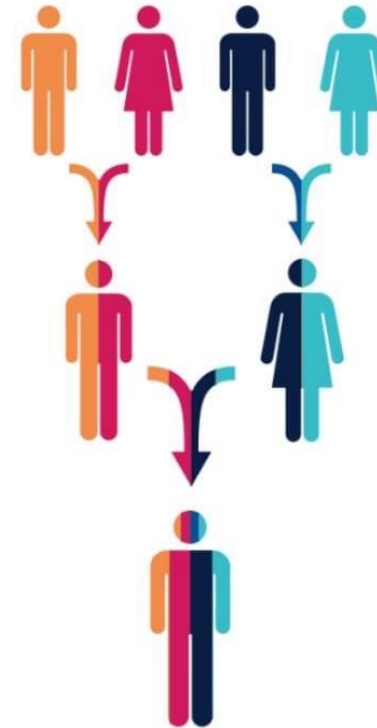
Types of DNA tests

- Y-DNA
- Autosomal DNA
- Mitochondrial DNA (mtDNA)

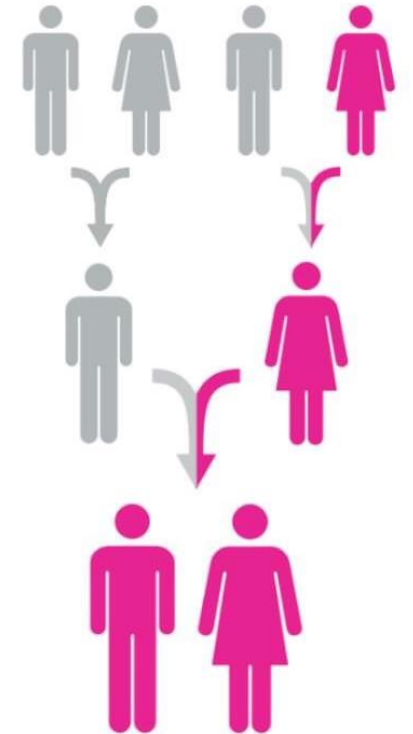
Y-Chromosome DNA is inherited from your male lineage



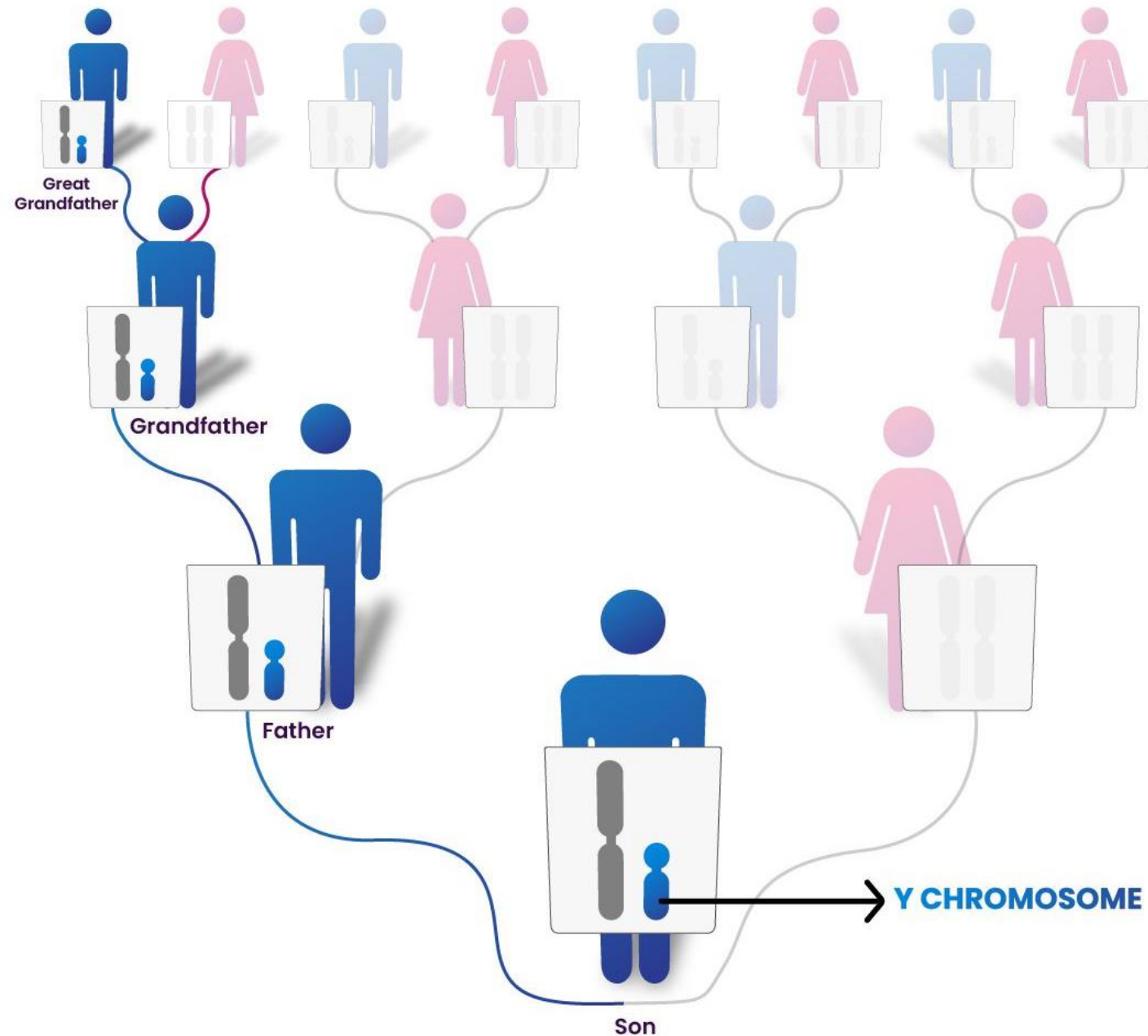
Autosomal DNA is inherited from all of your ancestors.



Mitochondrial DNA is inherited from your female lineage



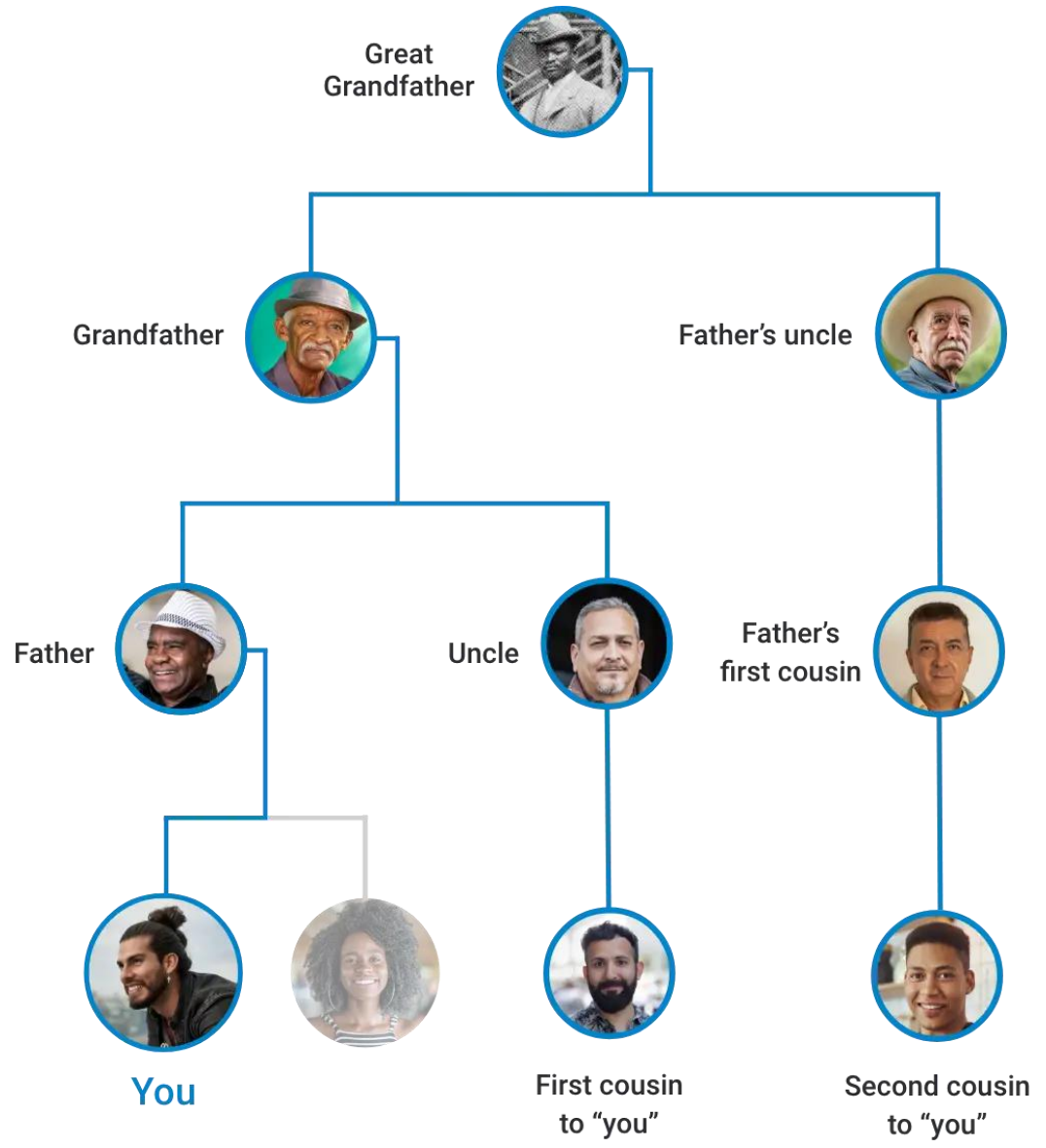
Y-DNA TEST



Y-DNA

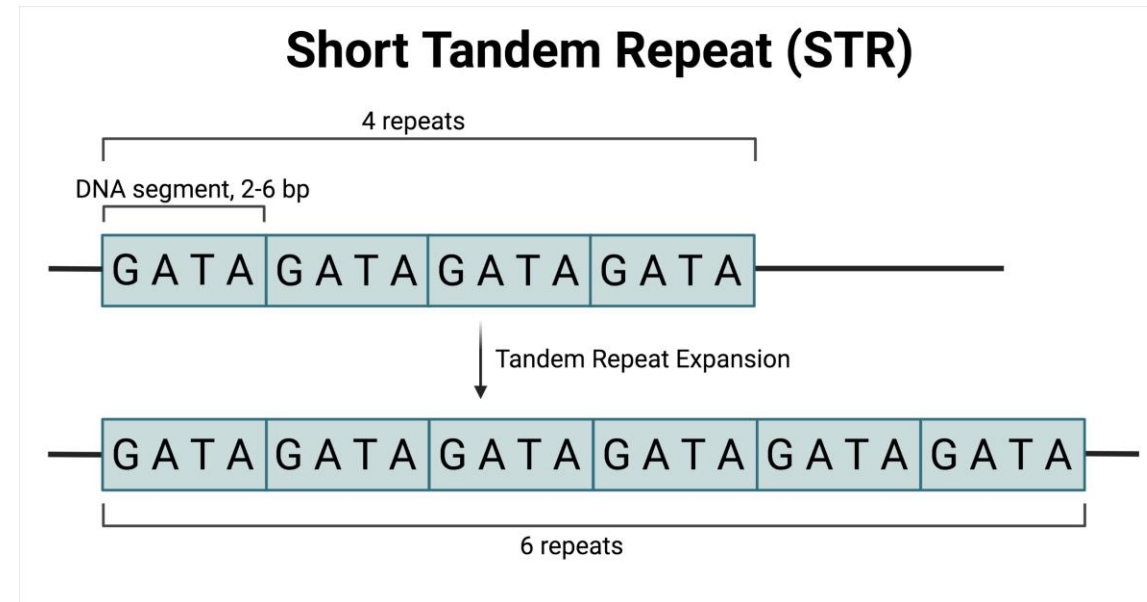
- Studies Y-chromosome (male sex chromosome)
- Handed down from father to son mostly intact
- Matches ancestors from many generations back, and their descendants
- Males have the **same** Y-chromosome their distant ancestors had

Y-DNA Inheritance



Y-DNA: STRs and Matches

- Short Tandem Repeat (STR): Common Y-DNA variation
- Men with same or close number of STRs will match
- Genetic Distance (GD): Number of STR differences (steps) between men



↙ Each column a number of STR repeats

R1b-U106 > Z307 > DF98 England-PA-MD (Dutton/Warburton Group)

MIN				13	24	14	11	11-14	12	12	12	13	13	29	17	9-10	11	11	24	14	19	30	15-15-15-16
MAX				13	24	14	12	11-14	12	12	12	13	13	29	17	9-10	11	11	25	14	19	31	15-16-16-17
MODE				13	24	14	11	11-14	12	12	12	13	13	29	17	9-10	11	11	25	14	19	30	15-15-16-16
331088	Richard Dutton, b. 1785 andd. 1857	England	R-DF98	13	24	14	11	11-14	12	12	12	13	13	29	17	9-10	11	11	25	14	19	30	15-15-15-16
102173	Thomas s/o PA John	Unknown Origin	R-M269	13	24	14	11	11-14	12	12	12	13	13	29	17	9-10	11	11	25	14	19	30	15-15-16-16
12715	Thomas s/o PA John	England	R-U106	13	24	14	11	11-14	12	12	12	13	13	29	17	9-10	11	11	25	14	19	30	15-15-16-16
998787	Samuel Dutton b. c.1736 Penn., d. Green Co. Ky.	United States	R-FGC13478	13	24	14	11	11-14	12	12	12	13	13	29	17	9-10	11	11	25	14	19	30	15-15-16-16
N49453	William Dutton b. 1851 London	United Kingdom	R-DF98	13	24	14	11	11-14	12	12	12	13	13	29	17	9-10	11	11	25	14	19	30	15-15-16-17
316047	John Dutton of Overton (PA)	England	R-DF98	13	24	14	11	11-14	12	12	12	13	13	29	17	9-10	11	11	25	14	19	30	15-16-16-16
414284	George Dutton, b.1745 Cheshire, d.1831 Flintshire	England	R-FGC13446	13	24	14	11	11-14	12	12	12	13	13	29	17	9-10	11	11	25	14	19	31	15-15-16-16
75848	Thomas Dutton, b.1660, Cheshire UK; d.1717, MD USA	England	R-FGC13444	13	24	14	12	11-14	12	12	12	13	13	29	17	9-10	11	11	24	14	19	30	15-15-16-16
318507	Thomas Dutton, b.1660 Cheshire UK; d.1717 Maryland	United Kingdom	R-DF98	13	24	14	12	11-14	12	12	12	13	13	29	17	9-10	11	11	24	14	19	30	15-15-16-16
159028	Thomas Dutton b.1660, Cheshire UK; d.1717, MD USA	England	R-FGC13444	13	24	14	12	11-14	12	12	12	13	13	29	17	9-10	11	11	25	14	19	30	15-15-16-16

STR Results

of STRs Tested

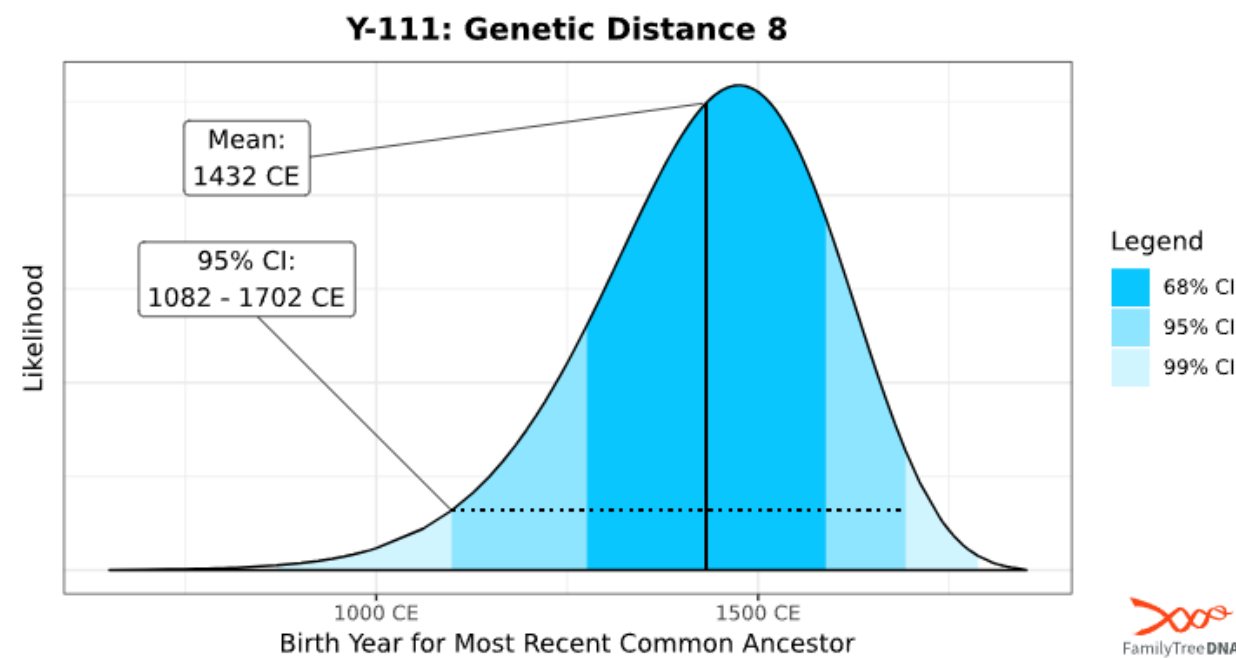
Genetic Distance

- Shows list of men with closest Genetic Distance, with their Earliest Known Paternal Ancestor
- Genetic Distance – used to make statistical prediction of Time to Most Recent Common Ancestor (TMRCA)

Name	Markers Tested	Genetic Distance	Big Y STR Differences	Y Haplogroup	Paternal Country of Origin	Paternal Earliest Known Ancestor	Match date
Parke	1 to 700	8 steps	10 of 657	R-FTC74761	Unknown Origin	Roger...	June 26 2022
Parks	1 to 111	8 steps	Not Available	R-M269	England	Samuel Parks b. 1759 (Roger...	June 26 2022
Park	1 to 111	9 steps	Not Available	R-M269	England	Roger>Roger...	June 26 2022
Park	1 to 111	9 steps	Not Available	R-M269	United States	James Park b. 1798 and d. B...	June 26 2022

Genetic Distance	Y-111 TMRCA ⓘ
0	1850 CE (1750 - 1950 CE)
1	1850 CE (1700 - 1900 CE)
2	1800 CE (1650 - 1900 CE)
3	1750 CE (1600 - 1900 CE)
4	1700 CE (1500 - 1850 CE)
5	1650 CE (1450 - 1800 CE)
6	1600 CE (1350 - 1800 CE)
7	1500 CE (1200 - 1750 CE)
8	1450 CE (1100 - 1700 CE)
9	1350 CE (950 - 1650 CE)
10	1250 CE (800 - 1600 CE)

Y-111: Genetic Distance 8



Statistic*	Years Before Present	Calendar Date
99% CI	1176 - 227	847 - 1796 CE
95% CI	941 - 321	1082 - 1702 CE
68% CI	747 - 435	1276 - 1588 CE
Mean	591	1432 CE

Y-DNA: SNPs and Haplogroups

- Single Nucleotide Polymorphism (SNP): Much rarer variation
- Men with same SNPs grouped into *haplogroups*
- Used to study whole population groups, human migrations, as well as families
- More definite matching

SNP short tandem repeat (STR)

↓

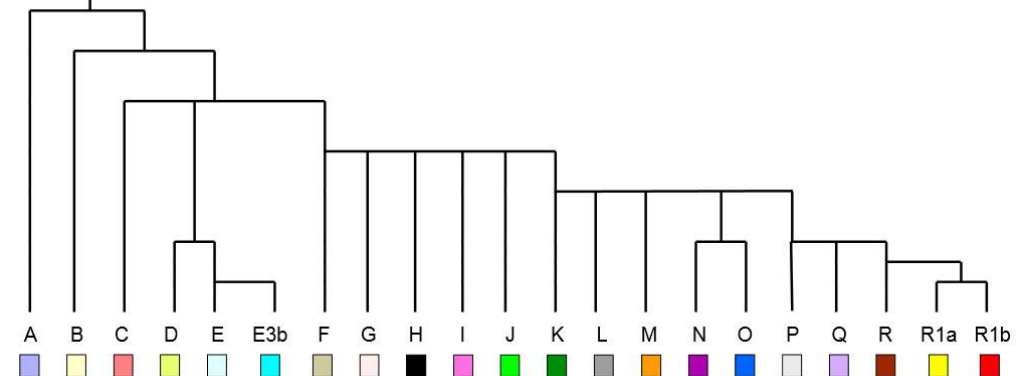
Man 1 GTACTAGACTACTACTACTACTGGTG...
 5 repeats

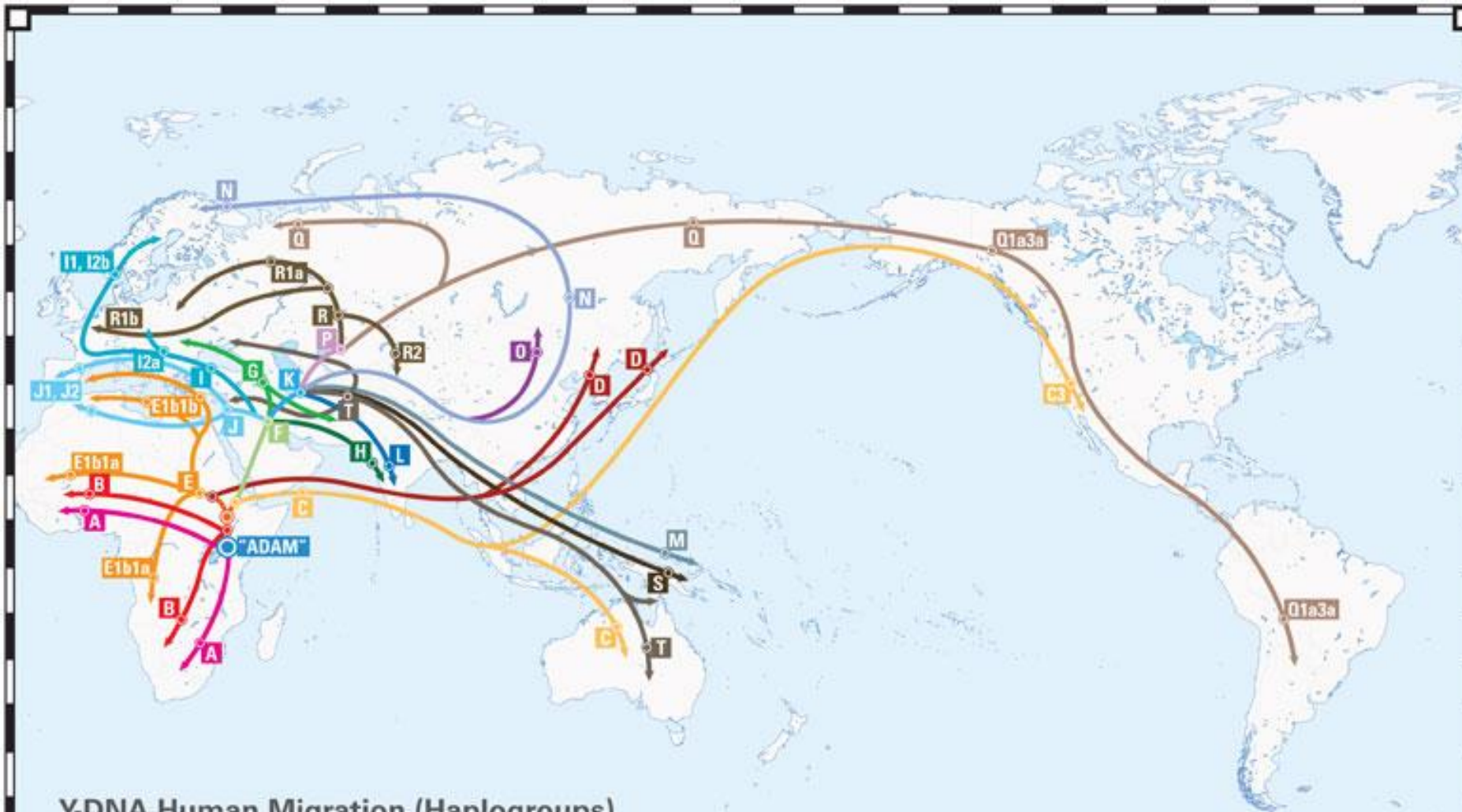
Man 2 GTACAGACTACTACTACTACTACTGGTG...
 6 repeats

Man 3 GTACAGACTACTACTACTACTACTGGTG...
 7 repeats



Simplified Tree of Y-Chromosome Haplogroups



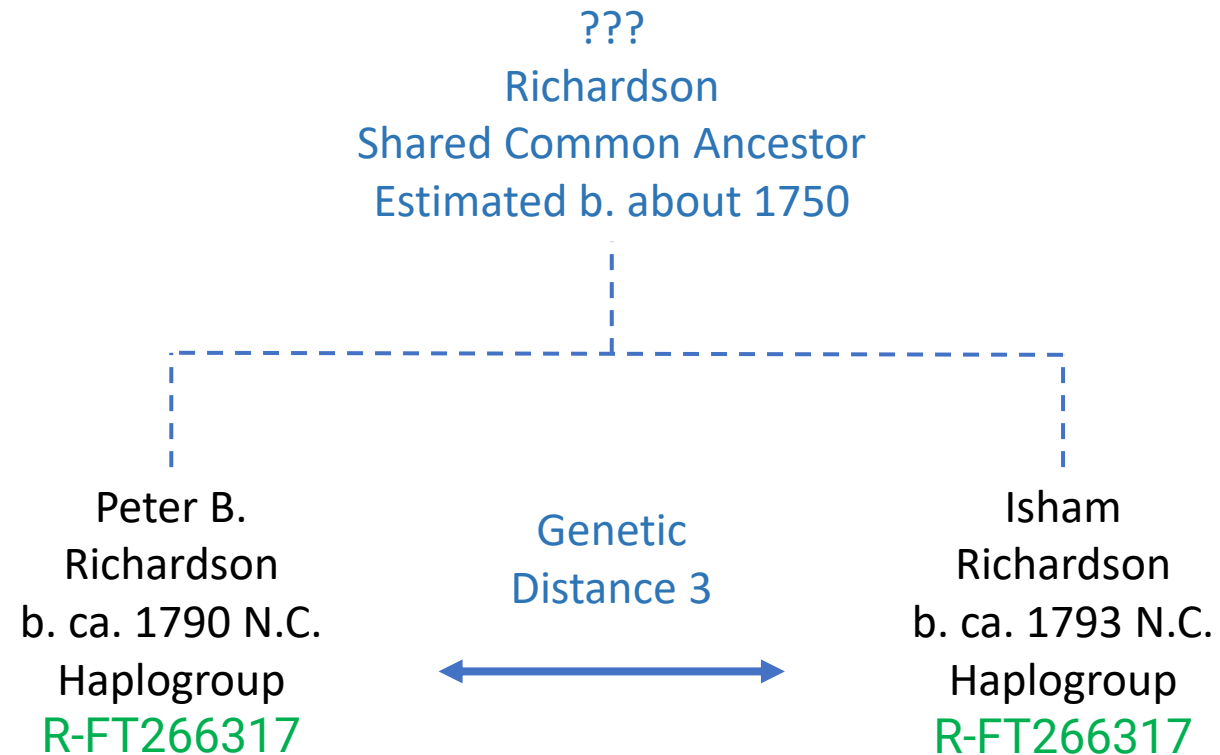


Y-DNA Human Migration (Haplogroups)
Thousands of Years Ago

A	60	G	20	O3	35
B	50	H	30	P	35
CT	50	I	25	Q	20
D	50	J	25	Q1a3a	10
E	50	K	40	R	30
E1b1a	20	L	30	R1a	10
E1b1b	20	M	10	R1b	25
C	50	N	10	S	10
F	45	O	35	T	10

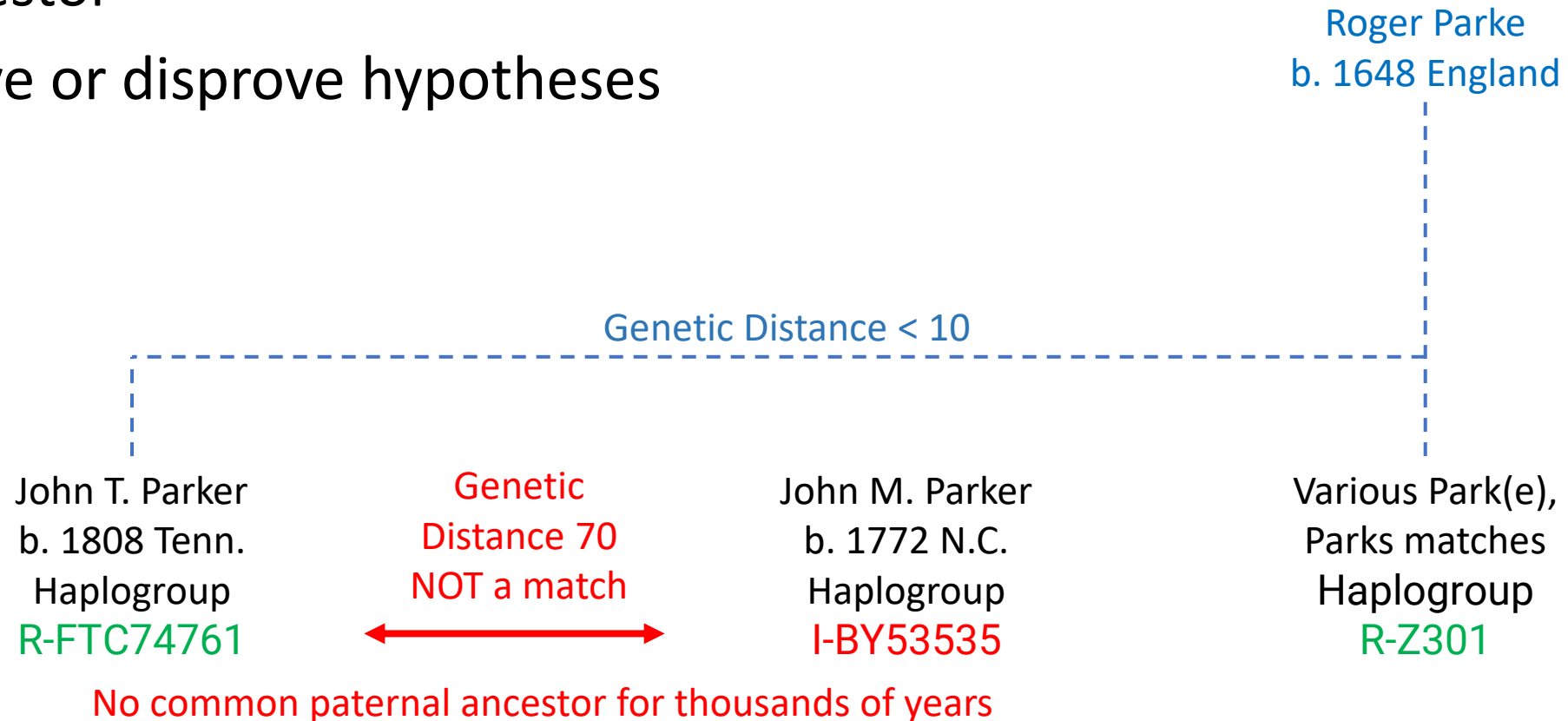
Y-DNA: Genealogical Applications (1)

- Matching other men means a shared common paternal ancestor
- Locate potential ancestors when paper trail is cold

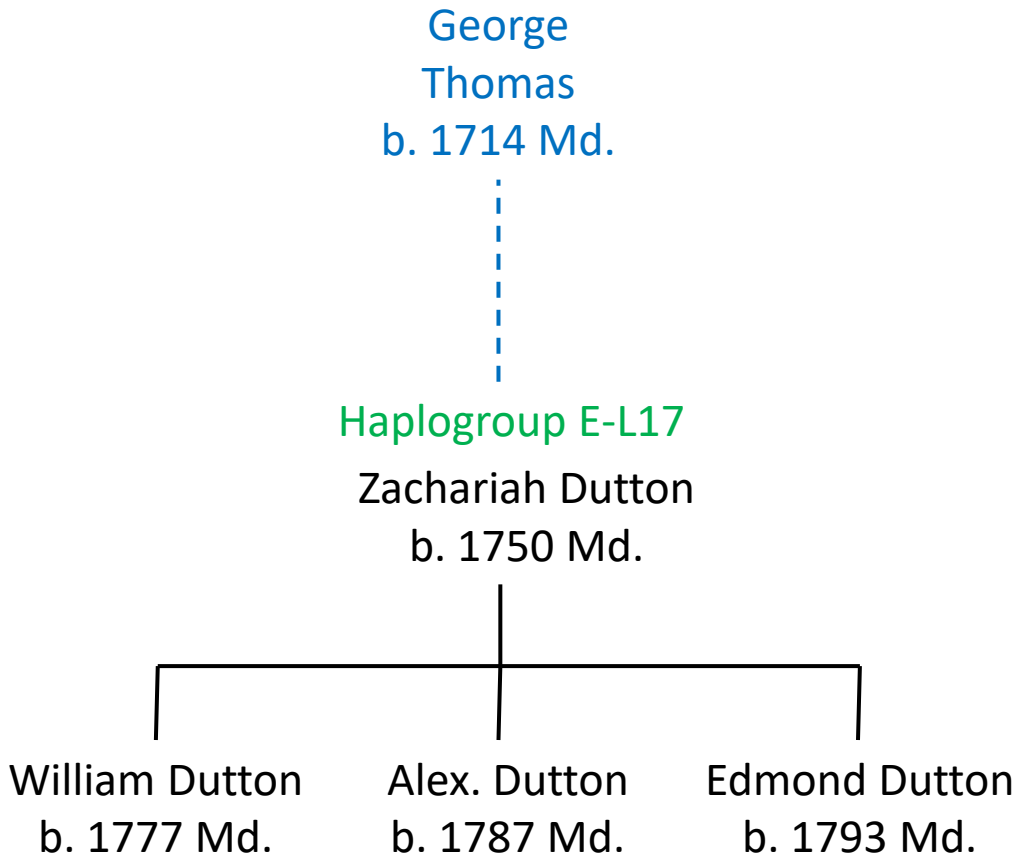


Y-DNA: Genealogical Applications (2)

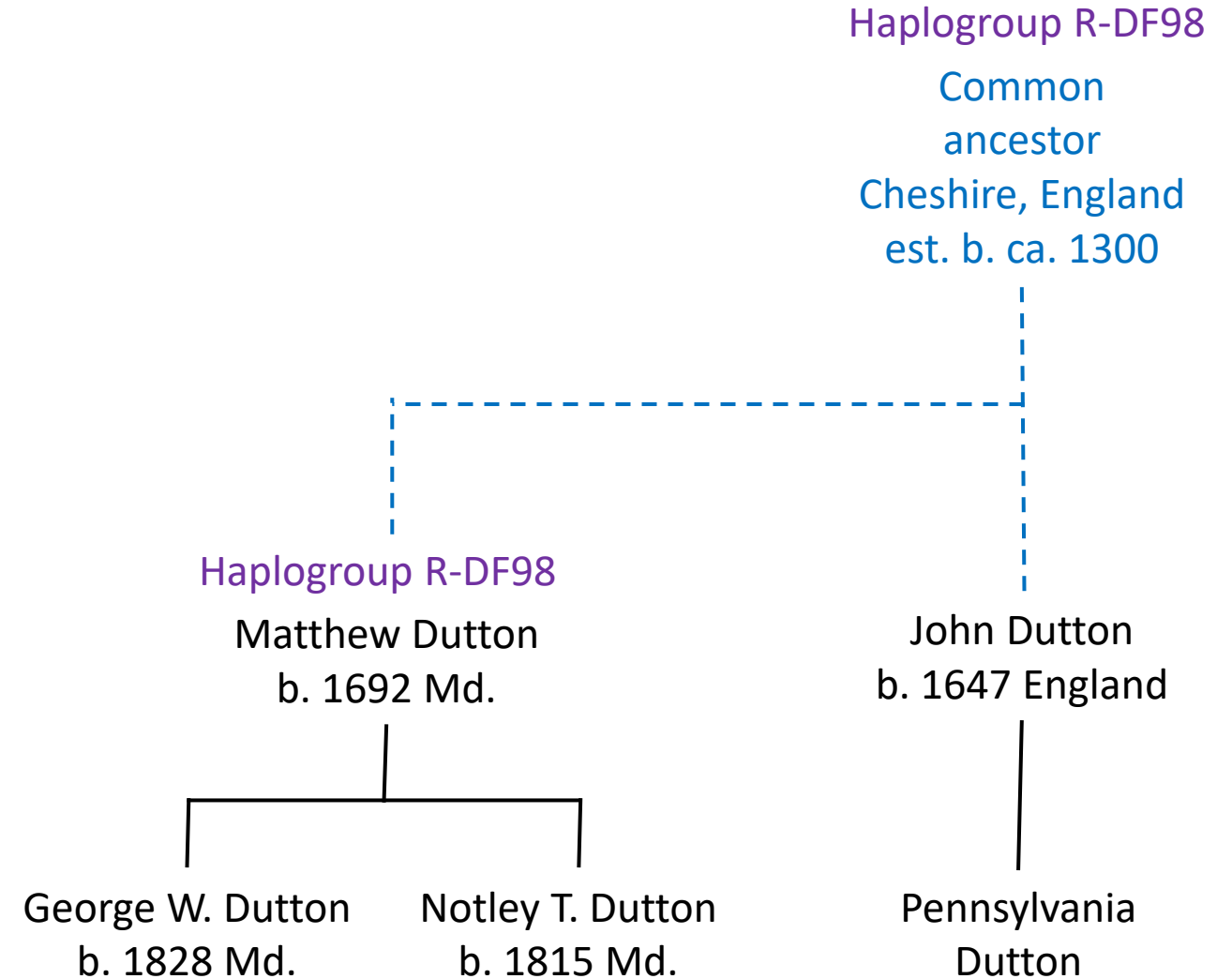
- **Not** matching other men means you **do not** share a common paternal ancestor
- Prove or disprove hypotheses



Y-DNA: Case Study



All match – confirms paper trail



Match each other, don't match Zachariah

Y-DNA: Ordering a Test

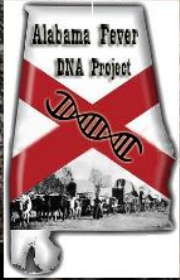


- Only major genealogy DNA provider offering Y-DNA testing is Family Tree DNA (<https://www.familytreedna.com>)
- Only genetic males can test
- Three levels offered:
 - Y-37: 37 STRs, basic testing
 - Y-111: 111 STRs, better testing
 - Big Y-700: 700+ STRs, 500k+ SNPs
- Can upgrade after initial test

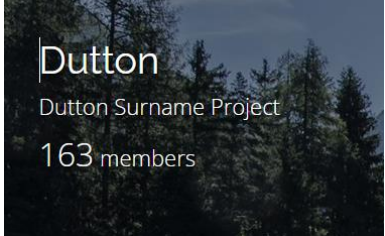
A GOOD START	REFINED MATCHING	GENEALOGIST FAVORITE
Y-37	Y-111	Big Y-700
\$119 USD	\$249 USD	\$449 USD
\$99 USD	\$219 USD	\$399 USD
37 markers is a great place to start and can confirm close relationships	Increase your marker count to 111 to identify closer matches.	For community research and the most informative results, check out Big Y-700!

Group Projects

- Family Tree DNA offers many group projects for surnames, ethnicities, localities, haplogroups
- Allows experts to help with your Y-DNA
- Allows you to see how your STRs match



Alabama Fever
Y-DNA, mtDNA, & Autosomal DNA Project
793 members



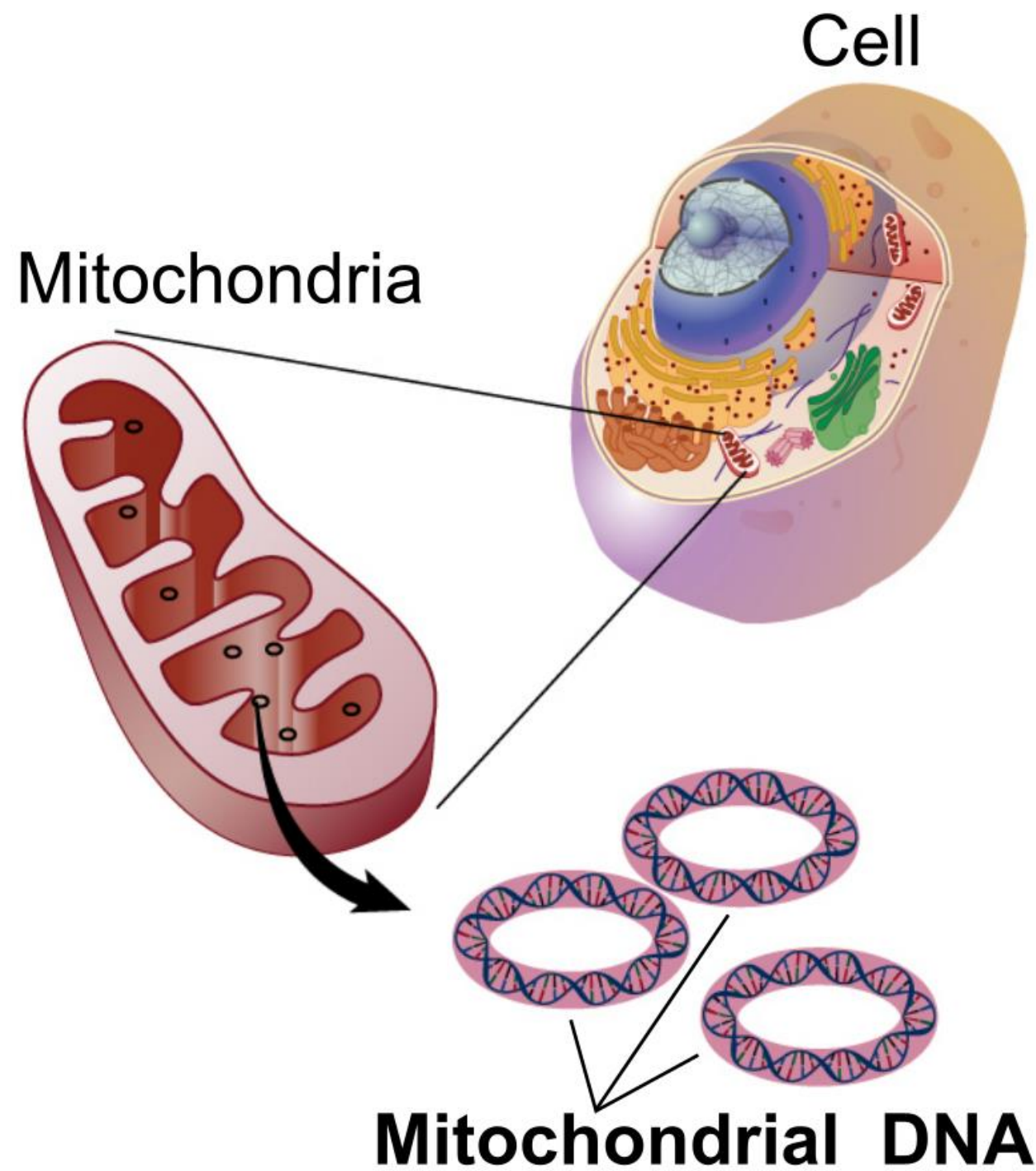
Dutton
Dutton Surname Project
163 members



CumberlandGap-YDNA
9181 members



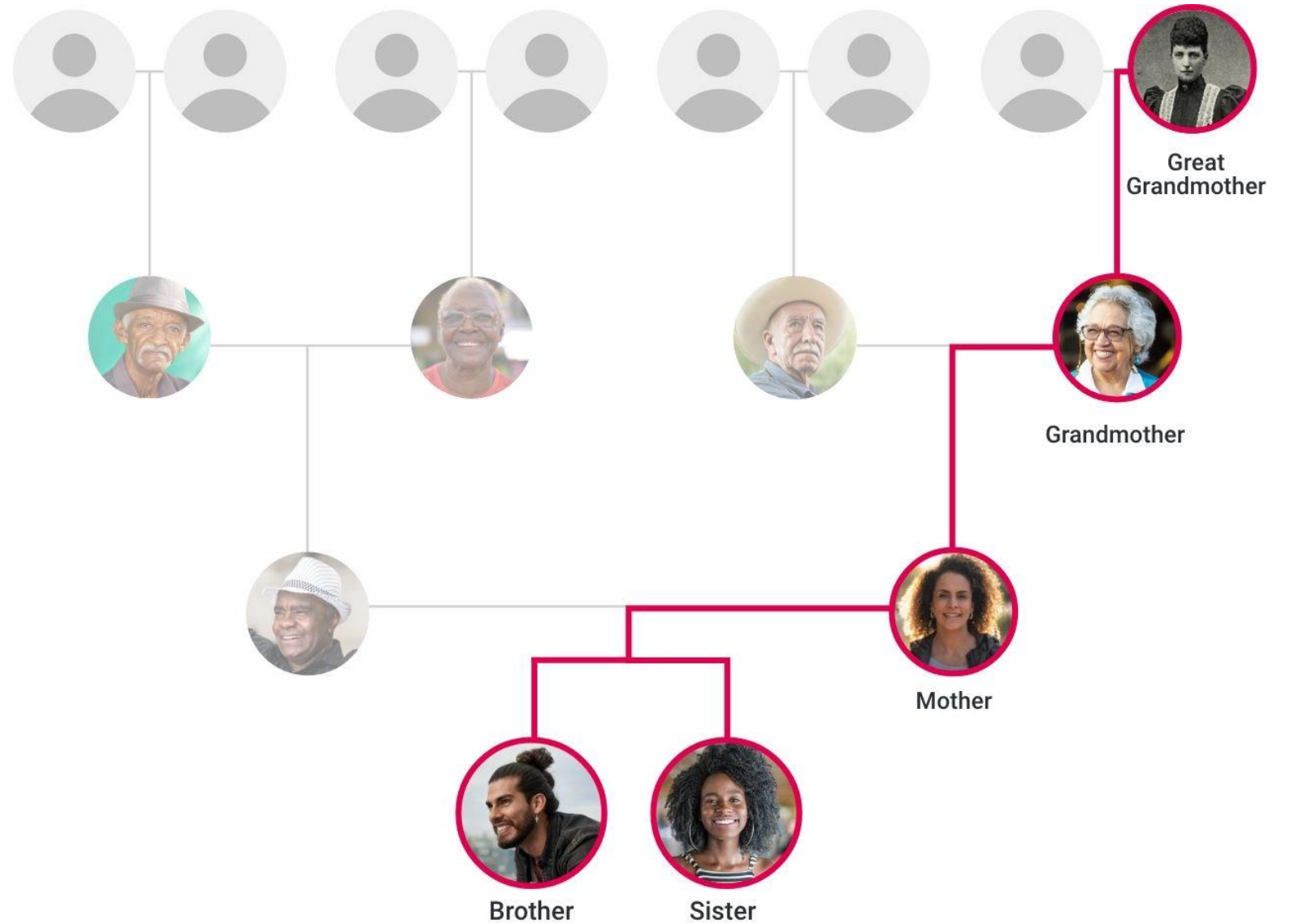
R-Z198 incl. R-SRY2627
R-Z198 and subclades R-ZS312 (incl. R-SRY2627), R-CTS4188 and R-L165
1622 members



Mitochondrial DNA (mtDNA)

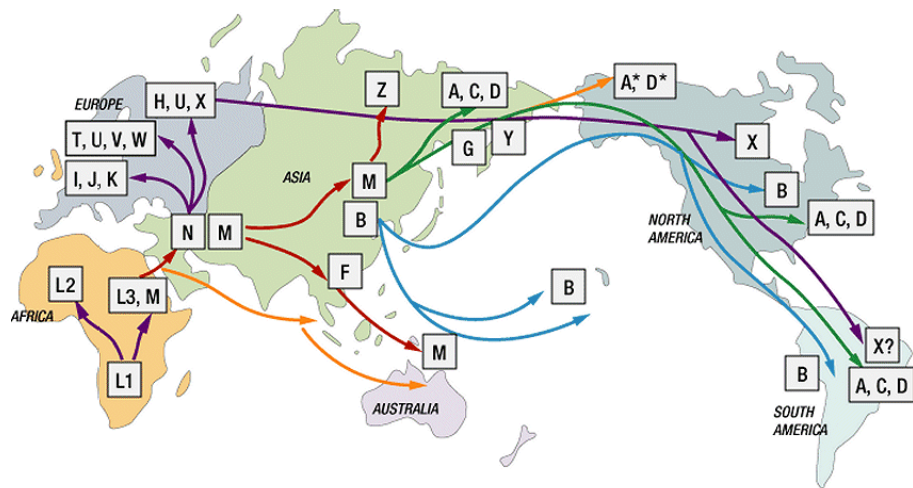
- DNA contained within *mitochondria* of cells rather than nucleus
- Passed from mother to child – follows *maternal* line
- Both men and women can test
- Used in forensics
- Has mutations and haplogroups similar to Y-DNA

Mitochondrial DNA Inheritance



Mitochondrial DNA

- Like Y-DNA, can chart human migration patterns
- Has Haplogroups, Genetic Distance



EXPANSION TIMES (years ago)	
Africa	120,000 - 150,000
Out of Africa	55,000 - 75,000
Asia	40,000 - 70,000
Australia/PNG	40,000 - 60,000
Europe	35,000 - 50,000
Americas	15,000 - 35,000
Na-Dene/Esk/Aleuts	8,000 - 10,000

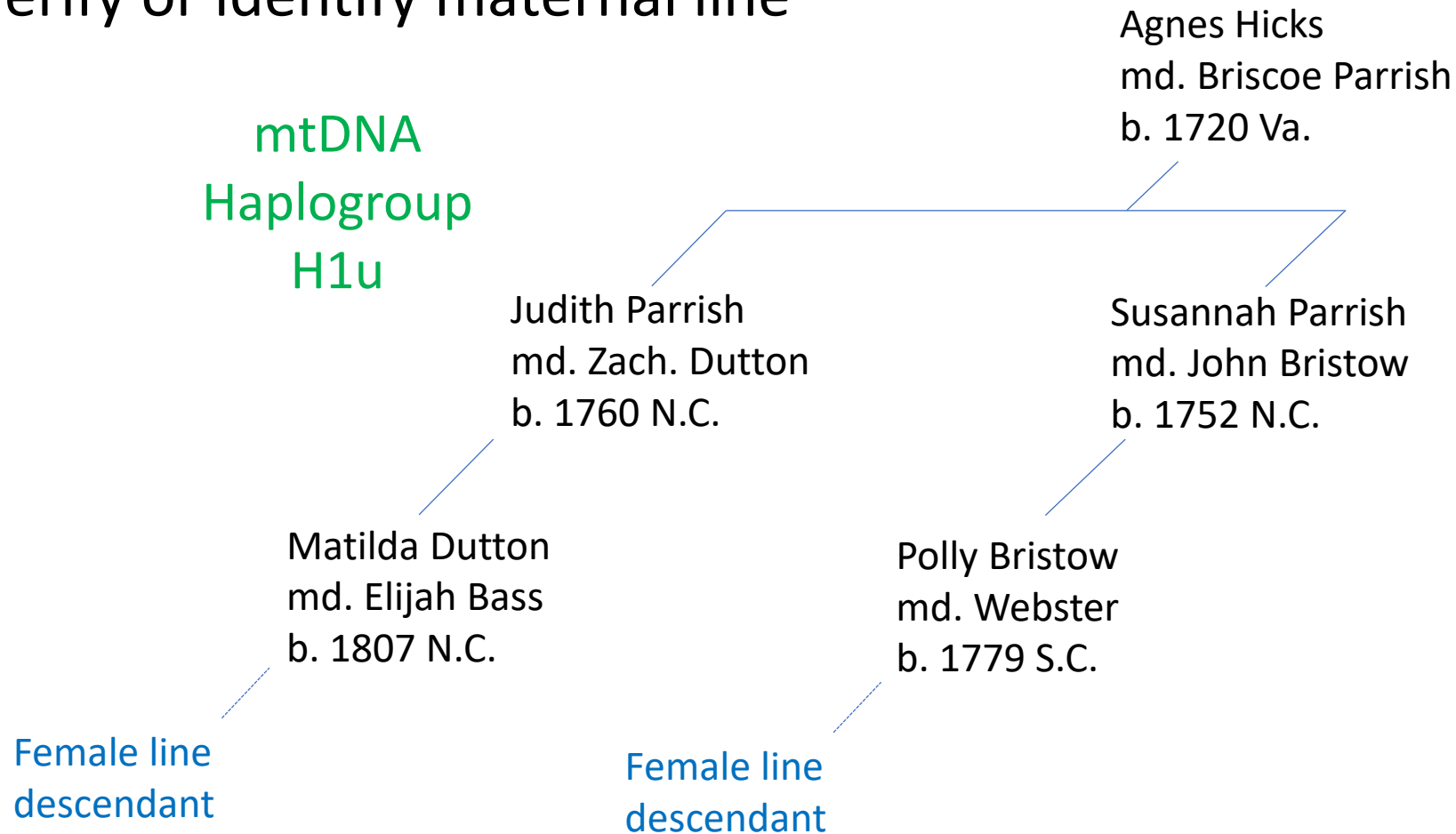


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HVR1, HVR2, CODING REGIONS - 39 MATCHES					
Page: 1 2 of 2					
Genetic Distance	Name		Earliest Known Ancestor	mtDNA Haplogroup	Match Date
1	Freeman	FMS FF	Mary Jones, b. 1794 and d. 1882	H1u	12/22/2022
1	Berg	FMS		H1u	7/28/2022
1	Mr. Charles Carroll White Jr.	FMS FF	Elizabeth Price, b. 1828 and d. 1904	H1u	5/23/2022
1	Mr. James Earl Cooley	FMS	Harriet Bennett	H1u	11/30/2021
1	Thornton	FMS FF		H1u	8/6/2020
1	Barber	FMS FF		H1u	1/9/2020
1	Moore Pless	FMS	Martha A. Frost, b 1841 and d. Bef. 1900	H1u	1/9/2020
1	Hamilton	FMS		H1u	1/9/2020
1	Brasher	FMS FF		H1u	1/9/2020

mtDNA: Genealogical Applications

- Difficult to use because of poor documentation of maternal lines
- Can verify or identify maternal line



mtDNA: Ordering a Test



- Only major genealogy DNA provider offering mtDNA testing is Family Tree DNA (<https://www.familytreedna.com>)
- One test currently being offered
- Can be packaged with other tests

Maternal Ancestry Test

REFINED RESULTS

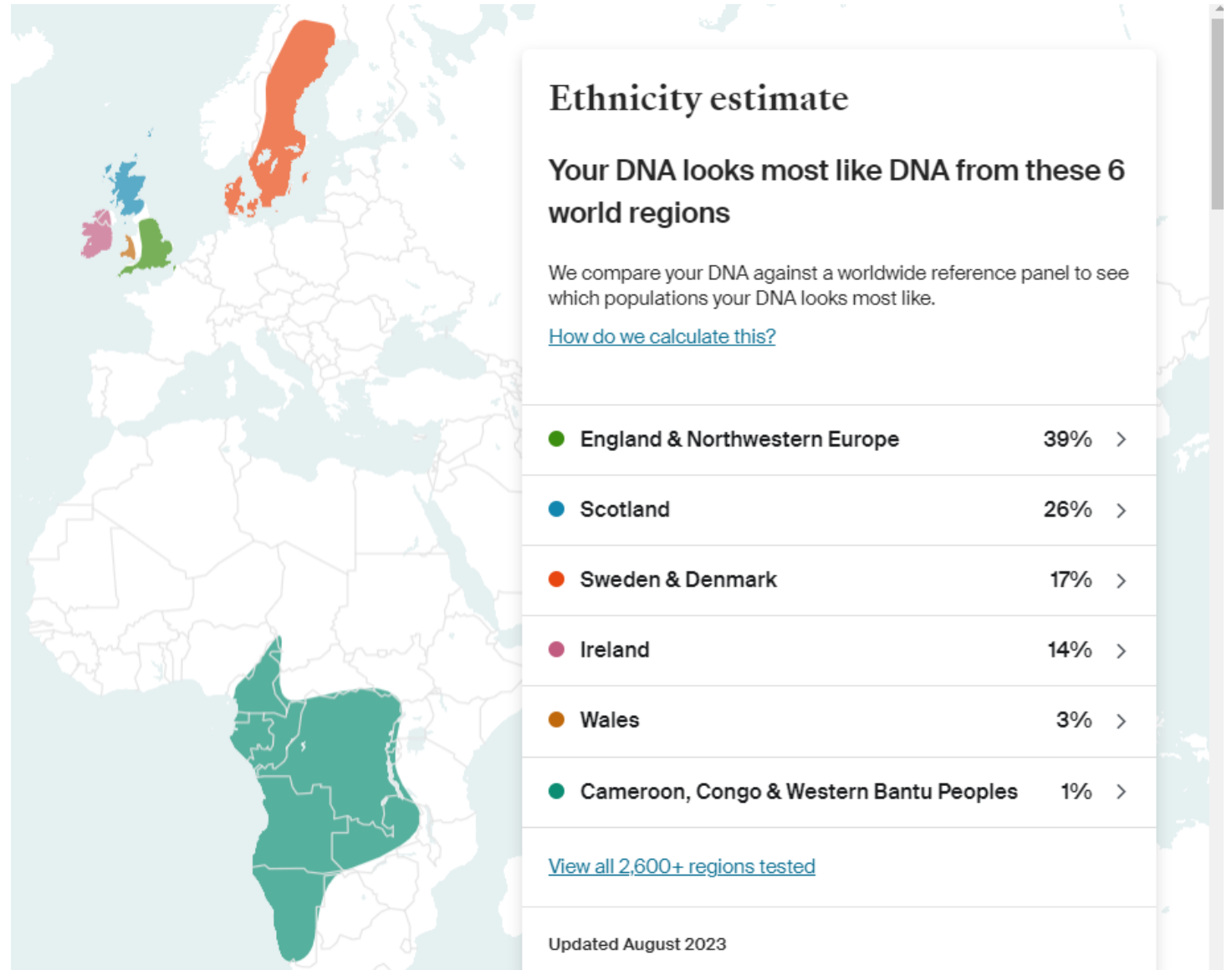
mtDNA
mtFull Sequence

~~\$159^{USD}~~ \$129^{USD} [Add to cart](#)

▼ View more

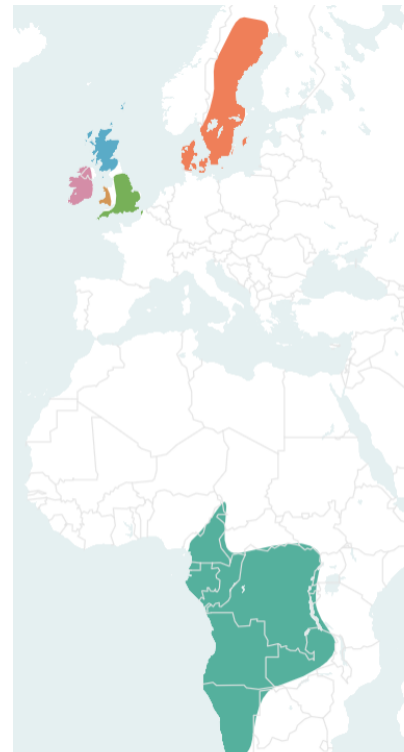
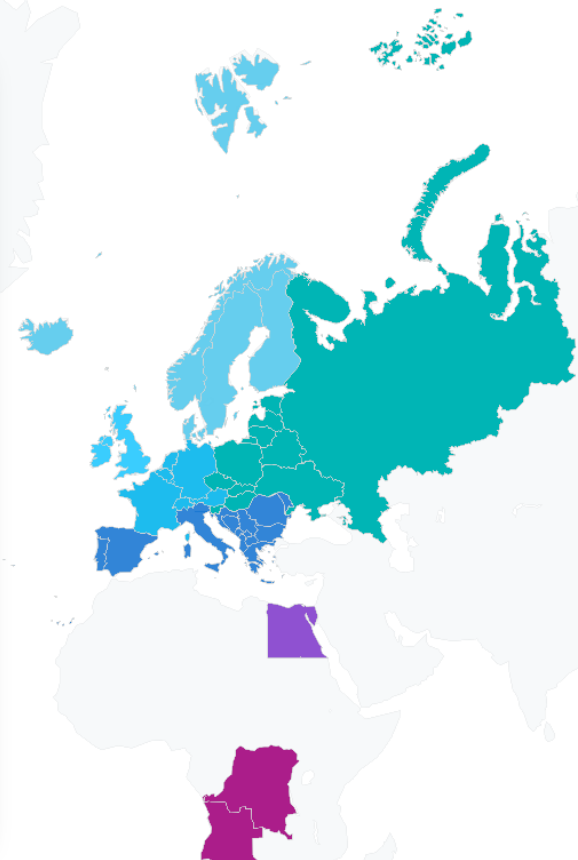
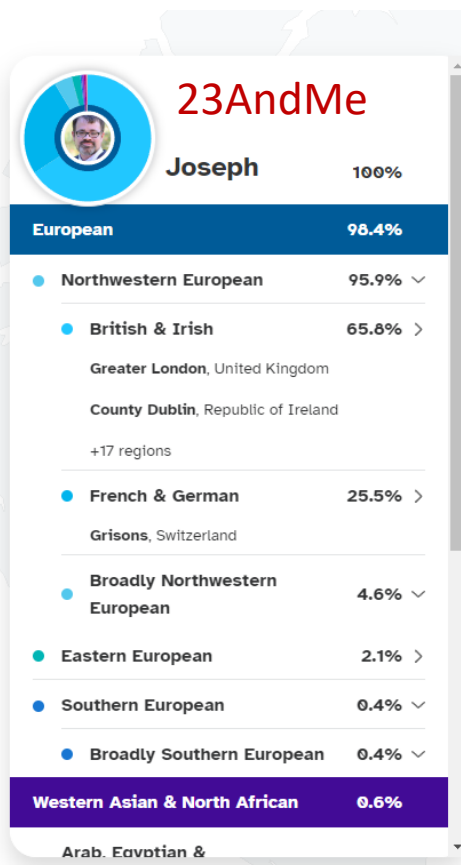
Autosomal DNA

- Compares DNA segments on 22 autosomes (non-sex chromosomes) against other testers
- Most common genealogical DNA test today (Ancestry, 23AndMe, MyHeritage, Family Tree DNA)
- Gives ethnicity estimate



Autosomal DNA: Ethnicity Estimate

- Subjective, not precise or genealogically useful; different at each site



Ethnicity estimate **AncestryDNA**

Your DNA looks most like DNA from these 6 world regions

We compare your DNA against a worldwide reference panel to see which populations your DNA looks most like.

[How do we calculate this?](#)

England & Northwestern Europe	39%
Scotland	26%
Sweden & Denmark	17%
Ireland	14%
Wales	3%
Cameroon, Congo & Western Bantu Peoples	1%

[View all 2,600+ regions tested](#)

Updated August 2023

myOrigins® **Version 3**

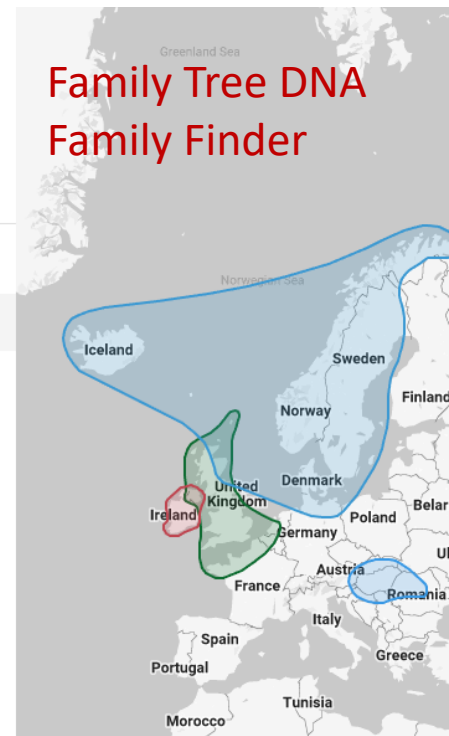
Uncover the unique genetic assemblage that has been passed down to you from your ancestors, and see to which of our 90 reference populations from ... [Read more](#)

myOrigins®

[Compare Origins](#)

Joseph Richardson

Europe	100%
Western Europe	
● England, Wales, and Scotland	81%
● Scandinavia	12%
● Ireland	7%
Eastern Europe	
● Magyar ⓘ	<1%





Thomas Richardson

Father
3,475 cM | 50% shared DNA
Paternal side

Public linked tree
6,823 People
Common ancestor



Rosemary Richardson

Mother
3,473 cM | 50% shared DNA
Maternal side

Public linked tree
3,010 People
Common ancestor

Close Family



Robert Pierson Richardson

Grandfather
1,748 cM | 25% shared DNA
Paternal side

Public linked tree
6,823 People
Common ancestor

My grandfather.



Sarah Ruth Cook

Grandmother
1,676 cM | 24% shared DNA
Paternal side

Public linked tree
6,823 People
Common ancestor

My grandmother.



L.D.
Managed by cls901

Grandaunt
834 cM | 12% shared DNA
Maternal side

Public linked tree
7,389 People
Common ancestor

Lorene Dutton Bryant, my great-aunt (test by Crystal, her ex-granddaughter-in-law).



Lorene Dutton

Grandaunt
832 cM | 12% shared DNA
Maternal side

Public linked tree
8,596 People
Common ancestor

Lorene Dutton Bryant, my great-aunt.



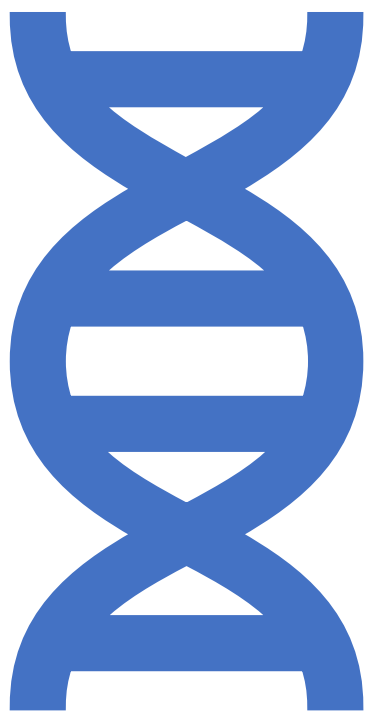
C.M.
Managed by

1st cousin 1x removed
556 cM | 8% shared DNA
Paternal side

Public linked tree
733 People
Common ancestor

Autosomal DNA: Matching

- List of DNA matches – cousins who share one or more common ancestors
- Shared centiMorgans (cM) or percentage
- Number of shared segments

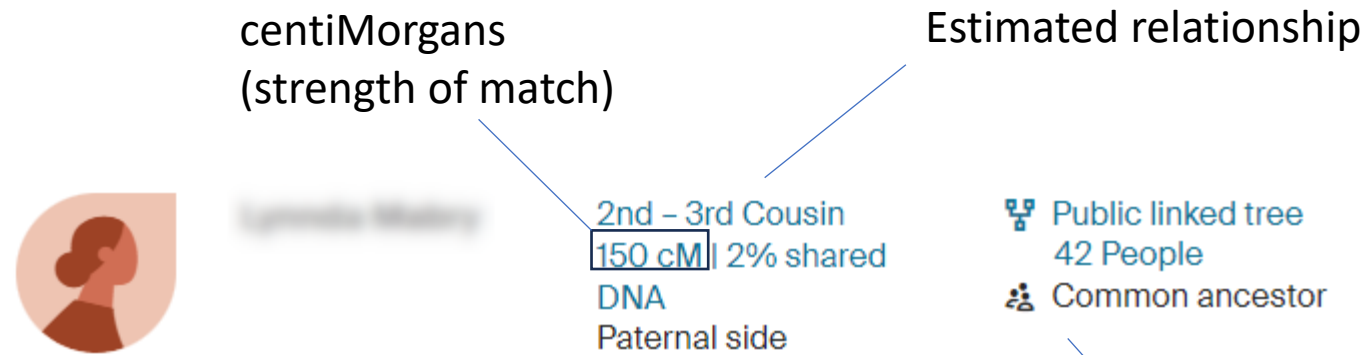


Autosomal DNA – Genealogical Applications

- Discovering unknown ancestors –
 - Finding people you share DNA with, with ancestors they have documented but you haven't
 - Projecting unknown common ancestry from matches
- Proving ancestral hypotheses

How am I related to a match?

- Identifying a match by the shared centiMorgans (cM)



- Can use Shared cM table & tool

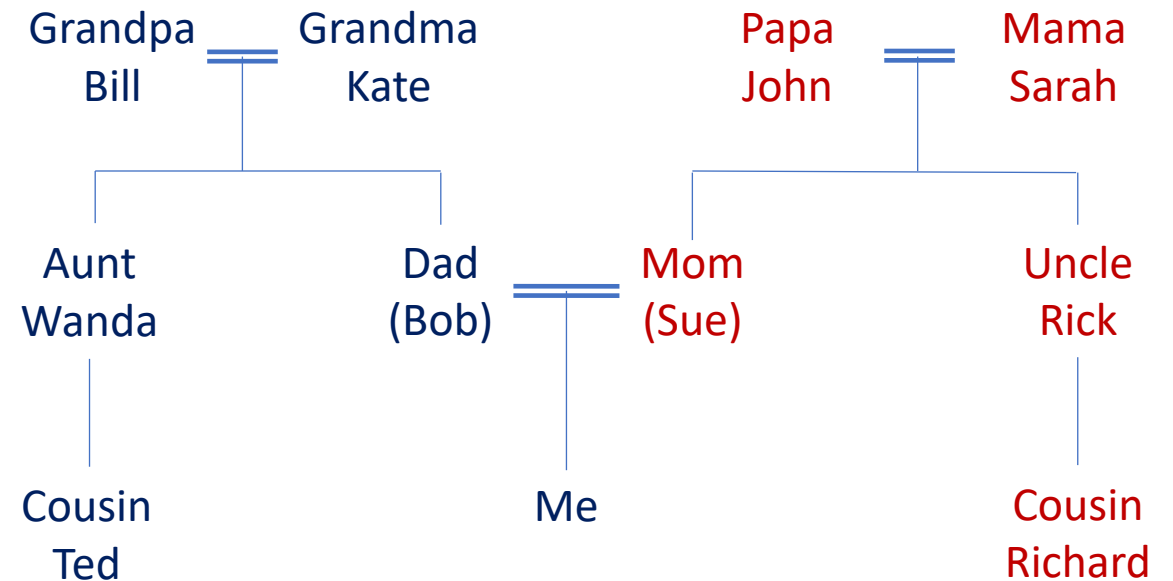
54%	Half 2C 2C1R Half 1C2R 1C3R
24%	Half GG-Aunt / Uncle 2C Half 1C1R 1C2R Half GG-Niece / Nephew
17%	Half 1C3R † 3C Half 2C1R 2C2R
5%	Half 2C2R † Half 3C 3C1R 2C3R

Statistical probabilities of different relationships

Calculated common ancestor, based on comparing family trees

Using Shared Matches: Basic Example

- My Unknown Match, Tom
 - Matches in common:
 - Me
 - **Cousin Richard**
- Means common ancestors will be on maternal side of family





Sarah Ruth Cook and

2nd – 3rd Cousin | Paternal side
2% shared DNA: 150 cM across 7 segments

Message

Edit Relationship

●●+ Add/edit groups

William Jefferson Bullard > William ...

Trees

Ethnicity

Shared Matches

Using Shared Matches

- Using two or more in-common-with (ICW) matches to identify what family line a match is likely on

Extended Family



William Riley Bullard

2nd – 3rd Cousin
171 cM | 2% shared DNA
Unassigned

Public linked tree
33,322 People
Common ancestor

Do you recognize them?

Yes

Learn more

William Riley Bullard > James Marion Bullard



J.P.

2nd – 3rd Cousin
127 cM | 2% shared DNA
Paternal side

Public linked tree
747 People
Common ancestor

Do you recognize them?

Yes

Learn more

William Jefferson Bullard > William Riley Bullard (5 generations from W. J.)



Bullard

2nd – 3rd Cousin
110 cM | 2% shared DNA
Paternal side

Public linked tree
20 People
Common ancestor

Do you recognize them?

Yes

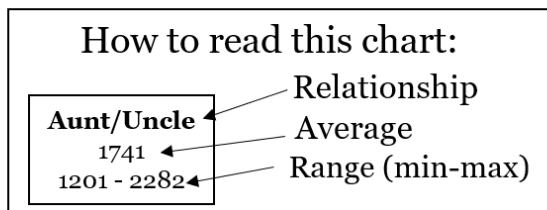
Learn more

William Jefferson Bullard > John W. R. Bullard

Custom color coding to group by known ancestor

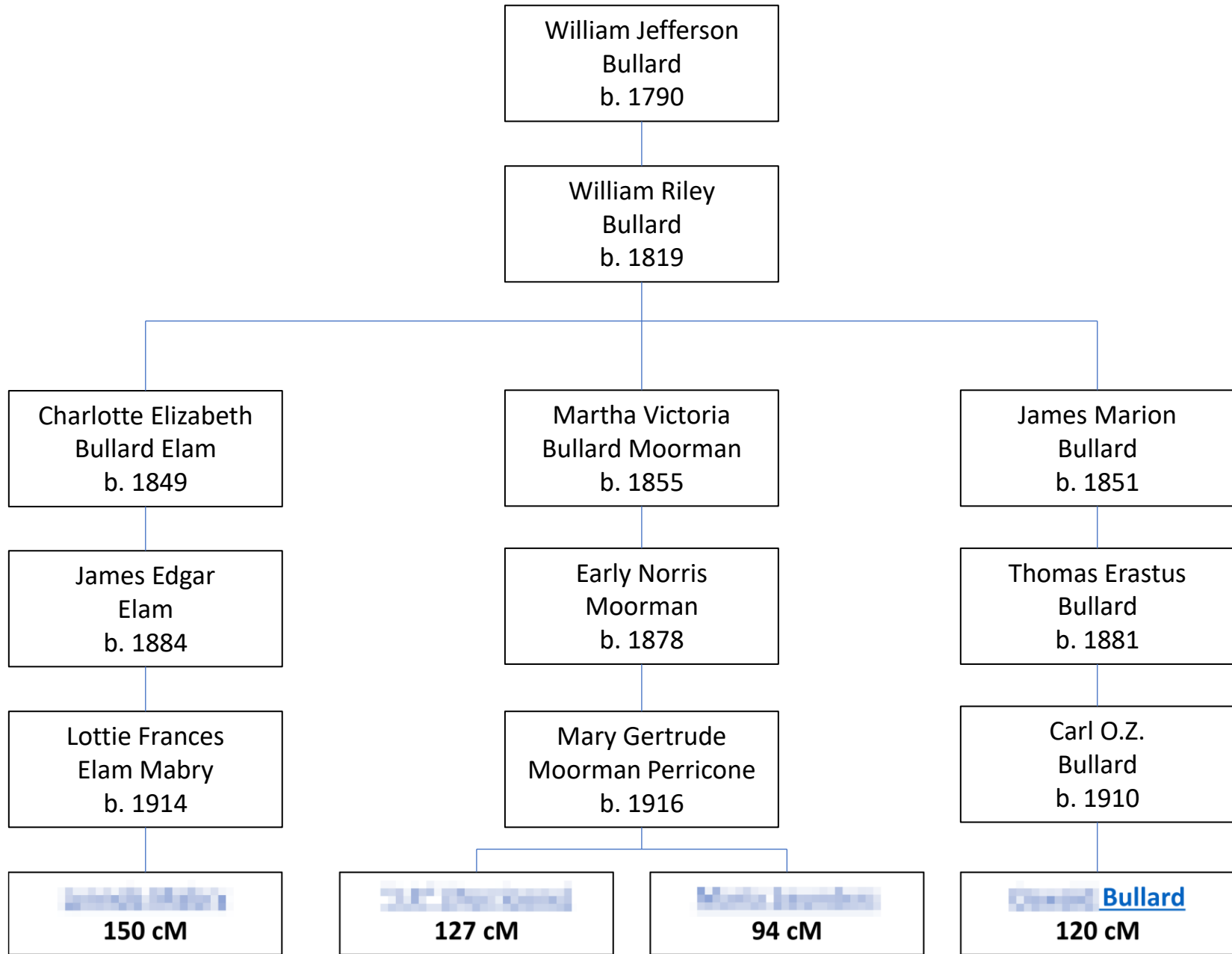
The Shared cM Project – Version 4.0 (March 2020)

Blaine T. Bettinger
www.TheGeneticGenealogist.com
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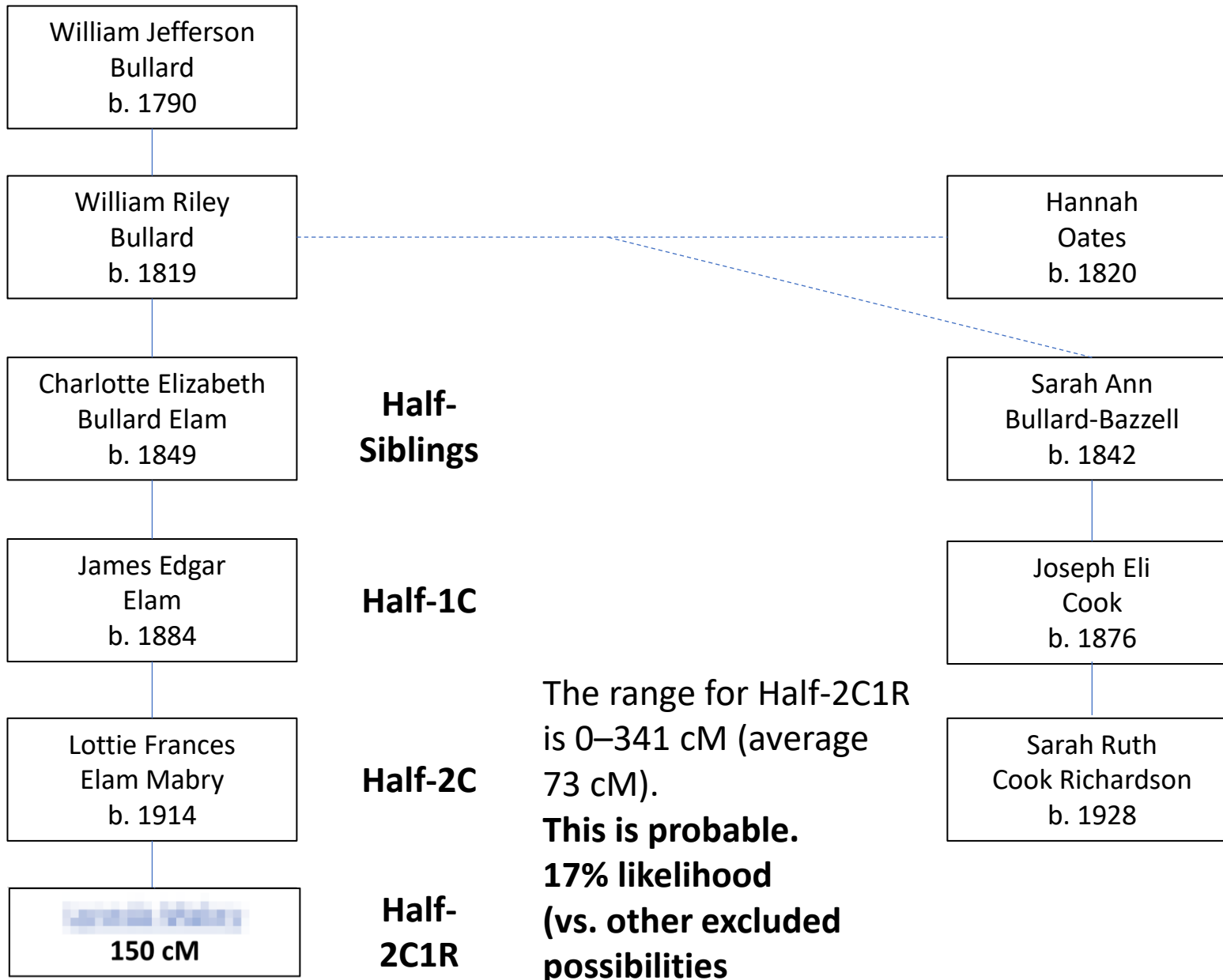


								Great-Great-Grandparent	GGGG-Aunt/Uncle		
								Great-Great-Grandparent	GGG-Aunt/Uncle		
Half GG-Aunt/Uncle 208 103 - 284	Great-Grandparent 887 485 - 1486						Great-Great Aunt/Uncle 420 186 - 713	1C3R 117 25 - 238	2c3R 51 0 - 154	Other Relationships	
Half 1C2R 125 16 - 269	Half Great-Aunt/Uncle 431 184 - 668	Grandparent 1754 984 - 2462				Great Aunt/Uncle 850 330 - 1467	1C2R 221 33 - 471	2c2R 71 0 - 244	3C2R 36 0 - 166	6C 18 0 - 71	
Half 2c1R 66 0 - 190	Half 1C1R 224 62 - 469	Half Aunt/Uncle 871 492 - 1315	Parent 3485 2376 - 3720		Aunt/Uncle 1741 1201 - 2282	1C1R 433 102 - 980	2c1R 122 14 - 353	3C1R 48 0 - 192	4C1R 28 0 - 126	6C1R 15 0 - 56	
Half 3c 48 0 - 168	Half 2c 120 10 - 325	Half 1C 449 156 - 979	Half-Sibling 1759 1160 - 2436	Sibling 2613 1613 - 3488	SELF	1C 866 396 - 1397	2c 229 41 - 592	3c 73 0 - 234	4c 35 0 - 139	5c 25 0 - 117	6C2R 13 0 - 45
Half 3c1R 37 0 - 139	Half 2c1R 66 0 - 190	Half 1C1R 224 62 - 469	Half Niece/Nephew 871 492 - 1315	Niece/Nephew 1740 1201 - 2282	Child 3487 2376 - 3720	1C1R 433 102 - 980	2c1R 122 14 - 353	3C1R 48 0 - 192	4C1R 28 0 - 126	5C1R 21 0 - 80	7C 14 0 - 57
Half 3c2R 27 0 - 78	Half 2c2R 48 0 - 144	Half 1C2R 125 16 - 269	Half Great Niece/Nephew 431 184 - 668	Great-Niece/Nephew 850 330 - 1467	Grandchild 1754 984 - 2462	1C2R 221 33 - 471	2c2R 71 0 - 244	3C2R 36 0 - 166	4C2R 22 0 - 93	5C2R 18 0 - 65	7C1R 12 0 - 50
Half 3c3R	Half 2c3R	Half 1C3R 60 0 - 120	Half GG Niece/Nephew 208 103 - 284	Great-Great-Niece/Nephew 420 186 - 713	Great-Grandchild 887 485 - 1486	1C3R 117 25 - 238	2c3R 51 0 - 154	3C3R 27 0 - 98	4C3R 19 0 - 60	5C3R 13 0 - 30	8C 11 0 - 42

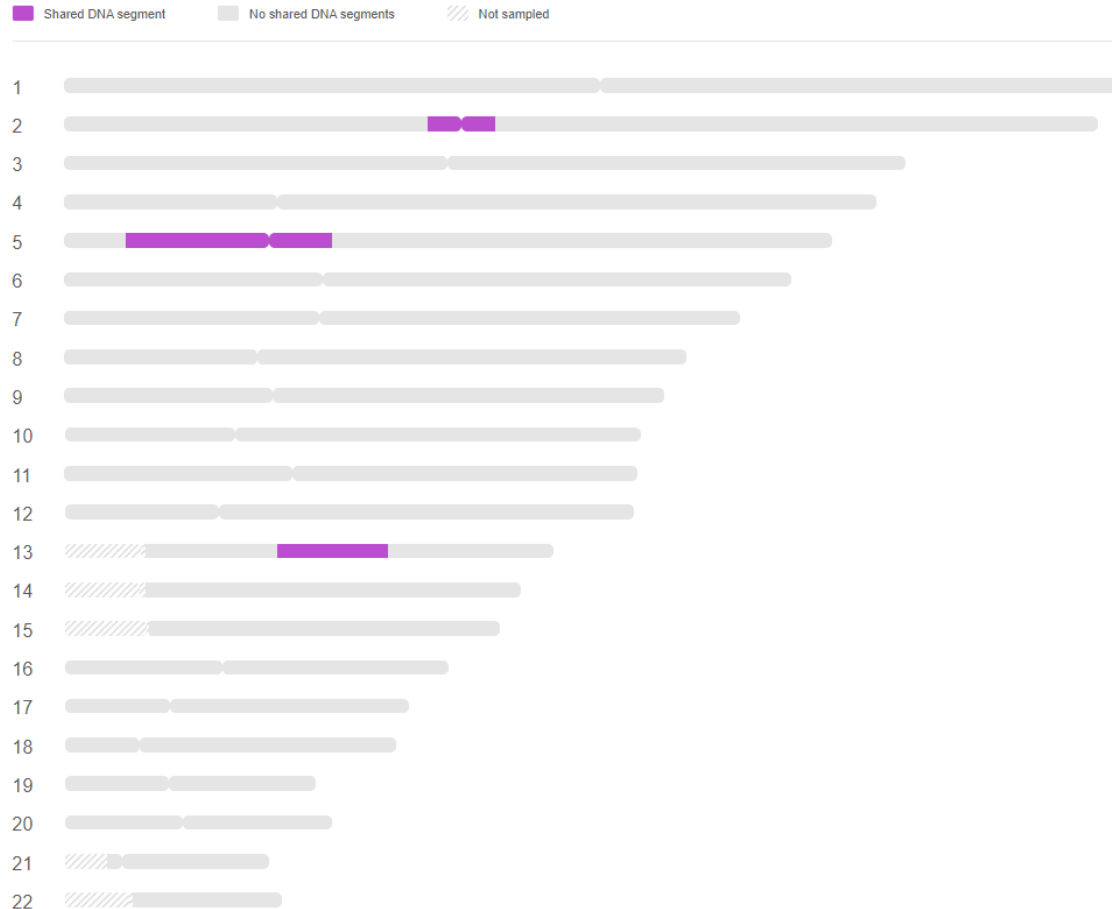
Minimum was automatically set to 0 cM for relationships more distant than Half 2C, and averages were determined only for submissions in which DNA was shared



Discovering the True Father of Sarah Ann (Bullard) Cook



Chromosome Browser



- Graphs what segments of DNA a match shares
- If two or more people share the same segment of DNA, they likely share the same common ancestor

Autosomal DNA: Ordering a Test

Testing Company	AncestryDNA	23AndMe	Family Tree DNA Family Finder	MyHeritage
Pros	Largest database = most people to match with; good family tree tools	Health information	Chromosome browser, group projects	Chromosome browser, good family tree and tools
Cons	No chromosome browser	No tools for family tree sharing or matching	Slow and clunky site; smaller autosomal database	Make you pay for everything
Cost	\$99	\$119 (ancestry only) \$229 (health+ancestry)	\$79	\$89

My recommendation:

- Test with more than one
- If you only do one, do Ancestry and upload to different sites
- If you do Y-DNA or mtDNA with FTDNA, add their autosomal also

Autosomal tips

- DO post your family tree
- DO test your oldest family members
- DO test as many family members as possible
- DO test with, or upload to, as many sites as possible
- DO check your messages regularly



Uploading DNA to Other Sites

Company	GEDmatch	AncestryDNA	23AndMe	Family Tree DNA	MyHeritage
Allows downloads	(does not test)	✓	✓	✓	✓
Allows uploads	✓	no	no	✓	✓

- Allows matching with other sites' database
- I highly recommend GEDmatch (<https://www.gedmatch.com>) as a site for advanced DNA tools (chromosome browser, etc.) and matching with tests from many different sites.

Advanced Topics

- Chromosome painting and mapping
- Phasing and reverse phasing
- Clustering



Sarah Cook Richardson Full

Female

~ 90% / 987 segments painted

DNA PAINTER

