ALBERTA EDUCATION

Released Items
Biology 30

Diploma Examinations Program **2021**

Alberta

This document was written primarily for:

Students	✓	
Teachers	✓	of Biology 30
Administrators	✓	
Parents		
General Audience		
Others		

Alberta Education, Government of Alberta

2020–2021

Biology 30 Released Items

Distribution: This document is posted on the Alberta Education website.

Contents

Please note that if you cannot access one of the direct website links referred to in this document, you can find diploma examination-related materials on the Alberta Education website.

Introduction

The questions in this document are from the *Biology 30 August 2021 Diploma Examination*. This material, along with the program of studies, *Biology 30 Information Bulletin*, *Biology 30 Archived Bulletin*, and *Biology 30 Student-based Performance Standards*, can assist teachers with instructional programming.

For further information, contact

Shannon Mitchell, Biology 30 Exam Manager, at
Shannon.Mitchell@gov.ab.ca, or

Tracy Onuczko, Biology 30 Examiner, at
Tracy.Onuczko@gov.ab.ca, or

Deanna Shostak, Director of Diploma Programs, at
780-422-5160, or
Deanna.Shostak@gov.ab.ca

Provincial Assessment at 780-427-0010
To call toll-free from outside Edmonton, dial 310-0000.

Additional Documents

Provincial Assessment supports the instruction of Biology 30 in classrooms with the following documents available online:

- *Biology 30 Information Bulletin*
- *Biology 30 Archived Information Bulletin*
- *Biology 30 Student-based Performance Standards*
- *Biology 30 Assessment Exemplars*
- School Reports and Instructional Group Reports

  Detailed statistical information is provided on provincial, group, and individual student performance on January and June diploma examinations.
- The *Biology 30 Practice Tests* contain questions from some previous diploma examinations that have been released and some practice questions.

Biology 30 August 2021 Diploma Examination: Blueprint Summary

Key: MC—Multiple Choice; NR—Numerical Response
RU—Remembering/Understanding; A—Applying; HMA—Higher Mental Activities

Question	Keyed Answer(s)	Outcome	Cognitive Level	Diff.*
MC1	C	A1.1k, A1.2k	RU	0.709
MC2	A	A1.1k	RU	0.751
MC3	D	A1.2k	RU	0.813
MC4	B	A1.1k, A1.3sts	A	0.596
NR1	1324	A1.3k	RU	0.610
MC5	B	A1.2k, A2.2k, A1.3sts	A	0.723
MC6	C	A1.4k, A1.2s	RU	0.659
MC7	A	A1.5k	RU	0.723
MC8	B	A2.1k, A2.2k	A	0.742
MC9	A	A2.2k, A2.4k	A	0.524
MC10	D	A2.3k, A2.1sts	A	0.766
MC11	D	A2.4k, A2.2k, A2.3k	A	0.660
MC12	B	A2.3k, A2.2k	A	0.793
MC13	A	A2.2k, A2.3k	A	0.625
MC14	A	A2.2k, A2.6k	A	0.467
NR2	5413, 5412	B1.2k, B1.2s	RU	0.639
MC15	D	B1.3k, B1.2k, B1.2s	A	0.544
MC16	A	B2.3k, B2.1k	RU	0.748
MC17	D	B2.3k, B1.2k, B2.1k, B2.1sts	A	0.540

*Difficulty — proportion of students answering the question correctly.

Key: MC—Multiple Choice; NR—Numerical Response
RU—Remembering/Understanding; A—Applying; HMA—Higher Mental Activities

Question	Keyed Answer(s)	Outcome	Cognitive Level	Diff.*
MC18	B	B1.1k, B1.5k, B1.2s	A	0.792
MC19	A	B1.3k, B2.1k, B2.2k, B2.2s	A	0.397
NR3	1324	B2.2k, B2.1k	RU	0.451
MC20	B	B2.1k, B3.5k, B3.1sts	RU	0.702
MC21	B	B3.2k, B3.5k, B3.1k, B3.1sts	RU	0.604
MC22	A	B3.2k, C1.1k, C1.4k	A	0.671
MC23	C	B3.3k	RU	0.452
NR4	4312	B3.2k, B3.2sts	HMA	0.787
MC24	D	C1.1k	A	0.468
MC25	C	C1.3k	A	0.751
NR5	1342	C1.2k	RU	0.552
MC26	C	C1.2k, C1.1sts	A	0.673
MC27	B	C1.3k, C1.4k, C1.5k, C1.2k	A	0.723
MC28	C	C1.3k, C1.1k, C1.2s	HMA	0.447
NR6	2311	C1.7k, C1.4k, C1.2s	HMA	0.632
MC29	A	C1.4k, C1.2s	HMA	0.358
MC30	C	C2.2k, C2.3s	A	0.754
MC31	C	C2.2k, C2.3s	A	0.652
MC32	D	C2.5k, C2.3s	HMA	0.587
NR7	0.50	C2.5k, C2.3s	A	0.761
NR8	1010, 8080	C2.2k, C2.3s	A	0.569

*Difficulty — proportion of students answering the question correctly.

Key: MC—Multiple Choice; NR—Numerical Response
RU—Remembering/Understanding; A—Applying; HMA—Higher Mental Activities

Question	Keyed Answer(s)	Outcome	Cognitive Level	Diff.*
MC33	D	C2.2k, C2.3s	A	0.635
MC34	A	C2.2k, C2.3s	HMA	0.614
MC35	C	C2.2k, C2.3s	HMA	0.622
NR9	2314, 4132	C2.3k, C2.3s	A	0.726
NR10	234 (any order)	C3.1k, C2.1k, C2.5k	A	0.609
MC36	C	C3.2k, C3.3k, C3.2s	A	0.704
MC37	B	C3.3k, C3.2s	A	0.759
NR11	6384	C3.3k, C3.2s	RU	0.763
MC38	B	C3.4k, C3.2sts	RU	0.721
MC39	A	C3.6k, C3.3k, C3.2s	A	0.438
MC40	C	D1.4k, C3.7k	HMA	0.658
MC41	D	D1.3k, D1.3s	A	0.694
NR12	2.47	D1.3k, D1.3s	A	0.426
MC42	D	D1.2k, D1.2sts	A	0.825
MC43	C	D2.1k, D2.3s	A	0.480
MC44	A	D2.3k	A	0.643
MC45	A	D3.1k	A	0.629
MC46	D	D3.2k, D3.3s	A	0.547
MC47	B	D3.3k, D3.3s	RU	0.573
MC48	B	D3.4k, D3.2k	A	0.642

*Difficulty — proportion of students answering the question correctly.

Biology 30 August 2021 Diploma Examination: Released Items

Use the following information to answer question 1.

The detection of an odour stimulates sensory neurons to send impulses to the brain.

1. Which of the following rows identifies the part of a sensory neuron **first** stimulated by an odour and the part of the brain that receives the impulse from the sensory neuron?

Row	Part of Sensory Neuron	Part of the Brain
A.	Axon	Cerebrum
B.	Axon	Cerebellum
C.	Dendrite	Cerebrum
D.	Dendrite	Cerebellum

---

2. The detection of an odour stimulates action potentials in the neurons of a person when

A. sodium channels open and the inside of the neuron becomes more positive relative to the outside

B. sodium channels open and the outside of the neuron becomes more positive relative to the inside

C. potassium channels open and the inside of the neuron becomes more positive relative to the outside

D. potassium channels open and the outside of the neuron becomes more positive relative to the inside

Use the following information to answer question 3.

Researchers have studied the brain activity of people who lost their vision during childhood. They found that in these people, the area of the brain that was once used mainly for vision is now used to help determine the location of nearby sounds.

Gougoux, Frédéric, Robert J. Zatorre, Maryse Lassonde, Patrice Voss, and Franco Lepore. 2005. A functional neuroimaging study of sound localization: Visual cortex activity predicts performance in early-blind individuals. *PLOS Biology* 3, no. 2 (February): 324–33. doi:10.1371/journal.pbio.0030027.

3. The two lobes of the brain that perform an auditory function in people who lost their vision during childhood are **most likely** the

A. frontal lobe and parietal lobe
B. frontal lobe and occipital lobe
C. temporal lobe and parietal lobe
D. temporal lobe and occipital lobe

Use the following information to answer question 4.

Congenital myasthenia gravis (MG) is a genetic disorder that affects dogs of some breeds. This disorder is caused by a reduced number of acetylcholine receptors on skeletal muscle cells. Congenital MG is treated with a drug that inhibits the action of cholinesterase.

4. One effect of the drug that treats congenital MG is expected to be that

A. acetylcholine will be broken down at an increased rate
B. acetylcholine will remain active for a longer period of time
C. the amount of acetylcholine released by the neuron will increase
D. the number of acetylcholine receptors on the muscle cell will increase

---

Use the following information to answer numerical-response question 1.

Some Events Involved in Nerve Impulse Transmission in a Reflex Arc

1 Stimulation of a sensory receptor
2 Conduction of an action potential along a motor neuron
3 Diffusion of sodium ions across the cell membrane of a sensory neuron
4 Release of neurotransmitters into the synapse between a neuron and an effector

Numerical Response

1. The order in which the events involved in nerve impulse transmission in a reflex arc occur is _____, _____, _____, and _____.

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

Use the following information to answer question 5.

Post-traumatic stress disorder (PTSD) is a condition that can occur in people who have survived accidents or other traumatic events. A drug known as propranolol blocks the action of epinephrine and is being investigated as a treatment for PTSD.

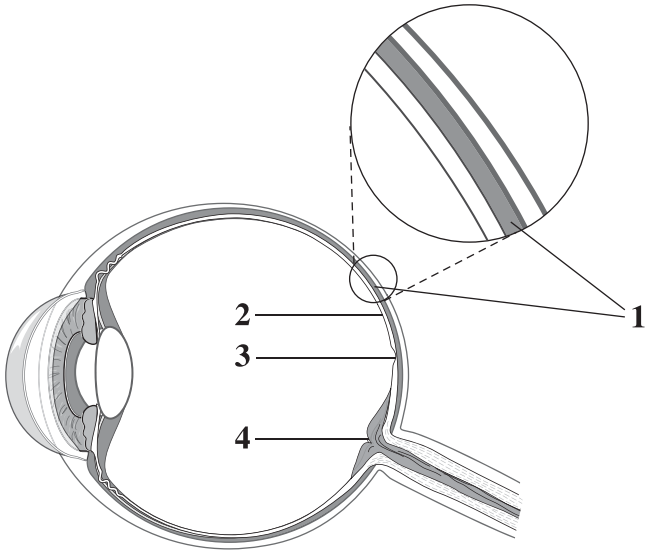
5. Propranolol is expected to help a person with PTSD manage symptoms by

A. increasing the activity of the sympathetic nervous system
B. decreasing the activity of the sympathetic nervous system
C. increasing the activity of the parasympathetic nervous system
D. decreasing the activity of the parasympathetic nervous system

Use the following information to answer question 6.

Some eye diseases result in the overgrowth of blood vessels in a tissue layer at the back of the eye. Fluid leaks from the blood vessels and accumulates, resulting in the scarring of the fovea and a severe loss of vision.

The Human Eye



6. In the diagram above, the structure that is scarred by the accumulation of fluid is numbered

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

Use the following information to answer question 7.

Scientists used gene therapy to reverse permanent deafness in guinea pigs. They inserted a gene known as *Atoh1* into genetic material of cells in the guinea pigs' cochleas, where the gene stimulated the regeneration of hair cells. A guinea pig's ear is similar in structure and function to a human ear.

Izumikawa, Masahiko, Ryosei Minoda, Kohei Kawamoto, Karen A. Abrashkin, Donald L. Swiderski, David F. Dolan, Douglas E. Brough, and Yehoash Raphael. 2005. Auditory hair cell replacement and hearing improvement by *Atoh1* gene therapy in deaf mammals. *Nature Medicine* 11, no. 3 (March): 271–76. doi:10.1038/nm1193.

7. The part of the ear in which hair cells were regenerated is the

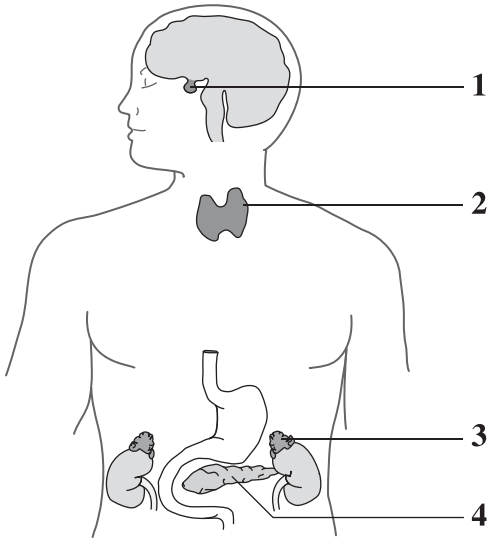
A. organ of Corti
B. auditory nerve
C. Eustachian tube
D. semicircular canal

Use the following information to answer question 8.

Research has shown that children who live in a noisy neighbourhood are more likely to exhibit signs of stress than children who live in a quiet neighbourhood.

Lercher, Peter, Alex Eisenmann, Luc Dekoninck, Dick Botteldooren, Ulrich Widmann, and Gary Evans. 2013. Noise exposure and health effects in children: Results from a contextual soundscape perspective. *AIA-DAGA 2013, International Conference on Acoustics, Merano*, March 18–21, 2013, 1465–68.

Some Endocrine Glands

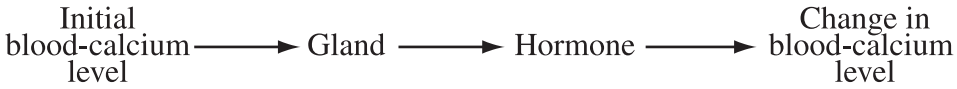


8. In the diagram above, the glands that are more active in children who live in a noisy neighbourhood are numbered

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

Use the following information to answer question 9.

Calcium Metabolism



9. Which of the following rows identifies the gland and the hormone in the diagram above when the initial blood-calcium level is low?

Row	Gland	Hormone
A.	Parathyroid gland	PTH
B.	Parathyroid gland	Calcitonin
C.	Thyroid gland	PTH
D.	Thyroid gland	Calcitonin

Use the following information to answer question 10.

Hyperthyroidism is a condition characterized by excessive secretion of thyroxine. Thyroxine levels in cats that have hyperthyroidism can be decreased safely and effectively by feeding the cats a special diet. The regulation and function of thyroxine is similar in cats and humans.

Melendez, L. M., R. M. Yamka, S. D. Forrester, and P. A. Burris. 2011. Abstract EN-16, Titration of dietary iodine for reducing serum thyroxine concentrations in newly diagnosed hyperthyroid cats. Research Abstract Program of the 2011 ACVIM Forum, Denver, Colorado, June 15–18, 2011. *Journal of Veterinary Internal Medicine* 25, no. 3 (May/June): 683.

10. Which of the following rows describes symptoms expected in a cat with hyperthyroidism before treatment and explains why the symptoms are expected?

Row	Symptoms	Explanation
A.	Decreased appetite and weight gain	A higher-than-normal level of thyroxine decreases metabolic rate.
B.	Decreased appetite and weight gain	A higher-than-normal level of thyroxine increases metabolic rate.
C.	Increased appetite and weight loss	A higher-than-normal level of thyroxine decreases metabolic rate.
D.	Increased appetite and weight loss	A higher-than-normal level of thyroxine increases metabolic rate.

Use the following information to answer questions 11 and 12.

The world's tallest man is 8 feet, 3 inches tall. For the first 10 years of his life, the man's level of hGH was normal; however, at the age of 10, a tumour developed in his pituitary gland, resulting in abnormally high hGH levels for approximately 15 years until the tumour was removed.

Guinness World Records. 2011. Tallest man: Living. *Guinness World Records*, February 8. www.guinnessworldrecords.com/world-records/tallest-man-living.

Cockcroft, Lucy. 2009. Sultan Kosen is world's tallest man at 8ft 1 in. *Telegraph*, September 17. www.telegraph.co.uk/news/newstopics/howabouthat/6199739/Sultan-Kosen-is-worlds-tallest-man-at-8ft-1in.html.

11. Which of the following statements describes a feedback mechanism that accounts for the man's excessive height?

A. Positive feedback occurred, during which high levels of hGH stimulated the secretion of more hGH.

B. Negative feedback occurred, during which high levels of hGH inhibited the secretion of hGH.

C. Positive feedback did not occur, and therefore high levels of hGH did not inhibit the secretion of more hGH.

D. Negative feedback did not occur, and therefore high levels of hGH did not inhibit the secretion of more hGH.

Use the following additional information to answer question 12.

Because of his excessive growth, the man is expected to have a high level of a protein known as insulin-like growth factor-1 (IGF-1) in his blood. IGF-1 has a similar function to insulin.

12. If the man has a high level of IGF-1 in his blood, then his blood-glucose level is expected to be

A. lower than normal because IGF-1 decreases blood-insulin level
B. lower than normal because IGF-1 decreases blood-glucose level
C. higher than normal because IGF-1 increases blood-insulin level
D. higher than normal because IGF-1 increases blood-glucose level

Use the following information to answer question 13.

The prairie vole, *Microtus ochrogaster*, is a rodent that mates exclusively with one partner. Bonding between mating partners is associated with aggression against other voles. Researchers investigated the role of ADH in the mating behaviours of prairie voles. The researchers concluded that in prairie voles, bonding with a mating partner and aggressive behaviour are associated with high levels of ADH. The structure and function of ADH are similar in voles and humans.

Winslow, James T., Nick Hastings, C. Sue Carter, Carroll R. Harbaugh, and Thomas R. Insel. 1993. A role for central vasopressin in pair bonding in monogamous prairie voles. *Nature* 365, no. 6446 (October 7): 545–48. doi:10.1038/365545a0.

13. Prairie voles that exhibit aggression when bonding with a mating partner are also expected to have

A. decreased urine output
B. increased blood-sodium levels
C. increased blood-glucose levels
D. decreased calcium reabsorption

Use the following information to answer question 14.

Tumours in the adrenal gland affect hormone secretions from the adrenal gland, which can result in disorders such as Conn syndrome or pheochromocytoma.

Conn syndrome is characterized by a higher-than-normal level of the hormone that stimulates sodium reabsorption.

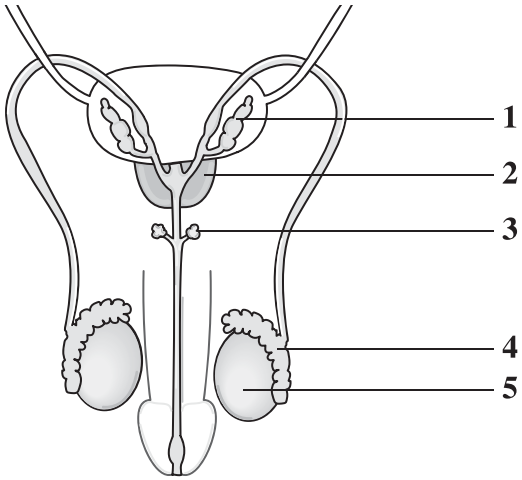
Pheochromocytoma is characterized by a higher-than-normal level of the hormone involved in the short-term stress response.

14. Which of the following rows describes a symptom expected to be found in a person with Conn syndrome and a symptom expected to be found in a person with pheochromocytoma?

Row	Symptom of Conn Syndrome	Symptom of Pheochromocytoma
A.	Elevated blood pressure	Increased conversion of glycogen to glucose
B.	Elevated blood pressure	Increased conversion of amino acids to glucose
C.	Excessive urine production	Increased conversion of glycogen to glucose
D.	Excessive urine production	Increased conversion of amino acids to glucose

Use the following information to answer numerical-response question 2.

Structures of the Human Reproductive System



Numerical Response

2. Match four of the structures of the human reproductive system numbered above with their functions given below. (There is more than one correct answer.)

Structure:	_____	_____	_____	_____
Function:	**Spermatogenesis**	**Maturation of sperm**	**Production of fructose**	**Production of alkaline buffer**

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

Use the following information to answer question 15.

Cross Section of Human Reproductive Tissue

15. Which of the following rows identifies Structure I and describes its normal function?

Row	Structure I	Function
A.	Mature follicle	Secretion of gonadotropins
B.	Mature follicle	Production of gametes
C.	Seminiferous tubule	Secretion of gonadotropins
D.	Seminiferous tubule	Production of gametes

16. Which of the following rows identifies a hormone imbalance and describes an effect of the hormone imbalance?

Row	Possible Hormone Imbalance	Effect
A.	A decrease in blood FSH levels	Decreased sperm production
B.	A decrease in blood FSH levels	Decreased testosterone production
C.	An increase in blood GnRH levels	Decreased sperm production
D.	An increase in blood GnRH levels	Decreased testosterone production

Use the following information to answer question 17.

Puberty blockers are drugs that are sometimes given to children who have entered puberty at an unusually early age. They act directly on the pituitary gland to block the release of reproductive hormones from the pituitary gland.

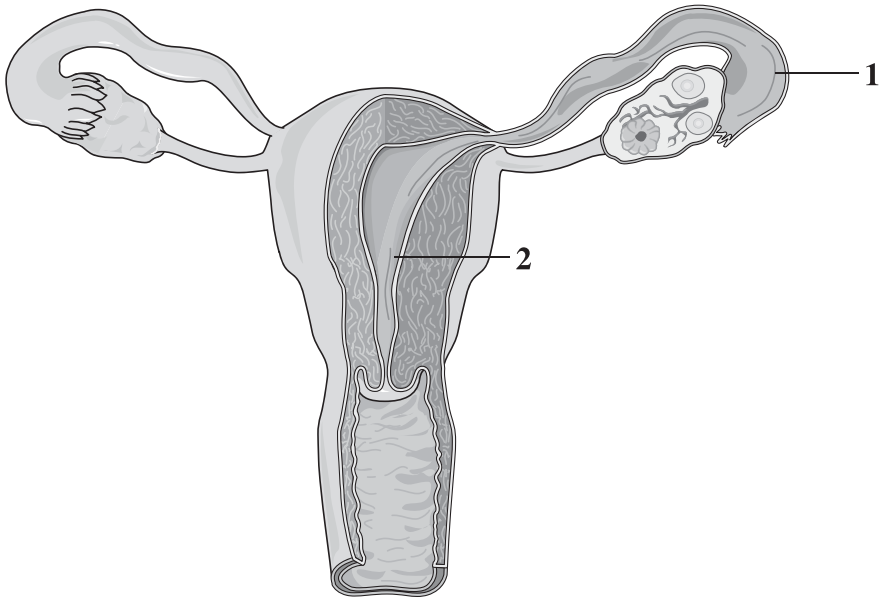
17. An expected effect of puberty blockers on the human reproductive system is a decrease in

A. GnRH, which leads to decreased stimulation of Sertoli cells
B. GnRH, which leads to decreased stimulation of interstitial cells
C. LH, which leads to decreased stimulation of Sertoli cells
D. LH, which leads to decreased stimulation of interstitial cells

Use the following information to answer question 18.

Chlamydia is a sexually transmitted infection caused by the bacterium *Chlamydia trachomatis*, which infects the endometrium. Permanent inflammation that results from this infection can cause ectopic pregnancies, which occur when an embryo implants outside its natural location, typically in the Fallopian tube.

The Human Reproductive System



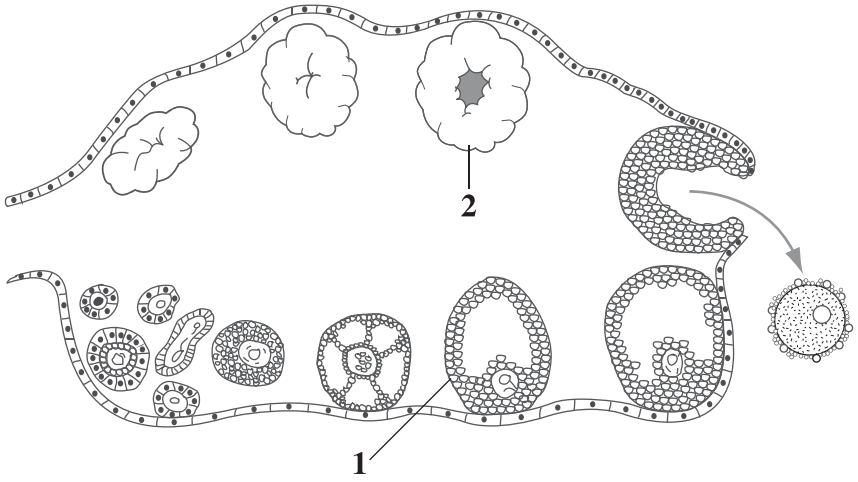
18. Which of the following rows identifies the location where an ectopic pregnancy typically occurs and describes an effect of a *C. trachomatis* infection?

Row	Location of Ectopic Pregnancy	Effect of a *C. trachomatis* Infection
A.	1	Decreases hormone production by the follicle
B.	1	Decreases nutrients available to the growing embryo
C.	2	Decreases hormone production by the follicle
D.	2	Decreases nutrients available to the growing embryo

Use the following information to answer question 19.

Inhibin B is a hormone produced and released by ovarian follicles in response to FSH secretions.

A Model of an Ovary



19. Which of the following rows identifies the structure that produces inhibin B and the expected hormone level of inhibin B during the luteal phase of the menstrual cycle?

Row	Structure That Produces Inhibin B	Expected Hormone Level of Inhibin B During the Luteal Phase
A.	1	Low
B.	1	High
C.	2	Low
D.	2	High

Use the following information to answer numerical-response question 3.

Some Events in the Menstrual Cycle

1 FSH is secreted.
2 Ovulation occurs.
3 LH secretion reaches its highest level.
4 Progesterone secretion reaches its highest level.

Numerical Response

3. Beginning at the start of the flow phase, the sequence in which the events in the menstrual cycle listed above occur is _____, _____, _____, and _____.

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

---

20. The hormone that is administered to stimulate the development of multiple ova prior to in vitro fertilization is **most likely**

A. LH
B. FSH
C. estrogen
D. progesterone

Use the following information to answer question 21.

Ova that are fertilized by in vitro fertilization are allowed to undergo cell division for approximately three to five days before they are transferred into a person and implantation takes place.

21. The hormone that is secreted by the implanted structure during the first trimester of pregnancy is

A. LH
B. hCG
C. estrogen
D. progesterone

Use the following information to answer question 22.

Following fertilization, the level of nitric oxide increases in a zygote. Following the increase in nitric oxide, the concentration of calcium ions increases, which promotes the division and development of the zygote.

22. Increased concentration of calcium ions in a zygote stimulates

A. mitotic divisions of a diploid cell
B. mitotic divisions of a haploid cell
C. meiotic divisions of a diploid cell
D. meiotic divisions of a haploid cell

---

23. Which of the following rows matches an embryonic germ layer with a structure that arises from it?

Row	Embryonic Germ Layer	Structure
A.	Mesoderm	Nervous system
B.	Mesoderm	Lining of the digestive system
C.	Ectoderm	Nervous system
D.	Ectoderm	Lining of the digestive system

Use the following information to answer numerical-response question 4.

Amniotic stem cells are fetal cells that can be removed from amniotic fluid and then grown in a lab to produce specific types of cells. Embryonic stem cells are cells that can be removed from an embryo and then grown in a lab to produce specific types of cells.

Some Statements Related to Stem Cells

1 Governments may restrict funding for stem cell research.

2 Amniotic stem cells and embryonic stem cells are grown in cultures in a lab.

3 More than 4 500 Canadians are currently waiting for an organ transplant. Researchers are hopeful that certain organs may be grown from stem cells in the future.

4 The use of amniotic fluid stem cells is not as controversial as the use of embryonic stem cells. Some people disapprove of the use of embryonic stem cells because it involves destruction of the embryo from which the cells are taken.

Numerical Response

4. Match each statement related to stem cells numbered above with the consideration that **best** describes it given below. (Use each number only once.)

Number:	_____	_____	_____	_____
Consideration:	**Ethical**	**Societal**	**Economic**	**Technological**

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

Use the following information to answer questions 24 and 25.

Scientists sequenced the genome of *Gallus gallus*, the red jungle fowl, which is an ancestor of the domestic chicken. The red jungle fowl has 38 pairs of autosomes and one pair of sex chromosomes. The sex chromosomes in a female bird are ZW, whereas the sex chromosomes in a male bird are ZZ.

International Chicken Genome Sequencing Consortium. 2004. Sequence and comparative analysis of the chicken genome provide unique perspectives on vertebrate evolution. *Nature* 432, no. 7018 (December 9): 695–716. doi:10.1038/nature03154.

24. The number of chromosomes in a somatic cell of a red jungle fowl is

A. $n = 38$
B. $n = 39$
C. $2n = 76$
D. $2n = 78$

25. Homologous sex chromosomes are found in both a

A. male red jungle fowl and a genotypically male human
B. female red jungle fowl and a genotypically male human
C. male red jungle fowl and a genotypically female human
D. female red jungle fowl and a genotypically female human

Use the following information to answer numerical-response question 5.

Some Events in Mitosis of Human Cells

1 The mitotic spindle forms.
2 The nuclear membrane forms.
3 Chromosomes line up at the equatorial plate.
4 Chromosomes arrive at opposite poles of the cell.

Numerical Response

5. The order in which the events in mitosis listed above occur is _____, _____, _____, and _____.

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

Use the following information to answer question 26.

Chemotherapy drugs known as anthracyclines interfere with an enzyme involved in DNA replication.

26. The phase of the cell cycle in which anthracyclines affect cancer cells is

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

Use the following information to answer question 27.

People with Turner syndrome have only one sex chromosome, an X chromosome.

27. The process that causes a person to have only one sex chromosome occurs during

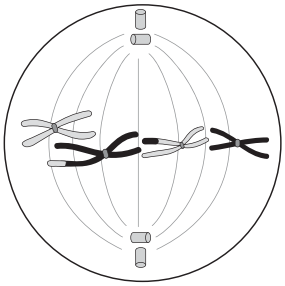
A. telophase of meiosis
B. anaphase of meiosis
C. telophase of mitosis
D. anaphase of mitosis

Use the following information to answer question 28.

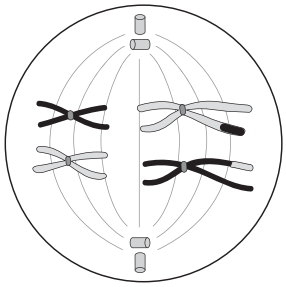
At a certain point during the development of an ovum in an animal, cell division stops and will resume only when a sperm enters the ovum's outer layers. The phase of the cell cycle in which cell division stops is metaphase II.

28. Which of the following diagrams illustrates the phase in which cell division stops during the development of an ovum in a theoretical animal in which $2n = 4$?

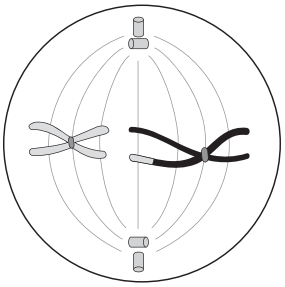
A.



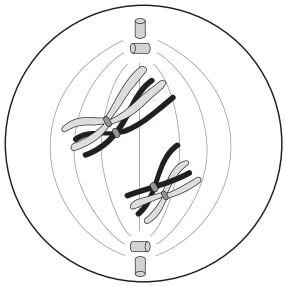
B.



C.



D.

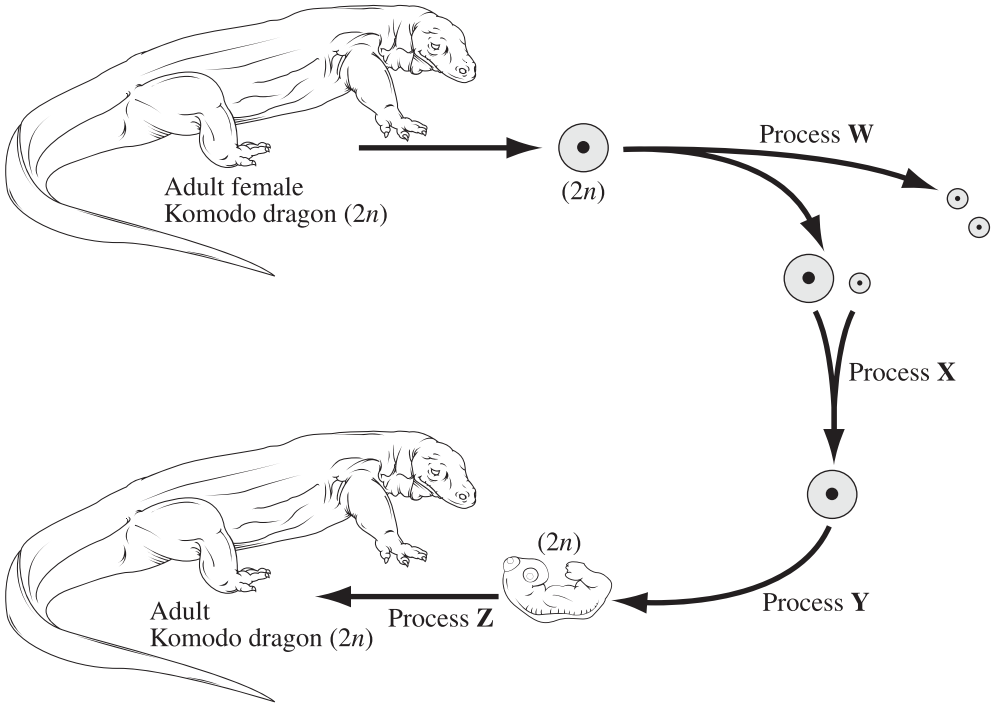


Use the following information to answer numerical-response question 6 and question 29.

Parthenogenesis is a type of asexual reproduction in which females produce offspring without fertilization by males. A female Komodo dragon in a zoo that had not been in contact with a male Komodo dragon laid diploid eggs, which hatched into offspring. Some scientists believe that each laid egg was produced when an ovum fused with a polar body.

Watts, Phillip C., Kevin R. Buley, Stephanie Sanderson, Wayne Boardman, Claudio Ciofi, and Richard Gibson. 2006. Parthenogenesis in Komodo dragons. *Nature* 444, no. 7122 (December 21): 1021–22. doi:10.1038/4441021a.

Parthenogenesis in a Komodo Dragon



Events

1 Mitosis
2 Meiosis
3 Fusion

Note: Fusion is a process similar to fertilization.

Numerical Response

6. Match the events numbered in the list with the processes given below that occur during parthenogenesis in a Komodo dragon. (A number may be used more than once.)

Number:	_____	_____	_____	_____
Process:	**Process W**	**Process X**	**Process Y**	**Process Z**

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

Use the following additional information to answer question 29.

Other scientists believe that the eggs laid by the Komodo dragon were produced by another type of asexual reproduction in which an ovum divides and then the two resulting daughter cells fuse.

Dawkins, Richard. 2006. The Komodo dragon's tale. The Richard Dawkins Foundation for Reason and Science, December 21. richarddawkins.net/articles/452.

29. Which of the following rows identifies the process by which the ovum divides during the type of asexual reproduction described above and describes the daughter cells produced?

Row	Process by Which the Ovum Divides	Daughter Cells Produced
A.	Mitosis	Genetically identical to the ovum
B.	Mitosis	Genetically identical to the Komodo dragon that produced the ovum
C.	Meiosis	Genetically different from the ovum
D.	Meiosis	Genetically different from the Komodo dragon that produced the ovum

Use the following information to answer question 30.

An autosomal recessive disorder that exists in some chicken breeds causes affected chickens to have epileptic seizures.

30. The probability that the offspring of two heterozygous chickens will **not** be affected with epileptic seizures is

A. 0.25
B. 0.50
C. 0.75
D. 1.00

Use the following information to answer question 31.

Neurofibromatosis type 2 is an autosomal dominant condition caused by a mutation in the *NF2* gene. A woman with a single mutated *NF2* allele and a man who does not have neurofibromatosis type 2 have a child.

U.S. National Library of Medicine. 2016. Health conditions: Neurofibromatosis type 2. *Genetics Home Reference*. ghr.nlm.nih.gov/condition/neurofibromatosis-type-2.

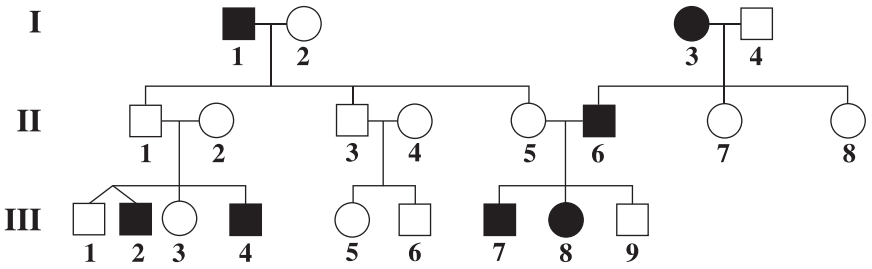
31. What is the phenotypic ratio expected in the offspring of the woman and the man?

A. All affected
B. 1 affected: 3 unaffected
C. 1 affected: 1 unaffected
D. 3 affected: 1 unaffected

Use the following information to answer question 32 and numerical-response question 7.

Red–green colour-blindness is an X-linked recessive disorder.

Pedigree Illustrating the Inheritance of Red–Green Colour-blindness



32. Which of the following rows describes the inheritance of the alleles for red–green colour-blindness in individuals **III-2** and **III-8**?

Row	III-2	III-8
A.	From the father	From the father
B.	From the father	From both parents
C.	From the mother	From the father
D.	From the mother	From both parents

Numerical Response

7. If individuals **II-5** and **II-6** have another child, what is the probability that this child will have red–green colour-blindness?

Answer: _____

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

Use the following information to answer numerical-response question 8.

The inheritance of skin colour in corn snakes is controlled by two pairs of alleles, as shown below.

Genotype	Phenotype
*B_R_*	Wild-type
B_rr	Black
*bbR_*	Red
bbrr	Albino

Numerical Response

8. What is the expected phenotypic ratio in the offspring resulting from a cross between a homozygous red corn snake and a heterozygous black corn snake?

Ratio:	_____	:	_____	:	_____	:	_____
Snake colour:	**Wild-type**		**Black**		**Red**		**Albino**

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

Use the following information to answer question 33.

Feather colour in some chickens is controlled by multiple alleles, as shown below.

Genotype	Phenotype
E	Black
E^{R}	Birchen
e^{+}	Wild-type
e^{Wh}	Dominant wheaten
e^{b}	Partridge
e^{s}	Speckled
e^{bc}	Buttercup
e^{y}	Recessive wheaten

The order of dominance of these alleles is $E > E^{R} > e^{+} > e^{Wh} > e^{b} > e^{s} > e^{bc} > e^{y}$.

A rooster with black feathers and a hen with partridge feathers produce some chicks with black feathers, some chicks with partridge feathers, and some chicks with buttercup feathers.

33. Which of the following rows identifies possible genotypes of the rooster and the hen?

Row	Genotype of the Rooster	Genotype of the Hen
A.	Ee^{b}	$e^{b}e^{bc}$
B.	Ee^{b}	$e^{b}e^{y}$
C.	Ee^{bc}	$e^{b}e^{b}$
D.	Ee^{bc}	$e^{b}e^{y}$

Use the following information to answer question 34.

A whippet is a particular breed of dog. Abnormal muscle development in whippets is associated with mutations in the *MSTN* gene.

Whippets with two copies of the mutated *MSTN* allele are more muscular than normal and are known as bully whippets.

Whippets with one unmutated and one mutated *MSTN* allele, a phenotype known as intermediate, are more muscular than normal whippets but not as muscular as bully whippets.

Whippets with two unmutated *MSTN* alleles have normal muscle development.

Dogs have 78 chromosomes and the *MSTN* gene is located on chromosome 37.

Mosher, Dana S., Pascale Quignon, Carlos D. Bustamante, Nathan B. Sutter, Cathryn S. Mellersh, Heidi G. Parker, and Elaine A. Ostrander. 2007. A mutation in the myostatin gene increases muscle mass and enhances racing performance in heterozygote dogs. *PlOS Genetics* 3 (5): 779–86. doi:10.1371/journal.pgen.0030079.

34. Which of the following rows describes the mode of inheritance of the *MSTN* gene and the combination of parents that would produce the greatest proportion of bully whippet offspring?

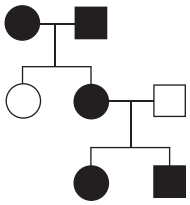
Row	Mode of Inheritance	Combination of Parents
A.	Incomplete dominance	A bully whippet female crossed with an intermediate male
B.	Incomplete dominance	An intermediate female crossed with an intermediate male
C.	Autosomal recessive	A bully whippet female crossed with an intermediate male
D.	Autosomal recessive	An intermediate female crossed with an intermediate male

Use the following information to answer question 35.

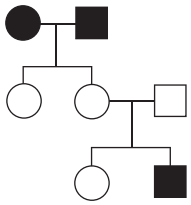
Phenylketonuria (PKU) is caused by the presence of two mutated *PAH* alleles on chromosome 12 in humans. If untreated, PKU can lead to reduced development of the brain, brain damage, and seizures.

35. Which of the following pedigrees illustrates the mode of inheritance of PKU?

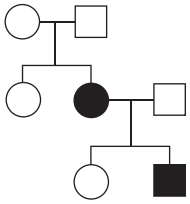
A.



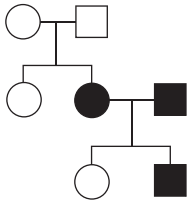
B.



C.



D.



Use the following information to answer numerical-response question 9.

The genome of *Drosophila melanogaster* (fruit fly) has been mapped. All of the following genes are located on the X chromosome.

1 Ruby eyes
2 Facet eyes
3 Echinus eyes
4 Crossveinless wings

Map distances between the four genes are shown below.

Genes	Distance in Map Units
1 and 3	2.0
1 and 4	6.2
2 and 3	2.5
2 and 4	10.7

Campbell, Neil A. 1987. *Biology*. Menlo Park: The Benjamin/Cummings Publishing Company, Inc.

Numerical Response

9. The order in which the four genes numbered above are arranged on the X chromosome in *Drosophila melanogaster* is _____, _____, _____, and _____.
(There is more than one correct answer.)

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

Use the following information to answer numerical-response question 10.

Some Scientists and Their Contributions to Molecular Genetics

1 Gregor Mendel determined that factors called genes are inherited in a particular manner.

2 Erwin Chargaff proposed a 1:1 ratio of purines and pyrimidines.

3 James Watson and Francis Crick created a model showing an anti-parallel double helix.

4 Rosalind Franklin revealed a helical structure in X-ray diffraction photographs.

5 Thomas Hunt Morgan studied fruit flies and proposed the chromosomal theory of inheritance.

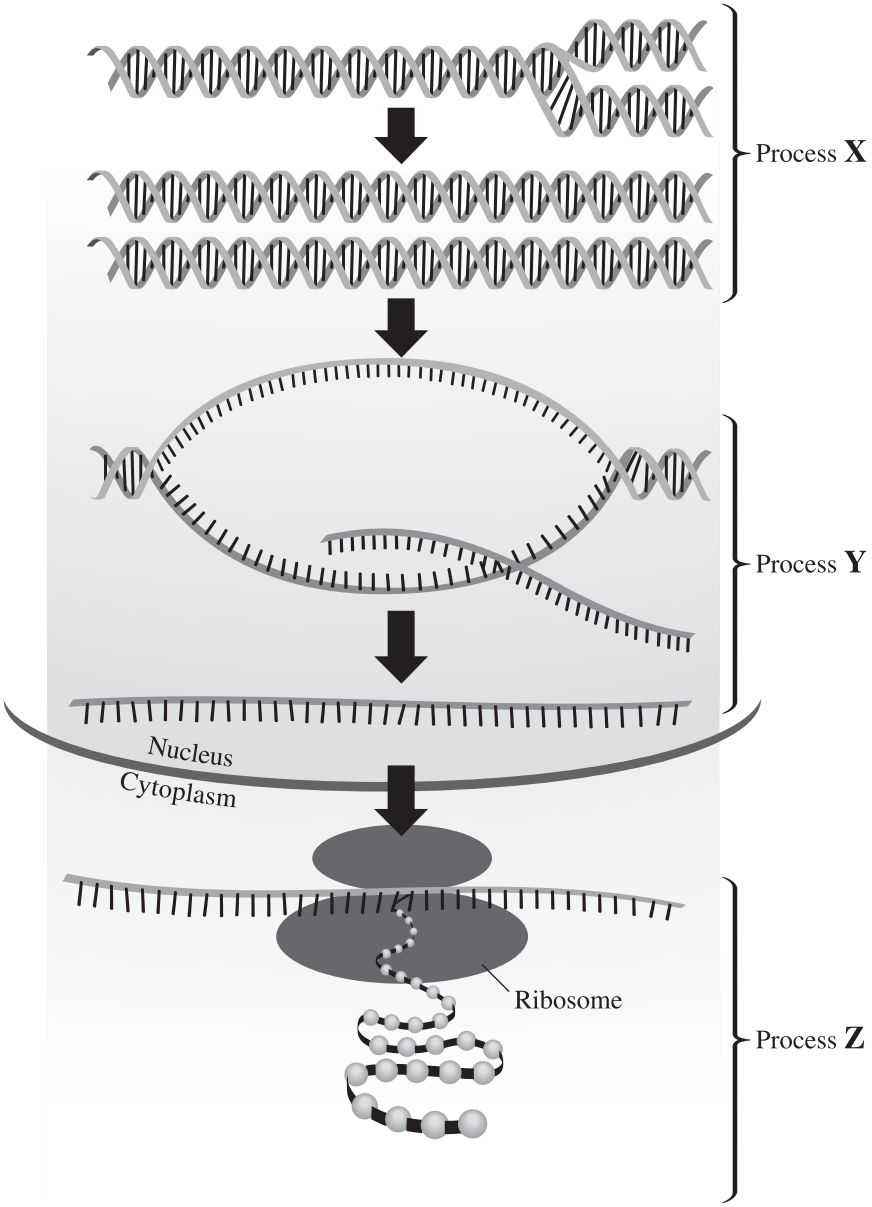
Numerical Response

10. The contributions that scientists made to the understanding of the structure of DNA are described in the statements numbered _____, _____, and _____.

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

Use the following information to answer question 36.

Some Processes That Occur in a Cell



36. Which of the following rows identifies processes X, Y, and Z, as labelled in the diagram above?

Row	Process X	Process Y	Process Z
A.	Transcription	Translation	Replication
B.	Transcription	Replication	Translation
C.	Replication	Transcription	Translation
D.	Replication	Translation	Transcription

Use the following information to answer question 37.

A Section of Insulin

Tyrosine—Threonine—Proline—Lysine

37. The anticodons on the tRNA molecules that bring the amino acids to the ribosome to make the section of insulin shown above are, respectively,

A. AUA, UGA, CCG, UUC
B. AUA, UGA, GGC, UUC
C. ATA, TGA, CCG, AAG
D. ATA, TGA, GGC, AAG

Use the following information to answer numerical-response question 11.

Some forms of deafness are associated with mutations in the *connexin 26* gene.

A Section of the *Connexin 26* Gene

TGC AAC ACC CTG

Institute of Medical Genetics. 2008. Gene symbol: GJB2. *Human Gene Mutation Database*. Cardiff University. www.hgmd.cf.ac.uk/ac/all.php.

Some Amino Acids

1 Serine
2 Valine
3 Leucine
4 Aspartate
5 Glutamine
6 Threonine
7 Asparagine
8 Tryptophan

Numerical Response

11. The amino acid sequence that is coded by the section of the *connexin 26* gene shown above is _____, _____, _____, and _____.

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

Use the following information to answer question 38.

A human gene codes for the production of insulin. Scientists have genetically modified a bacterium known as *E. coli* to produce human insulin.

38. Which of the following statements describes one step in the genetic modification of *E. coli* to produce human insulin?

A. Ligase was used to insert the insulin gene into *E. coli* DNA, resulting in the human producing a bacterial protein.

B. Ligase was used to insert the insulin gene into *E. coli* DNA, resulting in the *E. coli* producing a human protein.

C. Ligase was used to cut the insulin gene from human DNA, resulting in the human producing a bacterial protein.

D. Ligase was used to cut the insulin gene from human DNA, resulting in the *E. coli* producing a human protein.

Use the following information to answer question 39.

Canavan disease is a genetic disorder that results in damage to neurons in the brain. It is caused by several different mutations in the *ASPA* gene. One mutation results in the presence of alanine in the amino acid chain instead of the normal amino acid, glutamate.

Institute of Medical Genetics. 2009. Gene symbol: ASPA. *Human Gene Mutation Database*. Cardiff University. www.hgmd.cf.ac.uk/ac/all.php.

39. The gene mutation that would result in Canavan disease as described above is a change from

A. CTC to CGC
B. CTC to CUC
C. GAG to GCG
D. GAG to GCC

Use the following information to answer question 40.

Nias Island is located off the west coast of Indonesia in southeast Asia. Ancestors of the island's current inhabitants are believed to have emigrated from the mainland of southeast Asia. Scientists have discovered that the inhabitants of Nias Island have an extremely reduced genetic diversity in both their Y chromosomes and their mitochondrial DNA compared with the current population on the mainland.

van Oven, Mannis, Johannes M. Hämmerle, Marja van Schoor, Geoff Kushnick, Petra Pennekamp, Idaman Zega, Oscar Lao, Lea Brown, Ingo Kennerknecht, and Manfred Kayser. 2010. Unexpected island effects at an extreme: Reduced Y chromosome and mitochondrial DNA diversity in Nias. *Molecular Biology and Evolution* 28 (4): 1349–61. doi:10.1093/molbev/msq300.

40. Which of the following statements describes the difference in genetic diversity observed between the Nias Island population and the population on the mainland?

A. The Nias Island population is less genetically diverse for males only.
B. The Nias Island population is more genetically diverse for females only.
C. Genetic diversity in the Nias Island population is lower in both males and females.
D. Genetic diversity in the Nias Island population is higher in both males and females.

Use the following information to answer question 41.

Rhesus (Rh) factor is a protein found on the surface of red blood cells in some people. People who have the protein are Rh positive, and people who don't have it are Rh negative. The allele for Rh-positive blood (*R*) is dominant to the allele for Rh-negative blood (*r*). The frequency of Rh factor varies in different populations. For example, 17% of the British population has Rh-negative blood.

NHS Blood and Transplant. 2009. All about your blood types. The National Blood Service. www.blood.co.uk/pages/all_about.html. Accessed June 4, 2009.

41. What is the frequency of the Rh-positive allele in the British population?

A. 0.170
B. 0.345
C. 0.412
D. 0.588

Use the following information to answer numerical-response question 12 and question 42.

Canavan disease is an autosomal recessive disorder that causes progressive damage to neurons in the brain.

The frequency of the allele associated with Canavan disease is higher in certain populations than it is in others. In one particular population, the frequency of the allele is 0.0125.

U.S. National Library of Medicine. 2011. Genetic conditions: Canavan disease. *Genetics Home Reference*. ghr.nlm.nih.gov/condition/canavan-disease.

Numerical Response

12. What percentage of the population described above is heterozygous for Canavan disease?

Answer: _____%

(Record your answer **as a percentage rounded to two decimal places** in the numerical-response section on the answer sheet.)

Use the following additional information to answer question 42.

One population with a high frequency of Canavan disease originated in eastern and central Europe. Although the population has spread throughout the world, most members choose to marry and have families only with other members of the same group.

42. The higher frequency of Canavan disease in the population described above compared with other populations is **most likely** caused by

A. gene flow
B. immigration
C. genetic mutations
D. non-random mating

Use the following information to answer question 43.

As waves overturn large rocks in the ocean near southern California, the newly cleared area becomes colonized by photosynthetic green algae known as ulva (*Ulva lactuca*). The ulva reproduce quickly and resist invasion by other species. Crabs graze on the ulva, which allows for slower-growing red algae (*Gelidium coulteri*) to colonize the area of rock once occupied by the ulva.

Sousa, Wayne P. 1979. Experimental investigations of disturbance and ecological succession in a rocky intertidal algal community. *Ecological Monographs* 49, no. 3 (September): 227–54. doi:10.2307/1942484.

43. Which of the following rows describes the type of competition that exists between ulva and red algae and the relationship between the crab and ulva?

Row	Competition Between Ulva and Red Algae	Relationship Between the Crab and Ulva
A.	Intraspecific	Producer–consumer
B.	Intraspecific	Parasitism
C.	Interspecific	Producer–consumer
D.	Interspecific	Parasitism

Use the following information to answer question 44.

The Kīlauea volcano on the island of Hawaii is a highly active volcano that began erupting in 1983. The outflow of lava from each eruption has added more than 500 acres of new land to the shoreline of the island. A species of tree known as *Metrosideros polymorpha* was one of the first species to grow on the outflow of lava.

United States Geological Survey. 2014. Kīlauea's East Rift Zone (Pu'u 'Ō'ō)Eruption 1983 to present. Hawaiian Volcano Observatory. hvo.wr.usgs.gov/kilauea/summary/#Mar2011.

Drake, Donald R. 1992. Seed dispersal of *Metrosideros polymorpha* (Myrtaceae): A pioneer tree of Hawaiian lava flows. *American Journal of Botany* 79, no. 11 (November): 1224–28.

44. Which of the following rows identifies the type of succession that follows each eruption of the Kīlauea volcano and describes *M. polymorpha* as a species in the context of the succession described above?

Row	Type of Succession	*M. polymorpha*
A.	Primary	A pioneer species
B.	Primary	Part of the climax community
C.	Secondary	A pioneer species
D.	Secondary	Part of the climax community

Use the following information to answer questions 45 and 46.

Physella johnsoni is a snail species that lives in five different hot springs in Banff National Park and is not found anywhere else in the world. This snail species has very specialized habitat requirements, including a constant supply of spring water at a temperature of 30–38 °C.

P. johnsoni is threatened by a variety of factors, including copper from coins thrown into the hot springs. In 2000, *P. johnsoni* was classified as endangered.

Committee on the Status of Endangered Wildlife in Canada. 2003. Banff Springs snail. *Species at Risk*. Environment Canada. www.speciesatrisk.gc.ca/search/speciesDetails_e.cfm?SpeciesID=311.

45. The two growth factors that are **most likely** to influence the growth of the *P. johnsoni* population are

A. natality and mortality
B. natality and immigration
C. mortality and emigration
D. immigration and emigration

Use the following additional information to answer question 46.

In January 1999, Spring 2 contained approximately 7 800 snails. By May 1999, the population had declined to 600 snails.

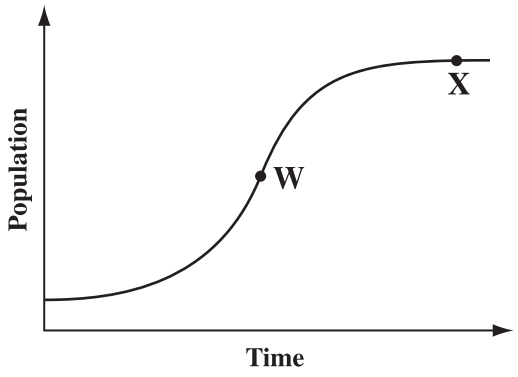
Lepitzki, Dwayne A. W. 2002. Status of the Banff Springs snail (*Physella johnsoni*) in Alberta. *Alberta Wildlife Status Report*, no. 40 (March). Alberta Sustainable Resource Development, Fish and Wildlife Division, and Alberta Conservation Association. aep.alberta.ca/fish-wildlife/species-at-risk-publications-web-resources/invertebrates/documents/SAR-BanffSpringsSnailAlberta-Mar2002.pdf.

46. What was the per capita growth rate of the *P. johnsoni* snail population in Spring 2 between January 1999 and May 1999?

A. 12
B. −12
C. 0.92
D. −0.92

Use the following information to answer question 47.

Logistic Population Growth



47. According to the graph of logistic population growth, the population growth rate is highest at point

A. W, when the population is near the carrying capacity of the environment
B. W, when the population is below the carrying capacity of the environment
C. X, when the population is near the carrying capacity of the environment
D. X, when the population is below the carrying capacity of the environment

---

Use the following information to answer question 48.

Fruit flies are ideal for genetic studies. When raised in ideal laboratory conditions, female fruit flies have an average lifespan of 26 days and male fruit flies 33 days. Female flies typically begin laying fertilized eggs at the age of 3 days. The time of development from egg to adult is typically 10 days. On average, female flies lay approximately 46 eggs during their lifespan.

48. One reason why fruit flies are ideal for genetic studies is that their reproductive strategy is

A. *r*-selected with a low biotic potential
B. *r*-selected with a high biotic potential
C. *K*-selected with a low biotic potential
D. *K*-selected with a high biotic potential