Statistical methods in genetic relatedness and pedigree analysis

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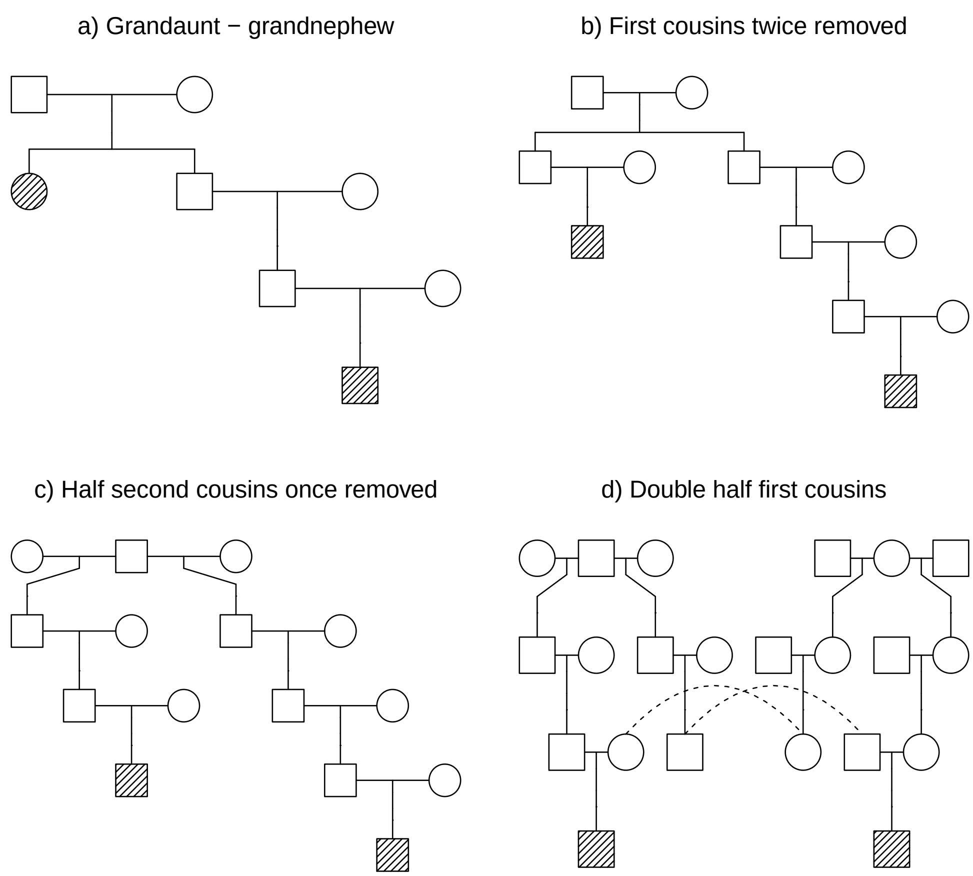
Solutions for exercise set I

Exercise I-1

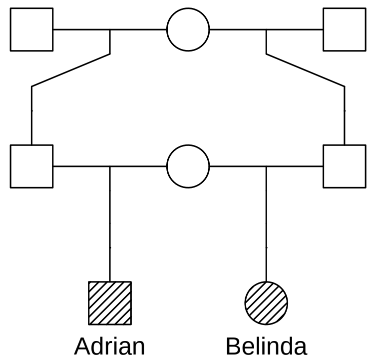
R versions of the pedigrees are shown below.



Exercise I-2

a) Adrian and Belinda are half first cousins.

b) With the new information, Adrian and Belinda are simultaneous (maternal) half siblings and first half cousins.



Exercise I-3

a) Answer omitted.

b)
- 1 is a double grandfather of 7
- 3 is simultaneously the father and an uncle of 7
- 3 is a double uncle of 8
- 7 and 8 are quadruple first cousins

Exercise I-4

a) The marker is an autosomal STR marker. Reasons: allele labels; more than two alleles.
b) Five alleles (13, 14, 15, 21 and 22) are observed. The alleles names indicate the number of repeats.
c) Both 4 and 5 has genotype 13/14 (because of their parents).
d) Individual 3 has genotype 21/22 (because his children must have gotten 13 from their mother).
e) The possible genotypes are 13/13, 13/14, 13/15 and 14/15, each with probability $\frac{1}{4}$.

Exercise I-5

a) B (forced inheritance from the mother).
b) A/B (deduced from her children 5 and 6).
c) A/B. (She got B from her father, but has given an A to her son individual 10). She inherited A from her mother.
d) Neither genotype is possible to determine from the data.
e) 10 and 11 are maternal half siblings. 5 is the (maternal) uncle of 11. 4 and 9 are unrelated.

Exercise I-6

a) $p_A^3 p_B = 1/16$.
b) $\frac{1}{2} p_A^3 p_B = 0.03645$.

Exercise I-7

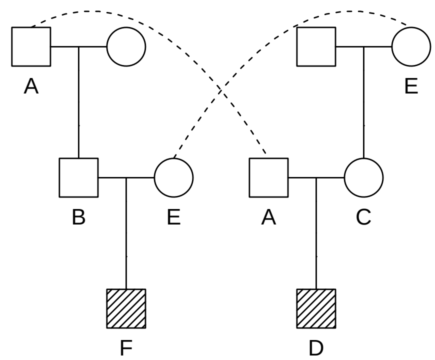
Let $p = P(A)$ and $q = P(B)$.

a) For a SNP in HWE the proportion of BB has expectation q^2. Setting $q^2 = 1/100$ gives $q = 1/10$, and thus $p = 9/10$. Our best guess is therefore $100 \cdot p^2 = 81$ individuals with AA, and $100 \cdot 2pq = 18$ individuals with AB.
b) Since $p^2 = 4q^2$, we find $p = 2q$. Inserting this into the identity $p + q = 1$, we get $2q + q = 1$, thus $p = 2/3$ and $q = 1/3$. The genotype frequencies for AA, AB and BB are therefore 4/9, 4/9 and 1/9.
c) It is not possible. If $P(AA) = P(BB)$ then $p^2 = q^2$, giving $p = q = 1/2$. But then $P(AA) = P(BB) = 1/4$ while $P(AB) = 2pq = 1/2$, contradicting the assumption.

Bonus exercises

Exercise I-8

a) Here is a plot of the pedigree:



b) Each is a half uncle of the other. This is the simplest example of a reciprocal asymmetric relationship.

Exercise I-9

In each case below, a father and a son have been typed with a SNP in Hardy-Weinberg equilibrium, with allele frequencies $P(A) = p$ and $P(B) = q = 1 - p$.

a) $P(A/A) = p$, $P(A/B) = q$, $P(B/B) = 0$.
b) $P(A/A) = p^2$, $P(A/B) = 2pq$, $P(B/B) = q^2$.
c) The conditional probabilities equal the Hardy-Weinberg proportions. This means that the genotypes of father and son does not tell us anything about the mother − her probabilities are exactly as for an unrelated person.

Exercise I-10

a) Given that both parents are A/B, the genotype probabilities of each child are $P(A/B) = 0.5$ and $P(A/A) = P(B/B) = 0.25$. Thus the pedigree to the right is the most likely, since it has more heterozygous children than the other.
b) Once the parents are given, the children's genotypes depend only on them, and have nothing to do with HWE.