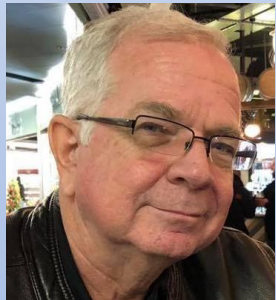


All About centiMorgans



Oct 10, 2023
Mesa Red Mountain Library



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Illustrations of.com #60477

All slides and handouts can be found at:

<http://www.familytreeaz.com/Presentations/>



QR Code: take photo to
open to presentations

First – Just What is a centimorgan??

- According to “Wikipedia:

Centimorgan

Article Talk Read Edit View history Tools

From Wikipedia, the free encyclopedia

In **genetics**, a **centimorgan** (abbreviated **cM**) or **map unit** (**m.u.**) is a unit for measuring **genetic linkage**. It is defined as the distance between **chromosome** positions (also termed **loci** or **markers**) for which the expected average number of intervening **chromosomal crossovers** in a single generation is 0.01. It is often used to infer distance along a chromosome. However, it is not a true physical distance.

?? Huh??
What...??!

Relation to the probability of recombination [edit]

Because **genetic recombination** between two markers is detected only if there are an odd number of chromosomal crossovers between the two markers, the distance in centimorgans does not correspond exactly to the probability of genetic recombination. Assuming **J. B. S. Haldane's** map function, in which the number of chromosomal crossovers is distributed according to a **Poisson distribution**,^[4] a genetic distance of d centimorgans will lead to an odd number of chromosomal crossovers, and hence a detectable genetic recombination, with probability

$$\begin{aligned} P(\text{recombination}|\text{linkage of } d \text{ cM}) &= \sum_{k=0}^{\infty} P(2k + 1 \text{ crossovers}|\text{linkage of } d \text{ cM}) \\ &= \sum_{k=0}^{\infty} e^{-d/100} \frac{(d/100)^{2k+1}}{(2k + 1)!} = e^{-d/100} \sinh(d/100) = \frac{1 - e^{-2d/100}}{2}, \end{aligned}$$

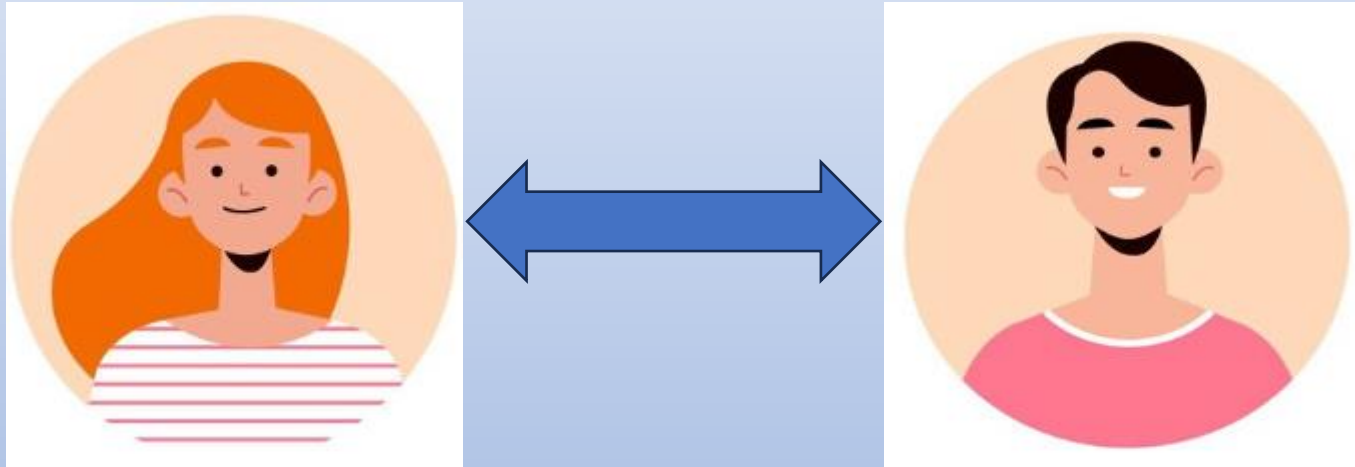
where \sinh is the **hyperbolic sine** function. The probability of recombination is approximately $d/100$ for small values of d and approaches 50% as d goes to infinity.

The formula can be inverted, giving the distance in centimorgans as a function of the recombination probability:

$$d = 50 \ln \left(\frac{1}{1 - 2 P(\text{recombination})} \right).$$

First – Just What is a centimorgan??

- Okay, for the rest of us:
- centiMorgans are simply a concept of DNA “relatedness” between two people



- Don't worry about the definition as it's complicated and statistical
- Just know that the larger the number is the more closely the two are related

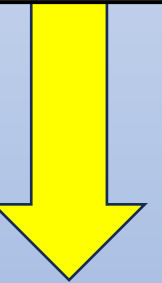
Put Another Way

- On a “number line” ...
- centiMorgans vary between 0 and ~3500

0 indicates
no DNA shared



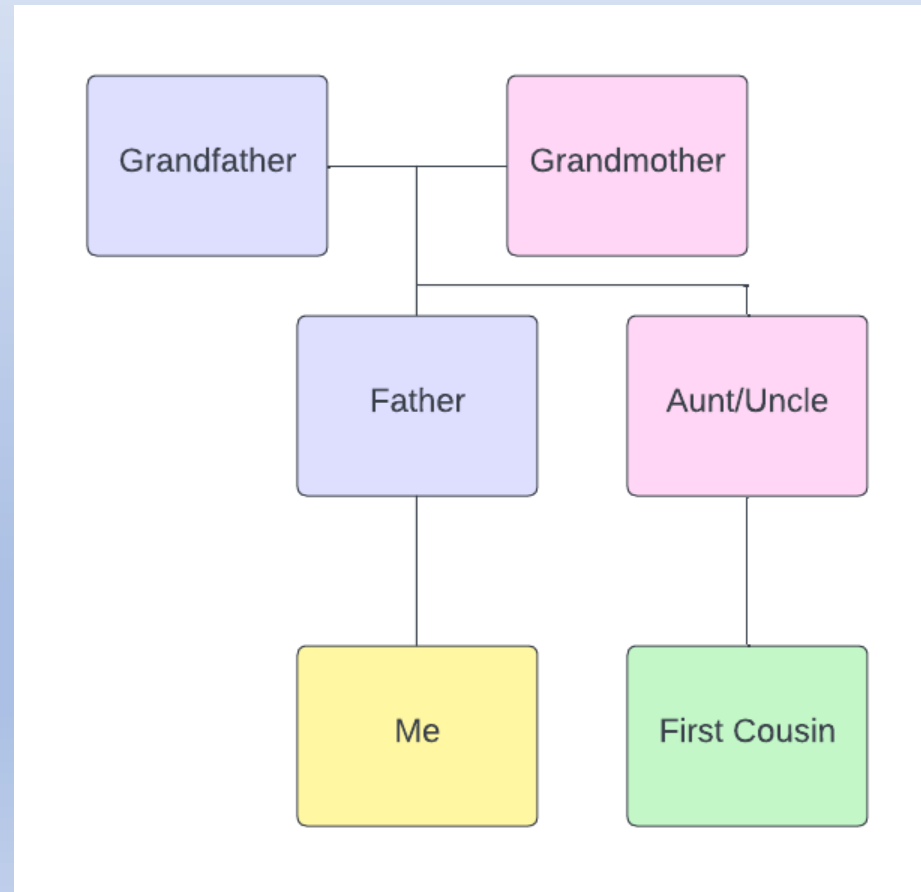
3500 indicates
parent/child



First, let's understand relationships a bit

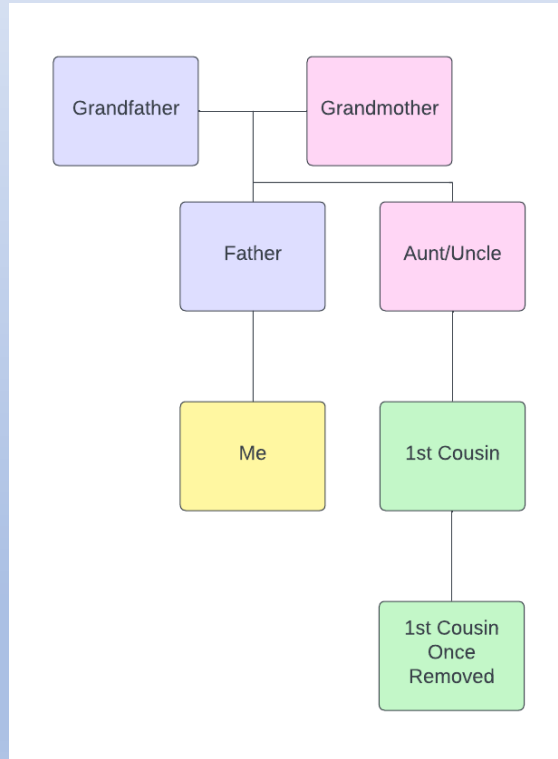
What's a 1st Cousin, once removed, half, etc.?

- 1st cousins share both of one set of grandparents, children of your aunt or uncle

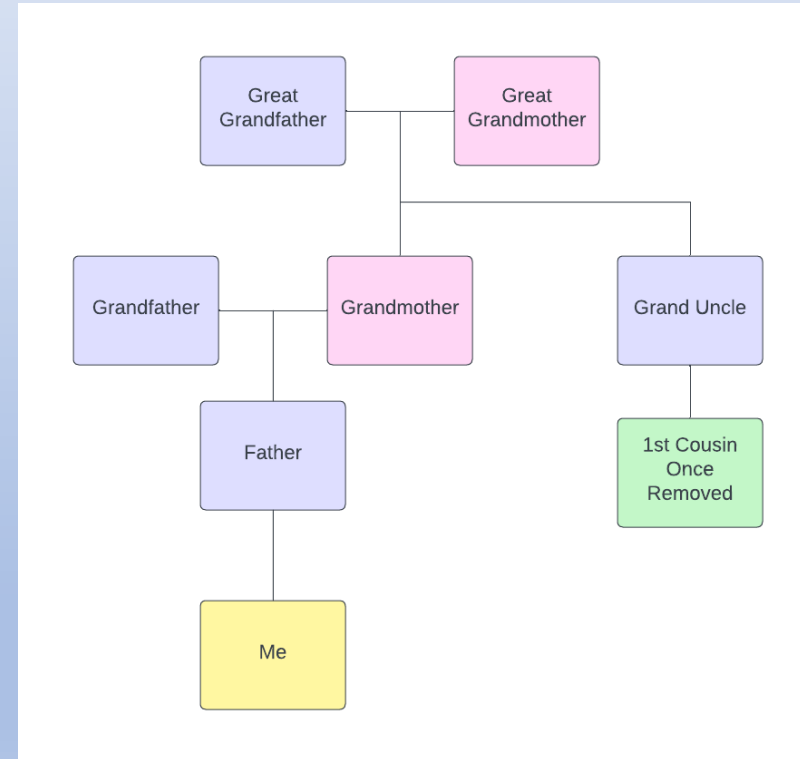


“Removed”

- Removed – simply means the difference of a generation

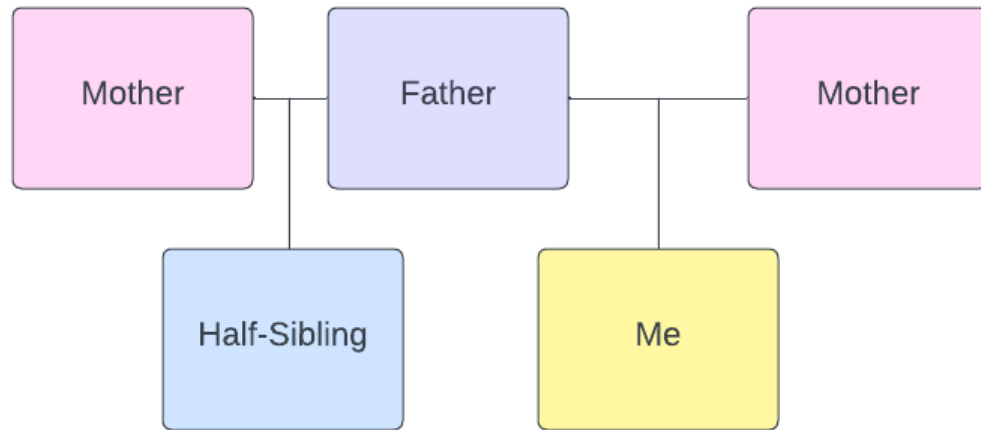


OR

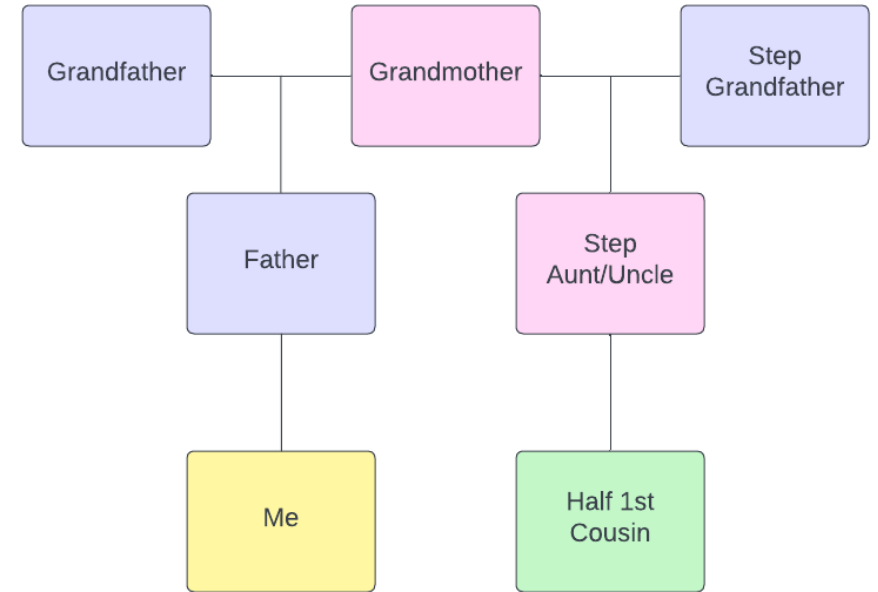


Once removed means the other person is either one generation older or one generation younger

“Half” Relationships



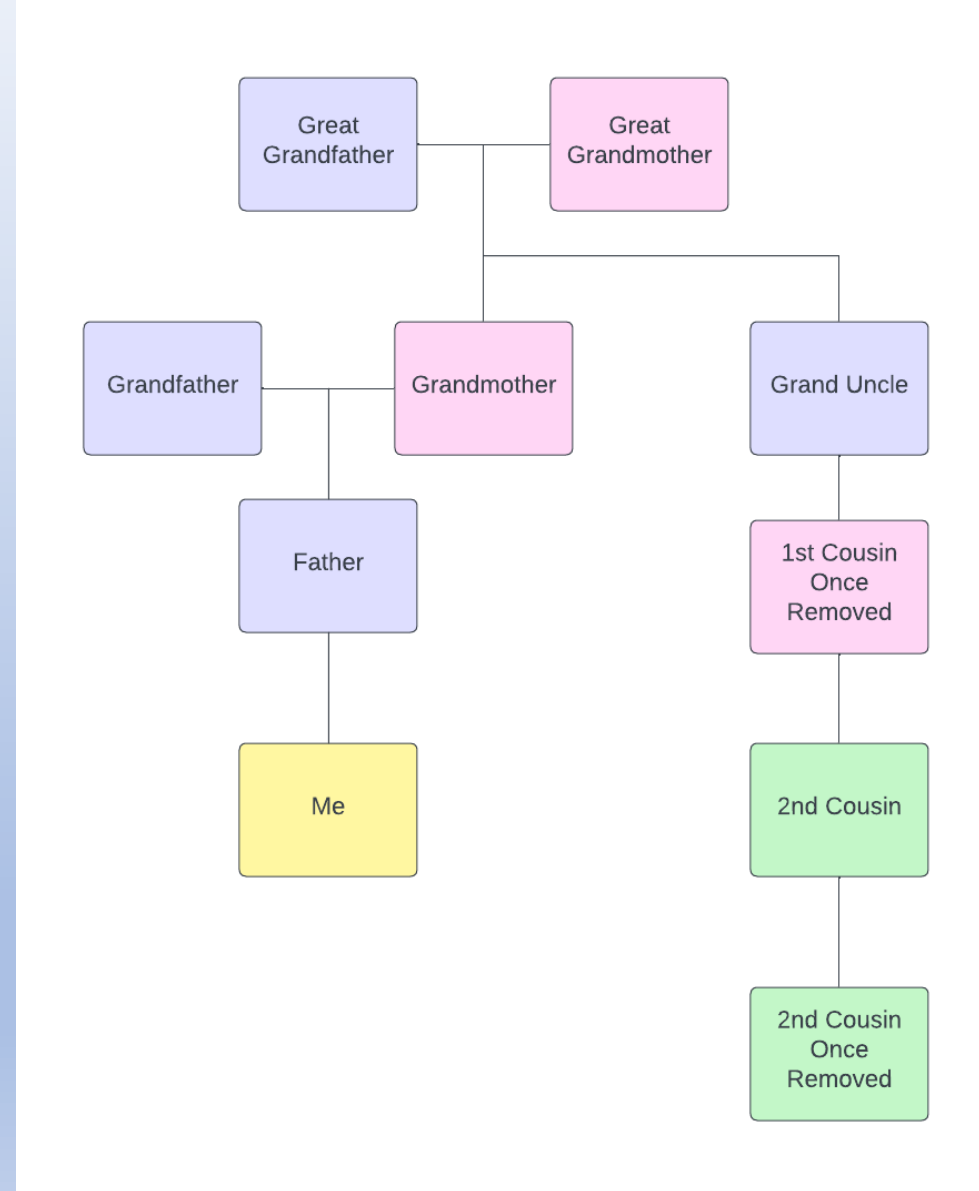
Half-sibling shares only one of two parents



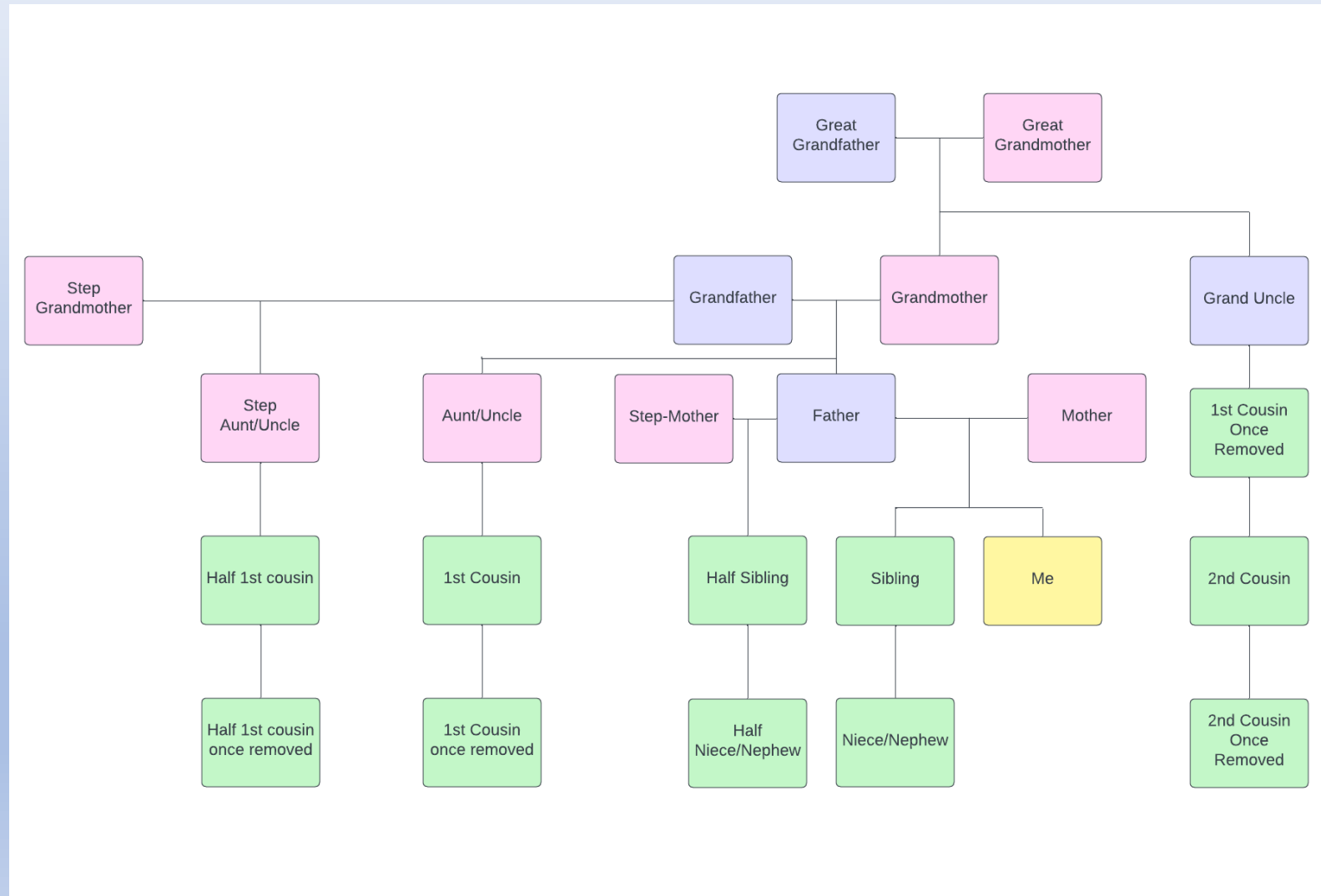
Half-1st cousin shares only one of two grandparents

Second Cousins

- 2nd cousins share a set of great-grandparents
- A child of a 2nd cousin would be your 2nd cousin once removed

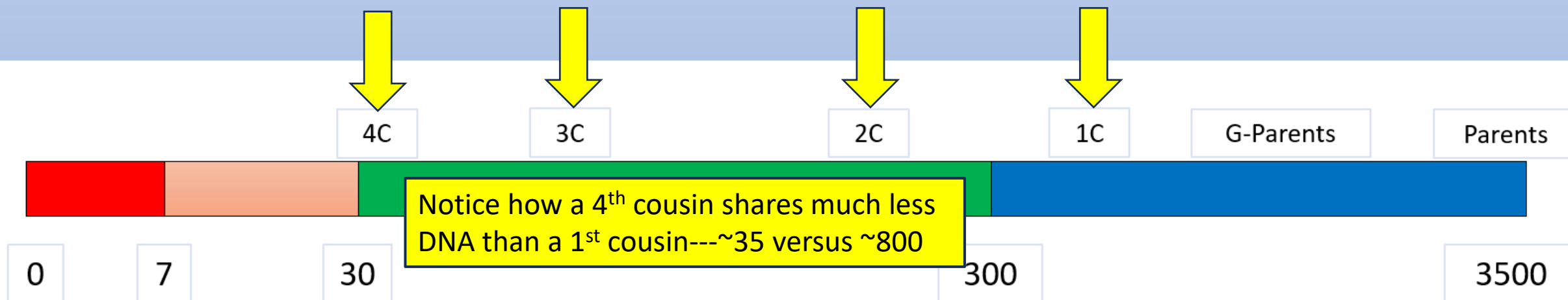


Putting it all together



Why is all this important??

- Relatedness is tied to the centiMorgan (cM) values
- For instance, 1st cousins typically are in a range from 400 to 1400 cMs
- A half-1st cousin is “generally” about half that range or 150 to 600 cMs
- Similarly, a 1st cousin once removed is also in the range of 150 to 600 cMs



Spectrum of “Relatedness bins”

- Parent-Child 3500 cMs
- Sibling 2500 cMs
- Aunt/Uncle/Niece/Nephew/Grandparent/Grandchild/Half-Sibling

Grandparent Aunt / Uncle Half Sibling
Niece / Nephew Grandchild

1800 cMs

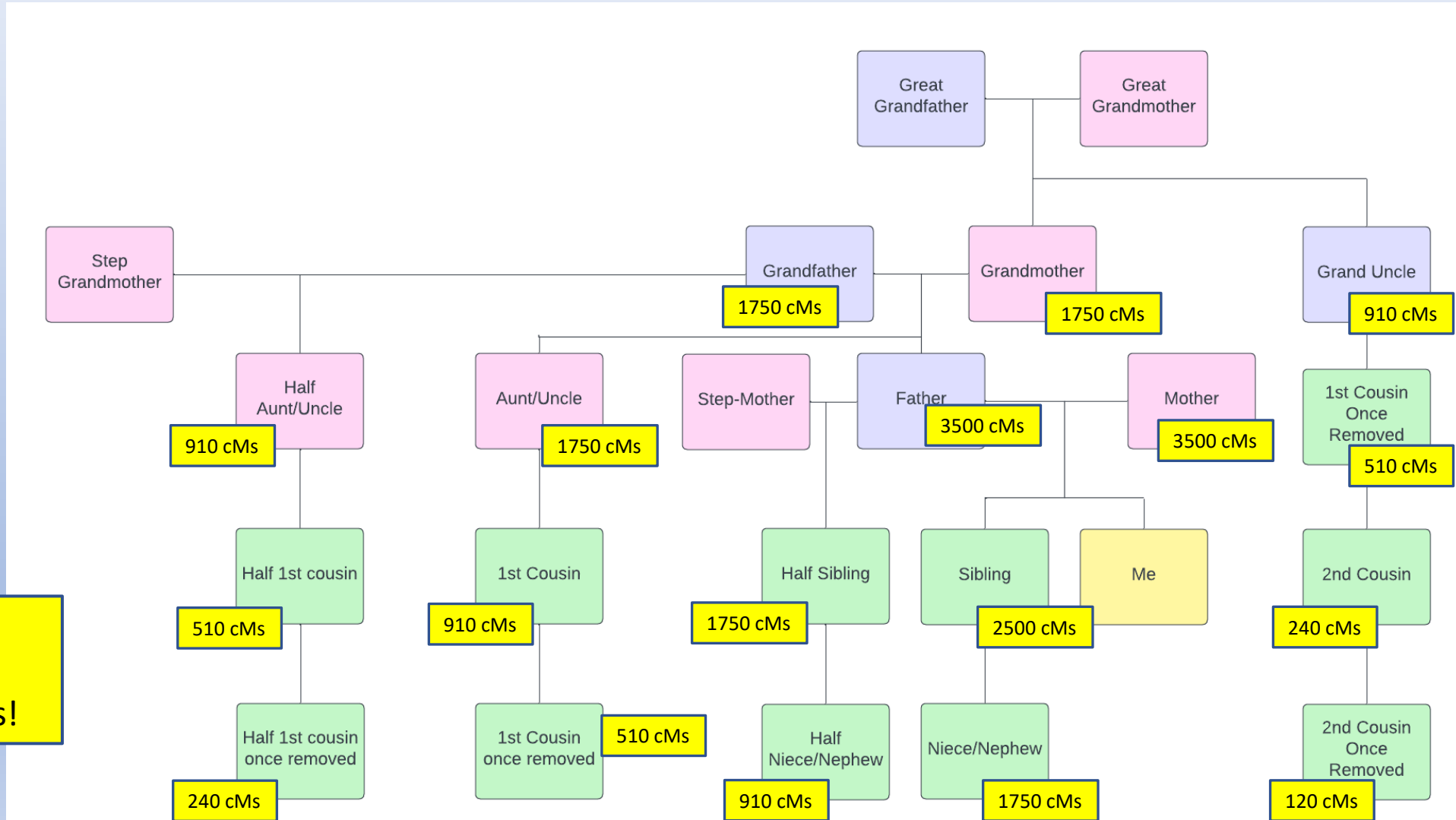
- 1st cousin

800 cMs, but range can actually be from 400 to 1000 cMs

So, if you have a match of 1800 cMs it could be any one of a number of relationships; you need to reduce the possibilities by considering generational differences and possible half relationships

Really important note: the more distant a relation is the higher the expected variation is in centiMorgan values. The values above are averages

Adding average centiMorgan strength to our diagram



REMEMBER:
these are
average values!

Shared centiMorgan Project is your friend!

- <https://dnapainter.com/tools/sharedcmv4>

DNA PAINTER Tools Help Subscribe

The Shared cM Project 4.0 tool v4

Read more about the tool and this update

March 2020
 Blaine T. Bettinger
 www.thegeneticgenealogist.com
 More about this project
 CC 4.0 Attribution License
 Interactive version v4 by Jonny Peri at DNA Painter
 Click here to contribute data to the shared cM project
 Last updated 26th March 2020

Enter the total number of cM for your match:

or enter %

Then any relationships that fit will stand out below
[Read more about cousin relationships](#)

How to read this chart

Relationship
 Average
 Range (low to high;
 99th percentile)

							Great-Great-Grandparent	GGG Aunt / Uncle			
							Great-Great-Grandparent	GGG Aunt / Uncle			
Half GG-Aunt / Uncle 208 103 – 284	Great-Grandparent 887 485 – 1486						Great-Great-Aunt / Uncle 420 188 – 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 125 330 – 1467	1C2R 221 33 – 471	2C2R 71 0 – 244		
3C2R 36 0 – 166	6C 16 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 448 156 – 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 – 76	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

Shared centiMorgan Project is your friend!

- Enter a centiMorgan value and see what the most likely possibility is

Enter the total number of cM for your match:

or enter %

Then any relationships that fit will stand out below
[Click here for a shareable link to the cM amount above](#)

Most distant common ancestors
Assuming no [pedigree collapse](#) or [endogamy](#), and that you're related in just one way, the furthest back you might need to go to find common ancestors for a match of 280cM is 3rd-Great-Grandparent level or generation 6 on your pedigree chart.
The connection may be closer.

Relationship probabilities (based on stats from [The DNA Geek](#))
🔗 Click on any relationship to view a histogram
New: [View these relationships in a tree](#)

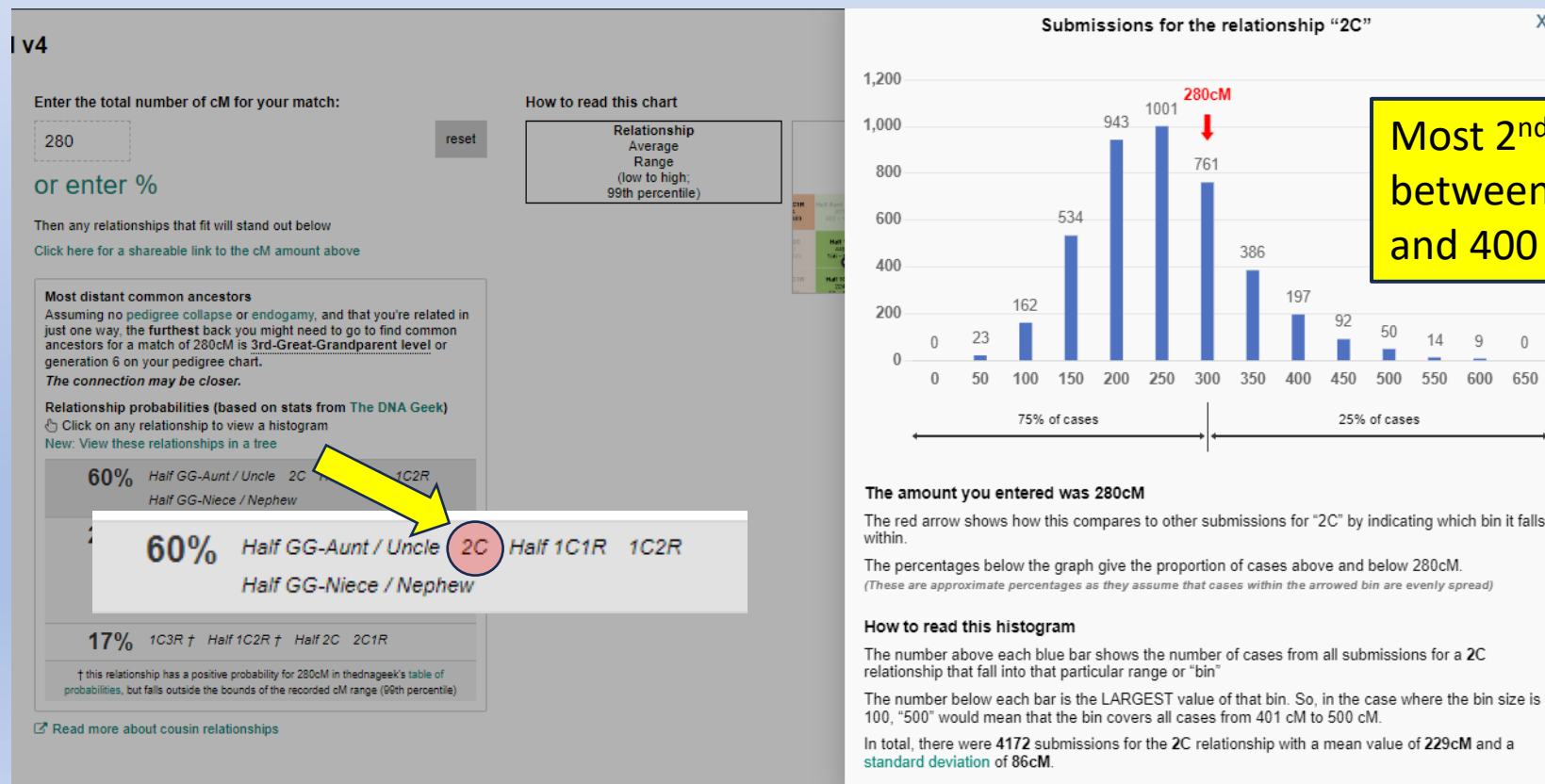
60%	<i>Half GG-Aunt / Uncle 2C Half 1C1R 1C2R Half GG-Niece / Nephew</i>
23%	<i>Great-Great-Aunt / Uncle Half Great-Aunt / Uncle Half 1C 1C1R Half Great-Niece / Nephew Great-Great-Niece / Nephew</i>
17%	<i>1C3R † Half 1C2R † Half 2C 2C1R</i>

† this relationship has a positive probability for 280cM in the [dndageek's table of probabilities](#), but falls outside the bounds of the recorded cM range (99th percentile)

A 280 cM match is mostly likely one of these relationships --- use other information such as age for generation difference or possible half relationships to narrow down to the most likely relationship

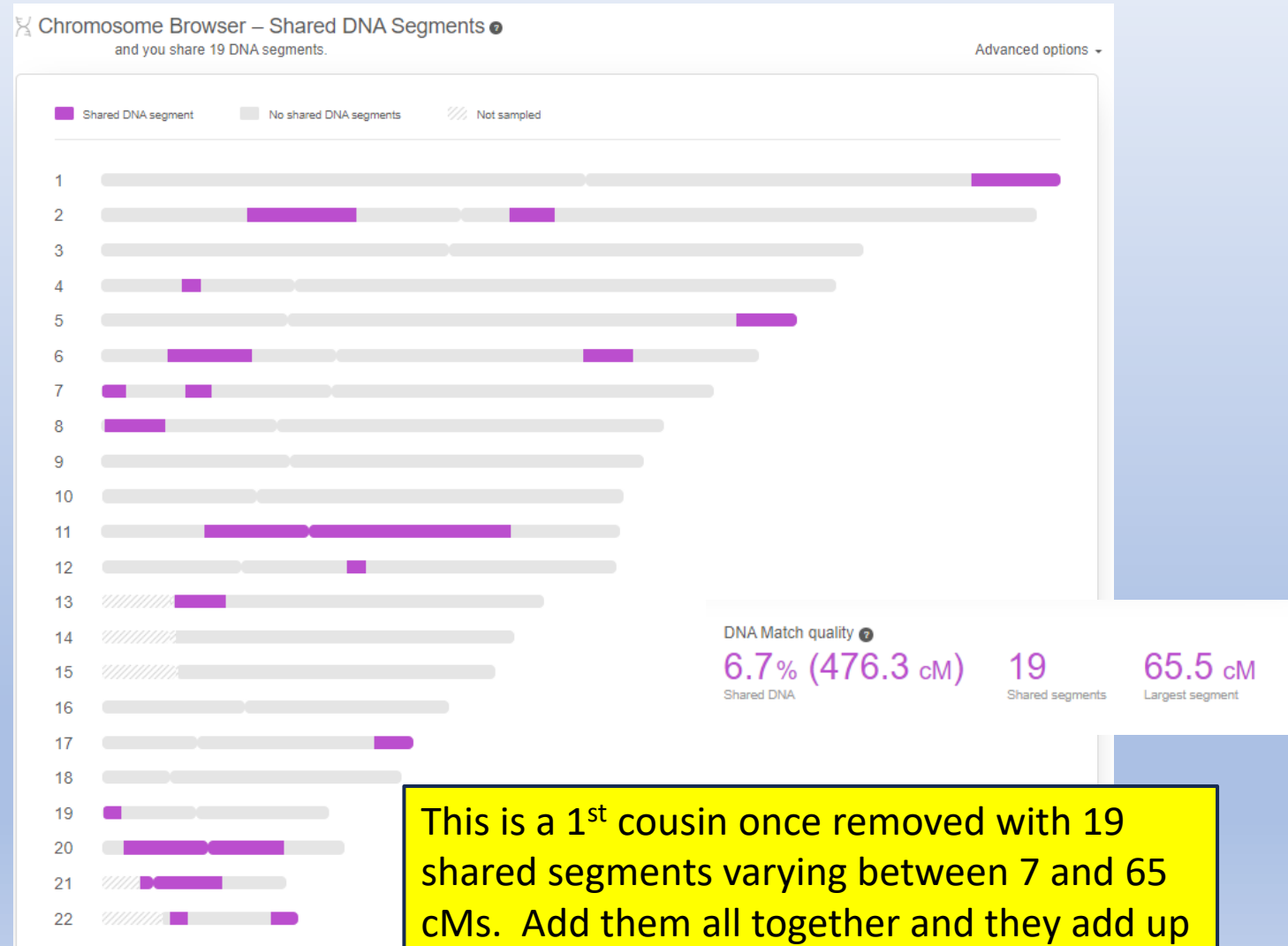
Shared centiMorgan Project is your friend!

- Click on one of the potential relationships to see histogram showing the distribution of 2nd cousin relationships



What does “total” cMs mean?

- You and your match share one or more segments of DNA of varying length
- Each segment has a centiMorgan value
- Add all the centiMorgan values together to get the total value



How are centiMorgans Displayed on
Different Platforms?

Ancestry

Parent/Child



Joan Anita
Craddock

Mother

3,474 cM | 50% shared DNA
Maternal side

- Public linked tree
2,965 People
- Common ancestor

View match

Mother, 3474/46.



23 and Me

- Do not show centiMorgan values but in percentages instead

Showing 1503 of 1503 relatives

Sort by Strength of Relationship ▾

☆ MC Michele (Chicago)

1st Cousin
12.88% DNA shared, 28 segments
Connected

Click on the match and then match details to get the actual centiMorgan value



Shared DNA
12.88%
959cM

Your genetic relationship ⓘ

Predicted relationship
1st Cousin ↙

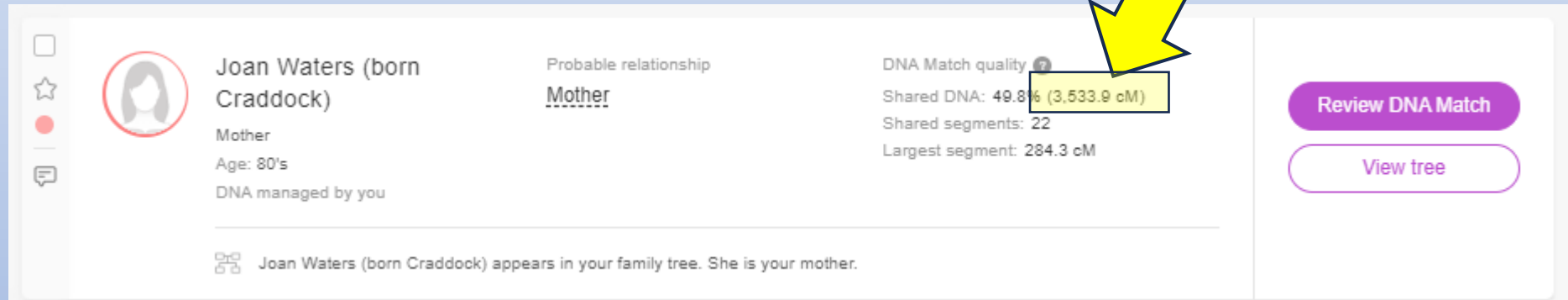
You and Michele likely share a set of grandparents. You could also be from different generations (removed cousins) or share only one ancestor (half cousins).

Shared DNA
12.88%
959cM

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 X

● Completely identical ● Half identical ● Not identical ● Not enough information

My Heritage



Joan Waters (born Craddock)

Mother
Age: 80's
DNA managed by you

Probable relationship
Mother






DNA Match quality [?]
Shared DNA: 49.8% (3,533.9 cM)
Shared segments: 22
Largest segment: 284.3 cM

[Review DNA Match](#)

[View tree](#)

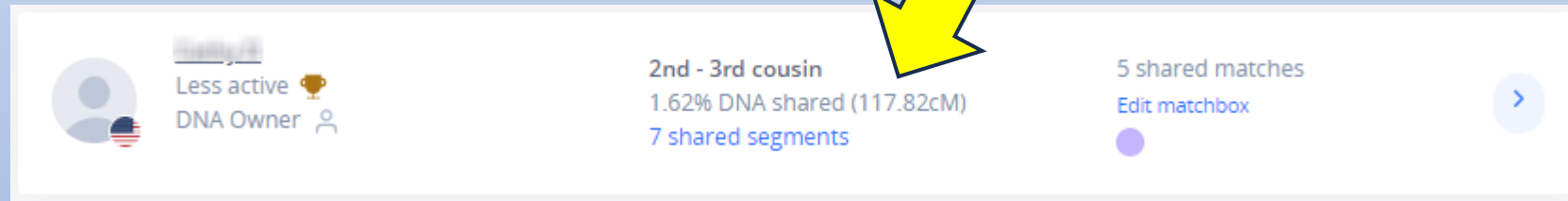
Joan Waters (born Craddock) appears in your family tree. She is your mother.



Family Tree DNA

<input type="checkbox"/>	 Joan Waters				  
Ancestral Surnames Not Provided	Haplogroup mtDNA:  N/A	Relationship Range Parent/Child MOTHER	Shared DNA 3565 cM	Longest Block 284 cM	X Match 181 cM <small>Match date: May 12 2021</small>

Living DNA


- Shows both percentages and the centiMorgan values



Less active 
DNA Owner 

2nd - 3rd cousin
1.62% DNA shared (117.82cM)
7 shared segments


5 shared matches
[Edit matchbox](#)



[>](#)

GEDmatch

- GEDmatch is not a testing site but a service where you can upload your downloaded DNA from any of the testing services



Select	Match No.	Kit	GED WikiTree	Sex	Largest	Gen	Total cM	Largest	ICW Tool	Source	Overlap	Age(days)	Mt	Y	Name (* => alias)
	1	A704134	GED	F	263.7	1.00	3587.1	196.1	Match	Migration - F2 - A	N/A	3626			Joan Craddock *****@gmail.com

- Hard to find here on this 1-to-many search but if you look closely you'll see the Total cM value

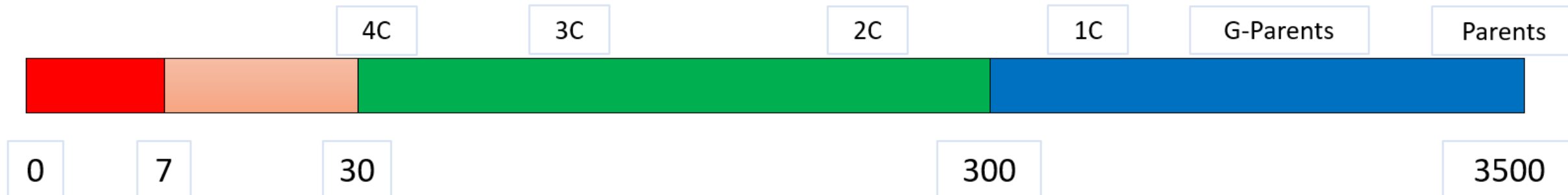
Total cM
3587.1

What does it mean if I share 0 (zero) cMs with a person?

- Simply that you do not share any DNA with that person
- Does that mean you are not related to the person?
- NO, well not necessarily anyway!
- If the person is believed to be a parent, child, brother, uncle, etc. then it IS a red flag that the relationship may not be what you expected
- But, for a more distant person such as a 4th cousin, it's entirely possible that you don't share any DNA simply due to what we call random recombination.

One Last Thing

- Why do I label this number line in different colors?
- BLUE: very close relatives, you **normally** would recognize someone who is in the 300-3500 cMs range
- GREEN: the most useful range for working with DNA matches as they can help identify great-grandparent and 2nd great-grandparent lines
- PINK: may be more difficult to identify as more distant and may even be false match
- RED: high chance of false match. Stay away from these most of the time



Summing Up

- centiMorgans are integral to analyzing DNA matches
- Range from 0 to 3500
- Get familiar with the DNA Painter site for Shared centiMorgans
- Understand the spectrum of centiMorgan values as well as the increasing uncertainties as you deal with smaller and smaller values

Quote of the Day

“DNA doesn't lie. But it sure can be misinterpreted.”

– Ken Waters

Upcoming Classes/Presentations

Saturday, Aug 18, 3 pm

Title: DNA Mysteries

Description: What mysteries can be revealed with a DNA test? We will discuss actual instances of surprise matches, how you can learn from them, and where to go from there.

Saturday, Dec 9, Time TBD

Title: DNA Q & A

Description: Do you have questions about DNA testing? Have you taken a DNA test and need some help? Bring your questions and mysteries to solve.



All library classes that are highlighted in blue are free to attend and require no registration and held at the Red Mountain Mesa Public Library at 635 N Power Rd in Mesa (unless otherwise noted above).

FamilyTreeAZ.com



Presentations:

<http://familytreeaz.com/Presentations>



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