

*January 2001*



*Biology 30*  
*Grade 12 Diploma Examination*



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January 2001

# Biology 30

## Grade 12 Diploma Examination

### Description

**Time:** This examination was developed to be completed in 2.5 h; however, you may take an additional 0.5 h to complete the examination.

This is a **closed-book** examination consisting of

- 48 multiple-choice and 8 numerical-response questions, of equal value, worth 70% of the examination
- 2 written-response questions, of equal value, worth 30% of the examination

This exam contains sets of related questions.

A set of questions may contain multiple-choice and/or numerical-response and/or written-response questions.

Tear-out data pages are included near the back of this booklet.

**Note:** *The perforated pages at the back of this booklet may be torn out and used for your rough work. No marks will be given for work done on the tear-out pages.*

### Instructions

- You are expected to provide your own calculator. You may use any scientific calculator or a graphing calculator approved by Alberta Learning. **NEW**
- You are expected to have cleared your calculator of all information that is stored in the programmable or parametric memory. **NEW**
- Use only an HB pencil for the machine-scored answer sheet.
- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- Read each question carefully.
- Consider all numbers used in the examination to be the result of a measurement or observation.
- If you wish to change an answer, erase **all** traces of your first answer.
- Do not fold the answer sheet.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Learning.
- Now turn this page and read the detailed instructions for answering machine-scored and written-response questions.

## Multiple Choice

- Decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

### Example

This examination is for the subject of

- A. biology
- B. physics
- C. science
- D. chemistry

Answer Sheet

- (B) ○ (C) ○ (D)

## Numerical Response

- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- If an answer is a value between 0 and 1 (e.g., 0.25), then be sure to record the 0 before the decimal place.
- **Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.**

### Examples

#### Calculation Question and Solution

The average of the values 21.0, 25.5, and 24.5 is \_\_\_\_\_.

(Round and record your **answer to one decimal place** in the numerical-response section on the answer sheet.)

$$\begin{aligned}\text{Average} &= (21.0 + 25.5 + 24.5)/3 \\ &= 23.666... \\ &= 23.7 \text{ (rounded to one decimal place)}\end{aligned}$$

**Record 23.7 on the answer sheet** →

2	3	.	7
		•	•
○	○	○	○
○	○	○	○
○	○	○	○
○	○	○	○
○	○	○	○
○	○	○	○
○	○	○	○
○	○	○	○
○	○	○	○
○	○	○	○
○	○	○	○
○	○	○	○
○	○	○	○

### Correct-Order Question and Solution

When the following subjects are arranged in alphabetical order, the order is \_\_\_\_\_.  
(Record your **four-digit answer** in the numerical-response section on the answer sheet.)

- 1 physics
- 2 chemistry
- 3 biology
- 4 science

Answer 3214

Record 3214 on the answer sheet

3	2	1	4
•	•		
0	0	0	0
1	1	●	1
2	●	2	2
●	3	3	3
4	4	4	●
5	5	5	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

### Selection Question and Solution

The birds in the following list are numbered \_\_\_\_\_.  
(Record your answer **in lowest-to-highest numerical order** in the numerical-response section on the answer sheet.)

- 1 dog
- 2 sparrow
- 3 cat
- 4 robin
- 5 chicken

Answer 245

Record 245 on the answer sheet

2	4	5	
•	•		
0	0	0	0
1	1	1	1
●	2	2	2
3	3	3	3
4	●	4	4
5	5	●	5
6	6	6	6
7	7	7	7
8	8	8	8
9	9	9	9

### Written Response

- Write your answers in the examination booklet as neatly as possible.
- For full marks, your answers must address **all** aspects of the question.
- Descriptions and/or explanations of concepts must be correct and include pertinent ideas, diagrams, calculations, and formulas.
- Your answers must be presented in a well-organized manner using complete sentences, correct units, and significant digits where appropriate.
- Relevant scientific, technological, and/or societal concepts and examples must be identified and made explicit.

### Additional Instructions for Students Using Word Processors

- Keep all work together. Diagrams, graphs, calculations, etc. should be placed directly on your word-processed pages.
- Staple your final printed work to the page indicated for each word-processed response.
- Indicate in the space provided on the back cover that you attached word-processed pages.



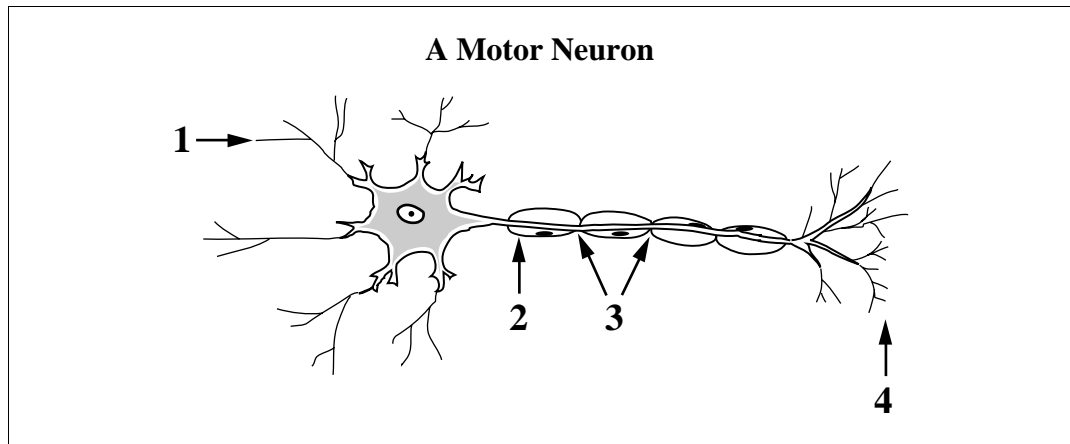
*Use the following information to answer the first question.*

After accidentally hitting your thumb with a hammer, you immediately withdraw your hand. You do not feel pain for a short period of time.

1. This sequence of events may be explained by the fact that the
  - A. threshold of the receptor has been so greatly exceeded that the neuron does not pass the message to the brain
  - B. neural impulse is so large that the brain is unable to interpret the signal because it is beyond the range of tolerance
  - C. neural processing occurred in the spinal cord first, which caused you to quickly remove your thumb from further damage
  - D. sensory receptors in the thumb were damaged by the blow and are unable to initiate a stimulus to the sensory nerve

---
  
2. Stimulation of an individual's sympathetic nervous system in response to imminent danger leads to all of the following responses **except**
  - A. dilation of the pupils of the eyes
  - B. constriction of the bronchioles of the lungs
  - C. constriction of the arterioles of the intestines
  - D. dilation of the arterioles of the skeletal muscles

Use the following information to answer the next question.



3. The part of the motor neuron that may release acetylcholine is labelled
- A. 1
  - B. 2
  - C. 3
  - D. 4
- 
4. What would happen if acetylcholine was released at a synapse, but no cholinesterase was present?
- A. The acetylcholine would fail to stimulate the postsynaptic neuron.
  - B. The acetylcholine would diffuse more rapidly across the synaptic cleft.
  - C. A single nerve impulse would be generated in the postsynaptic neuron.
  - D. The postsynaptic neuron would remain in a constant state of depolarization.



*Use the following information to answer the next question.*

The brain neurotransmitter dopamine is linked to the good feelings associated with actions such as receiving a friendly hug. When cocaine is present in synapses, it binds with dopamine transporters producing similar emotional effects. Normally, dopamine transporters carry dopamine back into the cells where it was formed.

—from *Page, 1997*

5. Dopamine transmission is affected when dopamine transporters, which normally carry dopamine back to the cell that formed it, are occupied by cocaine. The effects of cocaine occur because dopamine
- A. is produced in increased concentration
  - B. remains in the synapse in high concentration
  - C. levels drop rapidly as the molecules react with cocaine
  - D. is transported very effectively to the postsynaptic neuron
- 

*Use the following information to answer the next question.*

Morphine is a drug obtained from the opium plant. It is routinely given to postoperative patients on a short-term basis for pain. At high doses, it causes breathing and heart contraction to become suppressed.

6. What area of the brain is affected by high doses of morphine?
- A. Pituitary
  - B. Cerebrum
  - C. Cerebellum
  - D. Medulla oblongata

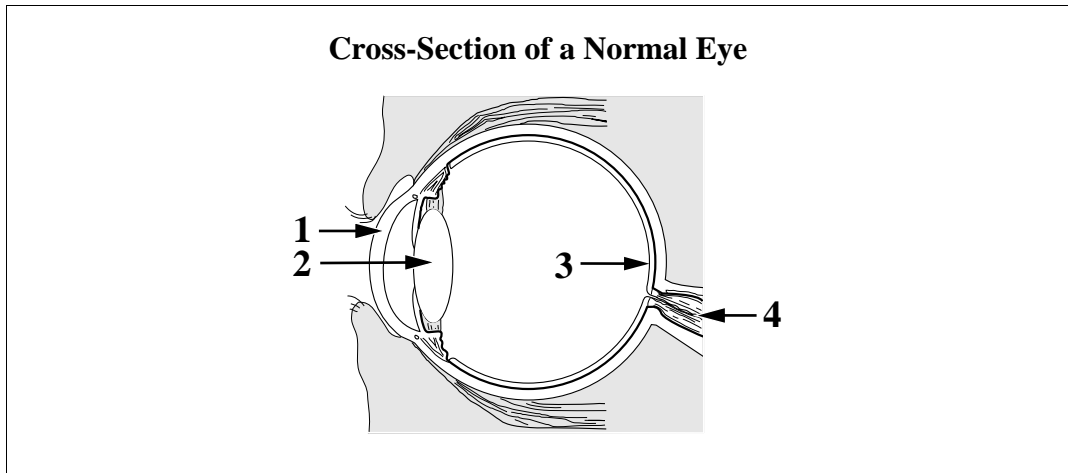
Use the following information to answer the next five questions.

A high percentage of purebred dogs have genetic defects. Some examples of these defects follow.

- 1 Hip dysplasia, a defect in the hip joints that can cripple a dog, occurs in 60% of golden retrievers.
- 2 Hereditary deafness, due to a recessive autosomal disorder, occurs in 30% of Dalmatians.
- 3 Retinal disease, which may cause blindness, occurs in 70% of collies.
- 4 Hemophilia, an X-linked recessive disorder, is common in Labrador retrievers. Dwarfism is also common in this breed of dog.

—from *Lemonick, 1994*

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



7. The structure that degenerates and causes blindness in collies is
- A. 1
  - B. 2
  - C. 3
  - D. 4
8. Collies that are bred for long noses and closely set eyes are more likely to have retinal disease. The **best** explanation for this is that
- A. closely spaced eyes cause retinal degeneration
  - B. breeders intentionally select for these three characteristics
  - C. genes for these three characteristics are on the same chromosome
  - D. the abnormal gene that causes retinal disease is on the X chromosome

## Numerical Response

1. What is the frequency of the abnormal allele that causes hearing defects in Dalmatians?

Answer: \_\_\_\_\_

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

*Use the following additional information to answer the next question.*

A healthy female Labrador retriever has won several ribbons for her appearance in dog shows. She was mated with two healthy male Labrador retrievers. In the two litters produced, some of the offspring had hemophilia and others were normal.

9. If the female is bred to one of her male offspring that does not have hemophilia, then the probability of the female offspring of this cross having hemophilia is
- A. 0%
  - B. 25%
  - C. 75%
  - D. 100%
10. The breeding of purebred dogs for certain characteristics related to appearance is blamed for the disturbing number of genetic defects in these animals. These defects are **most likely** the result of
- A. natural selection
  - B. non-random mating
  - C. geographic isolation
  - D. high rates of mutation

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

**Mature Human Oocyte**

**Human Sperm**

**Note:** The photos that originally accompanied questions 11 and 12 have been removed for electronic publishing.

11. The difference in size between the human oocyte and sperm is **mostly** due to the
- A. difference in magnification of the two photographs
  - B. distance that the sperm must travel in order to reach the oocyte
  - C. amount of cytoplasm present in the oocyte as compared with that in the sperm
  - D. number of chromosomes in the nucleus of the oocyte as compared with the number in the sperm
12. The nucleus of a human oocyte would normally be
- A. diploid and contain 23 chromosomes
  - B. diploid and contain 46 chromosomes
  - C. haploid and contain 23 chromosomes
  - D. haploid and contain 46 chromosomes

13. For the processes of spermatogenesis and oogenesis, respectively, the row that identifies the hormone that stimulates the process, the location where the process occurs, and the number of gametes produced per germ cell is

	Spermatogenesis			Oogenesis		
Row	Hormone	Location of process	Number of gametes produced	Hormone	Location of process	Number of gametes produced
A.	FSH	seminiferous tubules	4	FSH	ovaries	1
B.	LH	epididymis	8	LH	pituitary	1
C.	testosterone	interstitial cells	4	estrogen	follicle	4
D.	FSH	testes	8	progesterone	corpus luteum	4

*Use the following information to answer the next question.*

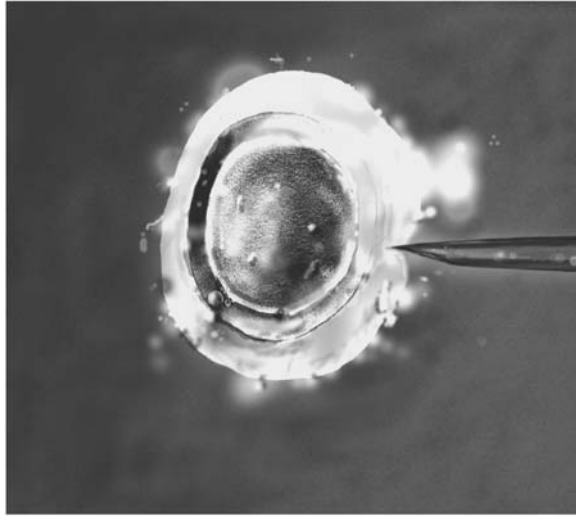
A male is having fertility problems. His sperm are not making their way to the oocyte in time to fertilize it. Analysis of his seminal fluid determines two insufficiencies.

14. The two insufficiencies in semen that would affect sperms' ability to travel to the oocyte are the lack of
- A. FSH and testosterone
  - B. fructose and testosterone
  - C. FSH and alkaline buffers
  - D. fructose and alkaline buffers

Use the following information to answer the next two questions.

The picture below shows how sperm is injected into an egg. This technology may be used to overcome infertility problems caused by sperm that are unable to penetrate an egg, or by sperm that lack a proper flagellum (tail).

### Intracytoplasmic Sperm Injection (ICSI)



15. Sperm are normally able to penetrate an egg by
- A. fusing their nuclei with the nucleus of the egg
  - B. releasing hydrolytic enzymes from the acrosome found in the head of the sperm
  - C. dissolving the covering of the egg with alkaline secretions from the prostate gland
  - D. dissolving the covering of the egg using the hydrolytic enzymes secreted from Cowper's gland
16. If, during the ICSI process, more than one sperm head were injected into the egg's cytoplasm,
- A. fraternal twins would be formed
  - B. identical twins would be formed
  - C. the zygote would develop into a male child since more male chromosomes would be present
  - D. the zygote would likely not develop because more than a diploid set of chromosomes would be present

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

Clomiphene citrate is a fertility drug used to induce ovulation in women. Clomiphene citrate, generally taken daily from day 3 to day 7 of the menstrual cycle, decreases the naturally circulating estrogen. The pituitary responds by increasing production of two gonadotropic hormones that then stimulate the ovary to ripen and release an egg. Follicle development and ovulation are usually monitored with a combination of home urine tests (on day 11 or 12) and a follow-up ultrasound examination. About 70% of women using clomiphene citrate will ovulate and 40% of those will become pregnant. The risk of multiple pregnancy (usually twins) increases by 6% to 7%.

—from Bay Area Fertility and Gynecology Medical Group

17. Without the negative feedback that results from increasing amounts of naturally circulating estrogen, the body responds by secreting more
- A. FSH
  - B. HCG
  - C. prolactin
  - D. progesterone
18. Following clomiphene citrate treatments, patients are advised to monitor their urine for the presence of a hormone that will signal ovulation. This hormone is
- A. LH
  - B. FSH
  - C. HCG
  - D. estrogen
19. The incidence of multiple births increases in women who use clomiphene citrate because high levels of
- A. progesterone may stimulate the release of more than one egg
  - B. FSH may stimulate the fertilized egg cell to divide and separate
  - C. FSH may stimulate the complete development of more than one follicle
  - D. progesterone may stimulate the fertilized egg cell to divide and separate

20. During the first three days of development, the human embryo obtains nutrients and energy from the
- A. HCG
  - B. amniotic fluid
  - C. cytoplasm of the mother's egg
  - D. mitochondria of the father's sperm

*Use the following information to answer the next question.*

**Human Embryo Six Weeks After Fertilization**

**Note:** The photograph that originally accompanied numerical response 2 has been removed for electronic publishing.

**Numerical Response**

2. Match each embryonic structure, as numbered above, with the letter that represents its function, as listed above.

**Structure:** \_\_\_\_\_  
**Function:**    **A**                    **B**                    **C**                    **D**

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



21. The presence of a particular hormone in urine indicates that pregnancy has occurred. This hormone is secreted by the
- A. ovary
  - B. amnion
  - C. chorion
  - D. pituitary

*Use the following information to answer the next question.*

**Some Events in Labour**

- 1 Uterine contractions increase in force.
- 2 Oxytocin travels through the bloodstream.
- 3 Nervous impulses are sent to the hypothalamus.
- 4 Oxytocin is released from the posterior pituitary.

**Numerical Response**

3. At the onset of labour, a baby's head pushes on the cervix. Following this, the events given above, listed in the order in which they occur, are \_\_\_\_\_, \_\_\_\_\_, \_\_\_\_\_, and \_\_\_\_\_.

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

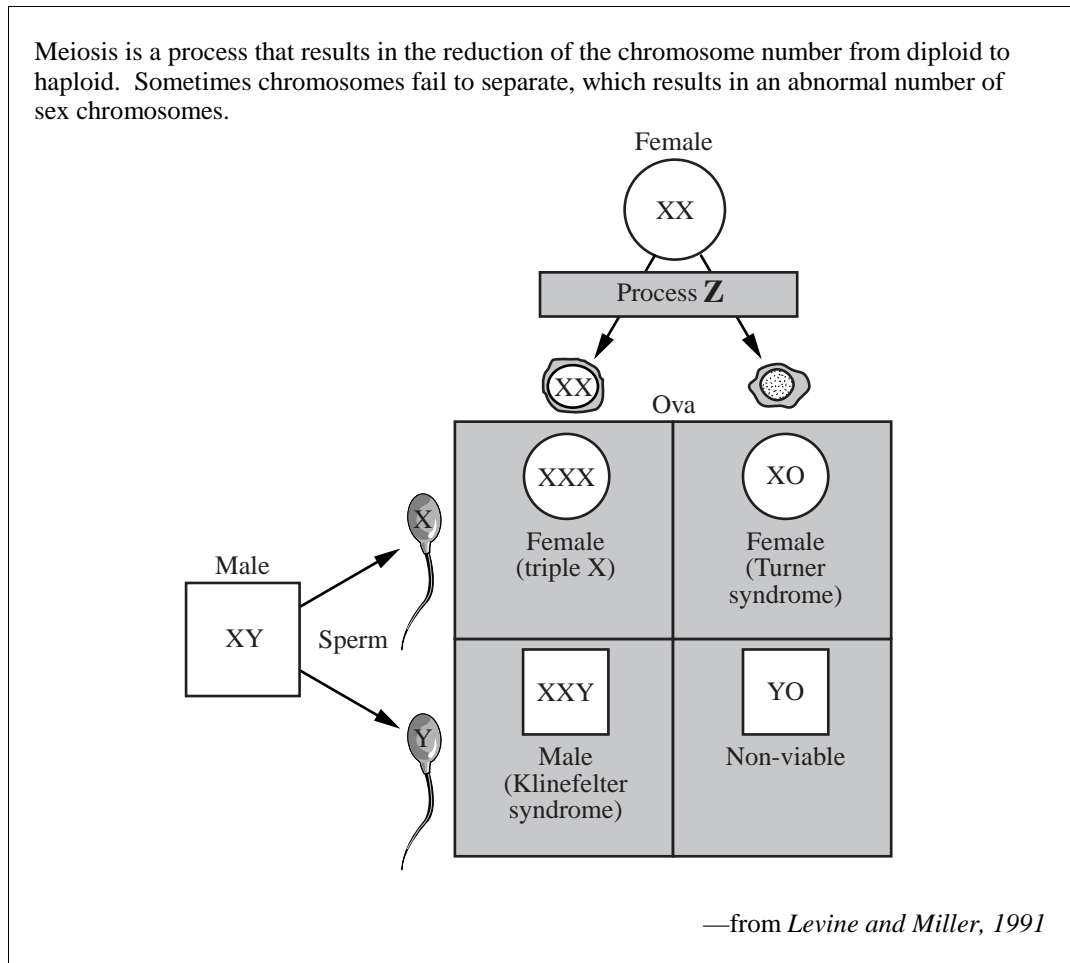
\_\_\_\_\_

*Use the following information to answer the next question.*

Premature infants born at 24-weeks gestation face a wide spectrum of physiological problems.

22. These problems arise because prior to the third trimester of pregnancy, fetuses
- A. have organs that are underdeveloped
  - B. have not yet begun cell specialization
  - C. depend upon amniotic fluid for oxygen
  - D. depend upon amniotic fluid for nutrients

Use the following information to answer the next three questions.



23. 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*

24. 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



25. 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 four questions.

Tay-Sachs disease is a hereditary disease that kills 1 in 360 000 individuals in the general population, but 1 in 4 800 among the Ashkenazi (Eastern European) Jews. The disease disrupts or halts proper formation of lysosomes and increases fat deposition around the nerve sheath. Individuals that are homozygous for the defective allele have Tay-Sachs disease and die at an early age. Studies suggest that heterozygous individuals have a higher survival rate against tuberculosis than the rest of the population. Biochemical tests can be done to determine if parents are carriers.

—from *Cummings, 1994*

26. What type of inheritance is demonstrated in Tay-Sachs disease?
- A. Autosomal recessive
  - B. Autosomal dominant
  - C. Sex-linked recessive
  - D. Sex-linked dominant
27. If tuberculosis regained its former role as one of the world's deadliest diseases, then the frequency of the Tay-Sachs allele over time would
- A. decrease because of a decreased selective advantage
  - B. increase because of an increased selective advantage
  - C. decrease because of an increased selective advantage
  - D. remain the same as a result of Hardy–Weinberg equilibrium

## Numerical Response

4. A young couple decided to have genetic screening done to determine if they were carriers of Tay-Sachs disease. If both individuals were carriers, what percentage of their offspring would be predicted to have protection from tuberculosis but not have Tay-Sachs disease?

Answer: \_\_\_\_\_%

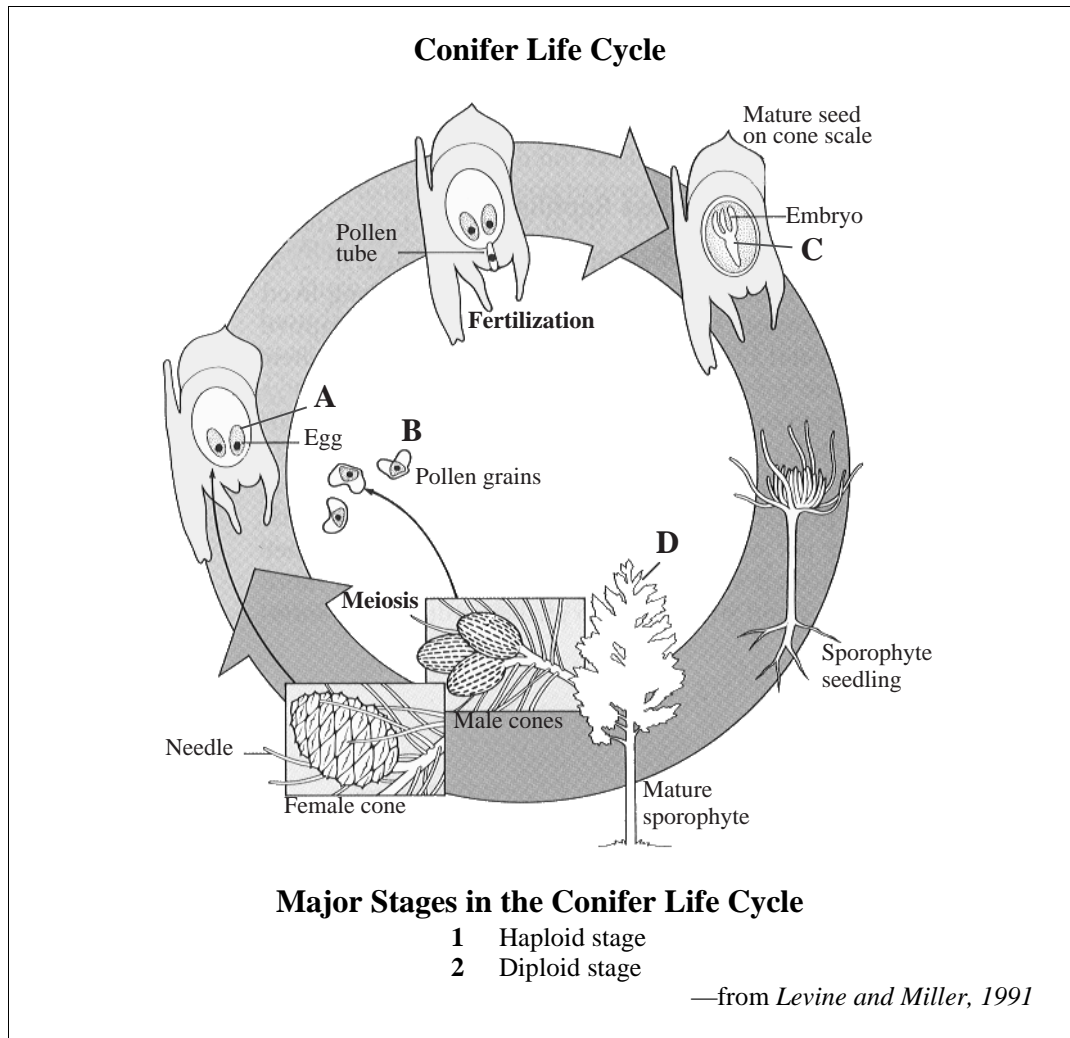
(Record your answer **as a whole number percentage** in the numerical-response section on the answer sheet.)

*Use the following additional information to answer the next question.*

Genetic screening can involve producing complimentary DNA probes of a gene's alleles and determining if these bind to an individual's DNA sample.

28. Genetic screening results show that an individual is a carrier of Tay-Sachs if the individual's DNA binds to
- A. none of the DNA probes
  - B. two of the normal allele DNA probes
  - C. two of the defective allele DNA probes
  - D. one of the normal allele DNA probes and one of the defective allele DNA probes

Use the following information to answer the next question.



**Numerical Response**

- 5.** Identify the stages in the conifer life cycle, as numbered above, that correspond with the letters that represent these stages on the diagram.

**Stages:** \_\_\_\_\_  
**Diagram:**      A                B                C                D  

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

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.

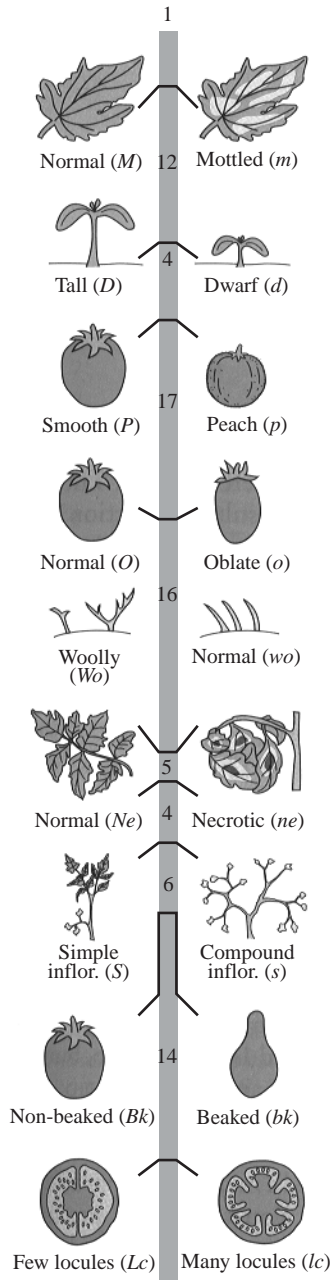
A purple-stemmed, red-tomato plant is crossed with a purple-stemmed, yellow-tomato plant. They produce:

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

29. The genetic composition of the parents is
- A.  $PpTt$  and  $PPTT$
  - B.  $PPTt$  and  $PpTT$
  - C.  $PpTt$  and  $PpTt$
  - D.  $PpTt$  and  $Pp tt$
30. 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



31. During meiosis, which of the following pairs of genes has the greatest chance of being separated by crossing over?
- A.  $(m)$  and  $(d)$
  - B.  $(ne)$  and  $(p)$
  - C.  $(m)$  and  $(lc)$
  - D.  $(p)$  and  $(o)$

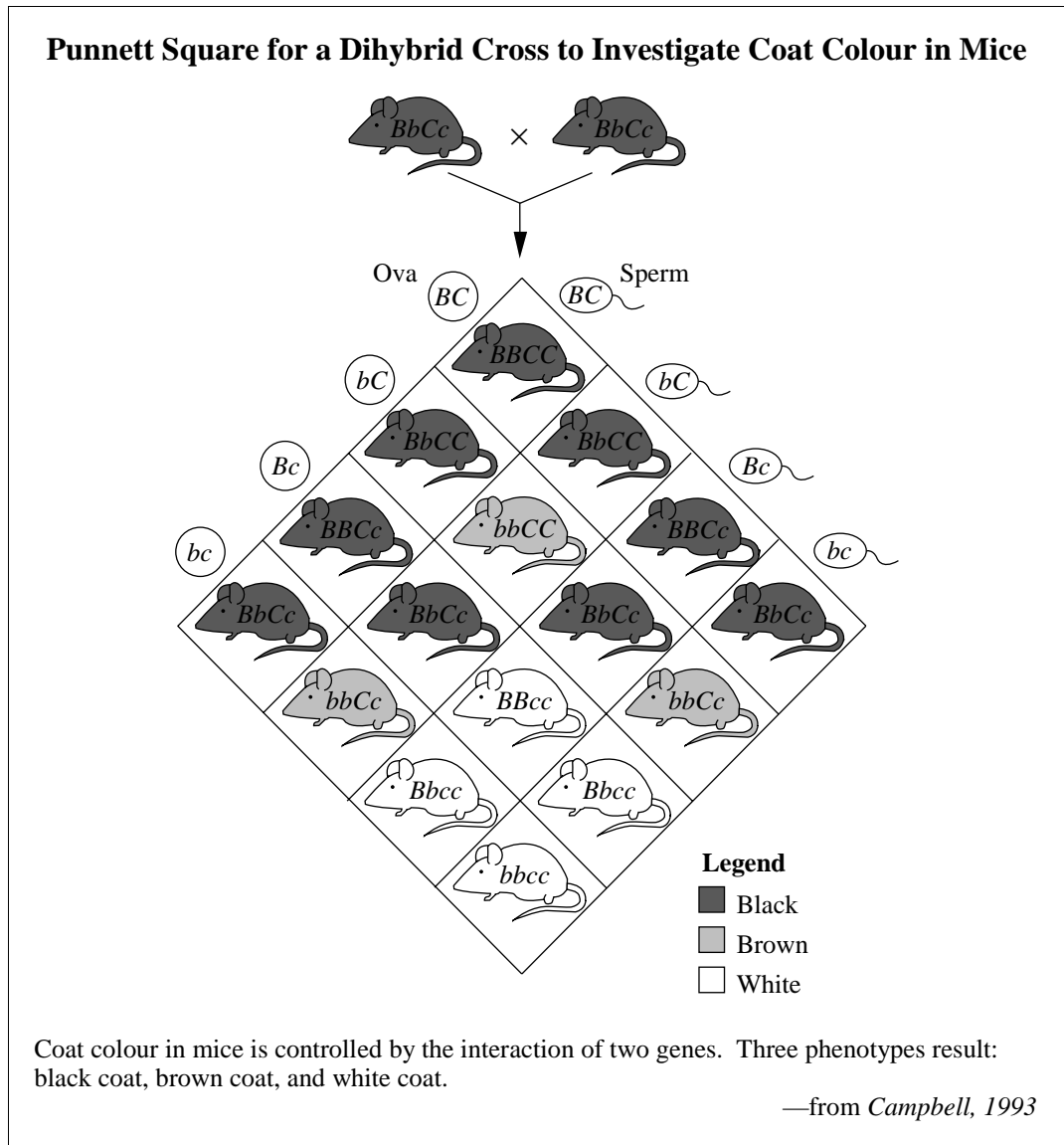
*Use the following additional information to answer the next question.*

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%

32. The cross-over frequency between genes  $O$  and  $S$  is
- A. 6%
  - B. 29%
  - C. 31%
  - D. 97%

Use the following information to answer the next three questions.



33. 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

### Numerical Response

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

Phenotypic Ratio: \_\_\_\_\_ : \_\_\_\_\_ : \_\_\_\_\_  
Coat Colour:      **Black**              **Brown**              **White**

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

### Numerical Response

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

Phenotypic Ratio: \_\_\_\_\_ : \_\_\_\_\_ : \_\_\_\_\_  
Coat Colour:      **Black**              **Brown**              **White**

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

*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*).

34. 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

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

Researchers have found a gene known as p53. It codes for a protein that binds to specific areas of DNA and activates them. This causes the production of a set of proteins that halts cell division or, in some cells, activates the cell's suicide program (apoptosis). The p53 gene is activated when a cell is damaged and/or undergoes a DNA mutation.

—from *Seachrist, 1996*

35. The normal function of the p53 gene is likely to
- A. encourage a cell to undergo mitosis
  - B. encourage a cell to undergo meiosis
  - C. prevent an abnormal cell from reproducing
  - D. prevent the transcription of a cell suicide gene

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

Research on the p53 gene was initially done with cancer cells obtained from a laboratory animal. These cells were grown in a petri dish. A cell with two normal *p53* alleles was found to have normal cell division. Cells with one normal and one mutated *p53* allele were also found to have normal cell division. Cells that had mutations in both *p53* alleles were unable to control cell division and were associated with cancer.

36. The initial research findings described above
- A. demonstrate that the activated p53 gene causes cancer in lab animals
  - B. demonstrate that the p53 protein causes the formation of cancer cells
  - C. indicate that the normal p53 gene is responsible for preventing cancer in all mammals
  - D. indicate that the normal p53 gene is responsible for preventing cancer under laboratory conditions
37. Gene therapy that might stop uncontrolled cell division due to the mutant *p53* allele would require
- A. one functional *p53* allele to be successfully inserted into cancer cells
  - B. two functional *p53* alleles to be successfully inserted into cancer cells
  - C. one functional *p53* allele to be successfully removed from cancer cells
  - D. two functional *p53* alleles to be successfully removed from cancer cells

38. Which of the following rows correctly describes a DNA molecule?

Row	Components	Backbone	Molecules that form the links between two strands
A.	amino acids, sugars, and bases	sugars and bases	amino acids
B.	amino acids, sugars, and bases	sugars and amino acids	bases
C.	phosphates, sugars, and bases	sugars and bases	phosphates
D.	phosphates, sugars, and bases	sugars and phosphates	bases

*Use the following information to answer the next question.*

A section of template DNA contains the following proportions of bases:

adenine—20%      thymine—30%      cytosine—10%      guanine—40%

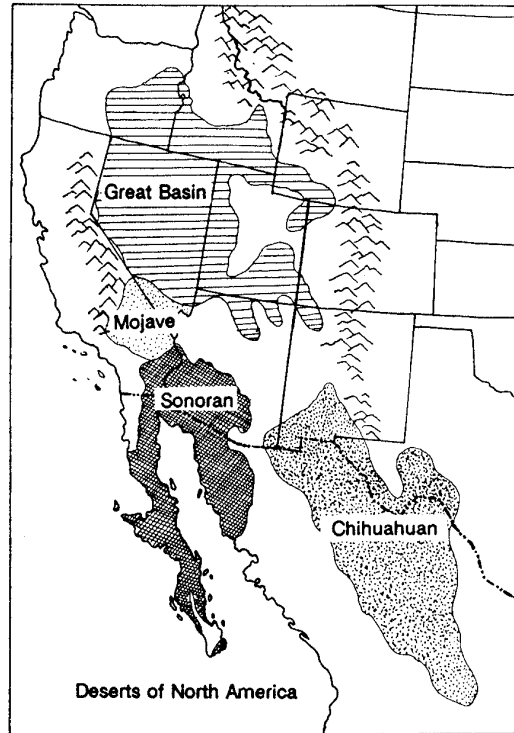
39. The proportions of three of the mRNA nucleotides produced from this DNA are

- A. 20% adenine, 30% uracil, and 10% cytosine
- B. 40% cytosine, 20% adenine, and 30% uracil
- C. 20% uracil, 40% cytosine, and 10% guanine
- D. 20% thymine, 30% adenine, and 10% guanine

Use the following information to answer the next two questions.

The location of the Sonoran Desert results in unique climatic conditions. It has a warmer average temperature, less frequent frosts, and more rainfall than other deserts. This unique climate results in more diversity in the organisms that occupy this particular desert.

—from *Naylor, 1995*



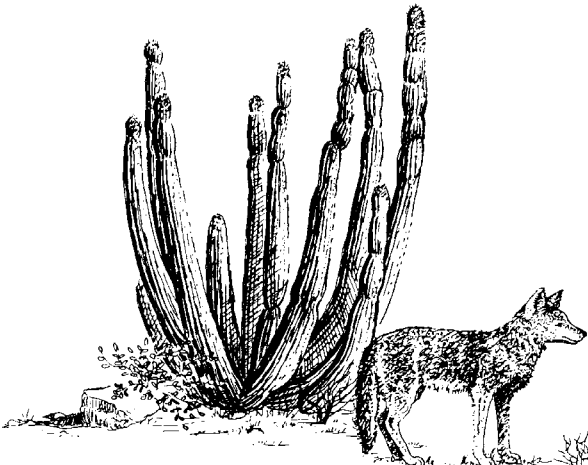
40. The factors that contribute most to the relatively great diversity of organisms in the Sonoran Desert as compared with that in other deserts are
- A. biotic factors that increase the biotic potential
  - B. abiotic factors that reduce reproductive isolation
  - C. abiotic factors that reduce environmental resistance
  - D. biotic factors that increase the carrying capacity of the area
41. In the Sonoran Desert, all the populations of all the organisms occupying that desert represent
- A. a habitat
  - B. a community
  - C. a geographic range
  - D. an ecological niche

Use the following information to answer the next two questions.

**Organ Pipe Cactus**

The organ pipe cactus has flowers that open at night. Bats and insects pollinate these flowers. The fruit of the cactus is eaten by birds and small mammals. Birds and small mammals scatter and distribute the fruit seeds. The coyote, in turn, feeds on the birds and small mammals.

— from *Naylor, 1995*



42. The relationships described above between the organ pipe cactus and insects, and between the organ pipe cactus and small mammals are identified in row

Row	Cactus and Insects	Cactus and Small Mammals
A.	predator–prey	predator–prey
B.	predator–prey	mutualism
C.	mutualism	mutualism
D.	mutualism	predator–prey

43. The flowers of the organ pipe cactus open during the night and close during the day to avoid dehydration during the heat of the day. This adaptation of the cacti to the desert climate **most likely** occurred as a result of
- A. increased mutation rates in flowers stimulated by high temperatures
  - B. increased reproductive success of cacti with flowers that opened at night
  - C. the intense heat of the desert, which destroyed all flowers that opened during the day and caused the cacti to open its flowers at night
  - D. the reaction of the cacti to the extreme heat, which caused it to close its flowers during the day and to gradually develop the behaviour of opening its flowers at night

*Use the following information to answer the next four questions.*

In Canada, to manage the harvest of fish, government departments issue quotas based on population estimates. Problems in salmon and cod fisheries have drawn attention to problems in the calculation of the estimates. Quotas based on these estimates have led to overharvesting and have driven the cod fishery into disaster.

44. The carrying capacity for northern cod in Canada's Atlantic region may be described as the
- A. harvest quota that permits sustainable yield
  - B. harvest quota that matches the natural mortality of the cod
  - C. decline on a growth curve that shows the population size dropping
  - D. plateau on a growth curve that shows the population size has reached a limit
45. The Atlantic cod moratorium was a government-enforced period of no fishing. The original two-year moratorium has been extended. Which of the following measures would be **most useful** when predicting the size of the cod population two years in the future?
- A. Cod lifespan and natality rate
  - B. Cod biotic potential and future fishing quotas
  - C. Migration patterns and predator population size
  - D. Present population size and present population growth rate
46. When fisheries' quotas were set too high, it may have been because assumptions were made by government regulators that led them to expect cod stocks to grow rapidly after harvest. One such assumption could have been that cod
- A. have low fecundity and high mortality
  - B. are relatively *r*-selected with a high biotic potential
  - C. have high competition and density independent natality
  - D. are relatively K-selected in regions of high environmental resistance



Use the following additional information to answer the next question.

<b>Terms and Descriptions Related to Populations</b>		
<b>Term</b>	<b>Effect of Small Population</b>	<b>Result of Rebuilt Population</b>
<b>1</b> Carrying capacity	<b>4</b> Increased mutation rate	<b>7</b> Hardy–Weinberg equilibrium
<b>2</b> Chaos theory	<b>5</b> Chance loss of genes	<b>8</b> Secondary succession to a different climax community
<b>3</b> Genetic drift	<b>6</b> Increased intraspecific competition	<b>9</b> Reduced genetic variability

### **Numerical Response**

- 8.** Drastic reduction of a population raises the concern that a rebuilt population may show significant differences from the original population. Identify the term, effect, and result, as numbered above, that describe this concern.

**Answer:** \_\_\_\_\_  
**Term**                      **Effect**                      **Result**

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

Use the following information to answer the next two questions.

The red-winged blackbird's adaptability has allowed it to become one of the most abundant birds in North America.

—photo from *Grolier Multimedia Encyclopedia*, 1999



### A Study of a Red-Winged Blackbird Nesting Site

The initial population of red-winged blackbirds was 208.

	End of Year 1	End of Year 2
Births	22	43
Deaths	4	7
Birds entering area	0	2
Birds leaving area	2	5

47. A conclusion about this nesting site study is that the red-winged blackbird population increased because
- A. natality plus immigration exceeded mortality plus emigration
  - B. mortality plus emigration exceeded natality plus immigration
  - C. natality plus emigration exceeded mortality plus immigration
  - D. mortality plus immigration exceeded natality plus emigration
48. Gause's principle states that when two different populations occupy the same ecological niche, one of the populations will be eliminated. Both the mallard duck and the red-winged blackbird occupy wetland areas. The duck and the red-winged blackbird can live in the same habitat because there is
- A. little intraspecific competition for food and breeding areas
  - B. little interspecific competition for food and breeding areas
  - C. significant intraspecific competition for food and breeding areas
  - D. significant interspecific competition for food and breeding areas

Use the following information to answer the next question.

Insulin-dependent diabetes mellitus (IDDM), also known as Type I diabetes or juvenile diabetes, is a disorder of glucose homeostasis in which the body's ability to produce insulin is impaired. People suffering from IDDM experience high blood sugar levels, increased thirst, frequent urination, extreme tiredness, and weight loss (despite an increased appetite). These symptoms can result in long-term complications that affect the eyes, kidneys, nerves, and blood vessels.

—from *OMIM*

**Written Response – 15%**

Staple your word-processed response for **this** question to this page.

- 1.** a. Explain why people with untreated IDDM often suffer from extreme tiredness and why they experience weight loss even though their blood sugar levels are higher than normal. **(2 marks)**
- b. Diabetes insipidus is a disorder that results from underproduction of ADH. Both diabetes mellitus and diabetes insipidus result in a large increase of urine output. Explain how a urine sample produced by a patient with diabetes mellitus and a urine sample produced by a patient with diabetes insipidus are different. **(1 mark)**

- c. About one in seven IDDM diabetics also suffer from “polyglandular autoimmune syndrome.” In addition to their diabetic symptoms, these individuals have thyroid disease and poorly functioning adrenal glands.
- i. Identify a hormone that is produced in either the thyroid gland or the adrenal gland that affects blood sugar levels. **(1 mark)**
  
  - ii. State the normal effect this hormone has on blood sugar levels when its secretion increases. Explain what causes the change in blood sugar levels. **(2 marks)**

*Use the following additional information to answer the next part of the question.*

Of individuals with IDDM, 50% also suffer from diabetic neuropathy. Nerves are progressively destroyed, possibly due to blockage of the tiny blood vessels that supply blood to the nerves.

—from *National Eye Institute*

- d. One patient with diabetic neuropathy walked on a broken ankle for two weeks without knowing it. Others, unknowingly, have foot ulcers (bleeding sores) on the soles of their feet. Based on this information, predict the type of neuron you suspect is damaged in these patients. Explain how the symptoms of diabetic neuropathy support your prediction. **(2 marks)**

Use the following additional information to answer the next part of the question.

The most common eye disease in individuals with IDDM is “diabetic retinopathy.” This disease is characterized by changes in the blood vessels of the retina. In some people, the blood vessels may swell and leak fluid, and in other people, abnormal blood vessels grow on the surface of the retina.

—from *National Eye Institute*

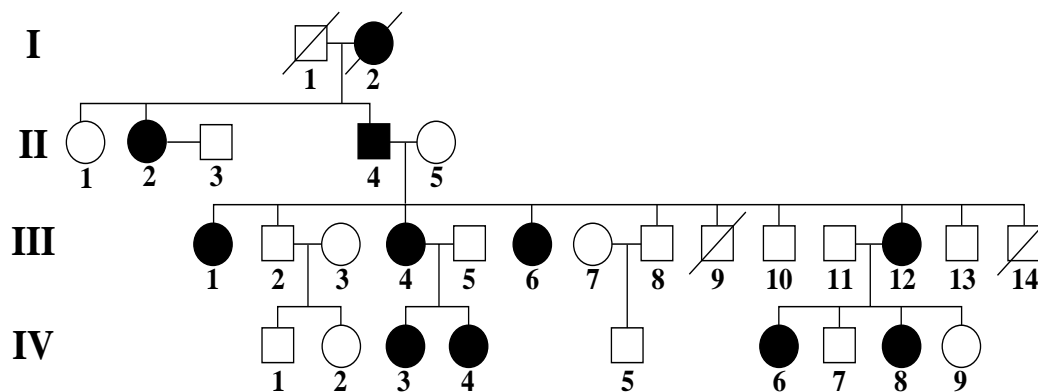
- e. Explain why diabetic retinopathy may result in some vision loss or blindness. In your answer, refer to the eye structure and the pathway of impulses to the brain. **(2 marks)**
- f. Insulin is a protein hormone. It has been hypothesized that a change in the 57<sup>th</sup> amino acid of this hormone from asparagine to another amino acid will result in an increased risk for developing IDDM.
- i. Write a DNA triplet that codes for asparagine. **(1 mark)**
- ii. Show how a single base change in this DNA triplet would code for an amino acid other than asparagine. Identify the amino acid coded for by the mutated DNA triplet. **(1 mark)**

Use the following information to answer the next question.

Larry and Danny Gomez, two boys known as “Wolf Boys,” have made the circus their adoptive family. Both boys perform as trampoline acrobats, and Danny also does motorcycle stunts. The boys have a condition called congenital hypertrichosis (CH), which is a very rare X-linked dominant inherited condition. CH is characterized by the growth of dark hair over the body, particularly on the face and upper torso in males. The palms of the hands, soles of the feet, and mucus membranes are not affected by this condition. A press release about the circus stated that Larry and Danny have travelled to many countries in search of a cure. When asked about the search for a cure in an interview by David Staples of *The Edmonton Journal* (May 14, 1997), Larry said, “I’d never take it off. I’m very proud to be who I am.” Outside the circus, the boys enjoy activities typical of most boys their age. Danny likes to play video and board games, and Larry is interested in science and is taking astronomy by correspondence.

Researchers continue to investigate the process of hair growth and the causes of hair distribution at the molecular level. The relevant molecules are expected to act on hair follicles. Hair follicle distribution in humans is primarily a hormone-dependent secondary sex characteristic. In addition to searching for a cure for CH, research in this area may also have significant applications in the treatment of acquired or inherited baldness.

The incidence of CH is very rare: only about 50 affected individuals have been reported since the Middle Ages. The incidence of this condition is considerably higher in a small Mexican village than it is in the rest of the human population. In 1984, researcher Macias-Flores studied CH in a large, five-generation Mexican family and found 19 individuals with CH. A partial pedigree showing the sampled individuals from the Macias-Flores study is shown below.



—from Staples, 1997, and Figuera et al., 1995

**Written Response – 15%**

Staple your word-processed response for **this** question to this page.

**2.** Write a unified response on the following aspects of CH.

- **Identify** the hormone responsible for secondary sex characteristics in males **or** females, and **describe** the secondary sex characteristics, including hair follicle distribution patterns, resulting from this hormone’s stimulation.
- **Identify** the genotypes for individuals II-4, II-5, III-11, III-12, IV-6, IV-7, IV-8, and IV-9 in one of the lines of inheritance on the pedigree. (Provide a key for the allele symbols you use.) **Construct** a Punnett square to predict the probability of individuals III-11 and III-12’s next child being a male with CH. **Explain** why more females than males inherit CH in generation III.







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A series of horizontal dotted lines for writing answers.

*You have now completed the examination.  
If you have time, you may wish to check your answers.*

## References

- MC5 Page, S. 1997. The pursuit of pleasure. *The Edmonton Journal*, 10 August.
- MC7–10, NR1 Lemonick, M.D. 1994. A terrible beauty. *Time*, 4 December, 54–58.
- MC17–19 Bay Area Fertility and Gynecology Medical Group. “Clomiphine citrate.” <http://www.ihr.com/bafertil/articles/clomiphe.html>
- MC24 Cummings, M. and W. Klug. 1997. *Concepts of Genetics*. Toronto: Prentice Hall Inc.
- MC26–28, NR4 Cummings, M. 1994. *Human Heredity*. St. Paul: West Publishing Company.
- MC35–37 Seachrist, L. 1996. “Only the strong survive, the evolution of a tumor favors the meanest, most aggressive cells.” *Science News* 149(4): 216–217.
- MC40–41  
MC42–43 Naylor, V.J. 1995. *Ajo Mountain Drive Road Guide*. Arizona: Southwest Parks and Monuments Association.
- WR1 OMIM: Online Mendelian Inheritance in Man. “Diabetes mellitus, juvenile-onset insulin-dependent; IDDM.” <http://www3.ncbi.nlm.nih.gov/Omim/>
- National Eye Institute. “Diabetic neuropathy: The nerve damage of diabetes” and “Don’t lose sight of diabetic eye disease.” <http://www.niddk.nih.gov/>
- WR2 Staples, D. 1997. Wolf Boys no freaks, just kids proud of who they are. *The Edmonton Journal*, 14 May.
- Figuera, L.E. et al. 1995. Mapping of the congenital generalized hypertrichosis locus to chromosome Xq24–q27.1. *Nature Genetics* 10: 202–207.
- Pivnick, E.K. et al. “Hypertrichosis, facial dysmorphism, pigmentary retinopathy: A new syndrome?” <http://www.circ.uab.edu/sergg/f95/neuro8.htm>

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## BIOLOGY DATA

## Symbols

Symbol	Description
$D_p$	population density
$N$	numbers of individuals in a population
$A$	area, space, or volume occupied by a population
$t$	time
$\Delta$	change
$r$	biotic potential OR maximum per capita population growth rate
$K$	carrying capacity
$\frac{\Delta N}{\Delta t}$	a change in population size during time interval
$>$	greater than, dominant over
$<$	less than, recessive to

Symbol	Description
$\sigma$	male
$\varphi$	female
$n$	chromosome number
$B, b$	alleles; upper case is dominant, lower case is recessive
$I^A, I^B, i$	alleles, human blood type (ABO)
$P$	parent generation
$F_1, F_2$	first, second filial (generation)
$p$	frequency of dominant allele
$q$	frequency of recessive allele

## Equations

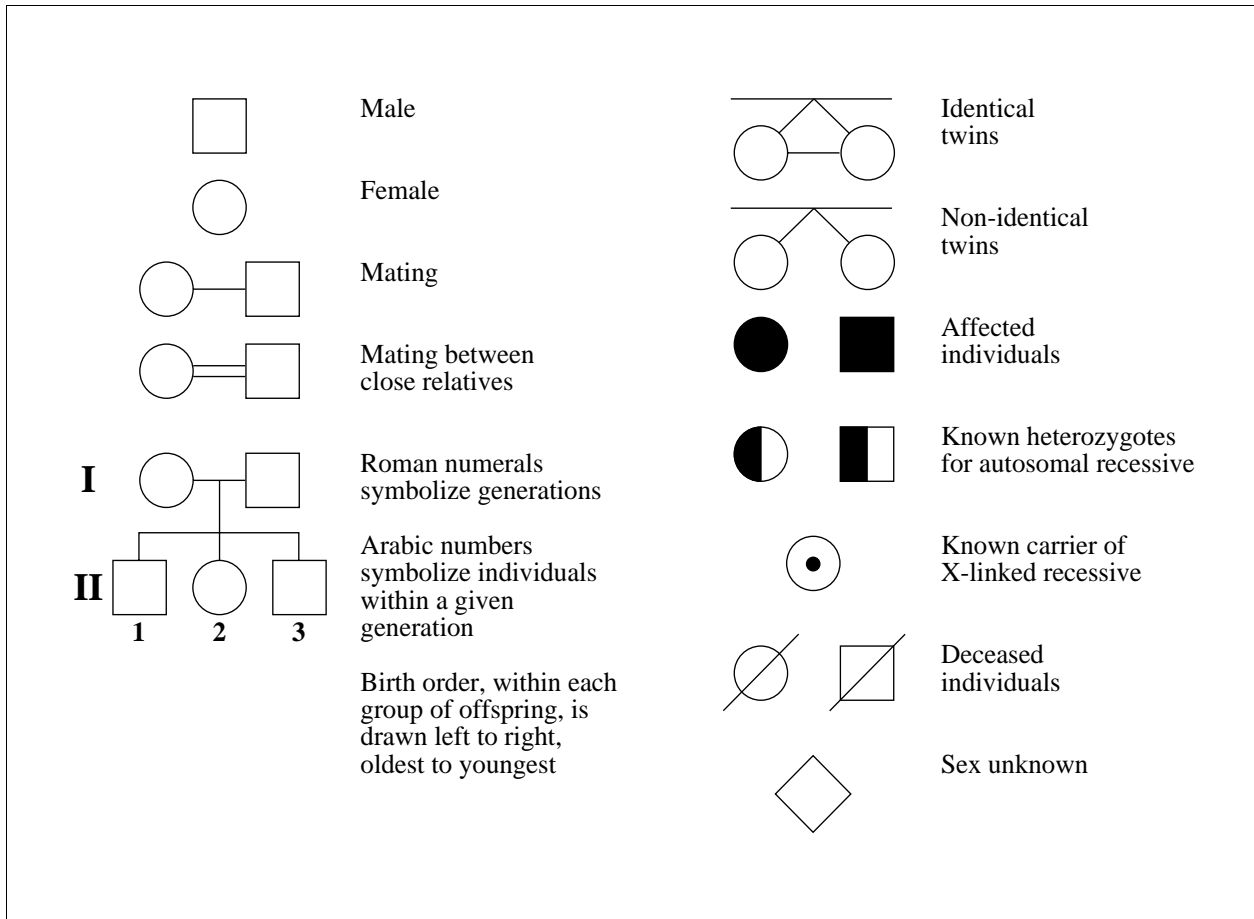
Subject	Equation
Hardy–Weinberg principle	$p^2 + 2pq + q^2 = 1$
Population density	$D_p = \frac{N}{A}$
Change in population size	$\Delta N = (\text{factors that increase pop.}) - (\text{factors that decrease pop.})$
Per capita growth rate (time will be determined by the question)	$cgr = \frac{\Delta N}{N}$
Growth rate	$\frac{\Delta N}{\Delta t} = rN$ $\frac{\Delta N}{\Delta t} = rN \frac{(K - N)}{K}$

Fold and tear along perforation.

### Abbreviations for Some Hormones

Hormone	Abbreviation
Adrenocorticotropin hormone	ACTH
Antidiuretic hormone	ADH
Follicle stimulating hormone	FSH
Human chorionic gonadotropin	HCG
Luteinizing hormone	LH (formerly ICSH in males)
Parathyroid hormone	PTH
Prolactin	PRL
Somatotropin (human growth hormone or growth hormone)	STH (HGH or GH)
Thyroid stimulating hormone	TSH

### Pedigree Symbols



**Messenger RNA Codons and Their Corresponding Amino Acids**

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU phenylalanine	UCU serine	UAU tyrosine	UGU cysteine	U
	UUC phenylalanine	UCC serine	UAC tyrosine	UGC cysteine	C
	UUA leucine	UCA serine	UAA stop **	UGA stop **	A
	UUG leucine	UCG serine	UAG stop **	UGG tryptophan	G
C	CUU leucine	CCU proline	CAU histidine	CGU arginine	U
	CUC leucine	CCC proline	CAC histidine	CGC arginine	C
	CUA leucine	CCA proline	CAA glutamine	CGA arginine	A
	CUG leucine	CCG proline	CAG glutamine	CGG arginine	G
A	AUU isoleucine	ACU threonine	AAU asparagine	AGU serine	U
	AUC isoleucine	ACC threonine	AAC asparagine	AGC serine	C
	AUA isoleucine	ACA threonine	AAA lysine	AGA arginine	A
	AUG methionine*	ACG threonine	AAG lysine	AGG arginine	G
G	GUU valine	GCU alanine	GAU aspartate	GGU glycine	U
	GUC valine	GCC alanine	GAC aspartate	GGC glycine	C
	GUA valine	GCA alanine	GAA glutamate	GGA glycine	A
	GUG valine	GCG alanine	GAG glutamate	GGG glycine	G

\* Note: AUG is an initiator codon and also codes for the amino acid methionine.

\*\* Note: UAA, UAG, and UGA are terminator codons.

**Information About Nitrogen Bases**

Nitrogen Base	Classification	Abbreviation
Adenine	Purine	A
Guanine	Purine	G
Cytosine	Pyrimidine	C
Thymine	Pyrimidine	T
Uracil	Pyrimidine	U

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*No marks will be given for work done on this page.*

*Fold and tear along perforation.*



***Biology 30  
Diploma Examination  
January 2001***

***Multiple–Choice Key,  
Numerical–Response Key,  
and  
Sample Answers to  
Written–Response Questions***

**Biology January 2001 Diploma Examination  
Multiple Choice and Numerical Response Keys**

- |       |       |
|-------|-------|
| 1. C  | 25. A |
| 2. B  | 26. A |
| 3. D  | 27. B |
| 4. D  | 28. D |
| 5. B  | 29. D |
| 6. D  | 30. B |
| 7. C  | 31. C |
| 8. C  | 32. C |
| 9. A  | 33. D |
| 10. B | 34. C |
| 11. C | 35. C |
| 12. C | 36. D |
| 13. A | 37. A |
| 14. D | 38. D |
| 15. B | 39. C |
| 16. D | 40. C |
| 17. A | 41. B |
| 18. A | 42. C |
| 19. C | 43. B |
| 20. C | 44. D |
| 21. C | 45. D |
| 22. A | 46. B |
| 23. C | 47. A |
| 24. A | 48. B |

- |           |            |
|-----------|------------|
| <b>1.</b> | 0.55       |
| <b>2.</b> | 3124       |
| <b>3.</b> | 3421       |
| <b>4.</b> | 50         |
| <b>5.</b> | 1122       |
| <b>6.</b> | 934        |
| <b>7.</b> | 332 or 664 |
| <b>8.</b> | 359        |

Use the following information to answer the next question.

Insulin-dependent diabetes mellitus (IDDM), also known as Type I diabetes or juvenile diabetes, is a disorder of glucose homeostasis in which the body's ability to produce insulin is impaired. People suffering from IDDM experience high blood sugar levels, increased thirst, frequent urination, extreme tiredness, and weight loss (despite an increased appetite). These symptoms can result in long-term complications that affect the eyes, kidneys, nerves, and blood vessels.

—from *OMIM*

**Written Response – 15%**

Staple your word-processed response for **this** question to this page.

- 1.** a. Explain why people with untreated IDDM often suffer from extreme tiredness and why they experience weight loss even though their blood sugar levels are higher than normal. **(2 marks)**

*Although there is a high level of glucose in the blood, in the absence of insulin, body cells are impermeable to glucose therefore glucose is not available as an energy source; resulting in fatigue.*

*Since glucose cannot be used as an energy source, fat or protein stores are metabolized resulting in weight loss. Also, glucose is not stored therefore weight gain is not possible.*

- b. Diabetes insipidus is a disorder that results from underproduction of ADH. Both diabetes mellitus and diabetes insipidus result in a large increase of urine output. Explain how a urine sample produced by a patient with diabetes mellitus and a urine sample produced by a patient with diabetes insipidus are different. **(1 mark)**

*Glucose would be found in the urine of the patient with diabetes mellitus.*

**or**

*The urine produced by a patient with diabetes insipidus would be insipid (tasteless). (The urine produced by a patient with diabetes mellitus would be sweet.)*

**or**

*The urine of the patient with diabetes mellitus could also have ketones present and could be slightly acidic.*

- c. About one in seven IDDM diabetics also suffer from “polyglandular autoimmune syndrome.” In addition to their diabetic symptoms, these individuals have thyroid disease and poorly functioning adrenal glands.
- i. Identify a hormone that is produced in either the thyroid gland or the adrenal gland that affects blood sugar levels. **(1 mark)**

*Thyroid gland → thyroxine*

*Adrenal gland → cortisol, epinephrine*

- ii. State the normal effect this hormone has on blood sugar levels when its secretion increases. Explain what causes the change in blood sugar levels. **(2 marks)**

*Thyroxine would decrease blood glucose level by increasing cellular metabolism rates.*

*Cortisol would increase blood sugar level by converting amino acids (or fatty acids or glycerol or fats or proteins) to glucose.*

*Epinephrine stimulates the conversion of glycogen to glucose by liver and muscle tissue, hence increasing blood sugar levels.*

*Use the following additional information to answer the next part of the question.*

Of individuals with IDDM, 50% also suffer from diabetic neuropathy. Nerves are progressively destroyed, possibly due to blockage of the tiny blood vessels that supply blood to the nerves.

—from *National Eye Institute*

- d. One patient with diabetic neuropathy walked on a broken ankle for two weeks without knowing it. Others, unknowingly, have foot ulcers (bleeding sores) on the soles of their feet. Based on this information, predict the type of neuron you suspect is damaged in these patients. Explain how the symptoms of diabetic neuropathy support your prediction. **(2 marks)**

*Sensory neurons were damaged since the patients could not feel the pain caused by the broken ankle or lesions but could still move their limbs. (i.e. motor skill intact)*

Use the following additional information to answer the next part of the question.

The most common eye disease in individuals with IDDM is “diabetic retinopathy.” This disease is characterized by changes in the blood vessels of the retina. In some people, the blood vessels may swell and leak fluid, and in other people, abnormal blood vessels grow on the surface of the retina.

—from *National Eye Institute*

- e. Explain why diabetic retinopathy may result in some vision loss or blindness. In your answer, refer to the eye structure and the pathway of impulses to the brain. **(2 marks)**

*Damage to or irregular functioning of blood vessels of the retina may result in permanent damage to the cells making up the retina (i.e. lack of O<sub>2</sub>/nutrients). If the rods or cones are damaged then there will be reduced sensory reception and reduced impulses in neurons to the occipital lobe. This would result in some vision loss or even blindness.*

**or**

*If the optic nerve is damaged by decreased blood flow the sensory information is not passed to the occipital lobe of the brain. This would result in vision loss or blindness.*

**or**

*The increase in blood vessels may obstruct the light reception by retina cells resulting in vision loss or blindness. Reduced sensory stimulation would occur so the neurons would send reduced impulses to the occipital lobe of the cerebrum.*

- f. Insulin is a protein hormone. It has been hypothesized that a change in the 57<sup>th</sup> amino acid of this hormone from asparagine to another amino acid will result in an increased risk for developing IDDM.

- i. Write a DNA triplet that codes for asparagine. **(1 mark)**

*DNA: TTA or DNA: TTG*

- ii. Show how a single base change in this DNA triplet would code for an amino acid other than asparagine. Identify the amino acid coded for by the mutated DNA triplet. **(1 mark)**

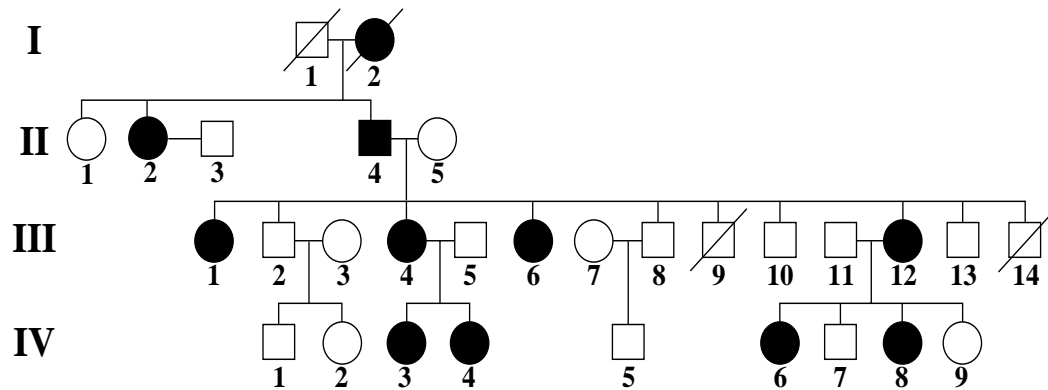
*Must show a point mutation (i.e. TTC codes for a.a. lysine).*

Use the following information to answer the next question.

Larry and Danny Gomez, two boys known as “Wolf Boys,” have made the circus their adoptive family. Both boys perform as trampoline acrobats, and Danny also does motorcycle stunts. The boys have a condition called congenital hypertrichosis (CH), which is a very rare X-linked dominant inherited condition. CH is characterized by the growth of dark hair over the body, particularly on the face and upper torso in males. The palms of the hands, soles of the feet, and mucus membranes are not affected by this condition. A press release about the circus stated that Larry and Danny have travelled to many countries in search of a cure. When asked about the search for a cure in an interview by David Staples of *The Edmonton Journal* (May 14, 1997), Larry said, “I’d never take it off. I’m very proud to be who I am.” Outside the circus, the boys enjoy activities typical of most boys their age. Danny likes to play video and board games, and Larry is interested in science and is taking astronomy by correspondence.

Researchers continue to investigate the process of hair growth and the causes of hair distribution at the molecular level. The relevant molecules are expected to act on hair follicles. Hair follicle distribution in humans is primarily a hormone-dependent secondary sex characteristic. In addition to searching for a cure for CH, research in this area may also have significant applications in the treatment of acquired or inherited baldness.

The incidence of CH is very rare: only about 50 affected individuals have been reported since the Middle Ages. The incidence of this condition is considerably higher in a small Mexican village than it is in the rest of the human population. In 1984, researcher Macias-Flores studied CH in a large, five-generation Mexican family and found 19 individuals with CH. A partial pedigree showing the sampled individuals from the Macias-Flores study is shown below.



—from Staples, 1997, and Figuera et al., 1995

**2.** Write a unified response on the following aspects of CH.

- **Identify** the hormone responsible for secondary sex characteristics in males **or** females, and **describe** the secondary sex characteristics, including hair follicle distribution patterns, resulting from this hormone's stimulation.

***Male secondary sex characteristics***

*Hormone: Testosterone*

- *Growth of facial, axillary, and pubic hair*
- *Receding hairline*
- *Growth of the larynx which causes lowering of the voice*
- *Strengthening of the muscles*
- *Increased secretion of body oils (acne)*
- *Thickening of the skin*
- *Increased red blood cell count*
- *Growth of long bones (and final fusing of epiphyses)*
- *Increased basal metabolic rate*

***or***

***Female secondary sex characteristics***

*Hormone: Estrogen*

- *Growth of axillary and pubic hair*
- *Maintains low blood cholesterol levels*
- *Growth of the breasts*
- *Increased deposits of subcutaneous fat, especially in hips and breasts (female fat distribution)*
- *Widening (and lightening) of the pelvis*
- *Increased basal metabolic rate*
- *Facilitates calcium uptake*
- *Increased water content of skin*
- *Growth of long bones (and final fusing of epiphyses)*
- *Increased secretion of body oils (acne)*

- **Identify** the genotypes for individuals II-4, II-5, III-11, III-12, IV-6, IV-7, IV-8, and IV-9 in one of the lines of inheritance on the pedigree. (Provide a key for the allele symbols you use.) **Construct** a Punnett square to predict the probability of individuals III-11 and III-12's next child being a male with CH. **Explain** why more females than males inherit CH in generation III.

**Genotypes:**

II-4:  $X^C Y$

II-5:  $X^c X^c$

III-11:  $X^c Y$

III-12:  $X^C X^c$

IV-6:  $X^C X^c$

IV-7:  $X^c Y$

IV-8:  $X^C X^c$

IV-9:  $X^c X^c$

**Alleles:**

$X^C$ —CH

$X^c$ —normal

**Punnett Square:**

	$X^C$	$X^c$
$X^c$	$X^C X^c$	$X^c X^c$
$Y$	$X^C Y$	$X^c Y$

- *Probability of III-11 and III-12's child being male with CH*

$$(male\ with\ CH)\ X^c Y = \frac{1}{4}\ or\ 25\%$$

- *More females than males inherit CH in generation III because individual II-4, a male, has CH and because CH is X-linked dominant the father's  $X^C$  will be passed on to all his female children in generation III (but not to his sons who received the father's Y chromosome).*
- **State** a possible experimental problem that could be investigated to find out more about CH or hair follicle distribution. **Evaluate** whether conducting research would be useful for affected individuals **or** for society. (An evaluation includes at least one advantage and one disadvantage.)

**State a possible experimental problem**

- *What effect does increasing (or decreasing) testosterone (or estrogen) have on hair follicle distribution?*
- *What gene(s) on the X chromosome codes for hair follicle distribution?*
- *What effect would increasing (decreasing) testosterone (estrogen) levels have on CH individuals?*
- *What protein molecule is produced in CH individuals that differs from individuals with normal hair follicle distribution?*
- *Or any other reasonable experimental problem that could be investigated.*



***Evaluate whether conducting research would be useful for affected individuals***

***Possible Advantages***

- *An advantage of CH research for individuals is that the research might ultimately lead to a cure for CH.*
- *An advantage of CH research for individuals is that the research might lead to treatment for individuals with acquired or inherited baldness.*
- *An advantage of CH research for individuals is that the information gained about the nature of CH could be used in counselling individuals that have CH and are planning on having children.*
- *Other responses may be appropriate*

***Possible Disadvantages***

- *A disadvantage of CH research for some individuals with CH, like Larry, is that these individuals do not want a cure for CH and in fact are proud of the hair they have on their bodies.*
- *A disadvantage of CH research for individuals is that possible cures would require experimentation. This experimentation would have to include most individuals with CH because the CH population is so small. Some individuals may not want to be experimental subjects.*
- *Other responses may be appropriate*

***Society***

***Possible Advantages***

- *An advantage of CH research to society is that it may lead to a better understanding of the actions of testosterone and estrogen. This increased knowledge could benefit society as a whole, potentially leading to health benefits for society.*
- *An advantage of CH research to society is that it may provide a better understanding of other X-linked traits. This increased knowledge could benefit society as a whole, potentially leading to health benefits for society.*
- *Other responses may be appropriate*

***Possible Disadvantages***

- *A disadvantage to society of research to find a cure for CH is that it is very costly and may not be warranted for such a small population of affected individuals.*
- *A disadvantage to society of research to find a cure for CH is that it sends the message to society that if an individual does not appear normal a cure must be found to rid society of a particular phenotype. Finding a cure does not promote the notion that society is at its best when made up of a mosaic of individuals.*
- *Other responses may be appropriate*

## Science

Score	Scoring Criteria
<p style="text-align: center;"><b>5</b> <b>Excellent</b></p>	<p><b>The student...</b></p> <ul style="list-style-type: none"> <li>• identifies testosterone or estrogen and describes 3 secondary sex characteristics, one of which is hair follicle distribution, resulting from stimulation by the identified hormone.</li> <li>• correctly identifies all the individuals' genotypes using sex-linked notation and provides a clear legend for the symbols.</li> <li>• communicates the probability of a CH male clearly using a Punnett square, and clearly explains why more females inherit CH in generation III.</li> </ul>
<p style="text-align: center;"><b>4</b> <b>Proficient</b></p>	<ul style="list-style-type: none"> <li>• identifies testosterone or estrogen and describes 2 secondary sex characteristics, resulting from stimulation by the identified hormone <b>or</b> describes 3 secondary sex characteristics.</li> <li>• correctly identifies most of the individuals' genotypes using sex-linked notation.</li> <li>• communicates the probability of a CH male using a Punnett square, and partially explains why more females inherit CH in generation III, <b>or</b> partially communicates the probability of a CH male and explains why more females inherit CH in generation III.</li> </ul>
<p style="text-align: center;"><b>3</b> <b>Satisfactory</b></p>	<ul style="list-style-type: none"> <li>• identifies testosterone or estrogen and describes 1 secondary sex characteristic resulting from stimulation by the identified hormone <b>or</b> describes 2 secondary sex characteristics.</li> <li>• correctly identifies some of the individuals' genotypes using sex-linked notation.</li> <li>• communicates the probability of a CH male using a Punnett square, <b>or</b> explains why more females inherit CH in generation III <b>or</b> partially communicates the probability of a CH male and partially explains why more females inherit CH in generation III.</li> </ul>
<p style="text-align: center;"><b>2</b> <b>Limited</b></p>	<ul style="list-style-type: none"> <li>• identifies testosterone or estrogen <b>or</b> describes one secondary sex characteristic resulting from stimulation by the identified hormone</li> <li>• identifies some of the individuals' genotypes as if autosomal dominant inheritance, autosomal recessive inheritance or sex-linked recessive inheritance occurred.</li> <li>• constructs a Punnett square, <b>or</b> communicates the probability of a CH male, <b>or</b> partially explains why more females inherit CH in generation III.</li> </ul>
<p style="text-align: center;"><b>1</b> <b>Poor</b></p>	<ul style="list-style-type: none"> <li>• One of the bullets is addressed at a 2 or 3 level.</li> </ul>

**INSUFFICIENT** is a special category. It is not an indication of quality. It should be assigned to papers that do not contain a discernible attempt to address the questions presented in the assignment or that are too brief to assess in this or any other scoring category.

## Technology and Society

Score	Scoring Criteria
<p style="text-align: center;"><b>5</b> <b>Excellent</b></p>	<p><b>The student...</b></p> <ul style="list-style-type: none"> <li>• clearly states a possible experimental problem that could be investigated to find out more about CH or hair follicle distribution.</li> <li>• evaluates whether conducting this research would be useful by describing one advantage and one disadvantage of CH research to the individual and/or society.</li> </ul>
<p style="text-align: center;"><b>4</b> <b>Proficient</b></p>	<ul style="list-style-type: none"> <li>• states a possible experimental problem that could be investigated to find out more about CH or hair follicle distribution but either the manipulated variable or responding variable is not clearly identified in the problem statement.</li> <li>• evaluates whether conducting this research would be useful by describing one advantage and partially describing one disadvantage <b>or</b> partially describing an advantage and describing one disadvantage of CH research to the individual and/or society.</li> </ul>
<p style="text-align: center;"><b>3</b> <b>Satisfactory</b></p>	<ul style="list-style-type: none"> <li>• suggests an experimental problem, or identifies an area of research that could be investigated to find out more about CH or hair follicle distribution.</li> <li>• evaluates whether conducting this research would be useful by describing one advantage or one disadvantage <b>or</b> partially describing one advantage and partially describing one disadvantage of CH research to the individual and/or society.</li> </ul>
<p style="text-align: center;"><b>2</b> <b>Limited</b></p>	<ul style="list-style-type: none"> <li>• suggests one area of research that could be investigated to find out more about CH or hair follicle distribution.</li> <li>• evaluates whether conducting this research would be useful by partially describing one advantage <b>or</b> one disadvantage of CH research.</li> </ul>
<p style="text-align: center;"><b>1</b> <b>Poor</b></p>	<ul style="list-style-type: none"> <li>• One of the bullets is addressed at a 2 level.</li> </ul>

**INSUFFICIENT** is a special category. It is not an indication of quality. It should be assigned to papers that do not contain a discernible attempt to address the questions presented in the assignment or that are too brief to assess in this or any other scoring category.