# Problems

**Question 1**. Haemophilia is a recessive X-linked condition. In one population, the allele frequency is about $4x10^{-5}$. If individuals are randomly chosen from the population, and assuming no differences in survival(!):
a. If a man is chosen, what is the probability he has haemophilia?
b. If a woman is chosen, what is the probability she has haemophilia?
c. If a woman is chosen, what is the probability she is a carrier of haemophilia?
d. If the woman's father did not have haemophilia, what is the probability she is a carrier?
e. If this woman's brother has haemophilia. What is the probability she is a carrier?
f. What is the probability that one of the woman's sons has haemophilia?

**Question 2**. This is based on a quiz show called "Let's Make a Deal!". At the end of the show, a contestant would be allowed to try for the big prize of a car. They were presented with three doors. The car was behind one, and there were cows behind the other two. The contestant would choose a door. Then the host, Monty Hall, would open one of the other doors, to reveal a cow. He would then give the contestant the opportunity to switch to the other door. Should the contestant switch, or stay? Or does it matter?

**Question 3**. In a famous court case in the 1990s, a woman was accused of murdering her two babies. The cause of death had been described as SIDS (Sudden Infant Death Syndrome). The main evidence from the prosecution came from an expert witness, who stated that, for a mother like the accused, the chances of one child dying of SIDS was 1 in 8500. Hence the chances of two dying was 1 in 73 million. And, as this was so small, the deaths could not have been due to SIDS.

a. What event does the 1 in 73 million figure refer to? Is it the same as the event the jury are interested in?
b. What assumption was made to reach the 1 in 73 million figure? Does it seem reasonable?

A subsequent study on SIDS found that, of 473 000 babies studied, 363 died from SIDS. Of those, 5 were babies from families where an older child had also died of SIDS.

c. What is the probability that a child dies of SIDS?
d. What is the probability that a child that died of SIDS was from a family where an older child had also died of SIDS?

The calculations above are calculations per child. However, interest in the case is on calculating the per-family probabilities.

e. Why are the two probabilities (per-child and per-family) different?

There are approximately 2 children born per family. If we assume that the number born, $n$, follows a Poisson distribution with mean $\lambda$, then

$$P(N=n|\lambda)=\frac{\lambda^n e^{-\lambda}}{\lambda!} \quad (1)$$

f. Approximately how many families were there in the study?
g. What is the probability that a family has 0 children? Approximately how many had children?
h. How many of the families had children who died of SIDS?
i. What is the probability that a family has more than one child who dies of SIDS?