Exercises Sheet 3

1. Des Jarlan's et al. (1991) examined failure to maintain AIDS risk reduction in a study of intravenous drug user's in New York. Findings were as follows

No. of Sexual Partners /month	**Risk Reduction Status** None	Not Maintained	Maintained	**Total**
0	20	17	43	80
1	37	45	95	177
>1	20	54	67	141
Total	77	116	205	398

On selecting a subject at random, what is the probability

(i) He/she did not initiate risk reduction
(ii) Given he/she had more than one sexual partner, that he/she maintained risk reduction
(iii) That he/she had no sexual partners and did not maintain risk reduction
(iv) He/she had one sexual partner or initiated no risk reduction

2. The probability that a person, selected at random from a given population, exhibits classical symptoms of a certain disease =0.2. The probability that a person, selected at random etc., has this disease =0.23. The probability that a person, selected at random etc., has the symptoms and has the disease =0.18. If a person, selected at random from the population, does not have the symptoms, what is the probability that he/she has the disease?

3. In a certain population, 10% of persons are colour blind. A random sample of 25 is drawn, find the probability that

(i) No more than 5 are colour blind.
(ii) At least 6 are colour blind.
(iii) Between 6 and 9 inclusive are colour blind.
(iv) Some 2,3 or 4 are colour blind.

4. In a study of aquatic organisms, a large number of samples are taken from a pond and the number of organisms in each sample counted. The average number of organisms in a sample is found to be 2. If counts are assumed to follow a Poisson, find the probability that

(i) Next sample will contain ≤ 1 organism
(ii) Exactly 3 organisms
(iii) $\geq$ 5 organisms

5. In a certain population, 13 new cases of oesophagal cancer are diagnosed on average each year. If we assume that the incidence of oesophagal cancer follows a Poisson, find the probability in a given year that the number of newly diagnosed cases of o.c.

(i) Equals 10 (iii) ≤ 12 (v) ≤ 7
(ii) $\geq$ 8 (iv) between 9 and 15 inclusive

6. From the moment generating function for a Binomial variable,

$$mgf(X) = \sum_{x=0}^{\infty} e^{tx} \binom{n}{x} p^x (1-p)^{n-x}$$

Obtain E{X}, E{X^2), Var{X} from first principles.

7. Mutation is the ultimate source of new alleles. Suppose the allelic frequency in a native population is p_{n_0}, where proportion m_i relative to the native population, **migrates** from *i* th population among *k*, to the native population every generation, (and where allelic frequency among immigrants from *i* th population is p_i), then allelic frequency in the mixed population is:

$$p_{n_1} = \left[1 - \sum_{i=1}^{k} m_i\right] p_{n_0} + \sum_{i=1}^{k} (m_i p_i)$$

Similarly,if mutation rate from wild to mutant is $\boldsymbol{u}$ andreverse mutation rate is $\boldsymbol{v}$ per generation, then give:

(i) The frequency p_{n1} of the wild type after one generation, assuming p_{n_0} is the wild type frequency in the population of the previous generation.

(ii) The equilibrium condition for p_{n_0} (setting allelic frequency change = 0)

Supposing selection is considered (either artificial or natural). If we have a two allele system, with fitness (1-Coefficient selection) for the three genotypes AA, Aa and aa = *f1,f2,f3* respectively, what form would you expect p_{n1} (allelic frequency for allele A) to take?

(Let p_{n_0} be the allelic frequency for A in the population before selection and consider the Coefficient of selection to be the measure of disadvantage of a given genotype in a population).

8. For the single-gene model, refer to the single-locus, two alleles *A* and *a* case, given in the notes, with same frequencies, *p* and *q* applying and the population mean as given. Then,

(i) Give the deviation of genotypic values from the mean for each genotype

(ii) For the gene substitution problem, obtain the mean values of the genotypes produced for the two types of gametes (containing allele A and allele a respectively) and hence obtain a value for the average effect of gene substitution α (a with A).

(iii) What are the breeding values for the three possible genotypes here?

(iv) What is the dominance deviation for genotype AA?

(v) Obtain the additive, dominance and total genetic variance of the genotypic values.

(vi) How would you expect these variances to change as the frequency of the *A* allele, *p*, increases from *0* to *1?* Sketch rough curves, using e.g. a=1, d = 0, 0.5 and 1.0