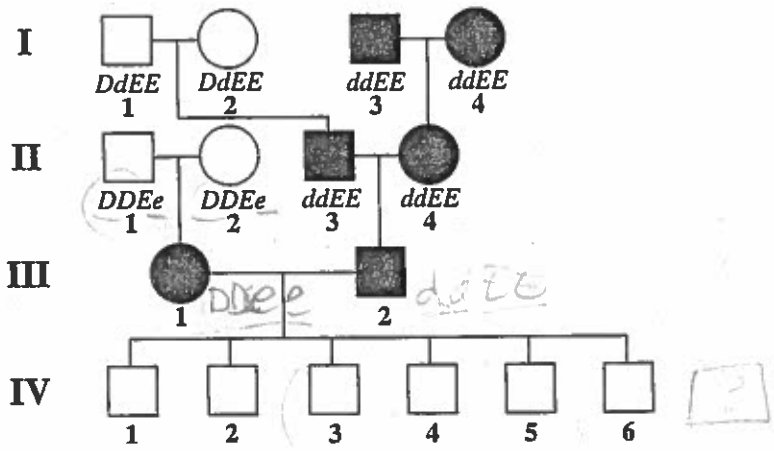
"A"

Use the following information to answer the next three questions.

Deaf-mutism is an autosomal recessive trait that is caused by two genes. Individuals who are homozygous recessive for either gene will have deaf-mutism. The two genes are designated as *D* and *E* in the diagram below.

Partial Pedigree for Deaf-Mutism



—from *Huskey, 1998*

1. A possible genotype of individual **IV-3** is DdEe

A. *ddEE*
B. *ddEe*
C. *DDee*
D. *DdEe*

2. Individuals **III-1** and **III-2** are expecting their seventh child. What is the probability of this child having deaf-mutism?

De
dE | DdEe

A. 0.00
B. 0.25
C. 0.50
D. 0.75

Numerical Response

dihybrid DdEe x DdEe

1. What is the probability of a couple that are heterozygous for both genes having a child with deaf-mutism?

9:3:3:1

Answer: 0.44

3+3+1 = 7

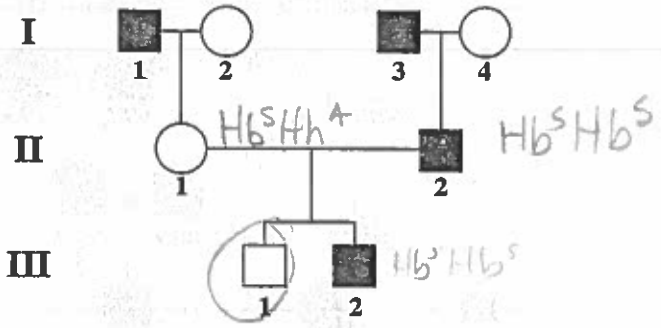
DdEe DDee ddEe ddee

(Record your answer as a value from 0 to 1, rounded to two decimal places, in the numerical-response section on the answer sheet.)

7/16 = 0.4375

Use the following information to answer the next three questions.

In the hypothetical pedigree below, shaded individuals have sickle cell anemia and are homozygous for the defective allele Hb^S. The normal allele is Hb^A. Carriers of the Hb^S allele are not identified in the pedigree.



3. Individual **III-1** has blood type A. His genotype could be

A. $I^A i\ Hb^A Hb^S$
B. $I^A I^A\ Hb^S Hb^S$
C. $I^A I^B\ Hb^A Hb^S$
D. $I^A I^A\ Hb^A Hb^A$

	Hb^S	Hb^S
Hb^S	$Hb^S Hb^S$	$Hb^S Hb^S$
Hb^A	$Hb^S Hb^A$	$Hb^S Hb^A$

4. If individual **II-1** has blood type A and individual **II-2** has blood type B, which of the following genotypes would be possible for their third child, if they had one?

A. $I^A i\ Hb^A Hb^S$
B. $I^A I^A\ Hb^S Hb^S$
C. $I^B I^B\ Hb^A Hb^S$
D. $I^A I^B\ Hb^A Hb^A$

A	i	
A	A	or
B	i	
B	B	

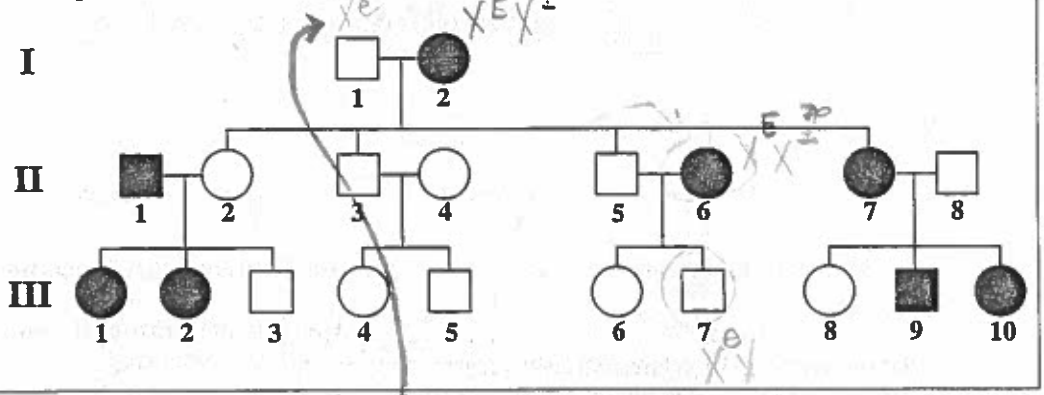
5. Which of the following rows indicates the relationship between the I^A and I^B alleles and the relationship between the I^A and i alleles for the blood type gene?

Row	Relationship between I^A and I^B	Relationship between I^A and i
A.	codominant	~~codominant~~
B.	codominant	dominant-recessive
C.	dominant-recessive	codominant
D.	dominant-recessive	dominant-recessive

Use the following information to answer the next three questions.

A dominant allele, X^E, carried on the X chromosome causes the formation of faulty tooth enamel and causes either very thin or very hard enamel.

Hypothetical Pedigree Showing the Incidence of Faulty Tooth Enamel



6. The genotypes of individuals **II-6** and **III-7** are identified in row

Row	II-6	III-7
A.	X^EX^E	~~X^EY~~
B.	X^EX^e	X^eY
C.	X^eX^e	~~X^EY~~
D.	X^EX^E	X^eY

Numerical Response

7. A woman heterozygous for faulty tooth enamel marries a man with normal tooth enamel. What is the probability that their first child will be a boy with normal tooth enamel?

Answer: 0.25

(Record your **answer as a value from 0 to 1, rounded to two decimal places,** in the numerical-response section on the answer sheet.)

$X^EX^e \times X^eY$

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

7. The faulty tooth enamel trait will appear in all of the daughters but none of the sons if the children have a father with

A. normal tooth enamel and a mother with normal tooth enamel
B. ~~normal~~ tooth enamel and mother with faulty tooth enamel
C. faulty tooth enamel and a mother with normal tooth enamel
D. faulty tooth enamel and a mother with faulty tooth enamel

Use the following information to answer the next two questions.

Cross-over Frequencies of Some Genes on Human Chromosome 6

Genes	Approximate Cross-over Frequencies
Diabetes mellitus (1) and ovarian cancer (2)	21%
Diabetes mellitus (1) and Rhesus blood group (3)	12%
Ragweed sensitivity (4) and Rhesus blood group (3)	10.5%
Rhesus blood group (3) and ovarian cancer (2)	9%
Ragweed sensitivity (4) and ovarian cancer (2)	19.5%

Numerical Response

3. On human chromosome 6, the order of the genes numbered above is 1, 4, 3, and 2.

(Record your **four-digit answer** in the numerical-response section on the answer sheet.)

8. What is the approximate cross-over frequency between the diabetes mellitus gene and the ragweed sensitivity gene?

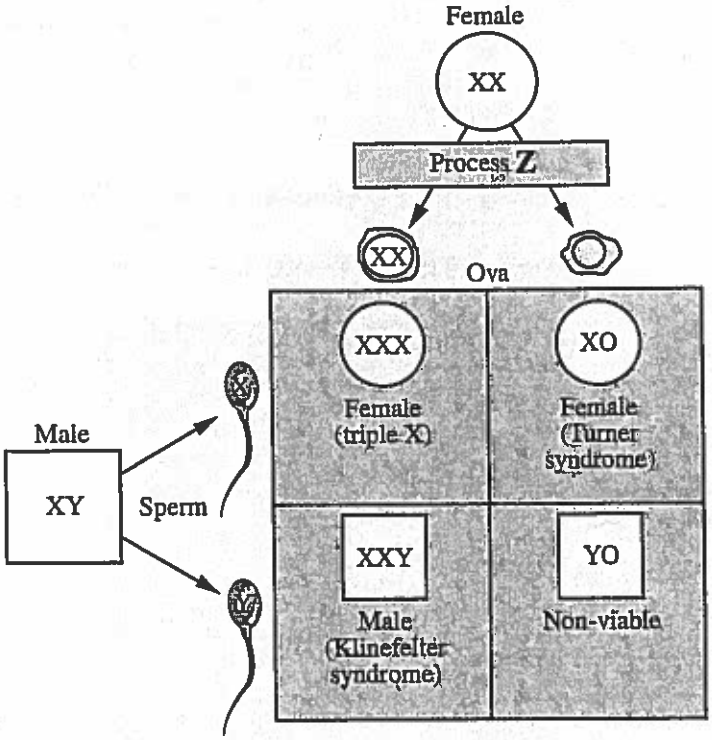
A. 1.5%
B. 10.5%
C. 15.0%
D. 22.5%

21 − (9 + 10.5)

= 1.5%

Use the following information to answer the next three questions.

Meiosis is a process that results in the reduction of the chromosome number from diploid to haploid. Sometimes chromosomes fail to separate, which results in an abnormal number of sex chromosomes.



—from *Levine and Miller, 1991*

9. Process **Z** represents

A. fertilization
B. crossing-over
C. nondisjunction
D. spermatogenesis

Use the following additional information to answer the next question.

Scientists studying Klinefelter and Turner syndromes wanted to determine which of several hypotheses about gender determination was most likely. These hypotheses were:

- presence of a Y chromosome causes maleness
- lack of a second X chromosome causes maleness
- the presence of two X chromosomes causes femaleness
- the Y chromosome is not involved in gender determination

Evidence noted by the scientists included the following points.

- Individuals with Klinefelter syndrome (XXY) have genitalia and internal ducts that are usually male, but their testes are underdeveloped.
- Individuals with Turner syndrome (XO) have female external genitalia and internal ducts; however, the ovaries are underdeveloped.

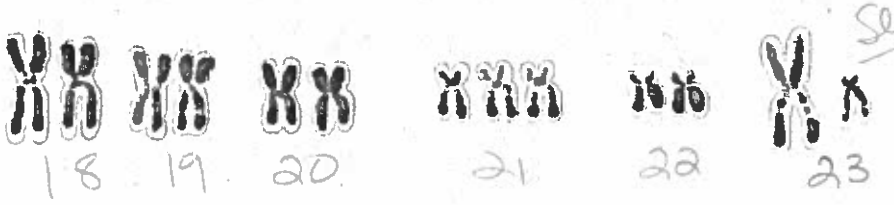
—from *Cummings and Klug, 1997*

10. This evidence **best** supports which of the scientists' hypotheses about gender determination?

A. The presence of a Y chromosome causes maleness.
B. The lack of a second X chromosome causes maleness.
C. The presence of two X chromosomes causes femaleness.
D. The Y chromosome is not involved in gender determination.

Use the following additional information to answer the next question.

Partial Human Karyotype



11. This partial human karyotype represents the **last** six chromosome pairs, in numerical order. The karyotype presented is that of a

A. male with trisomy 21
B. female with trisomy 21
C. male with Turner syndrome
D. female with Turner syndrome

Use the following information to answer the next two questions.

In tomato plants, purple stems (*P*) are dominant to green stems (*p*), and red tomatoes (*T*) are dominant to yellow tomatoes (*t*). The two genes are located on separate chromosomes.

A purple-stemmed, red-tomato plant is crossed with a purple-stemmed, yellow-tomato plant. They produce:

28 purple-stemmed, red-tomato plants
31 purple-stemmed, yellow-tomato plants
11 green-stemmed, red-tomato plants
9 green-stemmed, yellow-tomato plants

12. The genetic composition of the parents is

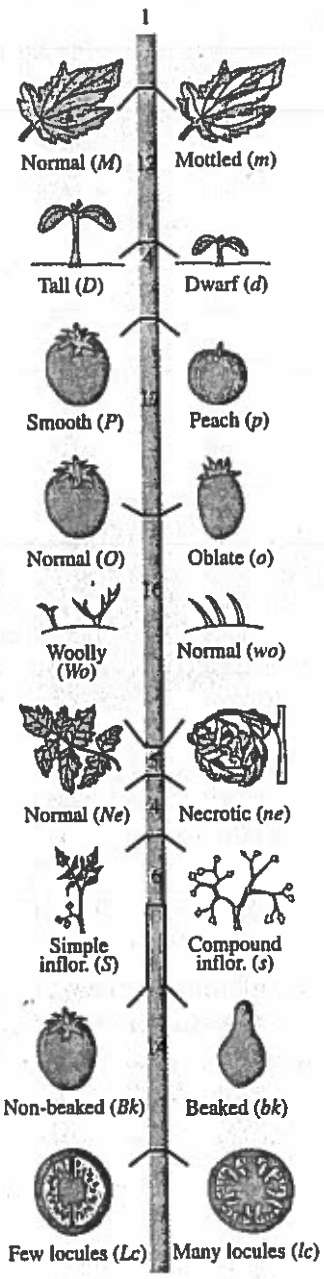
A. *PpTt* and *PPTT*
B. *PPTt* and *PpTT*
C. *PpTt* and *PpTt*
D. *PpTt* and *Pptt*

13. One of the green-stemmed, red-tomato plants was crossed with another tomato plant. One of the offspring was a purple-stemmed, yellow-tomato plant. If this offspring were crossed with a green-stemmed, yellow-tomato plant, then the possible phenotype or phenotypes of the offspring would be

A. green-stemmed, yellow-tomato plants
B. green-stemmed, yellow-tomato plants and purple-stemmed, yellow-tomato plants
C. green-stemmed, yellow-tomato plants; purple-stemmed, yellow-tomato plants; and purple-stemmed, red-tomato plants
D. green-stemmed, yellow-tomato plants; purple-stemmed, yellow-tomato plants; purple-stemmed, red-tomato plants; and green-stemmed, red-tomato plants

Use the following information to answer the next two questions.

Gene Loci for a Tomato Plant



—from *Griffiths et al., 1993*

14. During meiosis, which of the following pairs of genes has the greatest chance of being separated by crossing over?

farthest away.

A. (*m*) and (*d*) least
B. (*ne*) and (*p*) 3 away
C. (*m*) and (*lc*)
D. (*p*) and (*o*) least

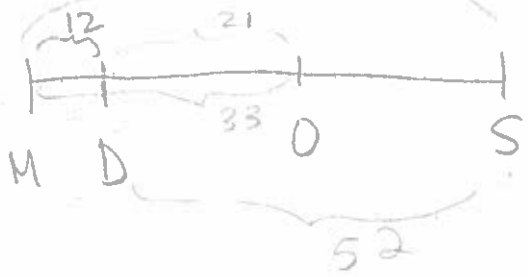
Use the following additional information to answer the next question.

Cross-over frequencies for some genes on a tomato plant:

Genes	Cross-Over Frequency
normal leaf (*M*) and tall plant (*D*)	12%
normal leaf (*M*) and normal tomato (*O*)	33%
normal leaf (*M*) and simple inflorescence (*S*)	64%
tall plant (*D*) and normal tomato (*O*)	21%
tall plant (*D*) and simple inflorescence (*S*)	52%

15. The cross-over frequency between genes *O* and *S* is 64

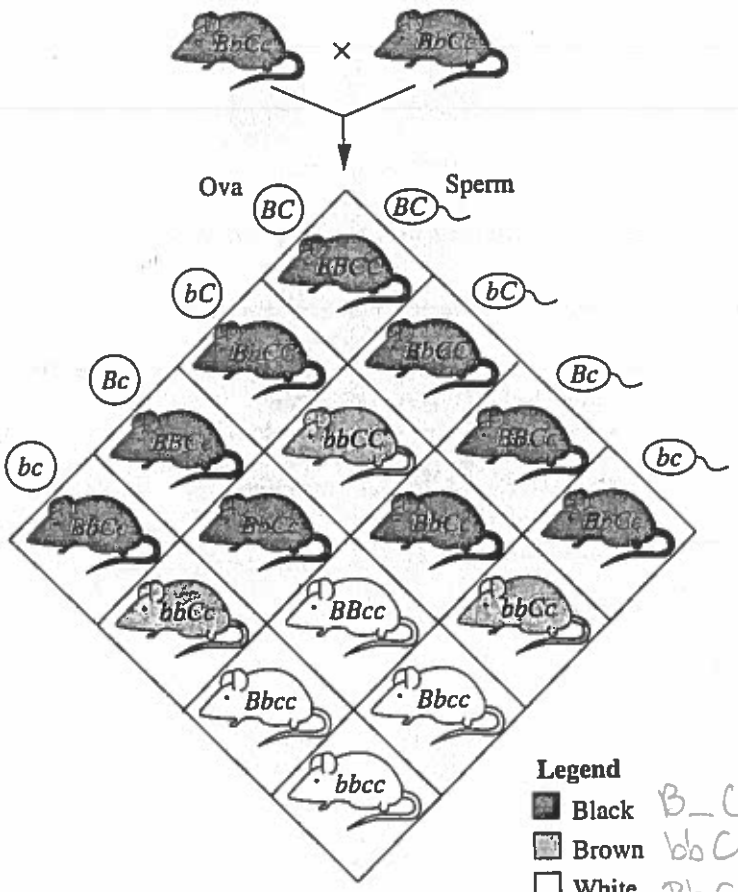
A. 6%
B. 29%
C. 31%
D. 97%



52 - 21 = 31

Use the following information to answer the next three questions.

Punnett Square for a Dihybrid Cross to Investigate Coat Colour in Mice



Coat colour in mice is controlled by the interaction of two genes. Three phenotypes result: black coat, brown coat, and white coat.

—from *Campbell, 1993*

16. In the dihybrid cross between the two black mice, the *C* allele codes for

A. black colour
B. brown colour
C. colour absent
D. colour present

BbCc x BbCc

black
9 B_C_
3 B_cc
brown 3 bbCc
white 1 bbcc

Numerical Response

4. What is the expected phenotypic ratio that results from a cross between two black mice heterozygous for both genes?

Phenotypic Ratio: 9 : 3 : 4
Coat Colour: **Black** : **Brown** : **White**

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

bbCc x BbCc
bC bc BC Bc bC bc

Numerical Response

5. What is the expected phenotypic ratio resulting from a cross between a *bbCc* female mouse and *BbCc* male mouse?

Phenotypic Ratio: 3 : 3 : 2
Coat Colour: **Black** : **Brown** : **White**

bC bc
BC | BbCC | BbCc
Bc | BbCc | Bbcc
bC | bbCC | bbCc
bc | bbCc | bbcc

(Record your **three-digit answer** in the numerical-response section on the answer sheet.)

3 black
3 brown 2 white

Use the following information to answer the next question.

Farmers who raise sheep for wool try not to produce offspring with black wool. Black wool is very brittle and difficult to dye; therefore, white wool is more desirable. If a farmer purchases a white ram, he will generally carry out a test cross to determine whether the ram is heterozygous or homozygous for white wool. White wool (*W*) is dominant to black wool (*w*).

Ww
ww homozygous recessive

17. If the ram is heterozygous for white wool, the expected phenotypes of the offspring of the farmer's test cross would be

A. all black

B. all white

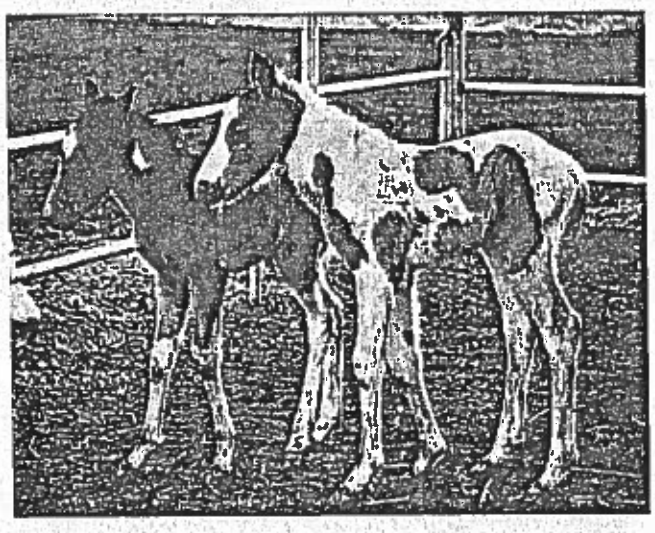
C. $\frac{1}{2}$ black and $\frac{1}{2}$ white

D. $\frac{3}{4}$ black and $\frac{1}{4}$ white

W w
w | Ww | ww
w | Ww | ww
1/2 white
1/2 black

Use the following information to answer the next three questions.

Tobiano Twin Colts



—Ramirez, 2000

Descriptions and Symbols Used to Represent One Type of Coat Colour in Horses

1	2	3	4
DNA sequence for coat colour	*TT, Tt*	*T*	Tobiano (white spotting pattern)
	tt	*t*	Not tobiano (no white spotting pattern)

Numerical Response

6. Using the numbers above, match these descriptions and symbols with the term below to which they apply.

Description or Symbol Number:	1	3	4	2
Term:	**gene**	**allele**	**phenotype**	**genotype**

(Record all **four digits** of your answer in the numerical-response section on the answer sheet.)

18. What are the genotypes for coat colour of two horses that are predicted to produce offspring in a 1:1 genotypic ratio?

A. *Tt* and *tt*
B. *Tt* and *Tt*
C. Tobiano and tobiano
D. Tobiano and not tobiano

Numerical Response

Given that the diploid number for horses is 64, what is the number of chromosomes found in a horse's somatic cell **and** what is the number of chromosomes found in a horse's gamete cell?

Number of Chromosomes: ____ ____ , ____ ____

Cell Type: somatic cell gamete cell

(Record **all four digits** of your answer in the numerical-response section on the answer sheet.)

Use the following information to answer the next six questions.

Cat coat colour results from the interaction of three different genes. A gene for black-based colours is located on an autosomal chromosome. A gene for red-based colours is located on the X chromosome. A different gene located on a separate autosomal chromosome determines pigment density in cat hair.

The black-based gene has three possible alleles: *B*–black, *b*–chocolate, and b^l–cinnamon. If pigmentation in cat hair is dense, the phenotypes listed below are possible.

Genotype	Phenotype
BB, Bb, Bb^l	black
bb, bb^l	chocolate
b^lb^l	cinnamon

19. According to the data above, the relationship among these alleles is such that the

A. black allele is codominant with the chocolate and cinnamon alleles

B. black allele is codominant with the chocolate allele, and the chocolate allele is codominant with the cinnamon allele

C. black allele is dominant over the chocolate and cinnamon alleles, and the chocolate allele is dominant over the cinnamon allele

D. black allele is dominant over the chocolate and cinnamon alleles, and the chocolate and cinnamon alleles are codominant

Use the following additional information to answer the next two questions.

There are two alleles for the pigment-density gene: dense pigment (*D*) and dilute pigment (*d*). The chart below shows the interaction of two autosomal genes affecting coat colour—the black-based gene and the density gene.

Black-based pigment gene	Density gene	
	*D_*	*dd*
*B_*	*B_D_* black colour	*B_dd* blue colour
bb; bb^l	*bbD_; bb^{l}D_* chocolate colour	*bbdd; bb^{l}dd* lilac colour
b^{l}b^l	*b^{l}b^{l}D_* cinnamon colour	*b^{l}b^{l}dd* fawn colour

20. A blue-coloured female cat is bred with a cinnamon-coloured male cat. The offspring produced are black-coloured, blue-coloured, chocolate-coloured, and lilac-coloured. The genotypes of the parental cats are indicated in row

Row	Female Cat	Male Cat
A.	*Bb^{l}dd*	*b^{l}b^{l}Dd*
B.	*Bb^{l}dd*	*b^{l}b^{l}DD*
C.	*Bbdd*	*b^{l}b^{l}Dd*
D.	*Bbdd*	*b^{l}b^{l}DD*

B_dd x b'b'D_

Black: bD, b'd

	bD	b'd
Bd	BbD_	Bb'dd — blue
b'd	b'bD_	b'b'dd — lilac

cinnamon

Bb'dd x bbDd

21. A black-coloured female cat with the genotype *BbDd* is bred with a fawn-coloured male cat. The percentage of their offspring predicted to be chocolate-coloured is

A. 13%
B. 19%
C. 25%
D. 50%

BbDd x b'b'dd

BD Bd bD bd — b'd

b'd

	b'd
BD	Bb'Dd
Bd	Bb'dd
bD	bb'Dd
bd	bb'dd

1/4

Use the following additional information to answer the next three questions.

In cats, red pigmentation is dominant to black pigmentation. The red pigment gene, which is located on the X chromosome, has two alleles: X^R and X^r. Cats with at least one X^R allele have some orange-coloured hair as a result of having the red-based pigment. Cats with only X^r alleles have no red-based pigment. Male cats with the X^R allele will be orange. However, female cats express the genes on only one X chromosome in each cell. This expression is random. Therefore, an orange-and-black (tortoiseshell) female cat is possible if it is X^RX^r. Some genotypes and their resulting phenotypes are shown below. In all cases, pigment density is high.

Genotype	Phenotype
X^RYBb	Orange male cat
X^rYBb^l	Black male cat
X^RX^rBb	Orange-and-black female cat (tortoiseshell)

22. The phenotype of a female cat with genotype $X^rX^rBb^l$ would be

A. a black cat
B. an orange cat
C. an orange-and-black cat
D. an orange, black, and cinnamon cat

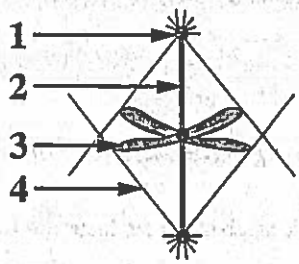
23. A cinnamon-coloured male cat ($X^rYb^lb^l$) is bred with an orange-coloured female cat (X^RX^RBB). What possible phenotypes could be produced in the offspring?

A. Tortoiseshell-coloured female cats and orange-coloured male cats
B. Tortoiseshell-coloured female cats, black-coloured female cats, and black-coloured male cats
C. Cinnamon-coloured male cats, orange-coloured female cats, and tortoiseshell-coloured female cats
D. Cinnamon-coloured male cats, black-coloured male cats, black-coloured female cats, orange-coloured female cats, and tortoiseshell-coloured female cats

Use the following information to answer the next three questions.

Investigators were interested in determining the role chromosomes play in the formation of the mitotic spindle. Using extracts of eggs from the African frog *Xenopus laevis*, they monitored spindle assembly in a test tube. The researchers replaced the chromosomes with beads coated with random sequences of DNA. The beads served as substitute genetic material, but centrosomes (centrioles) were absent. As well, a part of the centromere was missing.

Simplified Diagram of Normal Mitotic Cell



—from *Travis, 1996*

24. Which of the structures numbered above was replaced by the beads in the experimental setup?

A. 1
B. 2
C. 3
D. 4

Use the following additional information to answer the next question.

The investigators observed that the genetic material on the beads condensed and microtubules began to form. Within 90 minutes, the microtubules formed a spindle-like structure that lined up the beads along the centre of the cell.

—from *Travis, 1996*

25. Based on the results of this research, the structure or molecule that does **not** appear to be necessary for mitosis is

A. DNA
B. a spindle
C. centrosomes
D. microtubules

Use the following additional information to answer the next question.

> Other studies showed that the phase that involves pulling chromosomes to the two poles of mitotic cells can be delayed for up to 4.5 h by pulling a chromosome out of line from the centre of the cell.
>
> —from *Travis, 1996*

26. The phase that is delayed and the phase where the chromosomes line up at the equator are, respectively,

A. telophase and anaphase
B. metaphase and prophase
C. interphase and telophase
D. anaphase and metaphase

Use the following information to answer the next two questions.

> Cystic fibrosis is a recessive Mendelian trait in the human population. A symptom of cystic fibrosis is the production of large amounts of mucin protein. New studies indicate that although the cystic fibrosis condition is present at birth, increased mucin production is preceded by an infection with the bacterium *Pseudomonas aeruginosa*. Individuals who are not affected by cystic fibrosis produce a natural antibiotic, defensin, that kills the *Pseudomonas aeruginosa* and eliminates the stimulus for increased mucin production. Defensin is destroyed by a high chloride content in the tissues of individuals with cystic fibrosis as a result of faulty chloride-channel proteins.
>
> —from *Sternberg, 1997*

33. The allele that causes cystic fibrosis **most likely** results in a faulty amino acid sequence for the

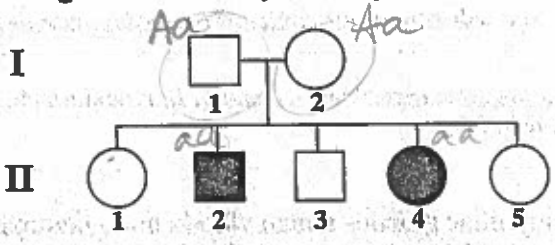
A. channel proteins
B. mucin molecules
C. defensin molecules
D. *Pseudomonas* bacteria

Use the following information to answer the next three questions.

Amniocentesis is a common prenatal procedure used to obtain cells to test for genetic abnormalities that lead to disorders such as Down syndrome, cystic fibrosis, and hemophilia. The test is usually offered between the 15th and 18th weeks of pregnancy to women who have an increased risk of having children with genetic abnormalities.

Use the following additional information to answer the next question.

Pedigree of a Family with Cystic Fibrosis



Note: Cystic fibrosis in this family is caused by a recessive allele that is found on chromosome 7.

27. Prior to performing amniocentesis, a genetic counsellor collected pedigree information regarding the incidence of cystic fibrosis within this family. The row that indicates the genotypes of individuals **I-1**, **I-2**, and **II-2** is

Row	I-1	I-2	II-2
A.	*Aa*	*Aa*	*aa*
B.	*AA*	*aa*	*Aa*
C.	X^AY	X^AX^A	X^aY
D.	X^AY	X^AX^a	X^AY

Down syndrome is a trisomy disorder that can be caused by the presence of three copies of chromosome 21. Which of the following chromosome combinations identifies Down syndrome?

A. 46 chromosomes consisting of 45 autosomes and 1 sex chromosome
B. 46 chromosomes consisting of 44 autosomes and 2 sex chromosomes
C. 47 chromosomes consisting of 45 autosomes and 2 sex chromosomes
D. 47 chromosomes consisting of 44 autosomes and 3 sex chromosomes

78. A genetic abnormality such as Down syndrome can be diagnosed by using the cells obtained during amniocentesis to create a

A. karyotype
B. therapeutic gene
C. DNA fingerprint
D. recombinant vector

Use the following information to answer the next two questions.

In humans, the allele for normal blood clotting, *H*, is dominant to the allele for hemophilia, *h*. The trait is X-linked.

79. A female hemophiliac marries a man who is not a hemophiliac. The row that indicates the probability of this couple having a child that is a hemophiliac and the sex that the child would be is

Row	Probability	Sex of Affected Child
A.	0.25	male
B.	0.25	either female or male
C.	0.50	male
D.	0.50	either male or female

$X^hX^h \times X^HY$

	X^H	Y
X^h	X^HX^h	X^hY
X^h	X^HX^h	X^hY

Numerical Response

71. A woman who is not a hemophiliac has a father who is a hemophiliac. If this woman marries a man who is a hemophiliac, what is the probability of them having a hemophiliac son?

Answer: 0.25

(Record your **answer as a value from 0 and 1, round to two decimal places** in the numerical-response section on the answer sheet.)

$X^HX^h \times X^hY$

	X^h	Y
X^H	X^HX^h	X^HY
X^h	X^hX^h	X^hY