1) Flowers on an Rrr trisomic tomato are fertilized using a trisomic RRR plant as the pollen source. A) Give the ratios expected in the progeny assuming R is fully dominant and that only females pass the disomic gamete.

<table>
<thead>
<tr>
<th>Female gametes</th>
<th>1 R</th>
<th>2 Rr</th>
<th>2 r</th>
<th>1rr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>2 R</td>
<td>2 RR</td>
<td>4 RRR</td>
<td>4 Rr</td>
</tr>
<tr>
<td>Gametes</td>
<td>1 r</td>
<td>1Rr</td>
<td>2 Rr</td>
<td>2 rr</td>
</tr>
</tbody>
</table>

Overall 5/6 R__ and 1/6 rr_

B) What would the ratio be if the reciprocal cross {RR female and Rrr male} was made?

<table>
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<th>2 R</th>
<th>1 RR</th>
<th>2 Rr</th>
<th>1r</th>
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<td>2 r</td>
<td>4 Rr</td>
<td>2 RRR</td>
<td>4 Rrr</td>
</tr>
</tbody>
</table>

Overall 8/9 R__ : 1/9 rr

2. a) What is gene conversion and what is the explanation.
It is changing one allele present in synapsed homologous chromosome to the other as a result of DNA repair that occurs of base pair mismatches in the heteroduplex region that initiates the potential crossover process.

b) How might it be distinguished from mutation?
a) The frequency will be much higher when nearby flanking markers show that recombination has occurred in that region. B) Backcrosses to the parent with that allele should not show any recombination, c) sequence analysis. Note that true single base revertants would not be separable, but second site changes etc. would be.

3. The primary gene for controlling human eye color (oca2) is on chromosome 15. We will ignore 7 other modifying genes in this example. OCA2 produces lots of melanin via “P” protein while homozygous oca2/oca2 coding region or promoter mutations do not. High levels of the protein result in basic brown eyes while low levels lead to blue eyes. (If P is totally non-functional, individuals are also near-albino in pigmentation.) A person with one blue eyed parent and one brown eyed parent has one obviously blue eye and one that is brown. Propose at least 2 different genetic mechanisms that could account for this ultra rare occurrence.
1. a somatic mutation in the OCA gene in an eye progenitor cell making the individual mosaic
2) a mitotic recombination occurred where the crossover is between the OCA gene and its centromere in a cell at an early stage of eye development
3) a Transposon moved into the functional allele in the early stage of development
4) The individual was a chimera resulting from fusion of 2 embryos with different genotypes.
4. The A gene locus in a tetraploid plant is far enough from the centromere that \( \frac{1}{2} \) the time a crossover between the gene and the centromere occurs in meiosis. A tetraploid with the genotype AAaa is self pollinated. (Assume that the 4 homologs form 2 pairs at random.)

a) What are the odds that one A bearing chromosome will pair with the other A in synapsis? \( \frac{1}{3} \)
What gametes will be formed when this happens? All Aa
How often will an A and a chromosome pair? \( \frac{2}{3} \)

b) What is the probability of getting an aaaa progeny?
Half way between chromosome segregation \((1/6)^2\) and chromatid segregation \((3/14)^2\), which is 3.685%

5. With regard to cytoplasmically inherited traits:
   a) What is the standard mode of inheritance?
      All progeny get the cytotype (mt of ct DNA) from the female
   b) Give an example where the same pattern of inheritance is not the result of ‘cytoplasmic inheritance’. Infectious heredity as in the case of CO2 sensitive Drosophila an maternal influence as in the case of shell coiling in snails.
   c) Why is there a problem in using prenatal diagnosis in predicting the outcome of a pregnancy even when the mother is a known carrier of MERRF (a mitochondrial defect) that can be detected using PCR?
The mother has to be heteroplasmic to be alive and the distribution of organelles into any daughter cell, including the egg is a chance event.

6. A gardener planted 25 pink carnations (annuals) and grew 4 randomly selected seeds from each plant the next generation, obtaining a ratio of 25 Red: 50 pink: 25 white. He saved and grew 4 seeds from each of these plants to get the next generation and got a ratio of 110 red: 180 pink : 110 white.
   What are the allele frequencies for R’ and R in each generation? 0.5 R’ and 0.5 R both generations
   Does this latest population fit Hardy-Weinberg equilibrium?
   If random mating occurred the expected frequency would be 100 red: 200 pink : 100 white
   The Chi square value is thus \( \frac{10 \times 10}{100} + \frac{20 \times 20}{200} + \frac{10 \times 10}{100} \) which is 4 and for 1 df is significant at the 5% level, so we can say it does not fit (unless we had opted to use a different level of significance).
The gardener actually expected to see 150 Red: 100 pink and 150 white in the second generation. What assumption was he making?
   He assumed the flowers reproduce by self pollination only
   How can the expectations and outcomes be explained?
The expectation likely came from the first generation but pink by pink would give the same ratio from selfing or crossing; the data suggest that there is some selfing and some outcrossing. \( F = \frac{180}{200} = 0.1 \)
7. Calculate the coefficient of inbreeding for G in the pathway below.

\[ F(G) = \left( \frac{1}{2} \right)^4 + \left( \frac{1}{2} \right)^4 = \frac{1}{8} = 0.125 \]

8. The biologist B. Battaglia raised the marine copepod *Tisbe reticulata* (a small free-swimming marine crustacean) under crowded conditions. *T. reticulata* gene V has two alleles, \( V_v \) and \( V_m \), with incomplete dominance. In one of his tanks, Battaglia counted 1751 copepods: 353 \( V_vV_v \), 1069 \( V_vV_m \), and 329 \( V_mV_m \).

Is the population in Hardy Weinberg equilibrium? If not, what is the most likely explanation?

For \( p = 0.507 \) and \( q = 0.493 \) the expecteds were 450 \( V_vV_v \) : 875 \( V_vV_m \) : 426 \( V_mV_m \)

The \( \chi^2 \) value of 86 which with 1 df is highly significant, so no the population is not in HW equilibrium. The much higher than expected number of heterozygotes suggests a strong heterozygote advantage.

9. In an often-studied species of fish, those from northern waters all were homozygous for \( LDH-2 \) allele A and those from the south were homozygous for \( LDH-2 \) allele B. In a controlled environment (30° C), tests showed that 57% of the eggs from southern fish hatched, 22% from northern females hatched but 87% from heterozygous females hatched.

A) Using standard technique, what are the fitness values for the AA, AB and BB individuals?

Converting the relative fitness by dividing each by 0.87 gives \( W_{AA} = 0.253 \), \( W_{AB} = 1 \) and \( W_{BB} = 0.655 \). The corresponding selection coefficients are 0.747 for the A allele and 0.345 for the B allele.

B) If started and continued as a large population (over 1,000 males and females) under the same environmental conditions, what would be the predicted equilibrium \( LDH-2 \) allele frequencies?

\[
\begin{align*}
    p_{eq} &= \frac{0.345}{(0.345+0.747)} = 0.316 \\
    q_{eq} &= \frac{0.747}{(0.345+0.747)} = 0.684
\end{align*}
\]
10. a) Show that $p^2 + pqF = p^2(1-F) + pF$

\[ p^2 + pqF = p^2 + p(1-p)F = p^2 + pF - p^2F = p^2(1-F) + pF \]

b) If 10% of the pups born in a large mouse population are from brother-sister matings, what fraction of the births the next generation will be homozygous for a recessive allele that is present at the frequency of $2 \times 10^{-3}$? (Ignore any other inbreeding that would be likely to occur)

this is easiest by using the formula as above that the level of homozygosity will be

$\frac{q^2 (1-F) + qF}{1-F}$

(1-F) is the proportion from random mating and qF the gain from inbreeding. F for brother sister matings is 0.25 and it involves 10% of the matings. Thus the answer becomes $4 \times 10^{-6} (0.9) + 0.025 \times 2^{-3}$.

11. Subspecies a-d were found to be homozygous for the following chromosomal arrangements for chromosomes 1 and 2:

a) 1 2 3 4 5 6 7
   A B C D E F

b) 1 4 3 2 5 6 7
   A B C 6 7

c) 1 4 3 2 5 6 7
   A B C D E F

d) 1 4 3 2 5 6 7
   A B C E D F

Assuming that the subspecies represent a series of stepwise changes, list a logical order of progression.

A to C to B to D or vice versa

Now, show how the chromosomes would pair in hybrids made between the first and second, second and third and third and fourth subspecies based on the order you derived. For each step, tell what chromosomal aberration occurred and predict the effects on fertility in males and females.

For A to C show a pericentric inversion; predict 50% loss in both sexes due to XO in loop.

C to B, is a reciprocal translocation, so show the cross configuration with paired genes and predict 50% sterility both sexes due to adjacent segregation.

B to D involves a paracentric inversion so show the loop inside a loop for one arm with all genes paired. Predict 50% sterility in males but not in females since any XO inside the inversion will lead lead to bridge formation and deletions and duplications that will end up in polar bodies.

12. a) The narrow sense heritability for potato weight in a starting population of potatoes is 0.42, and the mean weight is 1.4 lb. If a breeder crosses two plants that produce potatoes with average weights of 1.9 and 2.1 lb, respectively, what is the predicted average weight of potatoes in the offspring?

\[ 0.42 = \frac{R}{S} = \frac{(X-1.4)}{(2-1.4)}; \] solving for X gives a value of 1.652 pounds.
b) Assume the two plants used as parents are truebreeding and have a variance of 0.4 and 0.5 while it is 0.6 for the F1, but the variance is 1.2 in the F2 generation. What is the value for heritability in this case and why is it different?

\[ V_p = 1.2 \text{ (from the F2)} = V_e (0.5 \text{ from the average of the populations of the 2 parents and the F1 in which all plants have the same genotype) } + V_g, \text{ so } V_g = 0.7 \]

Then \( H^2 = \frac{0.7}{1.2} = 0.583 \). It is different because this estimate includes all types of genetic variability, not just the additive effects.

13. Both the AC in maize and P-element transposons in Drosophila ‘settle down’ to lower rates of transposing after a few generations than when first introduced. What keeps them in check?

\( \text{Ac is normally only expressed in rapidly dividing somatic cells and then at the time that the new strand remains unmethylated. Plants have a mechanism for silencing duplicate copies of genes introduced into the genome that involves DNA methylation, but mutations in the Ac or Ds terminal repeats make copies that can bind the TSase but can’t transpose while mutations also accumulate in the TSase gene or promoter region of Ac elements.} \)

In the case of the P element, it is normally only expressed in meiotic cells. Alternate splicing in the nurse cells of P containing flies leads to lots of one tailed P elements that can’t make transposes that but are bound by any active transposase present, effectively titrating out any chance for insertion at a new site in the genome.

14. List properties of \( C. \) elegans that make it useful for studying developmental genetics.

- 3 day life cycle
- selfing and crosses possible
- only around 1,000 cells/animal
- small genome for which sequence has been determined
- Temperature sensitive mutants available for many genes
- RNAi can be used at various stages to cut expression of specific genes
- Laser ablation of specific cells
- Predicted cell fates are all known
- Transposon tagged genes are available.

& Maybe more