ESWG PAPER CHALLENGE 2024

This year's paper challenge consists of a single exercise divided into three parts. In order to obtain the certificate, participants have to submit results for part a), whereas part b-c are optional. All data is given as files at https://familias.name/ESWG/ESWG2024_paperchallenge.zip in addition to some details given directly in the cases. Please fill out all answers in the supplied Excel questionnaire.

The legacy of elves and man

History has it that in a hidden valley where the air was fragrant with the whispers of ancient trees, Elrond Half-elven ruled as a wise and compassionate lord. His lineage was unique: part mortal, part immortal. But it was Aragorn, the heir of Isildur, who would forever alter the course of their lives. Aragorn, raised by Elrond as a foster son, had grown into a formidable warrior. His destiny lay in reclaiming the throne of Gondor, yet his heart yearned for Arwen Undómiel, Elrond's beloved daughter. Arwen, radiant as moonlight on a tranquil lake, had captured Aragorn's soul from the moment they met. Their love was forbidden, for Elrond foresaw the pain it would bring. He knew the choice that awaited Arwen: to remain immortal or to bind her fate to Aragorn's mortal life. Ultimately the union of Arwen and Aragorn was completed when their son, Eldarion was born.

The DNA mystery began when Elrond, in his vast library, discovered an ancient scroll. Its faded ink revealed a forgotten prophecy: "When the blood of Elves and Men mingles, a hidden power shall awaken." Elrond sensed that this prophecy held the key to their intertwined destinies and in particular for Eldarion. However, before Elrond could untangle the meaning of the prophecy he was mortally wounded.

In another age, called the modern age by some, archaeologists unearth graves bearing the inscriptions Elrond and Eldarion. We are baffled by the possibility that this could indeed be the remains of the historical persons alluded to above.

a) Based on the STR DNA data given in Table 1, compute the likelihood ratio comparing the hypotheses
   H1: Elrond is the maternal grandfather of Eldarion
   H2: Elrond is unrelated to Eldarion

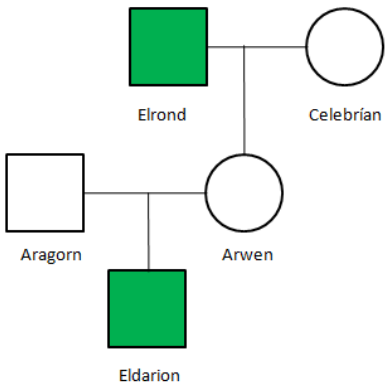

Figure 1. Pedigree illustrating the main hypothesis (H1) in part a). Data is available for the individuals with green fill.

Allele frequencies are given as a file, no population substructure is assumed (i.e. theta=0). We can disregard mutations (i.e. mutation rate=0). Silent alleles and other complicating factors can also be disregarded.

Table 1. Marker data for the two individuals involved in part a).

Marker	Elrond	Eldarion
CSF1PO	10,10	12,13
D13S317	10,11	10,8
D16S539	11,13	12,11
D18S51	13,16	17,14
D19S433	15,12	15,15
D21S11	29,30	30,29
D2S1338	23,26	26,23
D3S1358	16,16	15,16
D5S818	12,13	14,11
D7S820	10,8	10,12
D8S1179	13,12	12,13
FGA	23,20	24,25.2
TH01	7,9	7,6
TPOX	8,8	8,8
D10S1248	13,14	13,14
D12S391	22,17	24,18
D1S1656	13,16.3	14,17.3
D22S1045	15,15	15,16
D2S441	15,11	10,11
SE33	22.2,14.2	21,14.2
AMEL	X,Y	X,Y

b) Another excavation uncovers a third grave bearing the inscription *Galadriel*. From history books you learn that this could be the legendary *Lady of the Golden Wood.* From the old records you find the pedigree depicted below. Based on the DNA data in Table 2, find if Galadriel, Elrond and Eldarion are related as depicted in Figure 2. Construct relevant pedigrees for the comparison and report LR and posterior probabilities.

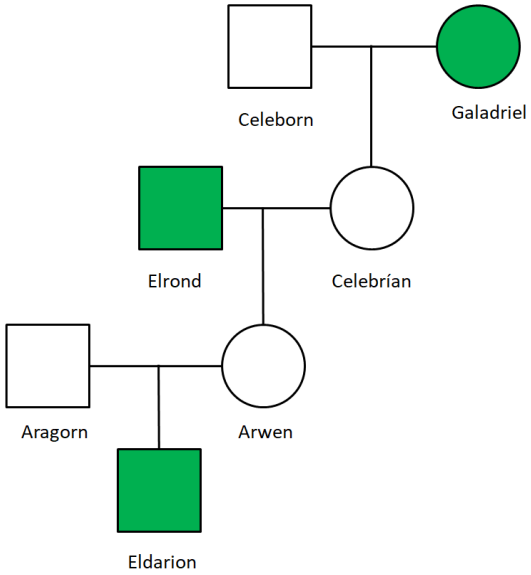

Figure 2. Pedigree illustrating the main hypothesis in part b). Data is available for the individuals with green fill.

Allele frequencies are given as a file, no population substructure is assumed (i.e. theta=0). We can disregard mutations (i.e. mutation rate=0). Silent alleles and other complicating factors can also be disregarded.

Table 2. Marker data for the two individuals involved in part b).

Marker	Elrond	Galadriel	Eldarion
CSF1PO	10,10	12,12	12,13
D13S317	10,11	12,10	10,8
D16S539	11,13	11,12	12,11
D18S51	13,16	17,13	17,14
D19S433	15,12	13.2,12	15,15
D21S11	29,30	30,29	30,29
D2S1338	23,26	25,16	26,23
D3S1358	16,16	15,15	15,16
D5S818	12,13	13,11	14,11
D7S820	10,8	12,8	10,12
D8S1179	13,12	12,11	12,13
FGA	23,20	20,24	24,25.2
TH01	7,9	9.3,11	7,6
TPOX	8,8	11,8	8,8
D10S1248	13,14	14,14	13,14
D12S391	22,17	24,20	24,18
D1S1656	13,16.3	14,15.3	14,17.3
D22S1045	15,15	14,16	15,16
D2S441	15,11	11,10	10,11
SE33	22.2,14.2	21,30.2	21,14.2
AMEL	X,Y	X,X	X,Y

c) It is told that Aragon (see Figure 3 below) is connected through a long unbroken paternal lineage to Elrond. Running a Y-STR analysis you are able to obtain profiles for comparison. We can assume Elrond and Aragorn are separated by 65 generations. In the calculations you can assume that the haplotype of Elrond is the founder haplotype and has been observed 10 times while the haplotype of Eldarion has never been observed. The size of the Y-database is 289,406. For simplicity we can assume that the mutation rate is equal to 0.001 for all included markers and that there is an equal chance for a loss or gain of a tandem repeat in the mutation model. Further assume that there is a 90% chance for a mutation to be single step, 9% two step and so forth.

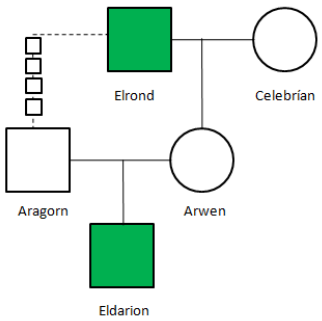

Figure 3. Pedigree illustrating the main hypothesis (H1) in part c). Data is available for the individuals with green fill.

Table 3. Marker data for the two individuals involved in part c).

Marker	*Elrond*	*Eldarion*
DYS19	14	14
DYS389I	13	13
DYS389II	29	30
DYS390	24	24
DYS391	10	10
DYS392	11	11
DYS393	12	12
DYS385	14,17	14,17
DYS437	15	15
DYS438	10	10
DYS439	12	12
DYS448	21	21
DYS456	15	15
DYS458	16	16
DYS635	21	21
YGATAH4	10	10
DYS481	22	22
DYS533	11	11
DYS549	12	12
DYS570	17	17
DYS576	15	15
DYS643	11	11

For part c) no data files are available online. Data is only provided in the table above.