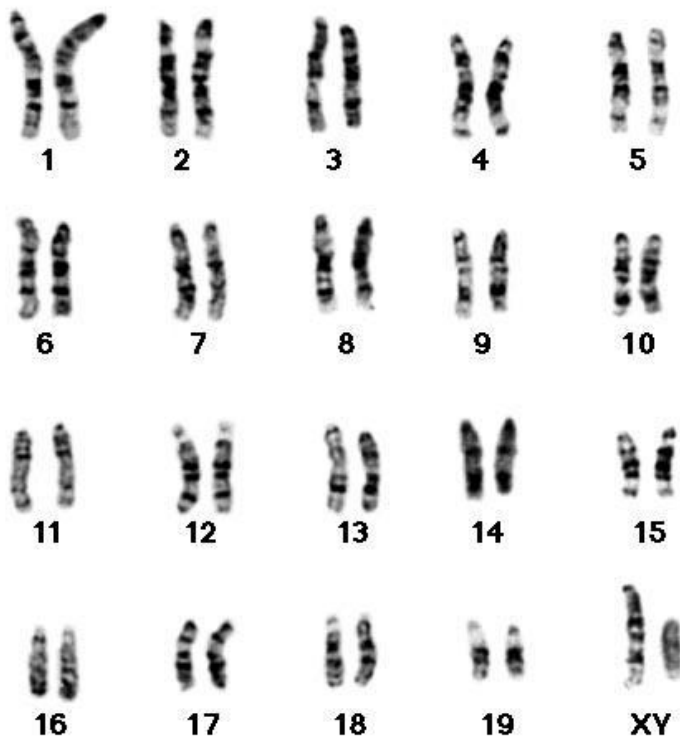




1. Use the karyotype below to answer the following question.



What are the N and c numbers in this karyotype?

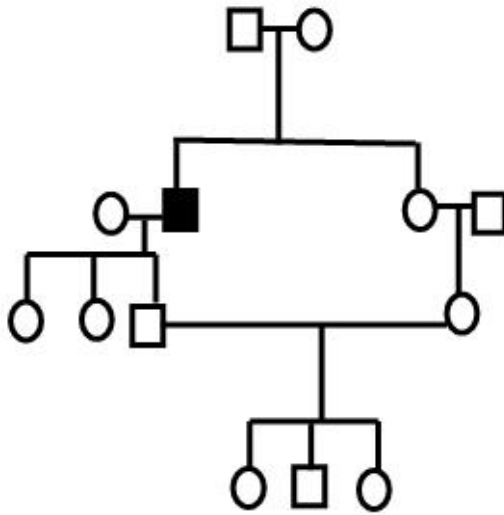
- a)  $N=20$ ;  $2c=40$
- b)  $2N=40$ ;  $4c=40$
- c)  $2N=40$ ;  $4c=80$
- d)  $2N=40$ ;  $2c=40$
- e)  $2N=46$ ;  $4c=92$

2. Read over the following statements. Of the below statements only one is true/correct. Indicate the correct statement.

- I. Chromatids joined together by a centromere are called a homologous pair.
- II. Polar bodies lack chromosomes.
- III. Cells are considered to be diploid when each chromosome is made up of two chromatids.
- IV. There are 23 chromatids present in a human secondary oocyte.
- V. DNA replication occurs during prophase I of meiosis.

- a) Statement I is correct
- b) Statement II is correct
- c) Statement III is correct
- d) Statement IV is correct
- e) Statement V is correct

**Questions 3-5.** The pedigree illustrates a rare trait controlled by a single gene, gene A. Use this information to answer the questions below.



3. What is the genotype of individual III-4?

- a)  $2/3$  AA ;  $1/3$  Aa
- b)  $1/3$  AA ;  $2/3$  Aa
- c)  $1/2$  AA ;  $1/2$  Aa
- d)  $1/3$  AA ;  $1/3$  Aa
- e) none of the above

4. What is the probability IV-2 is heterozygous?

- a)  $1/2$
- b)  $5/9$
- c)  $1/6$
- d)  $11/18$
- e)  $2/3$

5. If IV-1 were to marry IV-2, what is the probability that their first child would be affected with the trait?

- a) 25%
- b) less than 1%
- c) less than 5%
- d) less than 10%

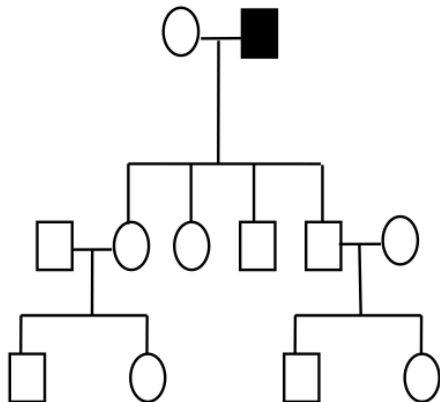
6. A heterozygous carrier for the sickle cell allele decides to take a trip and go hiking in the Rocky Mountains, almost 4000 m above sea level. They began to experience fatigue, weakness, and other mild symptoms of anemia. Which statement best describes the relationship between the  $\beta$ -globin alleles in this environment?

- a)  $\beta^A$  is dominant to  $\beta^S$
- b)  $\beta^S$  is dominant to  $\beta^A$
- c) the alleles show incomplete dominance
- d) the alleles are codominant
- e) the individual needs to exercise more

7. What is the best definition for Mendel's principle of segregation?

- a) two alleles segregate when gametes are formed
- b) dominant alleles segregate away from recessive alleles when gametes are formed
- c) dominant alleles segregate when gametes are formed
- d) identical alleles segregate when gametes are formed
- e) alleles segregate due to random fertilization

**Questions 8-11.** Fabry Disease (FD) is a very rare X-linked recessive neurological disorder. The gene is fully penetrant. The family illustrated in the pedigree below comes from a population where the frequency of males affected with FD is known to be 1 in 100. Individuals affected with FD are shaded. The next 3 questions refer to this information.



8. What is the probability that the first child of III-2 and III-3 will be affected by FD?

- a) 1/8
- b) 1/4
- c) 1/16
- d) 1/9
- e) 1/36

9. What is the approximate likelihood individual II-6 is a carrier of Fabry Disease?

- a) 0.2%
- b) 0.5%
- c) 2%
- d) 4%
- e) 8%

10. What is the approximate probability that the third child of II-5 and II-6 will be affected with Fabry Disease?

- a) 1/25
- b) 1/100
- c) 1/1000
- d) 1/2000
- e) none of the above

11. The level of X-linked gene expression in the skin cells of II-3 will be twice as high as the level of X-linked gene expression in the skin cells of II-4.

- a) Above statement is true
- b) Above statement is false

12. Dwarfism in pigs is caused by an autosomal dominant allele, *D*. Normal pigs are *dd*. A researcher hypothesizes that homozygous, *DD*, pigs die in utero and therefore all dwarfed pigs are heterozygous. To test his hypothesis, the researcher test-crosses several dwarfed pigs. If the researcher's hypothesis is correct, the expected phenotypic ratio of the offspring should be:

- a) 3 dwarfed: 1 normal
- b) 3 normal: 1 dwarfed
- c) 2 normal: 1 dwarfed
- d) 2 dwarfed: 1 normal
- e) 1 normal: 1 dwarfed

13. Read over the following statements. Of the below statements only one is false/incorrect. Indicate the false statement.

- a) Male mammals are heterogametic.
- b) In *D. melanogaster*, XXY flies develop as sterile females.
- c) The temperature the eggs are incubated at determines the sex of the offspring in the Japanese pond turtle.
- d) Female birds are heterogametic.
- e) A human with the XO genotype develops as a male with Klinefelter syndrome.

**Questions 14 – 16 .** You are studying fur colour in cats. In a sample of crosses between cats of varying colour, you find the following results:

<u>cross</u>	<u>male parent</u>	<u>female parent</u>	<u>kittens</u>
A	brown fur	white fur	2 brown fur, 2 white fur
B	white fur	white fur	3 white fur, 1 brown fur
C	brown fur	brown fur	7 brown fur

14. What is the most likely relationship between the two alleles for this gene?
- white is dominant to brown
  - brown is dominant to white
  - brown and white show codominance
  - brown and white show incomplete dominance
  - there is not enough information to be sure
15. What is the most likely genotype of the female parent in cross A?
- homozygous for brown allele
  - homozygous for white allele
  - heterozygous for the brown and white alleles
  - at least one brown allele, but may be homozygous or heterozygous
16. Look at cross A. The results of this cross tell you the genotype of the female parent. What kind of cross is represented here?
- a back cross
  - a test cross
  - a complementation test
  - a reciprocal cross
  - a genetic screen
17. The genotype,  $A/a ; B/b ; C/C ; d/d ; E/E ; F/f$ , represents an individual that is a:
- monohybrid
  - dihybrid
  - trihybrid
  - hexahybrid
  - true-breeding

**Questions 18-19.** Wire coats in dogs are controlled by a single gene, *W*. Dogs with at least one dominant allele, *W*, have wire coats. Homozygous recessive, *ww*, dogs have smooth coats. Another gene, *S*, controls the presence of white in the coat. Dogs that are *S-* have solid dark coats. Dogs that are *ss* dogs have white coats. A third gene controls ear shape. Dogs with at least one dominant allele, *F*, have upright ears. Dogs that are homozygous recessive, *ff*, have folded ears. All three genes are autosomal and independently assorting. Trihybrid females are crossed to trihybrid males. The next two questions refer to this information.

18. What is the probability that the first offspring of the above cross will be *WW Ff SS*?

- a)  $2/27$
- b)  $1/64$
- c)  $1/16$
- d)  $1/32$
- e) none of the above

19. The above cross produced an offspring with a upright ears. What is the probability that this offspring is *Ww FF ss*?

- a)  $1/24$
- b)  $1/12$
- c)  $1/16$
- d)  $4/27$
- e) none of the above

**Questions 20-21.** You cross a white cat with a brown cat and all of the progeny are white colored. Now you cross two of these white cats and in the *F2* progeny you see 1013 white colored cats, 450 brown colored cats and now, in addition, you see 338 black colored cats. The parental genotypes are *AA BB* (white) and *aa bb* (brown).

20. What term best describes the genetic interaction based on the phenotypes in the *F2* generation?

- a) Complete dominance
- b) Recessive epistasis
- c) Recessive lethal allele
- d) Complementation
- e) Dominant epistasis

21. Of the following options, which is NOT a possible genotype of the brown colored cat?

- a) *aa BB*
- b) *AA Bb*
- c) *aa Bb*
- d) *aa bb*

**Questions 22-23.** Scientists crossed two purple-flowered strains of the sweet pea (*Lathyrus odoratus*) and obtained the following progeny: 3583 purple, 853 yellow, and 260 white seedlings. As advanced geneticists, you propose a theory that there are two genes controlling flower colour in *L. odoratus* and that they are interacting by dominant epistasis.

22. Test your theory by calculating a  $\chi^2$  value for the data your observed.

- a) 0.7
- b) 4.2
- c) 5.7
- d) 0.3
- e) none of the above

23. What is your conclusion from your  $\chi^2$  statistical test?

- a) P value greater than 0.05. Fail to reject the null hypothesis.
- b) P value greater than 0.05. Reject the null hypothesis.
- c) P value less than 0.05. Reject the null hypothesis.
- d) P value less than 0.05. Fail to reject null hypothesis.

24. If you were performing another  $\chi^2$  statistical test, and you generated a P-value between 0.9 and 0.5, what does this conclude about your theory?

- a) There is between a 50% and 90% chance that you did the experiment correctly.
- b) There is greater than a 50% chance that the difference between expected and observed progeny is due to something other than chance.
- c) You probably made an error in calculating your expected progeny to obtain this probability.
- d) There is a between a 50% and 90% chance that the difference between expected and observed progeny is due to chance
- e) There is between a 50% and 90% chance that the difference between expected and observed progeny is significant

25. Which of the following is NOT an example of a modified dihybrid ratio?

- a) 9:3:4
- b) 15:3
- c) 12:3:1
- d) 9:7
- e) 15:1

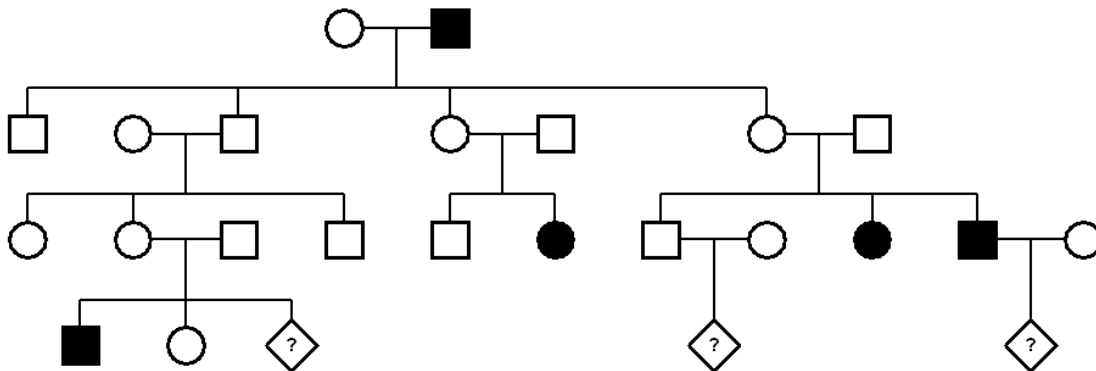
26. Which statement is false when describing euchromatin?

- a) Highly dynamic
- b) Low gene density
- c) Most of the chromosome
- d) Transcriptionally active
- e) More than one of the above is false

27. What is the effect of acetylation on histone tails?

- a) Tightening association of DNA around nucleosomes, silencing transcription
- b) Weakening association of DNA around nucleosomes, silencing transcription
- c) Tightening association of DNA around nucleosomes, permitting transcription
- d) Weakening association of DNA around nucleosomes, permitting transcription

**Questions 28 - 30.** Recent evidence suggests that a disease is associated with genomic imprinting. Below is a pedigree showing the pattern of inheritance of this trait.



28. If a father is affected by the disorder, what is the probability of his children being affected?

- a) 0%
- b) 25%
- c) 50%
- d) 100%

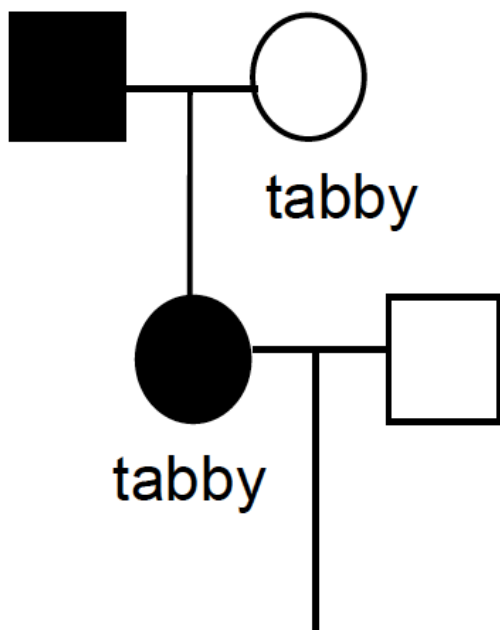
29. If a father is affected by the disorder and passes the mutation on to his daughter, will his grandchildren be affected?

- a) Yes, for each there is a 100% chance of being affected
- b) Yes, for each there is a 50% chance of being affected
- c) No, there is no chance of being affected

30. This is likely an example of:

- a) Maternal imprinting to silence the a gene
- b) Paternal imprinting to silence the a gene
- c) Y-linked inheritance
- d) X-inactivation
- e) More than one of the above

**Questions 31-33.** Bent tails and tabby coats are two rare dominant sex-linked traits in the mouse. The allele which produces bent tails, *Bn*, and the allele which produces tabby coats, *T*, are 16 map units apart on the X chromosome. Examine the pedigree below. Note: Mice with bent tails are indicated by solid symbols. Mice with tabby coats are indicated by the word “tabby” under the symbol. The next three questions refer to this information.



31. What is the probability that II-1 will produce *bn t* gametes?

- a) 8%
- b) 9%
- c) 42%
- d) 16%
- e) none of the above

32. What is the probability that the first offspring of II-1 and II-2 will have a bent tail and a non-tabby coat?

- a) 84%
- b) 76%
- c) 42%
- d) 8%
- e) none of the above

33. Imagine II-1 and II-2 have produced a male offspring with a bent tail. What is the probability this offspring will also have a tabby coat?

- a) 8%
- b) 16%
- c) 42%
- d) 84%
- e) none of the above

**Questions 34-36.** In pea plants, yellow peas (G) are dominant to green peas (g) and tall plants (T) are dominant to short plants (t). Imagine that gene G is linked to gene T and they are 32 map units apart. True-breeding yellow short pea plants are crossed with true breeding green tall pea plants. Use this information to answer the following three questions.

34. What is the genotype of the F1?

- a) Gt//gT
- b) GT//Gt
- c) gT//gt
- d) GT//gt
- e) More than one of the above is possible

35. The F1 offspring are test-crossed. What percentage of offspring will be yellow and short pea plants?

- a) 8%
- b) 16%
- c) 32%
- d) 34%
- e) 68%

36. The F1 offspring are intercrossed. What approximate percentage of offspring will be green short pea plants?

- a) 2%
- b) 8%
- c) 16%
- d) 32%
- e) none of the above

37. An individual with a trisomy in chromosome 13 will be diagnosed as having:

- a) Turner Syndrome
- b) Down Syndrome
- c) Edward Syndrome
- d) Patau Syndrome

38. A phenotypically normal female and a phenotypically normal male have a child with Klinefelter Syndrome who is  $XcbXcb Y$  and colourblind. Which of the following statements describes the meiotic event/s that gave rise to this child?

- a) A meiosis I nondisjunction occurred in the female parent.
- b) A meiosis II nondisjunction occurred in the female parent.
- c) A meiosis I nondisjunction occurred in the male parent.
- d) A meiosis II nondisjunction occurred in the male parent.
- e) None of the above

**Questions 39-41.** The fescue grass, *F. sativa* ( $2N=22$ ) was pollinated by *F. punctoria* ( $2N=26$ ) and this cross produced many hybrid plants. Most of the hybrids were infertile except for a few plants which were very robust with long leaves, long stems and large seeds. Breeders decided that the fertile hybrids were polyploids and gave them the name *F. titanica*. The next three questions refer to this information.

39. How many bivalents would be observed in *F. titanica* cells during Prophase I?

- a) 24
- b) 29
- c) 48
- d) 12
- e) none of the above

40. In the laboratory, *F. titanica* plants were back-crossed to *F. sativa*, to produce an infertile hybrid. How many chromosomes would be found in the somatic cells of the infertile hybrid?

- a) 43
- b) 48
- c) 35
- d) 11
- e) none of the above

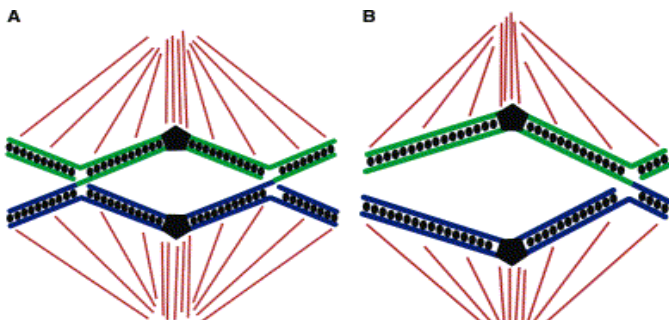
41. Germ cells from the infertile hybrid produced in question 40 do undergo meiosis. What would you expect to see at Prophase I?

- a) There are no homologous chromosomes so pairing would not be seen
- b) 15 bivalents and 14 univalents
- c) 11 bivalents and 13 univalents
- d) 24 bivalents and 9 univalents
- e) 24 bivalents and 22 univalents

42. Proteins encoded by mitochondrial genes:

- a) Function only in the mitochondria
- b) Are transported out of the mitochondria and function in the cytoplasm
- c) Are involved in the process of photosynthesis
- d) Can remain in the mitochondria or be transported out of the mitochondria to the cytoplasm

43. Why is the bivalent formed in image A more stable than the bivalent formed in image B?



- a) Increased cohesin distal to the crossover site in bivalent A compared with B
- b) Increased number of chiasmata in bivalent A compared with B
- c) Stronger synaptonemal complex formed in bivalent A compared with B
- d) A and B
- e) All of the above

44. A woman has pattern baldness and albinism (an autosomal recessive trait). She marries a man that is heterozygous for both of these traits. Of their male progeny, what proportion will show albinism and pattern baldness?

- a) 100%
- b) 50%
- c) 25%
- d) 12.5%
- e) none of the above

45. Epigenetic effects include:

- a) The compaction of one of the X chromosomes in female mammals.
- b) The imprinting of regions of chromosomes for greater or lesser expression by one parent and not the other.
- c) The methylation of a particular gene that alters that gene's expression.
- d) More than one of the above.
- e) All of the above.

**Table 3.5** Critical values of the  $\chi^2$  distribution

df	p									
	0.995	0.975	0.9	0.5	0.1	0.05*	0.025	0.01	0.005	
1	0.000	0.000	0.016	0.455	2.706	3.841	5.024	6.635	7.879	
2	0.010	0.051	0.211	1.386	4.605	5.991	7.378	9.210	10.597	
3	0.072	0.216	0.584	2.366	6.251	7.815	9.348	11.345	12.838	
4	0.207	0.484	1.064	3.357	7.779	9.488	11.143	13.277	14.860	
5	0.412	0.831	1.610	4.351	9.236	11.070	12.832	15.086	16.750	
6	0.676	1.237	2.204	5.348	10.645	12.592	14.449	16.812	18.548	
7	0.989	1.690	2.833	6.346	12.017	14.067	16.013	18.475	20.278	
8	1.344	2.180	3.490	7.344	13.362	15.507	17.535	20.090	21.955	
9	1.735	2.700	4.168	8.343	14.684	16.919	19.023	21.666	23.589	
10	2.156	3.247	4.865	9.342	15.987	18.307	20.483	23.209	25.188	
11	2.603	3.816	5.578	10.341	17.275	19.675	21.920	24.725	26.757	
12	3.074	4.404	6.304	11.340	18.549	21.026	23.337	26.217	28.300	
13	3.565	5.009	7.042	12.340	19.812	22.362	24.736	27.688	29.819	
14	4.075	5.629	7.790	13.339	21.064	23.685	26.119	29.141	31.319	
15	4.601	6.262	8.547	14.339	22.307	24.996	27.488	30.578	32.801	

P probability; df, degrees of freedom.

\*Most scientists assume that, when  $P < 0.05$ , a significant difference exists between the observed and the expected values in a chi-square test.