Set II

Single Answered

1. An example of multiple alleles is seen at a locus that determines the feather pattern of mallard ducks. One allele **M** produces the wild-type mallard pattern. A second allele $\mathbf{M^R}$ produces a different pattern called restricted, and a third allele, $\mathbf{m^d}$, produces a pattern termed dusky. In this allelic series, the dominance pattern is $\mathbf{M^R} > \mathbf{M} > \mathbf{m^d}$. In a cross between restricted and mallard ducks it was found that only dusky ducks were absent in the F1 generation. This indicates that the genotypes of the parents most likely could be

   (A) $(M^RM \times Mm^d)$ and $(M^Rm^d \times Mm^d)$

   (B) $(M^RM^R \times MM)$ and $(M^Rm^d \times Mm^d)$

   (C) $(M^RM \times Mm^d)$ and $(M^Rm^d \times MM)$

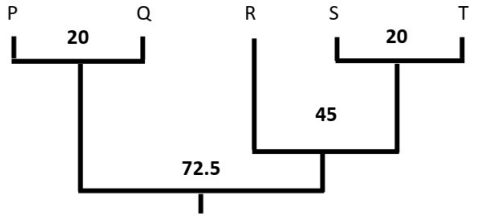
   (D) $(M^RM^R \times MM)$ only

2. UPGMA is a method of constructing phylogenetic trees using distance matrices between organisms. The following matrix depicts distance (measured as the difference in characters) between five organisms. The distance between a pair of organisms (say, **P** and **Q**) and a third organism (**R**) is calculated as an average of their individual distances from the third organism (example: New average distance between **PQ** and **R** is **R** to **PQ** = (60 + 50) / 2 = 55).

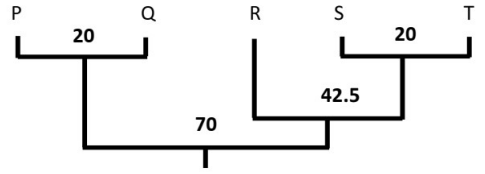
	P	**Q**	**R**	**S**	**T**
P	0				
Q	20	0			
R	60	50	0		
S	100	90	40	0	
T	90	80	50	20	0

Based on the distance matrix, the correct phylogenetic tree is

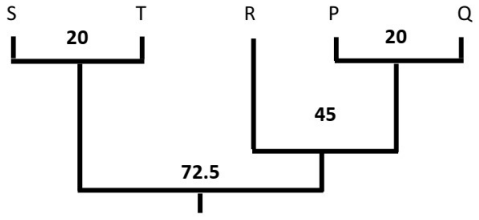
(A)



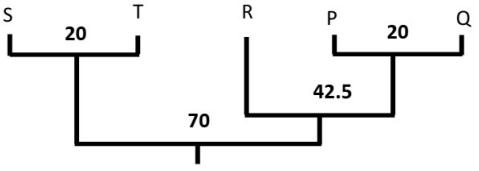
(B)



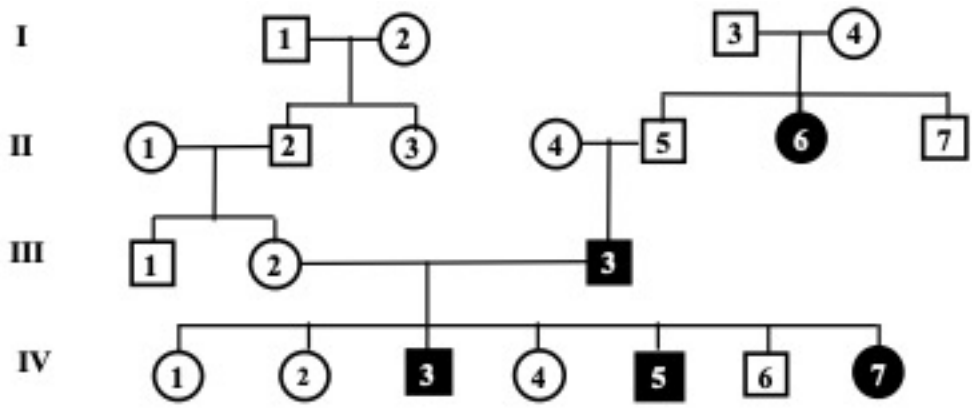
(C)



(D)



3. In the given pedigree, circles represent females and squares represent males. Filled shapes indicate affected individuals while unfilled shapes indicate unaffected individuals. Based on the pedigree information provided below, identify the inheritance pattern.



(A) Autosomal dominant

(B) Autosomal recessive

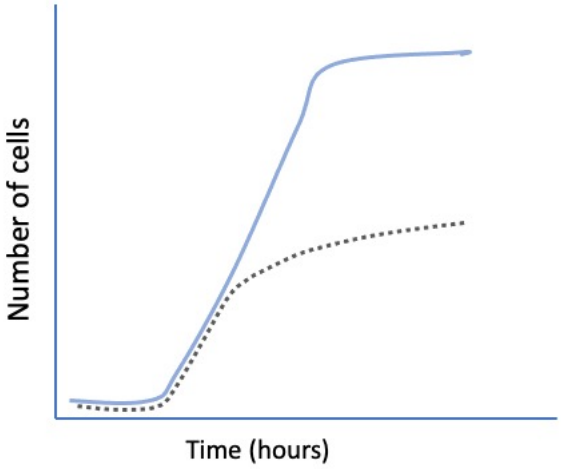
(C) X-linked dominant

(D) X-linked recessive

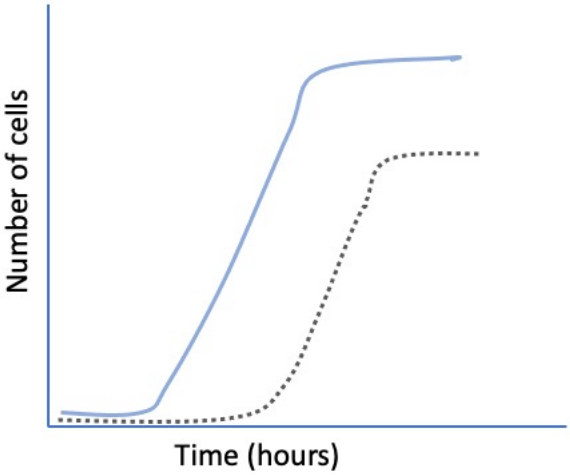
4. In an experiment with a facultative aerobic bacterial species, identical number of cells were inoculated in two 500 ml jars (**M** and **N**) with 250 ml volume of media in each. Both the jars contained the same concentration of glucose as the only energy source. Jar **M** was incubated in airtight conditions while **N** was maintained in aerobic conditions. Both the jars were kept in a sterile chamber and all other conditions of incubation were kept the same. The correct plot that depicts the growth patterns of these bacterial cultures in **M** (grey dotted line) and **N** (blue solid line) is

(A)

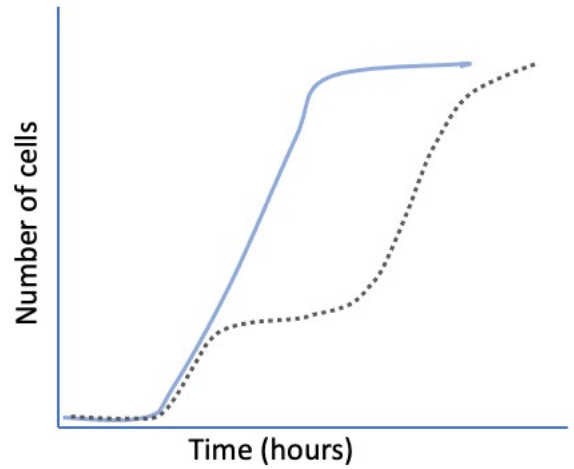
(B)

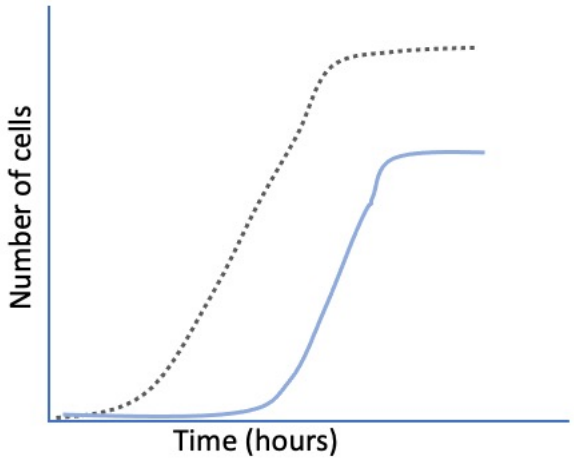


(C)

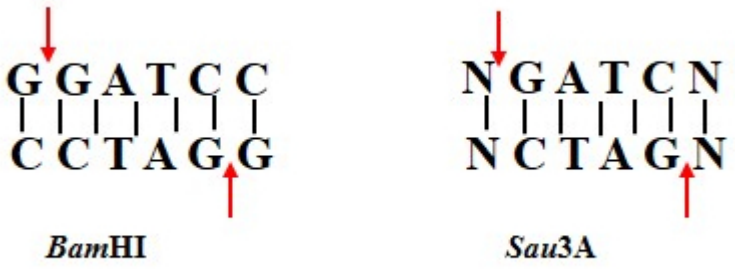


(D)





5. Restriction enzymes recognize certain sequences within the DNA and cleave them. If a DNA fragment is cleaved with *Bam*HI restriction enzyme, it generates sticky ends. If the same DNA fragment is cleaved with *Sau*3A restriction enzyme, it generates sticky ends. The cleaved fragments can be joined using DNA ligase. The recognition and cleavage site (red arrows) for *Bam*HI and *Sau*3A are given below. N represents any of the nucleotides.



Based on this information and assuming there is only a single cleavage site, choose the correct option.

(A) If a *Sau*3A cleaved end is ligated to a *Bam*HI cleaved end, the ligated fragment can be further digested using *Sau*3A irrespective of the neighbouring sequence.

(B) If a *Bam*HI cleaved end is ligated to a *Sau*3A cleaved end, the ligated fragment can be further digested using *Bam*HI irrespective of the neighbouring sequence.

(C) If both the recognition sequences are reverse complemented then it cannot be cleaved using either *Bam*HI or *Sau*3A.

(D) If a *Bam*HI cleaved end is ligated to a *Sau*3A cleaved end and reverse complemented then the ligated fragment can be digested using *Bam*HI irrespective of the neighbouring sequence.

6. A mutant bacterial strain having a shorter glycolytic pathway was discovered. If the mutant bacteria are grown aerobically, the net ATP yield was lowered to 28 (compared to the net ATP yield of 34 from Kreb's cycle for wild type bacteria). Except for the reaction that is bypassed in the mutant, assume that the other reactions of the pathway remain unaffected. The step that is most likely bypassed is

(A) phosphoenolpyruvate to pyruvate.

(B) glyceraldehyde-3-phosphate to 1,3-bisphosphoglycerate.

(C) fructose 6-phosphate to Fructose 1,6-bisphosphate.

(D) 1,3-bisphosphoglycerate to 3-phosphoglycerate.

7. The table below presents the kinetic data obtained for an enzyme in the absence and presence of two different inhibitors **P** and **Q**, each at a concentration of 10.0 mM.

Substrate (1/S) $(mM)^{-1}$	Without Inhibitor $(1/V_0)$ $(\mu mol/mL.s)^{-1}$	With Inhibitor **P** $(1/V_0)$ $(\mu mol/mL.s)^{-1}$	With Inhibitor **Q** $(1/V_0)$ $(\mu mol/mL.s)^{-1}$
1.000	0.28	0.31	0.39
0.500	0.16	0.19	0.22
0.250	0.10	0.13	0.14
0.125	0.07	0.09	0.09
0.083	0.06	0.08	0.08

Consider that the total enzyme concentration $[E]_T$ is the same for all the experimental conditions. **P** and **Q** respectively, are

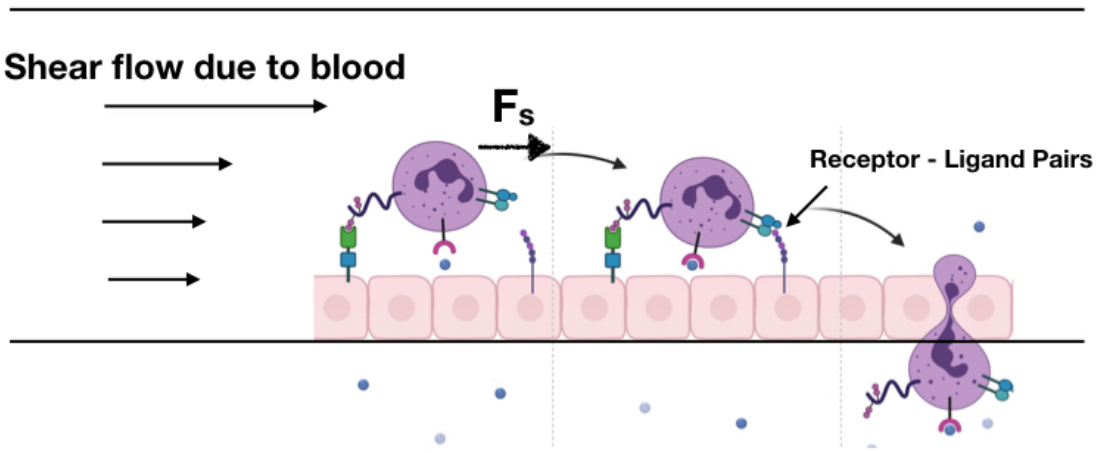
(A) competitive and non-competitive inhibitors.

(B) uncompetitive and competitive inhibitors.

(C) uncompetitive and non-competitive inhibitors.

(D) competitive and uncompetitive inhibitors.

8. Tissue damage alters the surface-adhesive behaviour of leukocytes resulting in leukocyte rolling. This involves several cycles of attachment and detachment of leukocytes on the surface of endothelial cells. Given that the typical rupture force for a ligand–receptor pair is 25 pN, multiple bonds must be formed at the same time to provide the necessary counterbalance to the shear force exerted by the flowing blood. The general schematic is depicted below.



Consider the effective cross-sectional area of the cell that experiences the shear and the following parameters.

Leukocyte radius (approximated to be a sphere)	5 μm
Rolling velocity	10 μm/s
Shear Stress due to blood flow	1 N/m^2

Among the given options, the minimum number of ligand-receptor pairs (bonds) that need to form at the same time to provide the counterforce against the shear force to stop the leukocyte rolling is

(A) 15 ligand-receptor pair

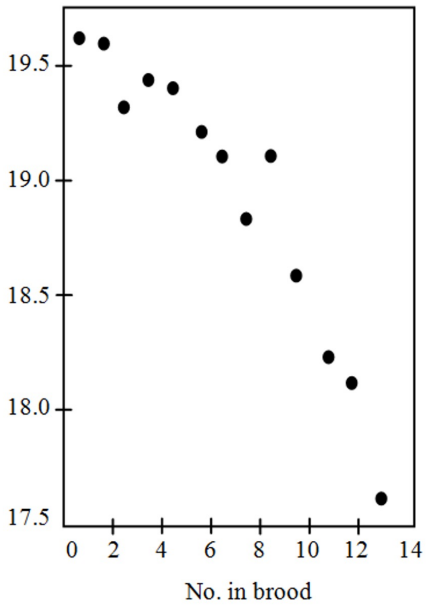
(B) 10 ligand-receptor pair

(C) 2 ligand-receptor pair

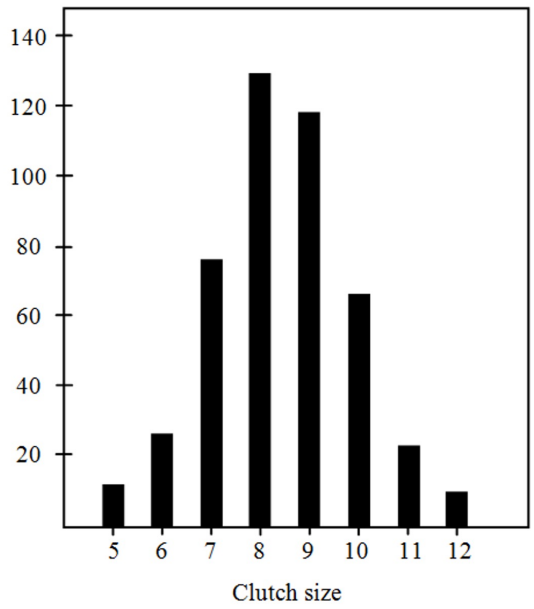
(D) 5 ligand-receptor pair

9. Clutch size in birds refers to the number of eggs laid in a single nesting attempt by a nesting pair of birds while number in brood refers to the number of young hatched. The graphs below represent the relationship between these parameters (clutch size and number in brood) and fitness in bird populations of the Great tit.

Graph I



Graph II



The Y-axes for graphs **I** and **II** could respectively be

(A) Average nest dimension; Average weight of young

(B) Average number of clutches; Average adult survival

(C) Average adult survival; Average nest dimension

(D) Average weight of young; Average number of clutches

10. A population has three genotypes, **XX**, **XY** and **YY**, where **X** is dominant over the **Y** allele. The number of each genotype in the population is as follows, **XX** = 1185, **XY** = 3045 and **YY** = 1300 individuals. Consider that there is random mating, no gene flow, no mutation and selection, and the population size is sufficiently large. The correct statement is

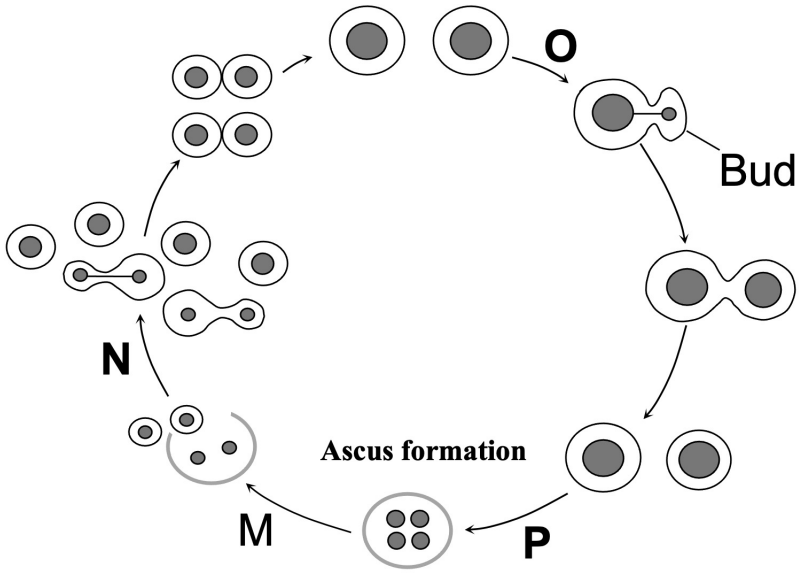
    (A) The population is in Hardy-Weinberg equilibrium and will remain the same if random mating is allowed for one generation.

    (B) The population is not in Hardy-Weinberg equilibrium but will come to equilibrium if random mating is allowed for one generation.

    (C) The population is in Hardy-Weinberg equilibrium and will deviate from equilibrium if selection is acting against any one genotype.

    (D) The population is not in Hardy-Weinberg equilibrium and will come to equilibrium if selection is acting against the dominant genotype.

11. The life cycle of yeast *Saccharomyces cerevisiae* which reproduces both sexually as well as asexually is depicted below.



M, **N**, **O** and **P** represent

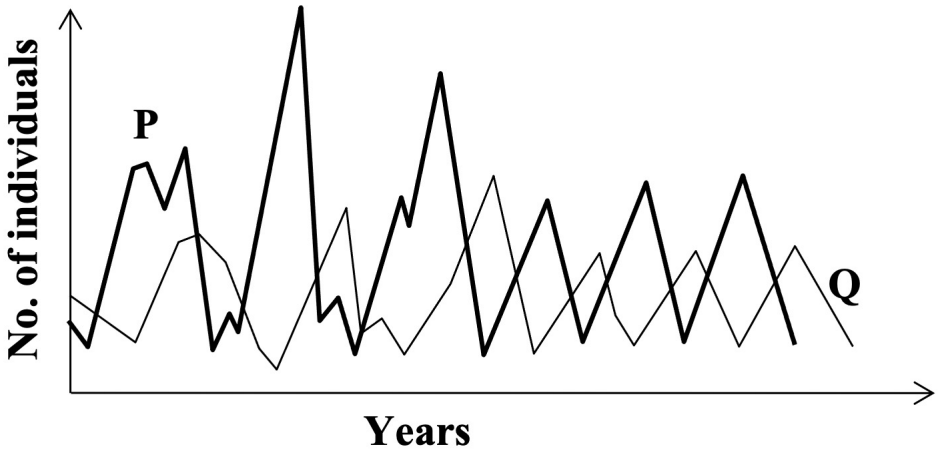
(A) **M** - Germination; **N** - Vegetative growth of haploid cells; **O** - Vegetative growth of diploid cells; **P** - Starvation

(B) **M** - Vegetative growth of haploid cells; **N** - Starvation; **O** - Germination; **P** - Vegetative growth of diploid cells

(C) **M** - Germination; **N** - Vegetative growth of diploid cells; **O** - Vegetative growth of haploid cells; **P** - Starvation

(D) **M** - Vegetative growth of diploid cells; **N** - Starvation; **O** - Germination; **P** - Vegetative growth of haploid cells

12. The population sizes of two organisms **P** and **Q** growing in a given habitat is shown.



If **P** and **Q** share ecological relationship, then they most likely represent

(A) **P**: Predator; **Q**: Prey

(B) **P**: Parasite; **Q**: Host

(C) **P**: Herbivore; **Q**: Carnivore

(D) **P**: Competitor of **Q**; **Q**: Competitor of **P**

Multiple Answered

13. Female beetles are known to prefer males with bigger mandibles. In an experiment, a population of these beetles were picked and divided into two groups. For one group, only those males who had larger than average mandible size were allowed to mate to produce next-generation offspring (group 1). For the other group, the males and females were allowed to mate randomly (group 2). These populations were maintained using this regime for 50 generations. After this, it was found that the male mandible size in group 1 was significantly larger than that of group 2. However, the females in group 1 produced fewer offspring than females in group 2. Possible explanation(s) of this observation is(are)

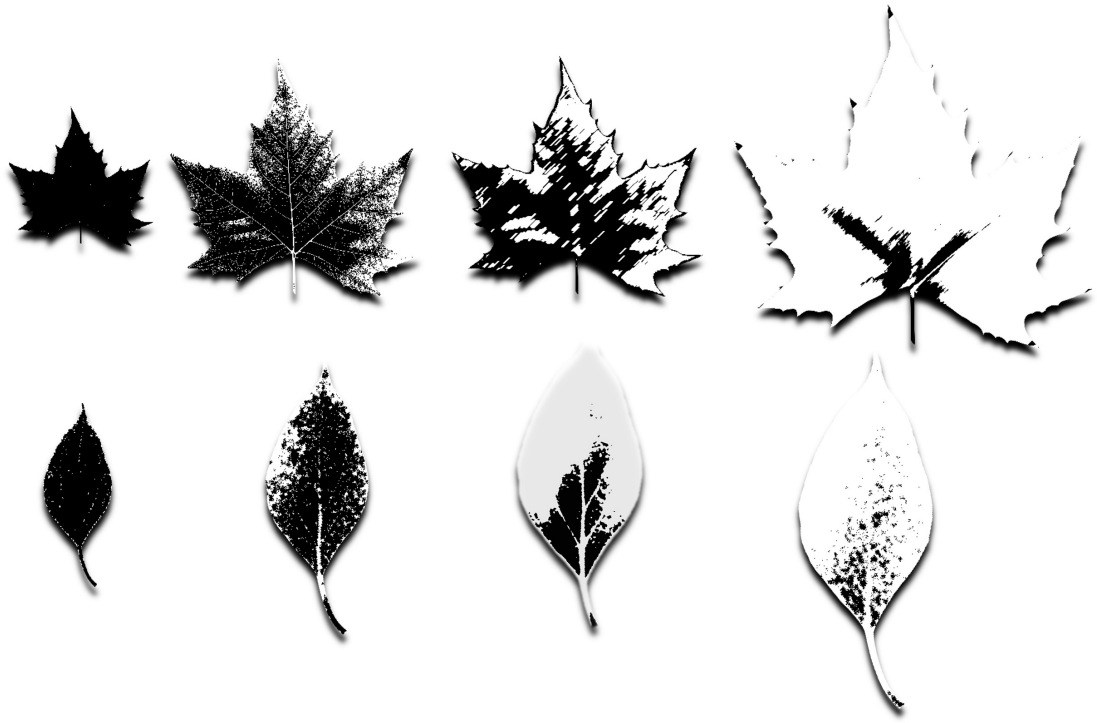
    (A) In the experiment, as selection on female reproduction was not imposed in group 1, female reproductive capability declined over time.

    (B) Group 1 males produced offspring with larger thorax (to support larger mandible) and hence smaller abdomen, which influenced the egg-carrying capacity in female offspring leading to a decline in female reproductive ability.

    (C) Under unlimited food condition, males with larger mandibles in group 1, preferred females with lesser reproductive ability as that allowed dominant individual males to have more resources for themselves.

    (D) Under limited food condition, females producing fitter offspring after mating with males with larger mandibles started producing fewer offspring to nourish them better.

14. Autoradiography of a green leaf of summer squash (upper panel) showed import of ^{14}C carbon from the source over a period of time. A similar experiment was carried out with an albino tobacco leaf (lower panel) which do not photosynthesize. Shaded portions denote ^{14}C labelling.



Based on these observations the correct option(s) is(are)

(A) In the early stages of development, the leaf acts as a source.

(B) Mature leaf gains the ability to load and export sugar.

(C) The import to export transition is dependent on the developmental stage of leaves irrespective of photosynthesis.

(D) Import cessation and export initiation are two separate events.

15. In a true-breeding homozygous lines of snapdragon, *Antirrhinium majus*, white coloured flower of personate shape was crossed with red coloured flower with peloric shape. The F1 flowers were pink and personate-shaped. Assuming that both these genes segregate independently, choose the correct option(s).

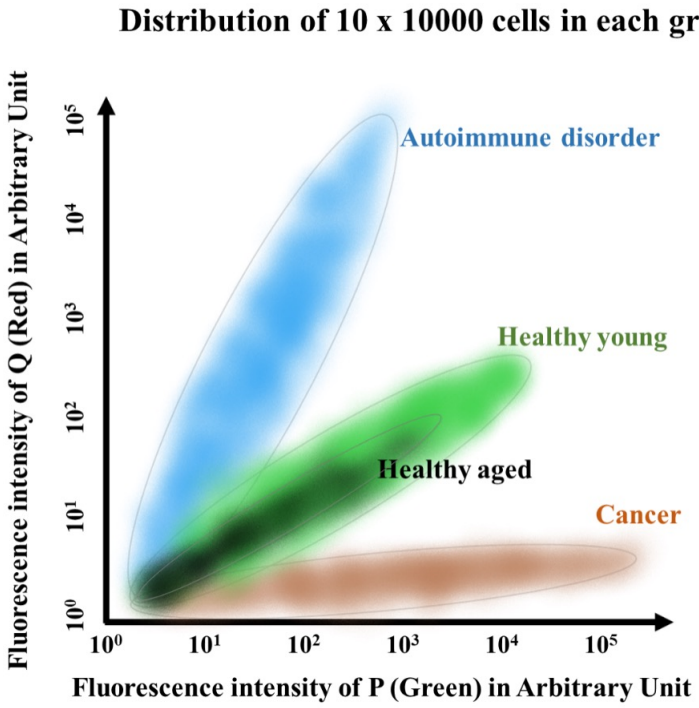
(A) F2 progeny will have $\frac{1}{4}$ probability of showing the parental phenotype.

(B) 50% of the progeny in the F2 generation will be pink in colour.

(C) In F2 progeny, peloric-shaped flowers with pink colour are expected to be in $\frac{1}{8}$ ratio.

(D) In F2 progeny, the ratio of red-coloured personate-shaped flowers would be $\frac{1}{4}$.

16. Specific fluorescence probes are used to label proteins present on the surface of specific immune cell type. A scientist labelled protein **P** with a green probe and protein **Q** with a red probe. A machine can provide quantitative information about the amount of these two proteins present on the surface of each cell by quantifying 10000 cells. This experiment is repeated for cells present in blood of multiple individuals who are healthy young, healthy aged, with cancer, and with auto-immune disorder. The data of 10 individuals per group is provided below.



If there are no other confounding factors, then based on this data, the correct inference(s) is(are)

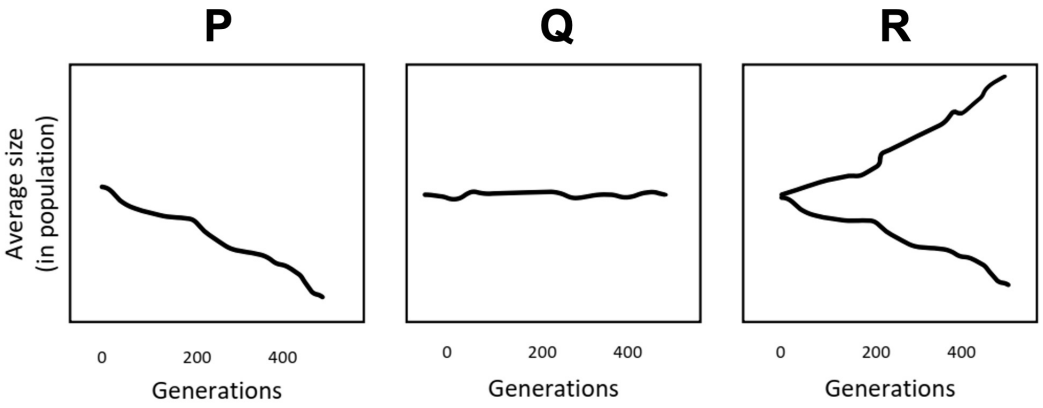
(A) In healthy aged individuals, the expression of **P** reduces drastically as compared to **Q**.

(B) Reduction of **Q** protein can be correlated with the development of cancer.

(C) Increased expression of **Q** protein can be correlated with the autoimmune disorder.

(D) In comparison to healthy individuals, the expression of **Q** in autoimmune condition is negatively regulated by expression of **P**.

17. The following graphs depict three different scenarios where the average body size of a population (assuming a normal distribution with a single mean) of a study organism has been plotted over several generations. If body size is heritable and there is no genetic drift present in the population, the correct option(s) that can give rise to the observed patterns would be



(A) **P** - Directional selection, **Q** - Stabilizing selection

(B) **Q** - No selection, **R** - Disruptive selection

(C) **P** - No selection, **R** - Disruptive selection

(D) **P** - No selection, **Q** - Directional selection