1. How did Mendel know that each of his pea plants carried two alleles encoding a characteristic ? (5 points)

2. By crossing two varieties of peas that differed in height, Mendel established that tall (*T*) was dominant over short (*t*). If a tall plant with the heterozygous genotype crosses with another tall plant with the homozygous genotype, what proportion of the progeny will be short ? (Please use a Punnett square)(5 points)

1. The following two genotypes are crossed: *Aa Bb Cc dd Ee* x *Aa bb Cc Dd Ee*. What will the proportion of the following genotypes be among the progeny of this cross?

    a. *Aa Bb Cc Dd Ee* (1 point)

    b. *Aa bb Cc dd ee* (1 point)

    c. *aa bb cc dd ee* (1 point)

    d. *AA Bb CC Dd EE* (1 point)

2. Pink-eye and albino are two recessive traits found in the deer mouse *Peromyscus maniculatus*. In mice with pink-eye, the eye is devoid of color and appears pink from the blood vessels within it. Albino mice are completely lacking color both in their fur and eyes. F. H. Clark cross pink-eyed mice with albino mice; the resulting F_1 had normal coloration in their fur and eyes. He then crossed these F_1 mice with mice that were pink eyed and albino and obtained the following mice. It is very hard to distinguish between mice that are albino and mice that are both pink-eyed and albino, so he combined these two phenotypes together.

Phenotype	Number of progeny
wild-type fur, wild-type eye color	12
wild-type fur, pink eye	62
albino	78
albino, pink-eye	
Total	152

    a. Give the expected numbers of progeny with each phenotype if the genes for pink-eye and albino assort independently. (3 points)
    b. Use a Chi-square test to determine if the observed numbers of progeny fit the number expected with independent assortment. (3 points)

Critical values of the χ^2 distribution				
df	1	2	3	4
P=0.05	3.841	5.991	7.815	9.488
P=0.01	6.635	9.210	11.345	13.277

1. Please find and correct the wrong statement(s): (2 points)

   a. Sister chromatids may carry different alleles at a locus.

   b. Homologous chromosomes segregate independently into gametes in mitosis.

   c. Gametes are diploid cells.

   d. Separation of sister chromatids takes place in meiosis II.

2. J.A. Moore investigated the inheritance of spotting patterns in leopard frogs. The pipiens phenotype had the normal spots that give leopard frogs their name. In contrast, the burnsi phenotype lacked spots on its back. Moore carried out the following crosses, producing the progeny indicated. (2 points)

Parent Phenotypes	Progeny Phenotypes
Burnsi X Burnsi	39 burnsi, 6 pipiens
Burnsi X Pipiens	196 burnsi, 210 pipiens

   a. Give the most likely genotypes of the parent in each cross.

   b. Use a Chi-square test to evaluate the fit of the observed number expected on the basis of your proposed genotypes. $(\chi^2_{1, 0.05} = 3.84)$

3. Miniature wings (X^m) in *Drosophila* result from an X-linked allele that is recessive to the allele for long wings (X^{m+}). Give the genotypes of the parents in the following cases. (4 points)

	Male parent	Female parent	Male offspring	Female offspring
a.	long	long	231 long, 250 miniature	560 long
b.	miniature	long	610 long	632 long
c.	miniature	long	410 long, 417 miniature	412 long, 415 minature
d.	long	miniature	753 minature	761 long

4. Dwarfism is a recessive trait in Hereford cattle. A rancher in western Texas discovers that several of calves in his herd are dwarfs, and he wants to eliminate this undesirable trait from the herd as rapidly as possible. Supposed that the rancher hires you as a genetic consultant to advise him on how to breed the dwarfism trait out of the herd. What crosses would you advise the rancher to conduct to ensure that the allele causing dwarfism is eliminated from the herd? (2 points)

1. In *Antirrhinum* plants, two pure-breeding, white-flowered lines are intercrossed, and all F1 progenies are white flowered plants. By self-pollinating an F1 progeny, 131 F2 progenies are white-flowered plants, while 29 F2 progenies are red-flowered plants.
   A) Deduce the genotypes of these phenotypes (including two parental lines, F1 and F2 progenies), using clearly defined gene symbols. (3 points)
   B) Predict the outcome of crosses of the F1 to each parental line. (3 points)

Critical values of the χ^2 distribution				
df	1	2	3	4
P=0.05	3.841	5.991	7.815	9.488

2. Assume that long ear lobes in humans are an autosomal dominant trait that exhibits 30% penetrance. A person who is heterozygous for long ear lobes mates with a person who is homozygous for normal ear lobes. What is the probability that their first child will have long ear lobes? (2 points)

3. In some goats, the presence of horns is produced by an autosomal gene that is dominant in males and recessive in females. A horned female is crossed with hornless male. The F_1 offspring are intercrossed to produce the F_2. What proportion of the F_2 female will have horns? (2 points)

1. The trait represented in the following pedigree is expressed only in the males of the family. Is the trait Y linked? Why or why not? If you believe the trait is not Y linked, propose an alternative explanation for its inheritance.
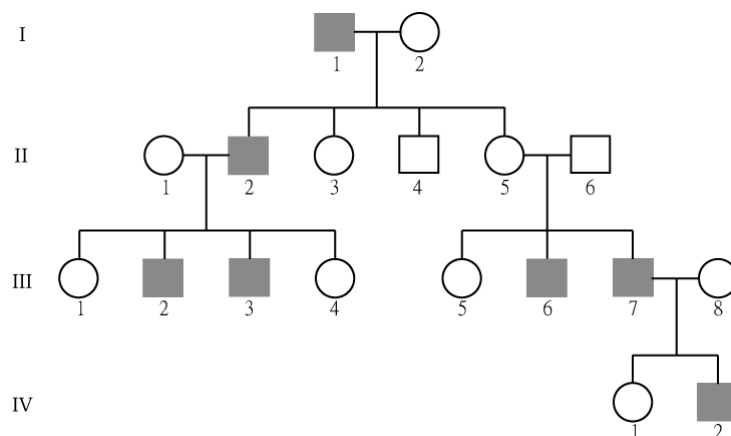
1. In the squirting cucumber *Echballium elaterium*, there are two separate sexes (it is dioecious [雌雄異株]), determined not by heteromorphic sex chromosomes, but by specific genes. It is known that the genes involved are *M* (male fertility), *m* (male sterility), *F* (female sterility), and *f* (female fertility). [註: fertility 具生殖能力；sterility 不具生殖能力.] In populations of this plant, individuals can be male (approximately 50 percent) or female (approximately 50 percent). In addition, a hermaphrodite type is found, but only at a very low frequency. The hermaphrodite has male and female sex organs on the same plant.

   a. What must be the full genotypes of a male plant and a female plant ? (2 points)

   b. How does the population maintain an approximately equal proportion of males and females? (1 points)

   c. What is the origin of the rare hermaphrodite? (2 points)

2. Fine spines (*s*), smooth fruit (*tu*) and uniform fruit color (*u*) are three recessive traits in cucumbers, the genes of which are linked on the same chromosome. A cucumber plant heterozygous for all three traits is used in a testcross, and the progeny (table on the right side) are produced from this testcross:

   a. Determine the order of these genes on the chromosome. (1 point)

   b. Calculate the map distances between the genes. (2 point)

   c. Determine the coefficient of coincidence and the interference among these genes. (1 point)

   d. Please write the parental genotypes in the testcross. Coupling or repulsion of alleles from all three genes needs to be indicated. (1 point)

S	U	Tu	2
s	*u*	*Tu*	70
S	*u*	*Tu*	21
s	*u*	*tu*	4
S	*U*	*tu*	82
s	*U*	*tu*	21
s	*U*	*Tu*	13
S	*u*	*tu*	17
Total			230

1. A geneticist isolates two new mutants, called rII_x and rII_y from the rII region of bacteriophage T4. *E. coli* B cells are simultaneously infected with phages carrying the rII_x mutation and with phages carrying the rII_y mutation. After the cells have lysed, samples of the phage lysate are collected. One sample is grown on *E. coli* K cells and a second sample on *E. coli* B cells. There are 8322 plaques on *E. coli* B and three plaques on *E. coli* K. What is the consequence you would expect if *E. coli* K cells are simultaneously infected with phages carrying the rII_x mutation and with phages carrying the rII_y mutation? (4 points)

2. DNA from a bacterial strain that is his^+ leu^+ lac^+ is used to transform a strain that is his^- leu^- lac^-. The following percentages of cells were transformed:

   a. What conclusion can you make about the order of these three genes on the chromosome? (3 points)
   b. Which two genes are closest? (3 points)

Genotypes of transformed cells	Percentage
his^+ leu^+ lac^+	0.02
his^+ leu^+ lac^-	0.00
his^+ leu^- lac^+	2.00
his^+ leu^- lac^-	4.00
his^- leu^+ lac^+	0.10
his^- leu^- lac^+	3.00
his^- leu^+ lac^-	1.50

A *Drosophila* mutation called *singed* (*s*) causes the bristles to be bent and misshapen. A mutation called *purple* (*p*) is another recessive mutation that causes the fly's eyes to be purple in color instead of the normal red. In the P generation, flies homozygous for singed and purple were crossed with flies that were homozygous for normal bristles and red eyes. The F1 were intercrossed to produce the F2, and the following results were obtained.

Cross 1

P : male, singed bristles, purple eyes x female, normal bristles, red eyes

F_1: 420 female, normal bristles, red eyes

　　426 male, normal bristles, red eyes

F_2: 337 female, normal bristles, red eyes

　　113 female, normal bristles, purple eyes

　　168 male, normal bristles, red eyes

　　170 male, singed bristles, red eyes

　　56 male, normal bristles, purple eyes

　　58 male, singed bristles, purple eyes

Cross 2

P : female, singed bristles, purple eyes x male, normal bristles, red eyes

F_1: 504 female, normal bristles, red eyes

　　498 male, singed bristles, red eyes

F_2: 227 female, normal bristles, red eyes

　　223 female, singed bristles, red eyes

　　225 male, normal bristles, red eyes

　　225 male, singed bristles, red eyes

　　78 female, normal bristles, purple eyes

　　76 female, singed bristles, purple eyes

　　74 male, normal bristles, purple eyes

　　72 male, singed bristles, purple eyes

a.　What are the modes of inheritance of singed and purple? Explain your reasoning.

b.　Give genotypes for the parents and offspring in the P, F_1, and F_2 generations of Cross 1 and Cross 2.

1. Approximately 70 percent of all white North Americans can taste the chemical phenylthiocarbamide, and the reminder cannot. The ability to taste is determined by the dominant allele T, and the inability to taste is determined by the recessive allele t. If the population is assumed to be in Hardy-Weinberg equilibrium, what are the **genotypic and allelic frequencies** for this locus in this population? (4 points)

2. Two inbred lines of beans are intercrossed. In the F_1, the variance in bean weight is measured at 1.5. The F_1 is selfed to produce the F_2 population. In the F_2, the variance in bean weight is 6.1. Estimate the **broad-sense heritability** of bean weight in this experiment. (3 points)

3. In an experimental population of flour beetles, the body length shows a continuous distribution with a mean of 6 mm. A group of males and females with body lengths of 9 mm are selected and interbred. The body lengths of their offspring average 7.2 mm. Please calculate the **realized heritability** for body length in this population. (3 points)

1. Please describe the definition of the haploinsufficient mutant and give an example. (3 points)

2. Please describe the definition of the trisomy mutant and give an example (3 points)

3. What are the same and the difference between a missense mutation and a nonsense mutation? (2 points)

4. Please describe how transposable element results in variegated kernel in maize (2 points)

1. Please write down the definition of the following genetic terms: (10 points)
   (1) Gene
   (2) Allele
   (3) Locus
   (4) Character
   (5) Trait

2. Please choose correct answers: (10 points)
   (1) Which is the correct order of stages in the cell cycle ?
      a. G1, S, prophase, metaphase, anaphase
      b. S, G1, prophase, metaphase, anaphase
      c. Prophase, S, G1, metaphase, anaphase
      d. S, G1, anaphase, prophase, metaphase
   (2) Which of the following events takes place in meiosis II but not in meiosis I ?
      a. Crossing over
      b. Contraction of chromosomes
      c. Separation of homologous chromosomes
      d. Separation of chromatids
   (3) Which structure is diploid ?
      a. Microspore　　b. Egg　　c. Megaspore　　d. Microsporocyte
   (4) A chi-square test comparing observed and expected progeny is carried out, and the probability associated with the calculated chi-square value is 0.72. What does this probability represent?
      a. Probability that the correct results were obtained.
      b. Probability of obtaining the observed numbers.
      c. Probability that the difference between observed and expected number is significant.
      d. Probability that the difference between observed and expected numbers could be due to chance.
   (5) What will be the sexual phenotype of a fruit fly with XXYYY sex chromosomes and two set of chromosomes?
      a. Male.　　b. Female　　c. Intersex　　d. Metamale

3. Please briefly answer questions below: (12 points)
   (1) How do complete dominance, incomplete dominance, and co-dominance differ?
   (2) What is the difference between heterozygous and hemizygous ?
   (3) How might you determine whether a particular trait is due to cytoplasmic inheritance or to genetic maternal effect ?

4. A horse has 64 chromosomes and a donkey has 62 chromosomes. A cross between a female horse and a male donkey produce mule, which is usually sterile. How many chromosomes does a mule have? Can you think of any reasons for the fact that most mules are sterile? (10 points)

5. Joe has a white cat named Sam. When Joe crosses Sam with a black cat, he obtains 1/2 white kittens and 1/2 black kittens. When the black kittens are interbred, all the kittens that they produce are black. On the basis of these results, would you conclude that white or black coat color in cats is a recessive traits? Explain your reasoning. (10 points)

6. Joanna has classic hemophilia, an X-linked recessive disease. Could Joanna have inherited the gene for this disease from following persons? (8 points)

		Yes	No
a.	Her mother's mother		
b.	Her mother's father		
c.	Her father's mother		
d.	Her father's father		

7. If there are five alleles at a locus, how many genotypes may there be at this locus? How many different kinds of homozygotes will there be? How many genotypes and homozygotes would there be with eight alleles at a locus? (10 points)

8. In *Antirrhinum* plants, two pure-breeding, white-flowered lines are intercrossed, and all F1 progenies are white flowered plants. By self-pollinating an F1 progeny, 131 F2 progenies are white-flowered plants, while 29 F2 progenies are red-flowered plants. (10 points)
   a. Deduce the genotypes of these phenotypes (including two parental lines, F1 and F2 progenies), using clearly defined gene symbols.
   b. Predict the outcome of progenies derived from the self-pollinated red-flowered plants.

9. You have been given a single virgin Drosophila female. You notice that the bristles on her thorax are much shorter than normal. You mate her with a normal male (with long bristles) and obtain the following F1 progeny: 1/3 short-bristle females, 1/3 long-bristle females, and 1/3 long-bristle males. A cross of the F1 long-bristle females with their brothers gives only long-bristle F2. A cross of short-bristle females with their brothers gives . 1/3 short-bristle females, 1/3 long-bristle females, and 1/3 long-bristle males. Explain these data. (10 points)

10. In tomatoes, two alleles of one gene determine the character difference of purple versus green stems and two alleles of a separate independent gene determine the character difference of "cut" versus "potato" leaves. The result for five separate matings of tomato plant phenotypes is given in the table below: (10 points)
    a. Determine which alleles are dominant.
    b. What are the most probable genotypes for parents in each cross ?

Mating	Parental phenotyes	Number of progeny			
		Purple, Cut	Purple, Potato	Green, Cut	Green, Potato
1	Purple, cut X green, cut	321	101	310	107
2	Purple, cut X Purple, potato	219	207	64	71
3	Purple, cut X green, cut	722	231	0	0
4	Purple, cut X green, potato	404	0	387	0
5	Purple, potato X green, cut	70	91	86	77

Critical values of the χ^2 distribution				
df	1	2	3	4
P=0.05	3.841	5.991	7.815	9.488

98-2 遺傳學　第二次期中考　試題

一、　問答題：

1. 請由古典遺傳學 (transmission genetics) 的觀點，以文字敘述「基因」的定義。(10 分)

2. 請說明 Seymour Benzer 如何設計實驗推論出基因的結構。答案應包括下列項目：

(1)　實驗系統 (遺傳材料及其外表型)。(5 分)

(2)　實驗的設計與實驗預期的結果。(20 分)

(3)　如何由實驗預期結果推論出基因的結構。(5 分)

3. 請由分子遺傳學的觀點，以繪圖的方式標示真核生物 (eukaryotic organisms) 的「基因」在染色體的 DNA 包括那些部份，以及標示轉錄之 pre-mRNA 的構造有那些部份。　(20 分)

二、　計算題：

已知一水稻在四個基因座上的基因型皆為異型結合，以符號表示為 *Aa Bb Dd Ee*，以大寫字母表示的對偶基因 (allele) 相對於以小寫字母表示的對偶基因為顯性。若將此水稻與基因型為 *aa bb dd ee* 的水稻進行試交，獲得 1000 株 F_1 雜交後代的基因型，依其基因型分類的結果，如右表所示。請問：

基因型	數目
aa Bb Dd Ee	42
Aa bb dd ee	43
Aa Bb Dd ee	140
aa bb dd Ee	145
aa Bb dd Ee	6
Aa bb Dd ee	9
Aa Bb dd ee	305
aa bb Dd Ee	310

1. 那些基因為相互連鎖 (linked)？請以卡方獨立性測驗 (χ^2 test of independence) 計算的結果說明 (18 分)

2. 若異型結合的水稻植株是由兩個純系雜交獲得，請問這兩個純系在這四個基因座上的基因型分別為何？(所有的可能都需要列出) (8 分)

3. 請繪製出相互連鎖基因的遺傳圖譜，此遺傳圖譜需要標示基因的排序及成對基因之間的遺傳距離。如果可能的話，請計算 interference (14 分)。

Critical values of the χ^2 distribution				
df	1	2	3	4
P=0.05	3.841	5.991	7.815	9.488

98-2 遺傳學　期末考　試題

1. 選擇題 (60 分; 每題 3 分)

(1) Which is the correct order of stages in the cell cycle ?
    a. G1, S, prophase, metaphase, anaphase.
    b. S, G1, prophase, metaphase, anaphase.
    c. Prophase, S, G1, metaphase, anaphase.
    d. S, G1, anaphase, prophase, metaphase.

(2) Which of the following events takes place in meiosis II but not in meiosis I ?
    a. Crossing over.
    b. Contraction of chromosomes.
    c. Separation of homologous chromosomes.
    d. Separation of chromatids.

(3) What was the genotype of the few F1 red-eyed males obtained by Bridges when he crossed a white-eyed female with a red-eyed male ?
    a. X^{+}.
    b. $X^{W}X^{+}Y$.
    c. $X^{+}Y$.
    d. $X^{+}X^{+}Y$.

(4) A male affected with an X-linked dominant trait will have what proportion of offspring affected with the trait ?
    a. ½ sons and ½ daughter.
    b. All daughters and no sons.
    c. All sons and no daughter.
    d. ¾ daughter and ¼ sons.

(5) For single crossovers, the frequency of recombinant gametes is half the frequency of crossing over because
    a. A testcross between a homozygote and heterozyogote produces 1⁄2 heterozyogous and 1⁄2 homozygous progeny.
    b. The frequency of recombination is always 50%.
    c. Each crossover takes place between only two of four chromatids of a homologous pair.
    d. Crossovers occur in about 50% of meiosis.

(6) Which process of DNA transfer in bacteria requires a virus?
    a. Conjugation.
    b. Transduction.
    c. Transformation.
    d. All of the above.

(7) Conjugation between an F$^+$ and an F$^-$ cell usually results in
    a. Two F$^+$ cell.
    b. Two F$^-$ cells.
    c. An F$^+$ and an F$^-$ cell.
    d. An Hfr cell and an F$^+$ cell.

(8) In complementation tests, Benzer simultaneously infected *E. coli* cells with two phages, each of which carried a different mutation. What conclusion did he make when the progeny phage produced normal plaques?
    a. The mutations occurred at the same locus.
    b. The mutations occurred at different loci.
    c. The mutations occurred close together on the chromosome.
    d. The genes were in the cis configuration.

(9) A dicentric chromosome is produced when crossing over takes place in an individual heterozygous for which type of chromosome rearrangement?
    a. Duplication.
    b. Deletion.
    c. Paracentric inversion.
    d. Pericentric inversion.

(10) Species A has 2n=16 chromosomes and species B has 2n=14. How many chromosomes would be found in an allotriploid of these two species?
    a. 21 or 24.
    b. 42 or 48.
    c. 22 or 23.
    d. 45.

(11) How do the sugars of RNA and DNA differ?
    a. RNA has a six-carbon sugar; DNA has a five-carbon sugar.
    b. The sugar of RNA has a hydroxyl group that is not found in the sugar of DNA.
    c. RNA contains uracil; DNA contains thymine.
    d. DNA's sugar has a phosphorous atom; RNA's sugar does not.

(12) What is the tertiary level of DNA structure?
    a. Structure of the nucleotides.
    b. How the nucleotides are joined together.
    c. Three-dimensional structure of the double helix.
    d. Higher-order folding of DNA.

(13) Most of the genes that encode proteins are found in
  a. Unique-sequence DNA.
  b. Moderately repetitive DNA.
  c. Highly repetitive DNA.
  d. All of the above.

(14) Discontinuous replication is a result of which property of DNA?
  a. Complementary.
  b. Charges phosphate group.
  c. Anti-parallel nucleotide strands.
  d. Five-carbon sugar.

(15) Which class of RNA is correctly paired with its function?
  a. Small nuclear RNA (snRNA): processes rRNA.
  b. Transfer RNA (tRNA): attaches to an amino acid.
  c. MicroRNA (miRNA): carries information for the amino acid sequence of a protein.
  d. Ribosomal RNA (rRNA): carries out RNA interference.

(16) If a splice site were mutated so that splicing did not take place, what would the effect be on the protein encoded by the mRNA?
  a. It would be shorter than normal.
  b. It would be longer than normal.
  c. It would be the same length but would have different amino acids.

(17) A codon is
  a. One of three nucleotides that encode an amino acid.
  b. Three nucleotides that encode an amino acid.
  c. Three amino acids that encode a nucleotide.
  d. One of four bases in DNA.

(18) Which of the following changes is a transition base substitution?
  a. Adenine is replaced by thymine.
  b. Cytosine is replaced by adenine.
  c. Guanine is replaced by adenine.
  d. Three nucleotide pairs are inserted into DNA.

(19) Which statement is not an assumption of the Hardy-Weinberg law?
  a. The allelic frequencies (p and q) are equal.
  b. The population is randomly mating.
  c. The population is large.
  d. Natural selection has no effect.

(20) If the environmental variance (V_E) increases and all other variance components remain the same, what will the effect be?
  a. Broad-sense heritability will decrease.
  b. Broad-sense heritability will increase.
  c. Narrow-sense heritability will increase.
  d. Broad-sense heritability will increase, but narrow-sense heritability will decrease.

2. 問答題 (24 分; 第 1、2 題各 6 分, 第 3 題 12 分)

(1) How do complete dominance, incomplete dominance, and co-dominance differ?

(2) How might you determine whether a particular trait is due to cytoplasmic inheritance or to genetic maternal effect ?

(3) Please write down the names of the six mutant types in Muller's classification (based on the degree of severe phenotypes) and the possible gene action (dominance or recessive) for each type of mutant alleles.

3. 計算題 (16 分; 第 1、2 題各 4 分, 第 3 題 8 分)

(1) Assume that long ear lobes in humans are an autosomal dominant trait that exhibits 30% penetrance. A person who is heterozygous for long ear lobes mates with a person who is homozygous for normal ear lobes. What is the probability that their first child will have long ear lobes?

(2) In an experimental population of flour beetles, the body length shows a continuous distribution with a mean of 6 mm. A group of males and females with body lengths of 9 mm are selected and interbred. The body lengths of their offspring average 7.2 mm. Please calculate the realized heritability for body length in this population.

(3) In *Antirrhinum* plants, two pure-breeding, white-flowered lines are intercrossed, and all F1 progenies are white flowered plants. By self-pollinating an F1 progeny, 131 F2 progenies are white-flowered plants, while 29 F2 progenies are red-flowered plants. A) Deduce the genotypes of these phenotypes (including two parental lines, F1 and F2 progenies), using clearly defined gene symbols. B) Predict the outcome of crosses of the F1 to each parental line.

Critical values of the χ2 distribution

df	1	2	3	4
P=0.05	3.841	5.991	7.815	9.488