Genetics Practice Exam from Summer 2021
(originally on Gradescope)

These are examples of answers. Your answers could use different words or sentences and still obtain full marks if they contain all of the same concepts and are clear with proper terminology.

New Questions (Summer 2022)

-N1. Please describe the differences between Mitosis in Meiosis for the following:

i) location of cell division and number of nuclear divisions

- ***Mitosis:*** *Occurs in somatic cells; one round of nuclear division*
-
- ***Meiosis:*** *Occurs in germline cells; two rounds of nuclear division*

ii) chromosome alignment in Metaphase:

- Mitosis: Sister chromatids (duplicated chromosomes comprised of two identical chromosomes connected at the centromere region) align at the metaphase plate (a plane that is equally distant from the two cell poles).

- ***Meiosis:*** *Homologous chromosome pairs align on either side of the metaphase plate in metaphase I.*

iii) number of daughter cells produced and ploidy if parent cell is diploid:

- ***Mitosis: Two*** *daughter cells are produced. Each cell is diploid containing the same number of chromosomes as the original parent cell.*
- ***Meiosis: Four*** *daughter cells are produced. Each cell is haploid containing one-half the number of chromosomes as the original cell.*

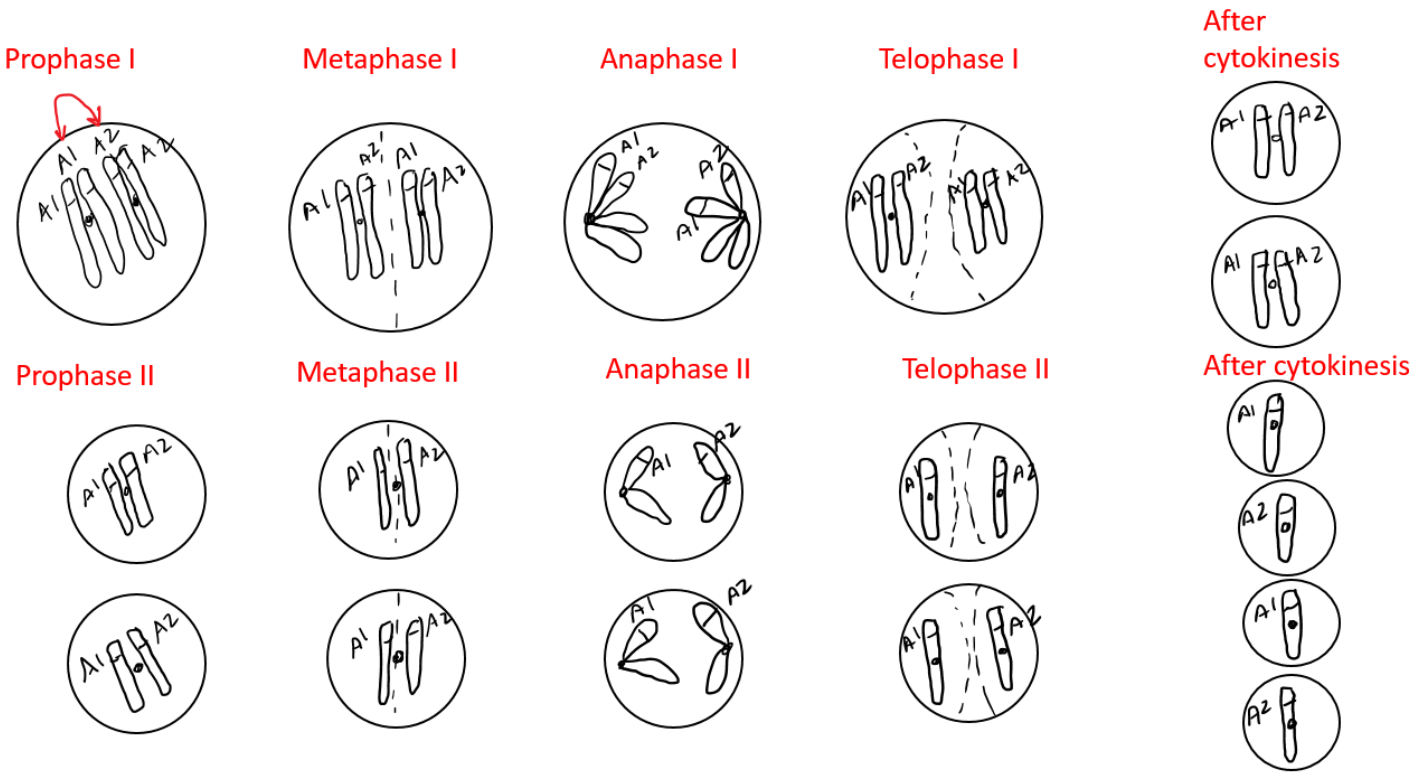
iv) genetic composition of daughter cells, i.e. are they identical to parent or unique and why:

- ***Mitosis:*** *The resulting daughter cells in mitosis are genetic clones (they are genetically identical).* ***No recombination or crossing over occur****.*
- ***Meiosis:*** *The resulting daughter cells contain different combinations of genes.* ***Genetic recombination occurs*** *as a result of the random segregation of homologous chromosomes into different cells and by the process of crossing over and recombination (exchange of DNA and the associated genes between homologous chromosomes).*

v) Chromosome /Chromatid Separation:

- ***Mitosis:*** *During anaphase,* ***sister chromatids separate*** *and move toward opposite poles of the cell. A separated sister chromatid is considered a full chromosome.*
- ***Meiosis:*** *Homologous chromosomes move toward opposite poles of the cell during anaphase I.* ***Sister chromatids do not separate*** *until anaphase II.*

Q-N2 Please a schematic of a 2n=2 cell with the genotype (A1/A2) undergoing meiosis. Start with the cell in early Prophase I and within the cell for each phase and end with the final daughter cells.



SUMMER 2021 PRACTICE QUESTIONS

Question 1 – Mitosis & Meiosis

Question 1.1 – Answer: None of the above.

EXPLANATION

Not mitosis, because at the end of mitosis, the sister chromatids should have separated (1 pt).

EXPLANATION

Not meiosis I, because there are too many copies of each homologous chromosome. At the end of meiosis I the homologs should have separated and each cell should only contain one homolog (1 pt).

EXPLANATION

Not meiosis II, because there are too many copies of each homologous chromosome and at the end of meiosis II the sister chromatids should have separated to form haploid gametes (1 pt).

Question 1.2 – Answer: Meiosis I

EXPLANATION

Not mitosis, because there are too few copies of each homologous chromosome. Also, at the end of mitosis the sister chromatids should have separated (1 pt).

EXPLANATION

Not meiosis II, because at the end of meiosis II, the sister chromatids should have separated to form haploid gametes (1 pt).

EXPLANATION

Not none of the above, because meiosis I is correct since unique copies of each homologous chromosome are present as expected (two chromatids each) at the end of meiosis I (1 pt).

Question 1.3 Answer: Mitosis

EXPLANATION

Not meiosis I, because there are too many copies of each homologous chromosome. By the end of meiosis I, the homologous chromosomes should have separated and each cell should only contain one homolog (present as sister chromatids) (1 pt).

EXPLANATION

Not meiosis II, because there are too many copies of each homologous chromosome – the gametes should be haploid, meaning unique copies of each homologous chromosome should be present (1 pt).

EXPLANATION

Not none of the above, because mitosis is correct. Two copies of each homologous chromosome are present as expected at the end of mitosis (1 pt).

Question 2. Mitosis, Meiosis

2.1- Mitosis

EXPLANATION

MITOSIS. At anaphase of Mitosis, sister chromatids are moving to different poles (0.5) to produce two genetically identical diploid daughter cells (0.5). This is what is shown in the figure.

2.2 Meiosis II

EXPLANATION

MEIOSIS II. At anaphase of Meiosis II, sister chromatids are separating, which is what is shown in the figure (0.5). The homolog with the A2/B2 genotype would have segregated to a different daughter cell during meiosis I, which is why these sister chromatids do not appear in this cell (0.5).

2.3- Meiosis I

EXPLANATION

MEIOSIS I. At anaphase of meiosis I, homologous chromosomes are separating, which is what is being shown in this figure (0.5). This will result in daughter cells each with a copy of the homologous replicated chromosome, as expected at the end of meiosis I (0.5).

2.4- None of the above

EXPLANATION

NOT POSSIBLE. Multiple alleles of the same gene should not be on the same chromatid (0.5). Every gene has one location (or locus) on a chromosome (0.5).

Question 3 – Meiosis

3.1 – crossing-over

If sister chromatids are two halves of a replicated chromosome; **how** is it possible that the sister chromatids in this cell have different alleles? **When** would this change have occurred?

EXPLANATION

This combination of alleles was produced by crossing over between non-sister chromatids during prophase I (0.5). A chiasma must have formed between the centromere and the B alleles (0.5), resulting in the exchange of DNA material containing the A and B alleles between non-sister chromatids (0.5). This exchange of DNA segments resulted in chromosomes with the A1/B1 alleles on one chromatid, and the A2/B2 alleles on the other (0.5).

3.2 – independent assortment

Considering the figure above, will the A and B genes assort independently? Briefly explain why or why not. Include a definition of independent assortment in your answer.

EXPLANATION

No, the A and B genes will not assort independently (0.5). Independent assortment of genes means that the allele of one gene separates independently from the allele of another gene (0.5). However, because the A and B genes are linked (they are on the same chromosome) and since the opportunity for crossing-over has passed (the figure shows a meiotic cell at anaphase I, whereas crossing-over occurs during prophase I) (0.5) the A and B genes will travel together and thus will be inherited together into haploid gametes (0.5).

Question 4. Random fusion of gametes

Briefly explain how the random combination of gametes can contribute to genetic variation in the resulting zygotes.

The gametes from two different individuals will be genetically different from each other. Specifically, they will have the same genes on the same kind of chromosomes (molecules of DNA), but they will likely have different sequences of base pairs on those chromosomes; and hence different alleles for each of the genes. The two different parents will also have had different crossing- over events, which will result in recombination of maternal and paternal alleles; and their chromosomes will have independently assorted into their gametes. Because these gametes are different from each other, randomly choosing one from each parent will result in many different combinations of unique chromosomes, with novel combinations of alleles, leading to genetic diversity in the result zygotes.

Question 5 – Beetles, Mode of Inheritance

5.1 Antenna length

Dominant phenotype = short antennae

The F1s are heterozygous, inheriting the allele from long antennae from the father, and the allele for short antennae from their mother. However, they all have short antennae, which indicates that the allele for short antennae is dominant to the allele for long antennae. Also, the F2 show a 75% short antennae (96) and 25% long antennae ratio (32), which is the 3:1 ratio we would expect from a cross of 2 heterozygotes if the allele for short antennae is dominant to the allele for long antennae. (I would include specific numbers)

5.2 Mode of inheritance – antennae length

- autosomal

- In the F2 generation, there is a 3:1 phenotypic ratio of short to long antennae (96:32), which is the 3:1 ratio we would expect from a cross-between 2 heterozygotes if the gene is autosomal. Also, the F1 males and females had short antennae, and the F2 males (48:16) or females (48:16) did not differ in their phenotype frequencies indicating the gene for antennae length if autosomal and not X-linked.

5.3 Heterozygote x test cross – list all of the antenna length phenotypes

- expected 30 individuals with short antennae, 30 individuals with long antennae

5.4 Body shape

- *Dominant phenotype = square*
- *why – F1 females are heterozygous because they inherit an allele for a square body from their father and a round body from their mother. All F1s have a square body shape, indicating that allele for a square body is dominant to the allele for an oval body.*

5.5 Mode of inheritance - body shape

- X-linked

- The F1 males and F1 females have different body shapes (males: oval; females: square) suggesting that the sex of the individual matters and the gene is on the X-chromosome. In the F2 generation there is a 1:1 ratio of oval:square bodies in both males (32:32) and females (32:32), which is the expected patterns if the gene is X-linked and the mother is a heterozygote and the father is carrying the recessive allele.

5.6 Cross – between male and female with oval body shapes

- male oval: female oval 1:1

- oval shape is recessive and since both parents only have recessive alleles; all offspring can only inherit recessive alleles and manifest the recessive phenotype (oval body shape)

Question 6 – Mouse Cross – fur colour, ear size

6.1 Mode of inheritance for black fur colour in mice.

Mode of Inheritance: Autosomal dominant.

Explanation.
First, define alleles: B1 = Black fur, B2=Brown fur
Next, define genotypes: B1B1=Black fur, B1B2 = Black fur, B2B2=brown fur

P = B1B1 (Black mother) x B2B2 (Brown father)

	B2
B1	B1B2

.
Predict F1 = All heterozygotes (B1B2)

Cross F1s

	B1	B2
B1	B1B1	B1B2
B2	B1B2	B2B2

Predict F2s = 3:1 phenotypic ratio of black fur to brown fur

Compare predicted to observed:

F1 – Predict – all mice have black fur = observed phenotypes

F2 – Predict – 3:1 phenotypic ratio of black fur:brown fur. Observed 123 mice with black fur and 37 mice with brown fur = 3:1 ratio. Females: 62 black: 18 bro.) Males: 61 black, 19 brown. So, no phenotypic differences between males and females.

Conclusion: Data support the hypothesis that black fur has an autosomal dominant mode of inheritance.

6.2 Hypothesized that mode of inheritance for ears of normal size is X-linked recessive.

Claim: No, normal ear size in mice is not an X-linked recessive trait.

Explanation: Start by defining alleles and genotypes based on hypothesis that normal ear size is X-linked recessive.

Normal ear size = X^e
Small ears = X^E

X^eX^e = normal ears X^EX^e = small ears X^EX^E = small ears

P = X^eX^e x X^EY

	X^e
X^E	X^EX^e
Y	X^eY

F1 Prediction (if normal ear size is an X-linked recessive trait)

= Females will all have small ears (because they inherit dominant allele from father) and males will all have normal ears (because they inherit recessive allele from mother)

F2 Prediction (if normal ear size is an X-linked recessive trait)

	X^E	X^e
X^e	X^EX^e	X^eX^e
Y	X^EY	X^eY

= Predict that half of all F2 females and F2 males will normal sized ears and half of all males and females will have small ears.

Compare observed and predicted values

- *F1s Predicted all F1 females will have small ears and all F1 males will have normal ears.*
  Observed all F1 females have normal ears and all F1 males have normal ears (opposite)
  Observed data does not match predicted data.
- *F2s Predicted that half of all males and females will have normal sized ears and half will have small ears*
  Observed all 80 F2 females have normal ears and half of F2 males (41) have normal ears and half of the males (39) have small ears.

- *Therefore observed data does not match predicted data for the F1 and F2 generation*

Conclusion – The data do not support the hypothesis that normal ear size is an X-linked recessive trait.

Question 7 – Bird Cross – beak shape, leg length

7.1. Prediction of the relative frequency of F2 offspring phenotypes if the two genes are on different chromosomes.

1:1:1:1 Blunt beaks, long legs/Blunt beaks, short legs/Pointy beaks, long legs/Pointy beaks, short legs

7.2 What phenotypes would be present in the F2 generation if the two genes were on the same chromosome but far apart?

Blunt-beaks, short-legs
Blunt-beaks, long-legs
Pointy-beaks, short-legs
Pointy-beaks, long-legs

7.3 What are the predicted relative frequencies of the F2 offspring if the two genes were on the same chromosome but far apart?

Blunt-beak, long legs and pointy breaks, short legs > pointy-beaks, long-legs and blunt beaks, short legs.

7.4 – Cell in G1 phase

2n=6. Assume two genes are on the same chromosome, which diagram represents a cell from the Cross 1 blunt-beaked, long-legged parent in G1 phase>

- *correct answer is C.*