

1. An individual's blood group is determined by the ABO gene. Each of us has two copies of the gene on chromosome 9 - one copy inherited from each parent. There are three possible alleles of the gene: a, b and o. The table below shows the possible genotypes and the resulting phenotype - the blood group.

Genotype		Phenotype
Allele from father	Allele from mother	Blood group
a	a	A
a	o	
o	a	
b	b	B
b	o	
o	b	
a	b	AB
b	a	
o	o	O

- (a) Classify the following events as **mutually exclusive**, **independent** or **neither**.

i. E_1 : Inheriting allele a from father.
 E_2 : Inheriting allele o from father.

ii. E_1 : Inheriting allele a from father.
 E_2 : Inheriting allele o from mother.

iii. E_1 : Inheriting allele b from mother.
 E_2 : Inheriting allele a from father.

iv. E_1 : Possessing blood group A.
 E_2 : Possessing blood group O.

v. E_1 : Inheriting allele a from mother
 E_2 : Possessing blood group O.

vi. E_1 : Inheriting allele b from father.
 E_2 : Possessing blood group AB.

- (b) In the human population, the alleles a and b occur with probabilities $P(a) = 1/5$ and $P(b) = 4/25$. What is the probability of occurrence of the allele o?

- (c) Using the probabilities calculated above, and the addition and multiplication rules of probabilities, calculate the probabilities of the following events:

i. Inheriting allele a **OR** b from father.
 ii. Inheriting allele a from father **AND** allele b from mother.

- iii. The probability of occurrence of blood group AB.
 - iv. The probability of a random individual having blood group A **OR** B.
2. An anti-aircraft gun can take a maximum of four shots at an enemy plane moving away from it. The probabilities of hitting the plane on the first, second, third and fourth shot are 0.4, 0.3, 0.2 and 0.1 respectively. What is the probability that the gun hits the plane?
 3. Let us (optimistically) assume that it rains in Vancouver on 4 out of every 5 days during the winter ($p(R) = 4/5$). Independent of the rain, the probability that you have a Math-103 lecture on a randomly chosen day is $p(C) = 2/7$.
 - (a) How likely is it to get rain 30 days in a row?
 - (b) How likely is it to rain for more than 25 days in a 30 day period?
 - (c) What is the probability that on a randomly picked winter day, it rains **AND** you have a class?
 - (d) What is the probability that on a randomly picked winter day, it neither rains, nor do you have a lecture?
 4. The Australian brush-turkey usually lays 16-24 eggs into one clutch. Biologists have discovered that the male/female ratio of the chicks varies with the incubation temperature of the eggs. At $T_1 = 34^\circ\text{C}$, the probability of hatching a male or a female chick is the same, i.e. 50%. At a lower incubation temperature of $T_2 = 31^\circ\text{C}$, the probability of hatching a male chick is increased to $p(m) = 0.8$ ($p(f) = 1 - p(m) = 0.2$). For a clutch of 20 eggs, evaluate the following at both the temperatures (T_1 and T_2):
 - (a) The expected number of male chicks.
 - (b) The probability of getting 10 female chicks.
 - (c) The probability that the **first 10** chicks to hatch are male.
 5. A fish bowl contains 3 plump goldfish and 7 scrawny goldfish. Felix, the cat, hungrily scoops 3 fish out of the bowl. They are all plump goldfish, and Felix prepares to eat them. Just then his master, a math professor with a cruel sense of humour happens by and says, "Felix, if you can repeat this performance 2 times out of the next 3 tries, I'll let you eat the goldfish. If you can't, then you'll be fed your usual meal of chopped up snails!" What is the probability that Felix gets fish for supper?
 6. A couple is trying to have a child. Their probability of conception in any given month is $1/8$.
 - (a) What is the mean number of months until conception occurs?
 - (b) What is the smallest number n , such that there is greater than 50% probability that they conceive in n months or less?
 7. Sickle cell anemia is a recessive genetic disorder caused by a defect in the gene which codes for hemoglobin. There are two alleles of the gene: a normal allele, A, and a defective variant, S. Individuals who are homozygous with the defective allele (SS) suffer from sickle cell anemia, while those who are heterozygous (SA) are phenotypically normal (i.e. healthy) carriers of the allele.

After graduation, you and 19 friends build a raft, sail to a deserted island, and start a new population totally isolated from the rest of the world. Two of your friends are heterozygous carriers of the recessive allele S.

- (a) Assuming that the frequency of this allele does not change as the population grows (Hardy-Weinberg equilibrium), what percentage of the island's population will eventually suffer from sickle cell anemia?
- (b) Calculate frequencies of all the possible genotypes in the second generation by constructing a table of genotypes (see example on page 148 of course notes). Does your answer to part (a) match the outcome of this explicit calculation?
8. Individuals with the defective allele S for hemoglobin possess an increased resistance to malaria. If 9% of an African population is born with sickle-cell anemia (SS), what percentage of the population will be more resistant to malaria?
9. The table below summarizes the number of job applications processed per day by an employment agency over a 100 day period.

Number of applications processed per day	Number of days
7	10
8	10
10	20
11	30
12	20
14	10

- (a) What is the mean number of applications processed per day over this period?
- (b) Make a table of the cumulative frequency distribution for this data.
- (c) What is the median number of applications processed per day?