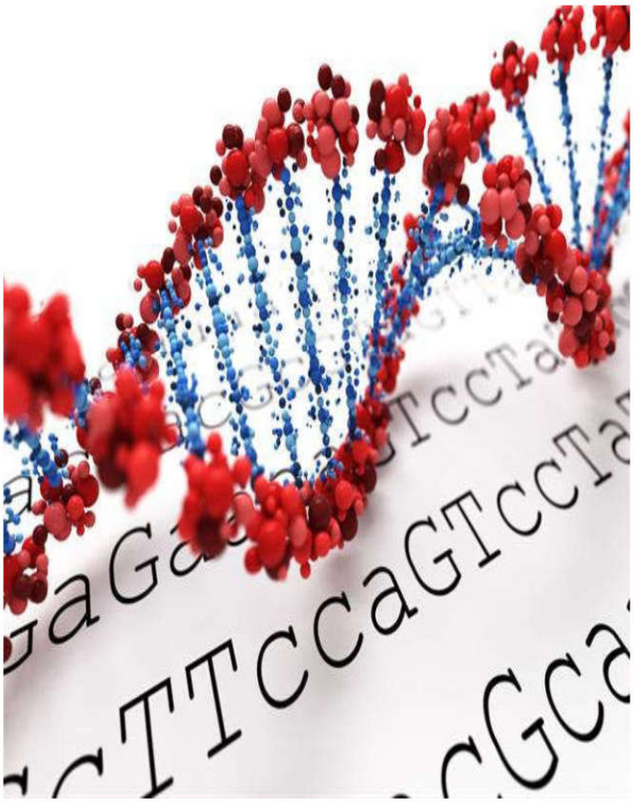

Cytogenetics

Practical part

2022-2023

Year:

Second Year

Chemistry Zoology

Prepared by:

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PROBLEMS

1st Law (the principle of segregation):

1. In a genetic cross between two heterozygous individuals (Aa), what is the probability that their offspring will be homozygous dominant (AA)?

2. In a study of stem length in pea plants, 2 tall plants were crossed and the calculated offspring showed: 28 tall plants & 10 short plants. Explain the results showing the genotype.

3. In peas, seeds may be round (R) or wrinkled (r). What proportion of the offspring in the following crosses would be expected to be wrinkled?
   a. true-breeding round x true-breeding wrinkled.
   b. two heterozygous round individuals.
   c. Rr x rr

4. For the purpose of this problem assume that in humans the gene for brown eyes is dominant to that for blue eyes.
   a. A brown-eyed man marries a blue-eyed woman, and they have eight brown-eyed children. What are the genotypes of all the individuals in the family?
   b. What is the probability that the first child produced in parents who are both heterozygous for brown eyes will be blue-eyed?
   c. If the first child is a brown-eyed girl (same parents as in b), what is the probability that the second child will be a blue-eyed boy?

5. In cats, long hair is recessive to short hair. A true-breeding (homozygous) short-haired male is mated to a long-haired female. What will their kittens look like?

6. Two cats are mated. One of the parent cats is long-haired (recessive allele). The litter which results contains two short-haired and three long-haired kittens. What does the second parent look like, and what is its genotype?

7. Mr. and Mrs. Jones have six children. Three of them have attached earlobes (recessive) like their father, and the other three have free earlobes like their mother. What are the genotypes of Mr. and Mrs. Jones and of their numerous offspring?

8. About 80% of the human population can taste the chemical phenol-thiocarbamide (PTC), while the other 20% can't. This characteristic is governed by a single gene with two alleles, a tasting allele and a non-tasting allele. What does this statistic tell us about which allele (tasting or non-tasting) is dominant?

9. Red-flowered peas were crossed with white-flowered peas, half of the offspring was red-flowered and half was white-flowered. If the resulted red-flowered peas were self-pollinated, what are the proportions of genotype & phenotype of the offspring?

10. In a study of eye color in Drosophila (fruit fly), red-eyed flies were crossed and the numbers of offspring was: 100 red-eyed and 30 white-eyed. Explain the results on genetic basis.

11. Wild-type of drosophila body color is determined by the dominant allele (b^+), while the recessive allele is (b) for black color. A test cross was performed for a female of wild-type, and the offspring showed: 50 black flies & 54 wild-type flies. Explain the results showing genotype and phenotype.

12. On genetic basis, show how can you obtain female white-eyed fruit flies from red-eyed flies only. And if the resulted white-eyed flies were crossed with a red-eyed partner, what are the genotypes and phenotypes of the offspring? And what is your comment about males and females resulted from that cross?

13. A farmer wants to breed a variety of corn that is resistant to a certain pest. He has a heterozygous (Rr) plant, which is resistant to the pest, and a homozygous recessive (rr) plant, which is not resistant. What is the expected phenotype ratio of the offspring if the heterozygous and homozygous recessive plants are crossed?

14. A male with idiocy (I) married a normal female. Show on genetic basis what are the proportions of the offspring expected to have idiocy. (use "I" for idiocy and "+" for normal)

2nd Law (the principle of independent assortment):

1. What is the probability of having AaBb peas from the cross aaBb x AaBb?

2. In peas cross of flower color and flower position between 2 unknown parents, it was found that 1st generation plants were 2/8 (purple - axial), 2/8 (purple - terminal), 2/8 (white - axial), and 2/8 (white - terminal). What are the genotypes and phenotypes of parents?

3. A left-handed man with black eyes married a right-handed woman with blue eyes, and they got 2 children with the following phenotypes:
   a. Right-handed, black-eyed.
   b. Right-handed, blue-eyed.
   What are the genotypes of all members if you know that black and right-handed are the dominant alleles?

4. Consider 3 yellow-round peas labeled A, B, and C. Each was grown into a plant and crossed with green-wrinkled peas. Exactly 100 peas were collected from each cross and they showed that:
   A: 51 yellow-round, 49 green-round
   B: 100 yellow-round
   C: 24 yellow-round, 26 yellow-wrinkled, 25 green-round, 25 green-wrinkled.
   What are the genotypes of A, B, and C?

5. A pig with rough-black hair was crossed with a female with rough-white hair. The offspring was: 3/8 (rough-black), 3/8 (rough-white), 1/8 (soft-black), 1/8 (soft-white). What are the genotypes of individuals if you know that rough is dominant on soft & black is dominant on white?

6. In genetic experiments of a particular plant. Determine the genotype of each cross in the following knowing that the traits being studied are seeds color and stem length:

	y-t	y-d	g-t	g-d
yellow-tall x yellow-tall	90	30	31	11
yellow-dwarf x yellow-dwarf	0	40	0	14
yellow-dwarf x green-tall	20	19	23	21

7. A type of poultry produces a crest due to a dominant allele (C), while smooth head has the recessive allele (c). Feather color also is determined by dominant allele (B) for black, and recessive allele (b) for red. If a black homozygous parent with smooth head was crossed with a red with a crest (homozygous), what are the genotype and phenotype of 1st and 2nd generations?

8. Divided hoof of pigs is the normal phenotype determined by a recessive allele (c), while non-divided hoof is dominant (C). Black skin colour also is determined by a recessive allele (w) while white is dominant (W). A test cross was performed for a (white/non-divided hoof) pig and the offspring was: (white/divided), (black/non-divided), (white/non-divided), and (black/divided). Analyze the cross genetically.

9. In Drosophila (fruit flies), grey body color is the wild trait dominant on ebony, and long wings is dominant on vestigial. What are the genotypes and phenotypes of 1st and 2nd generation flies resulted from the cross between (grey/long-winged) and (ebony/vestigial-winged)?

10. A plant breeder wants to create a new variety of tomato that has both large fruit size and disease resistance. The breeder has two tomato plants, one with large fruit size (L) and one with disease resistance (D),

and they are both heterozygous (Ll and Dd, respectively). What is the expected phenotype ratio of the offspring if the two plants are crossed?

11. You have the following alleles: B=blue, b=green, H=two-horned and h=one-horned: What is the cross most likely produced the following results?

54 blue, two-horned lizards	18 green, two-horned lizards
18 blue, one-horned lizards	6 green, one-horned lizards

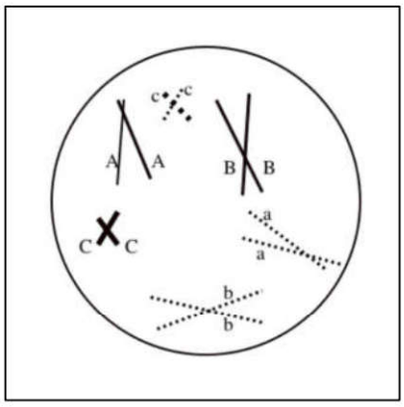
12. In a cross of fruit fly strain, (dark/long-winged) fly was crossed with (light/short-winged) fly. 1st filial flies were entirely (light/long-winged), while the 2nd filial was:
    a. 44 (light/long-winged)
    b. 16 (dark/long-winged)
    c. 14 (light/short-winged)
    d. 6 (dark/short-winged)

    Explain the results showing the genotypes.

13. When a male pig of true-breeding black, solid-hooved pigs was crossed to a female from a breed (homozygous) of red, cloven-hooved pigs, their several progenies all looked alike with regard to color and hooves. These progenies were all mated to members of the same breed as their red, cloven-hooved mother pig. The offspring from the final cross were: (11 black/cloven-hooved), (10 red/solid-hooved), (8 black/solid-hooved), and (14 red/cloven-hooved).
    a. For each of these two genes, which allele is the dominant one? Explain you reasoning.
    b. What were the phenotypes of the progeny produced by the first mating in this process?

14. In Drosophila, ebony body colour is produced by a recessive gene (e) and wild type (gray) body colour by its dominant allele (e^+). Vestigial wings are governed by a recessive gene (vg) and normal wing size (wild type) by its dominant allele (Vg^+). If wild type dihybrid (Heterozygous) flies are crossed and produce 256 progenies, how many of these progeny flies are expected in each phenotypic class?

15. Assume that the cell below is from an insect testis and is about to undergo spermatogenesis (gamete production by meiosis). The letters represent dominant or recessive alleles at particular gene positions on each chromosome.



a. What is the haploid chromosome number of the insect?
b. How many genetically different kinds of gametes could be formed from this cell (assume no crossing over)?
c. How many pairs of homologous chromosomes would you observe in a muscle cell from this insect?
d. What is the probability that a gamete produced by this cell will be completely recessive for the alleles shown?
e. Which of Mendel's laws tells us that a gamete containing a chromosome with an "A" allele will not necessarily contain a chromosome with a "B" allele?
f. Which of Mendel's laws tells us that a gamete cannot contain both an "A" allele and an "a" allele?

16. What proportion of the plants from the following crosses would be tall with yellow, wrinkled seeds?

a.	TtYYRr	x	ttYYrr	c.	ttYyrr	x	ttyyRr
b.	TTYyRr	x	TtYyRr	d.	TtYyRr	x	TtYyRr

17. What will be the gametes formed from the parents and the genotypes of the offspring obtained from the following matings and give the ratio of F_2 generation?

a.	PPQQRR	x	ppqqrr
b.	PpQqRr	x	PpQqRr

Incomplete dominance & Co-dominance

1. A black Andalusian fowl was crossed with a white. The offspring was blue (bluish-grey). Explain the results showing the genotypes. And if you know that the 2nd generation yields 500 individuals, how many individuals expected to have 1st parents' phenotypes?

2. Suppose you own a nursery, and you know that striped flowers are best-sellers giving you the best profit. Show the cross that would be necessary to get the most striped flowers of red and white colors. And what is the phenotypic ratio if you crossed 2 striped flowers?

3. In cattles: RR= Red, RW=Roan, and WW=white. What are the predicted-color phenotypes and their frequencies for the offspring resulted from the following crosses?
   a. Red bull x White cow
   b. Red bull x Roan cow
   c. Roan bull x Roan cow

4. In some breeds of Siamese cats, the individuals differ in the length of the tail. The cross between two medium-tailed cats resulted in 3 long-tailed, 6 medium-tailed, and 3 short-tailed cats. Determine the genotype of each of the parents and offspring, and state the pattern of inheritance in this case.

5. Two wavy-haired people (one male and one female) married and got eight children. Of these eight, how many straight-haired children assuming that the family follows the expected statistically-predicted pattern? And suppose you examined the actual children and discovered that three of the eight is curly hair, what do you suppose went wrong?

6. Shorthorn breeder has a roan bull and a white cow. He needs a herd of red cattles only. Prove genetically how can he achieve this?

7. A man with dark (dominant), curly hair married a woman with light, straight hair. Their daughter, who happens to have dark hair, married a man with light, wavy hair. Answer the following questions about this daughter and her family:
   a. Draw a Punnett's square for this marriage, and predict the phenotypic ratio among the offspring of the daughter and her husband.
   b. What is the chance that they will have a child with hair just like his or her father's?

8. In soybean, broad leaf is incompletely dominant over narrow. The heterozygote is intermediate. Purple is dominant over white.
   a. What will be the phenotypic ratio of F2 of a broad-leaved plant with a homozygous purple flower crossed with a narrow leaf white flowered plant?
   b. What will be the offspring of the cross between F1 and narrow leaf white flowered plant?

Multiple Alleles

1. Suppose there is a disputed child between two families and this child's blood type is (O). The parents' blood types in the 1st family are (A) and (AB), while in the 2nd family are (B) and (O). To which of the two families could this child belong?

2. A female with (AB) blood type has a son with the same blood type. What is the possible blood type of this father?

3. A man with (O) blood type married a woman with (AB) blood type. Among their children, what proportion would you expect to have blood types like one or the other of these parents? And what proportion would you expect to have blood types different from both parents? Explain.

4. If the father of a fetus is (Rh^+) and the mother is (Rh^-). What are the chances that there will be a mother-fetus incompatibility problem? Assume that the couple has already had a child and that there has been no medical treatment to prevent this problem.

   a. 100%
   b. At least 50%
   c. Less than 50%
   d. 0%

5. A woman with blood type A and a man with blood type B have three children. What is the probability that all three children will have blood type AB?

6. The father of two children is type O^+, and the mother is type A^+. The children are O^- and A^+. Given this information, what can you say about the genotypes of father and mother?

7. If one parent is type AB and the other is B, but . of the children are A, . AB and the rest B, what are the genotypes of the parents?

8. A man with type AB blood is married to a woman with type O blood. They have two natural children, and one adopted child. The children's blood types are: A, B, and O. Which child was adopted? (show on genetic basis).

9. Given what you know about human A-B-O blood types, what parental cross would yield an F1 consisting of 50% type A, 25% type AB, and 25% type B?

10. Write the phenotype and genotype segregation in the following multiple allelic series crosses where the dominance relationship is:

    $C > C^{ch} > c^{h} > c$

    C: Coloured, C^{ch}: Chinchilla, c^{h}: Himalayan, c: colourless

    1) $C\ c^{h}$ x $c^{ch}\ c^{h}$

    2) C c x $c^{ch}\ c^{h}$

    3) c^{ch} c x c^{h} c

    4) C c x C c

    5) c c x C c^{ch}

Lethal Genes

1. In fruit flies, the gene for wing shape has an unusual allele called 'curly' (designated 'Cy'). The normal (wild type) allele is designated 'cy.' A fly homozygous for cy (cy cy) has normal, straight wings. The heterozygote (Cy cy) has wings which curl up on the ends (and, incidentally, can't really fly). The homozygote for the Cy allele (Cy Cy) never hatches out of the egg. In other words, this allele is lethal in the homozygous condition. If two curly winged flies are mated, and the female lays 100 eggs, predict the following, showing appropriate work:
   a. How many eggs will produce living offspring?
   b. How many straight winged flies do you expect among the living offspring?
   c. What percentage of the living offspring do you expect to be curly winged like the parents?

2. A pair of codominant alleles is known to govern cotyledon leaf colour in soybeans. The homozygous genotype C^GC^G produces dark green, the heterozygous genotype C^GC^Y produces light green, and the other homozygous genotype C^YC^Y produces yellow leaves so deficient in chloroplasts that seedlings do not grow to maturity. If dark green plants are crossed to light green plants and the F_1 crosses are made randomly to produce F2, what phenotypic and genotypic ratios would be expected in the mature F2 plants?

3. A genetic condition on chromosome 2 in the fruit fly is lethal when homozygous (pm/pm), but when heterozygous (pm/pm+) produces a purplish eye colour called plum. The other homozygous condition (pm+/pm+) produces wild type colour. On chromosome 3, a gene called stubble produces short, thick bristles when heterozygous (sb/sb+), but

is lethal when homozygous (sb/sb). The homozygous condition of its alternative allele (sb+/sb+) produces bristles of normal size (wild type). What phenotypic ratio would be expected among progeny from cross between plum, stubble parents?

4. Cross a male with Huntington's disease with a normal female. What are the chances a child will have Huntington's?

Epistatic Gene Interaction

1. An inhibition of pigment production in onion bulbs (I-) exhibits dominant epistasis over another locus, the genotype (iiR-) producing red bulbs and (iirr) producing yellow bulbs.
   a. A pure white strain crossed to a pure red strain and produce all white F_1 and F_2 with 12/16 white, 3/16 red, and 1/16 yellow. What are the genotypes of the parents?
   b. In F_2, 32 were found to be of genotype iirr. Workout the proportion of others (phenotypes).

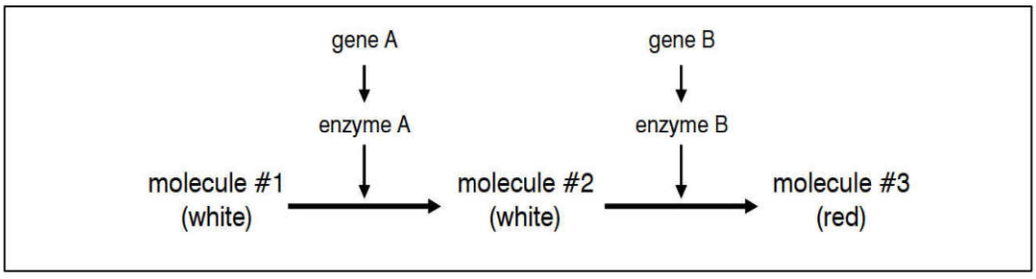
2. In Shepherd's purse, triangular capsule is dominant over round and it is due to duplicate genes C and D. What are the genotypes of the parents that would produce the following results?
   a. 15 Triangular and one round
   b. 3 Triangular and one round

3. Matings between black rats of identical genotype produced offspring as 14 cream coloured, 47 black and 19 albinos.
   a. What epistatic ratio is approximated by these offspring?
   b. What type of epistasis is operative?
   c. What are the genotypes of parents and offspring?

4. Two white flowered strains of sweet pea *Lathyrus odoratus* were produced an F1 with purple flowers. Random crossing among F1 produced 96 progeny plants, 53 exhibiting purple flowers and 43 with white flowers.
   a. What phenotypic ratio is approximated by the F2?
   b. What is the type of interaction involved?
   c. What are the probable genotypes of parents and offspring?

5. In mice, coat color is determined by a gene, B, which has black and brown alleles. Black is completely dominant over brown. However, there is a second gene, C, which also affects color. Mice must have at least one dominant allele of this gene in order to show any color (black or brown); if they do not, they're white.
   a. A pure-breeding brown mouse is crossed with a mouse that is homozygous recessive for both genes. What are the genotypes and phenotypes of these two parents?
   b. What are the genotypes and phenotypes of their F1 offspring?
   c. If two of the F1 mice are crossed, what will be the phenotypes of their offspring, and in what proportions?

6. A certain kind of flower is red because of a red pigment that requires two different genes. Gene A encodes an enzyme which catalyzes the conversion of colorless molecule #1 into a second colorless molecule, #2. The enzyme encoded by gene B catalyzes conversion of molecule #2 into a red pigment, molecule #3. Both enzymes must be working in order to make the red pigment, as shown below:



A pure-breeding white-flowered plant that produces no functional enzyme A or B is crossed with a pure-breeding red-flowered plant. Predict the phenotypes and ratios of the F2 offspring.

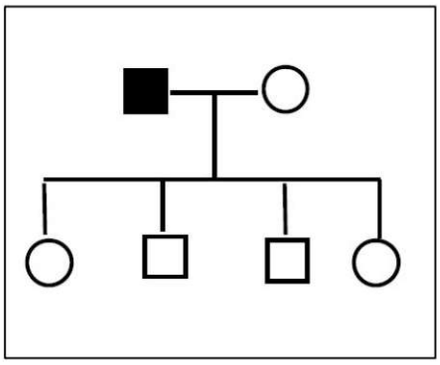
7. Formation in a human's cells of an interferon is connected with complementary interaction of two dominant non-allelic genes (A and B).
   a. In one of parents there is no ability to form an interferon in consequence of absent in him a gene "A", another is healthy and all his relatives are healthy too. What probability of a healthy children birth?
   b. Parents are healthy, but are double heterozygous in genes A and B. Determine probability of a healthy children birth.

8. In chickens, comb shape is determined by alleles at two loci (R, r and P, p). A walnut comb is produced when at least one dominant allele R is present at one locus and at least one dominant allele P is present at a second locus (genotype R_ P_). A rose comb is produced when at least one dominant allele is present at the first locus and two recessive alleles are present at the second locus (genotype R_ pp). A pea comb is produced when two recessive alleles are present at the first locus and at least one dominant allele is present at the second (genotype rr P_). If two recessive alleles are present at the first and at the second locus (rr pp), a single comb is produced. Progeny with what types of combs and in what proportions will result from the following crosses?
   a. RR PP × rr pp
   b. Rr Pp × rr pp
   c. Rr Pp × Rr Pp
   d. Rr pp × Rr pp
   e. Rr pp × rr Pp
   f. Rr pp × rr pp

9. A summer-squash plant that produces disc-shaped fruit is crossed with a summer-squash plant that produces long fruit. All the F1 have disc-shaped fruit. When the F1 are intercrossed, F2 progeny are produced in the following ratio: 9/16 disc-shaped fruit: 6/16 spherical fruit: 1/16 long fruit. Give the genotypes of the F2 progeny.

Pedigree Analysis

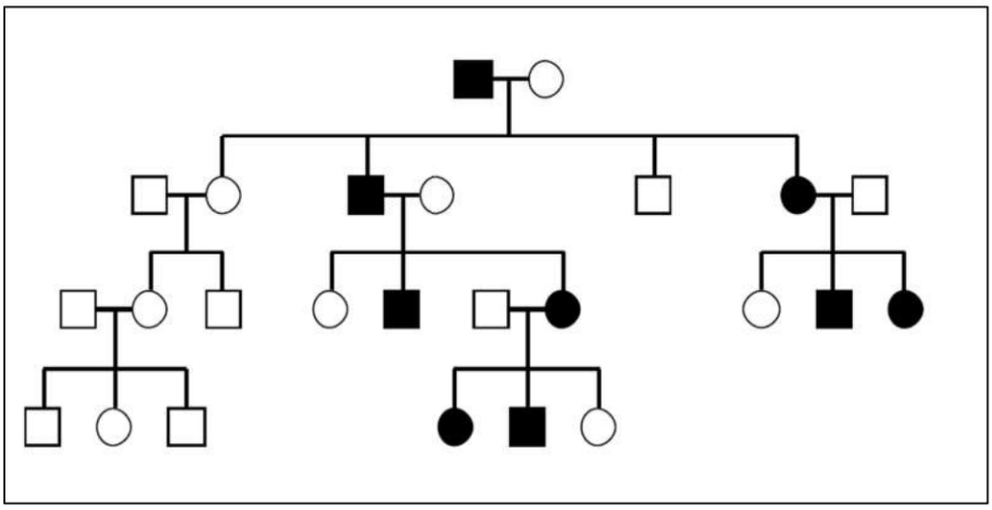
1. A man with a specific unusual genetic trait marries an unaffected woman and they have four children. Pedigree of this family is shown below. For each type of the following inheritance, indicate how many children of each gender are expected to express the trait by filling in the appropriate circles and squares. Assume that the trait is rare and fully penetrant.



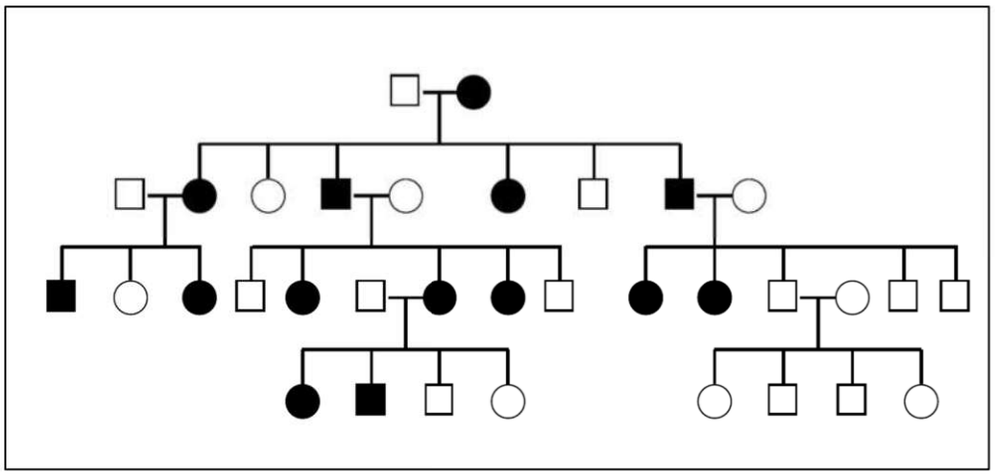
   a. Autosomal recessive trait
   b. Autosomal dominant trait
   c. X-Linked dominant trait
   d. X-Linked recessive trait
   e. Y-Linked trait

2. For each of the following pedigrees, give the most likely mode of inheritance, assuming that the trait is rare. Carefully explain your reasoning.

   a.



b.



c.