**(1) For each of the following characteristics, indicate whether it is a categorical or quantitative characteristic:**

a) Kernel color in a strain of wheat in which 2 codominant alleles are segregating at a single color locus. There are 3 phenotypes , white, light and medium red.

b) Body weight in a family of Labrador retrievers where an autosomal recessive allele that causes dwarfism is present. Two phenotypes are seen: dwarf (<13 kg); and normal (>13kg).

c) The number of toes in guinea pigs, which is influenced by genes at many loci.

d) The number of fingers in humans where polydactyly (>5) is governed by the presence of an autosomal dominant allele.

***Answer:***

***a)*** *categorical 3 phenotype classes, codominant allele interactions.*

***b)*** *categorical two phenotype classes, no intermediates, even though many genes contribute to body weight and environmental effects are possible, a mutation with large effect (dwarfism) has created 2 categories: dwarf and wild type.*

***c)*** *quantitative: many genes thus polygenic, or quantitative character.*

***d)*** *categorical: many genes must contribute to hand development , in the same way as guinea pig toes, but a gene of large effect causes extra fingers, compared to wild type.*

**(2) The following are related to a normal distribution:**

a) what term applies to the value along the x axis that corresponds to the peak of the distribution and summarizes the character state of a population or sample.

b) If two normal distributions have the same mean but different variances, which is broader - *extends further to the right or left*?

c) What proportion of the population is expected to lie within one standard deviation of the mean ?

d) What proportion is expected to lie within two standard deviations of the mean?

***Answer:***

***a)*** *mean or average;* ***b)*** *distribution with larger variances;* ***c)*** *68 %* ***d)*** *95%*

**(3) The mean adult weight in a flock of 100 broiler chickens is 700g and the standard deviation is 100 g. Assuming adult chicken weight is normally distributed:**

a) How many chickens are expected to weigh more than 700g ?

b) How many chickens are expected to weigh more than 900g ?

c) If $H^2$ is 1.0 what is the genetic variance for this population ?

**Answer**

a) assymmetrical distribution 50% above, 50% below - 50

b) 2 sd. > 700= 900 gm , 95% (5 chickens in both tails) greater half = 2.5

c) $H^2 = 1.0$, all genetic variance : sd = 100 variance = $100^2$

**(4) What are differences between quantitative and Mendelian traits, in terms of (a) causes of variation (b) nature of phenotypic variation and (c) analysis of variation ?**

***Answer***
***a) Causes:*** *Mendelian- few genes of large effect, no environmental effects, no intermediates, few alleles, full dominance although codominance and other modifications of classical ratioscan be explained.*
*Quantitative: many genes of small effect, environmental effects, many alleles, codominance or additive effects, dominance effect is a variance component.*

***b)Nature of variation:*** *quantitative : many genes of small effect, many alleles, environment causes , whereas Mendelian requires few genes of large effect, few alleles, no environmental effects.*
***c) Analysis:*** *Mendelian analysis identifies the segregation of a few alleles, few genes, quantitative partitions inherited causes of variance and environmental effects.*

**(5)** When we compare a quantitative trait in the $F_1$ and $F_2$ generations obtained by crossing two inbred strains (parentals): (a) which generation (Parentals, $F_1$,$F_2$) supply an estimate of the environmental variance; (b) what determines the variance of the other generation(s)? (c) in which generation do you get the best estimate of phenotypic variance?
(a) *best* $V_E$ estimate average from Parentals (*2 inbred* ) + $F_1$(*outbred but 1 genotype*)
(b) $F_2 = V_G + V_E$
(c) $V_P = F_2$

(6) What does a narrow-sense heritability of 1.0 mean ? Does a heritability of 0.0 mean that genes do not code for and express the trait ? What does a heritability of 0 indicate ? What does a heritability of 0.5 mean ?
*Answer*
*$h^2$ = 1.0= all phenotypic variation is due to additive allele segregation and gene assortment in the population.*
*$h^2$= 0 = all phenotypic variation is due to environmental effects or there are no genes for the character segregating in the population.*
*$h^2$ = 0.5 = an equal mix of environmental and genetic effects regulates phenotyic variation.*

**(7) Two inbred strains of mice are crossed and the $F_1$ generation has a mean tail length of 5 cm and a standard deviation of 1.5cm. The $F_2$ generation has a mean tail length of 5cm and a deviation of 4cm . What are the environmental variance, the genetic variance and the broad sense heritability ($H^2$)?**

*$V_E$ = ( 1.5 cm)$^2$ =2.25 Variance = standard deviation$^2$*
*$V_P$ = ( 4 cm)$^2$ = 16*
*$V_G$= $V_P$ -$V_E$ = 13.75*
*$H^2$ = $V_G$/ $V_P$= 13.75 / 16 = 0.86*

(8) **A selection experiment was carried out to estimate the heritability of maze learning ability. From a population in which the average number of trials necessary to learn the maze was 10.8, with a variance of 4.0, animals that learned the maze in an average of 5.8 trials were selected to breed. Their offspring required an average of 6.8 trials to learn the maze. What was the estimated narrow-sense heritability of maze learning ability in this population ?**

*Answer*
*S = 10.8 - 5.8 = 5.0*
*R =10.8 - 6.8 = 4.0*
$h^2 = R / S = 0.8$

(9**) Phenotypic variation in mouse tail length has the following components:**
Additive genetic variance ($V_A$) = 0.5
Dominance variance ($V_D$) =0.2
GE interaction variance ($V_{GE}$) =0.1
Environmental variance ($V_E$) = 0.2
(a) What is the broad sense heritability ($H^2$) ?
(b) What is the narrow sense heritability ($h^2$)?
*Answer*
***a)*** $H^2 = (0.5+0.2+0.1) / 1.0 = 0.8$
***b)*** $h^2 = 0.5 / 1.0 = 0.5$

(**10) The narrow sense heritability of Drosophila head width is 0.8. The narrow sense heritability of wing length is 0.7. The genetic correlation between wing length and head width is -0.86.**
(a) If a geneticist selects on head width, what does he expect will happen to wing length ?
(b) If the genetic correlation was + 0.9, what would he expect ?
**(*a)*** *If he selects for larger head width, wing length should decrease, if he selects for smaller head width, wing length should increase.*
***(b)*** *If she selects for larger head width, wing length should get proportionally larger, if selection is for smaller head width, wings should get smaller.*

(11) Assume you could isolate plant or animal clones, inbred strains or families that could be randomly divided into two equal-sized groups, and you could get them to breed in two important sub-environments in the population range (e.g. dry and wet). What evidence would indicate that (1) genotype variation governed phenotype variation (2) environmental variation determined phenotype variation or (c) genotype by environment interactions were an important component of phenotypic variation ?

***1) see Lecture 10, slide 21 #1****: note that there are differences in the size of the genotypes (genetic variation) but no differences in the average in the 2 environments.*
***2) see Lecture 10, slide 21 #2*** *: note there is no difference in genotype size in either environment, but there is a difference in environmental means in each environment.*
***3) see Lecture 10, slide 21 #4*** *Note there are differences in genotype sizes in each environment, there may also be differences in the environmental averages, regardless,*

*there is a non linear (non-additive) differences in the interaction of genotype and environment (in other words, the genotype 'norm of reaction' lines cross between environments.*

(11) List 3 different ways of estimating $H^2$ and 2 ways of estimating $h^2$
$H^2$ (1) variance components $V_P$, $V_G$, $V_E$, Correlation between relatives
H2 (1) variance components, (2) midparent regression on offspring average (3) selection