## Unit 7: Review Answers

**Student Textbook pages 668–671**

### Answers to Understanding Concepts Questions

**1.** The term "cell cycle" refers to the phases in the life of a somatic cell. The phases are G1, S, G2, mitosis, and cytokinesis. The first phase is G1 (Gap 1 or Growth 1) phase. In this phase, the new cell carries out rapid growth and metabolic activity. The second phase is S, or synthesis, phase. In this phase, the cell begins preparing for cell division by synthesizing a complete duplicate set of genetic material: the DNA in the nucleus is replicated. In the third phase, G2 (Gap 2 or Growth 2) phase, proteins and other molecules that are needed for cell division are produced. Mitosis is the phase of nuclear division in which the chromatin that were duplicated in S phase migrate as chromosomes to opposite poles of the cell. Finally, the cytoplasmic division of the parent cell is called cytokinesis. Here the cytoplasm and the organelles are divided between the two new daughter cells.

**2.** The order of events in mitosis is as follows: prophase, metaphase, anaphase, and telophase.

**3. (a)** A leaf cell immediately following cytokinesis will have $2n = 54$ chromosomes.

**(b)** A gametophyte cell at the conclusion of the S phase of mitosis will have $n = 27$ chromosomes, each of which has two identical chromatids.

**(c)** A sporophyte cell at the conclusion of anaphase I has the equivalent of 108 chromosomes. The 54 chromosomes—as duplicate chromatids—have separated (54 + 54) and are still in the same cell.

**4.** The law of segregation is derived from the separation of the chromosomes during anaphase I of meiosis. The two alleles for each characteristic segregate during the production of gametes. The law of independent assortment is derived from the assortment of the chromosomes during metaphase I of meiosis. Chromosomes are arranged independently of each other such that one allele faces one pole of the cell, and the other allele faces the other pole. Which allele faces which pole of the cell occurs by chance, and is independent of the other alleles on the other chromosomes.

**5. (a)** Genotype refers to the genetic make up of an individual, usually expressed as letters, for example, *PP*, *Pp*, and *pp*. Phenotype refers to the observed appearance of an individual, for example, purple flowers and white flowers.

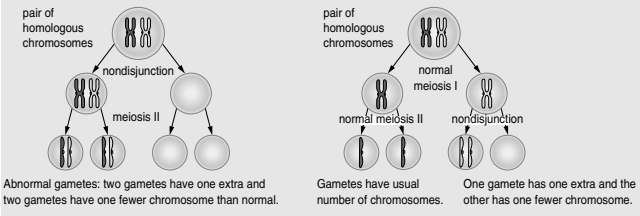
**(b)** In a homozygote, both alleles are the same, for example, *PP* and *pp*. In a heterozygote, the alleles are different, for example, *Pp*.

**(c)** When dominant and recessive alleles are present in a heterozygote, the dominant allele is fully expressed in the organism's phenotype, and the recessive allele has no noticeable effect on the phenotype.

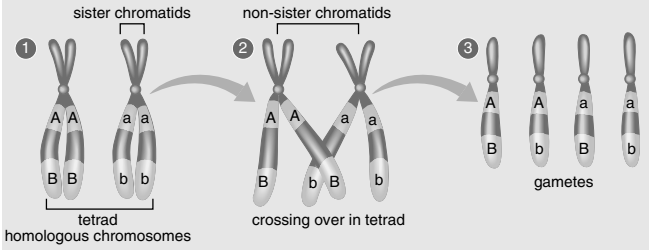
**6.** The probability would be in 1 in 8 388 608 ($2^{23}$). Of her 23 maternal and 23 paternal chromosomes, all the chromosomes from one parent would have to be facing the same pole, and all the chromosomes from the other parent would have to face the opposite pole of the cell, in metaphase I.

**7. (a)** Students' diagrams should resemble those below.

Nondisjunction from Figure 16.13




Crossing over from Figure 16.14A




**(b)** Nondisjunction is likely to result in non-viable daughter cells because the addition or deletion of chromosomes is a greater genetic change, and is likely to have more adverse consequences than crossing over.

**8.** In humans, all somatic cells throughout life are diploid cells with two sets of chromosomes. Testes and ovaries produce haploid sperm cells and egg cells by meiosis. Meiosis occurs prior to fertilization. Fertilization occurs internally in the Fallopian tubes of the female, and development of the offspring occurs in the uterus.

In ferns the adult multicellular sporophyte is diploid. Spores are produced by meiosis on the underside of the fronds (leaves). Spores are released, and if they land in a favourable environment, they will grow into a small haploid gametophyte. The gametophyte grows by mitosis, and produces haploid gametes that fuse. The resulting zygote grows by mitosis into a diploid adult sporophyte. The fern life cycle is an alternation of sporophyte and gametophyte generations. In humans, the haploid generation is only one cell, the sperm cell or egg cell. Reproductive advantages of the fern life cycle: Spores are small and light and can, therefore, be transported to a new environment that may be more favourable to growth and in which competition from the parent plant is reduced; gametophytes can form gametes that fuse and create a new sporophyte without fertilization, so that another fern is not required at this stage in the fern life cycle.

Reproductive advantages of the human life cycle: In the fern life cycle, the gametophyte is exposed to the environment, where it is very vulnerable due to its small size. In human reproduction, the egg and sperm (gametophytes) fuse in the Fallopian tube: the haploid cells are not exposed to the external environment.

**9. (a)** In terms of classical Mendelian genetics, the laws of heredity can be explained in the following ways:

- The law of segregation states that heritable factors (genes) separate during the formation of gametes in such a way that each gamete receives one copy of every factor.
- The law of independent assortment states that pairs of alleles separate independently of the alleles for

other genes during the formation of gametes. This means that traits are transmitted to offspring independently of one another.

**(b)** In terms of molecular genetics, the laws of heredity can be explained in the following ways:

- The law of segregation is derived from the separation of the chromosomes during anaphase I of meiosis. The two alleles of each gene segregate during the production of gametes.
- The law of independent assortment is derived from the assortment of the chromosomes during metaphase I of meiosis. Chromosomes are arranged independently of each other, such that one allele faces one pole of the cell, and the other allele faces the other pole. The two alleles for each gene assort into gametes independently.

**10. (a)** The $F_1$ generation would all be normal-winged.

**(b)** The $F_2$ generation would be 3 normal-winged:1 short-winged.

**11.** Cross the black-eyed fly with a grey-eyed fly. If any grey-eyed flies occur in the offspring, then the black-eyed fly is heterozygous *(Bb)*. If no grey-eyed flies occur in the offspring, then the black-eyed fly is homozygous *(BB)*.

**12.** The $P_1$ genotypes are *Ww* and *ww*.

**13. (a)** Normal wings = 750 offspring.

**(b)** Black eyes and short wings = 188 offspring.

**(c)** Grey eyes and short wings = 63 offspring.

**14.** The probability that their next child will have hemophilia (*hh*) is 0.25, or 1 in 4, as shown in the Punnett square. Students should assume that neither parent has hemophilia.

| ♂ \ ♀ | $X^H$ | $X^h$ |
|---|---|---|
| $X^H$ | $X^HX^H$ | $X^HX^h$ |
| $Y$ | $X^HY$ | $X^hY$ |

**15. (a)** "A" represents the transcription of DNA to mRNA.

**(b)** "B" represents the translation of the mRNA genetic code to a protein.

**16. (a)** 5'-AAATACACATGCATCTTT-3'
3'-TTTATGTGTACGTAGAAA-5`

**(b)** The 3' end of the segment has the free –OH group.

**(c)** The amino acid sequence of the polypeptide product of this gene is "methionine-cysteine-threonine-stop."

**(d)** Sample answer: A nucleotide substitution in the DNA segment 5'-TACACATGCATC-3' to 5'-TACACATGGATC-3' would be a point silent mutation because there is no change in the amino acid threonine, coded by TGG.

**17. (a)** During DNA replication, DNA polymerase inserts into the replication bubble and adds nucleotides, one at a time, to create a strand of DNA that is complementary to the parent strand.

**(b)** DNA ligase joins (splices) together Okazaki fragments, short fragments of DNA that are formed during the replication of the lagging strand of the parent DNA.

**(c)** RNA primase makes an RNA primer strand of about 10 nucleotides, to which DNA polymerase adds nucleotides during replication of the parent strand of DNA.

**(d)** RNA polymerase is a complex of enzymes that, during transcription, unwinds the DNA double helix. It then binds to the sense strand of the DNA molecule and synthesizes an mRNA molecule that is complementary to the sense strand of DNA.

**(e)** Helicase cleaves and unwinds short sections of DNA ahead of the replication fork.

**18.** Three types of RNA and their roles in gene expression are as follows:

- Ribosomal RNA (rRNA) is found in the ribosomes, which is where the messenger RNA (mRNA) is read and the amino acids are assembled to form a polypeptide.
- Messenger RNA (mRNA) transcribes the genes, the sequence of nitrogen bases in a strand of DNA, and carries this "message" from the DNA in the nucleus to the ribosomes in the cytoplasm.
- Transfer RNAs (tRNA) in the cytoplasm bond to individual amino acids and take them to the complementary codons of the mRNA at the binding site on the ribosome, where a growing polypeptide chain is built.

**19. (a)** A restriction endonuclease is an enzyme that "recognizes" a short sequence of DNA nucleotides (called the target sequence) on a strand of DNA. The restriction endonuclease cuts the strand at a particular point within the nucleotide sequence, known as a restriction site. Two characteristics of restriction endonucleases that are useful to genetic engineers are specificity and staggered cuts. These characteristics enable genetic engineers to use restriction endonucleases to create recombinant DNA.

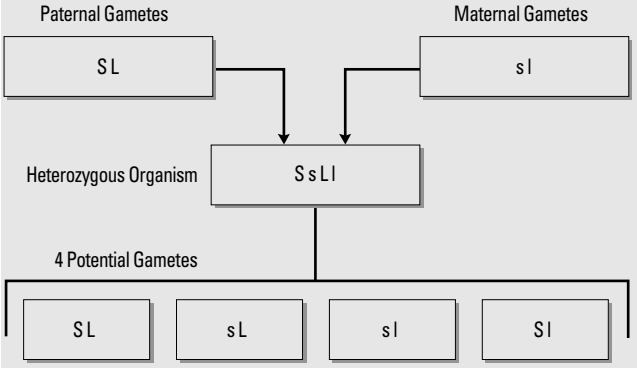
**(b)** A DNA microarray is a glass microscope slide or a polymer membrane that contains a grid of thousands of wells. Each contains a nucleic acid sequence that can bind with one of the mRNA molecules transcribed during gene expression. A DNA microarray allows scientists to analyze the activity of thousands of genes at once, and pinpoint the genes

that are responsible for particular functions or conditions.

**(c)** A DNA vector carries foreign DNA into target cells in the patient. One type of DNA vector commonly used in gene therapy trials is a modified form of virus. Viruses are well-suited to gene therapy because most have the ability to target certain types of living cells and to insert their DNA into the genomes of these cells. DNA vectors enable genetic engineers to change the function of a gene in order to treat a genetic disorder.

**(d)** Recombinant DNA is DNA that includes genetic material from different sources, and is used to produce certain characteristics in different organisms. For example, the gene for human insulin is inserted into bacterial DNA to manufacture insulin.

**20. Note: This question should also state that the gene for long stems (L) is dominant to the gene for short stems (l).**




**21.** If a somatic cell that has a mutation is part of the asexually reproducing tissue, then the mutation will be transmitted to the new offspring. This asexually reproducing tissue is in effect the germ line.

**22.** Two characteristics of restriction endonucleases that are useful to genetic researchers are specificity and staggered cuts. Specificity refers to the cuts made by an endonuclease in the target sequence of DNA nucleotides, which are specific and predictable. Staggered cuts refers to how most restriction endonucleases produce a staggered cut that leaves a few unpaired nucleotides on a single strand at each end of the restriction fragment. These shortstrands, often referred to as "sticky ends," can then form base pairs with other short strands that have a complementary sequence.

**23.** In gel electrophoresis, the negatively charged DNA fragments are attracted to and travel toward the positive terminal. The smaller fragments move more easily through the spaces between the protein molecules of the gel and migrate the farthest from the well.

## Answers to Applying Concepts Questions

**24.** "Every cell is haploid for at least part of its life cycle" is not a true statement. In cell reproduction in diploid organisms, the $2n$ number of chromosomes is replicated in S phase of the cell cycle. Now the cell has the equivalent DNA of a $4n$ cell. This remains until telophase, when the chromatids, distribute now separate, into two daughter cells, "restoring" the $2n$ number of chromosomes.

**25.** A karyotype permits examination of the chromosomes to determine if nondisjunction has occurred and additional chromosomes are present, or chromosomes are missing. It also permits examination of the chromosomes to determine if chromosomes are missing, or have additional segments. A slide of a cell culture that is actively going through mitosis is prepared and stained. If any cells are in metaphase, the slide is photographed. Individual chromosomes are cut out of the photograph and matched according to their length and banding pattern. The arranged chromosomes are then photographed, with the resulting picture depicting the cell's karyotype.

**26.** The researcher is correct. Microtubules are necessary for the development of the spindle fibres, without which metaphase and anaphase cannot occur. The tumour will not reproduce, as mitosis will be arrested at prophase.

**27.** During S phase of the cell cycle, the replication of DNA will be disrupted. Without DNA ligase, the Okazaki fragments of DNA on the lagging strand will not be joined to form a continuous strand of new DNA. Without DNA replication, two new daughter cells, if formed, will not have a complete set of genetic material, and the cells will likely die.

**28.** FMF exhibits an autosomal dominant inheritance pattern.

Genotypes: I 1, I 2, II 1, II 2, III 2, III 3, III 4, and IV 1 are heterozygous (*Aa*). II 3, III 1, and IV 2 are homozygous recessive (*aa*). One cannot be sure of the genotypes of II 4 and IV 3.

Phenotypes: Individuals II 3, III 1, and IV 2 have FMF. All other individuals have normal phenotypes with respect to FMF.

**29.** Genotypes: II 4 and III 2 are $X^LX^L$. I 1, II 2, and III 3 are $X^LX^l$. I 2, II 1, and II 3 are $X^LY$. III 1 is $X^lY$.

Phenotypes: III 1 has Lesch-Nyhan syndrome. I 1, I 2, II 1, II 2, II 3, II 4, III 2, and III 3 have normal phenotypes with respect to Lesch-Nyhan syndrome.

**30. (a)** Congenital deafness is an autosomal recessive disorder. Both parents are heterozygous (*Hh*) for congenital deafness, and the recessive allele from both parents was passed to the II-3 offspring (*hh*).

**(b)** If the male parent is homozygous (*HH*) for normal hearing, and the female parent has congenital deafness (*hh*), then all the offspring will be (*Hh*) and have normal hearing. It is not possible to be certain of the male parent's genotype, because if he were

heterozygous (*Hh*), the probability of having a child with congenital deafness (*hh*) is 0.5.

**(c)** The II-3 woman is a carrier for congenital deafness (*Hh*), and her husband, who has a sister with the condition, may be either (*HH*) or (*Hh*). The Punnett square (A) shows the possible genotypes of the offspring if he is homozygous for normal hearing. The Punnett square (B) shows the possible genotypes of the offspring if he is heterozygous for normal hearing

A

| | *H* | *H* |
|---|---|---|
| *H* | *HH* | *HH* |
| *h* | *Hh* | *Hh* |

If the husband is homozygous for the dominant allele, they have no chance of having a congenitally deaf child.

B

| | *H* | *h* |
|---|---|---|
| *H* | *HH* | *Hh* |
| *h* | *Hh* | *hh* |

If the husband is heterozygous, the couple has a1 in 4 chance of having a congenitally deaf child.

**31.** No, Elsie will not be able to do this. If black and white feather colour is an example of co-dominance in these chickens, the genotype for black feathers is *BB*, the genotype for white feathers is *bb*, and the genotype for speckled feathers is *Bb*. The cross of a black rooster and a white hen will result in the genotypes shown in the Punnett square below.

| | *B* | *b* |
|---|---|---|
| *B* | *BB* | *Bb* |
| *b* | *Bb* | *bb* |

If Elsie crosses a speckled black and white chicken (*Bb*) with a white chicken (*bb*), she will still only get speckled black and white chickens or white chickens, as shown in the Punnett square below. She will not get any chickens that are white with a few black feathers, no matter how many crosses she performs.

| | *b* | *b* |
|---|---|---|
| *B* | *Bb* | *Bb* |
| *b* | *bb* | *bb* |

**32.** The babies and parents belong together as follows:

- Baby C: blood type AB. Parents 1: blood types A and B
- Baby D: blood type O. Parents 2: blood types O and O
- Baby A: blood type A. Parents 3: blood types AB and O
- Baby B: blood type B. Parents 4: blood types B and B

**33. (a)** The farmer should grow the seeds and cross-pollinate lemon trees that successfully grow in the cooler climate.

**(b)** A new variety of lemon could be produced if the gene(s) for growth in cooler climates could be isolated. Then, using restriction endonuclease enzymes, the gene(s) could be inserted in the egg cell or sperm nucleus of a lemon tree. Then the seed is planted.

**(c)** An advantage of artificial selection is that it is likely much easier and less expensive to do than genetically engineering the cooler climate gene(s). A disadvantage is that it may take a long time to achieve the desired result. It may require growing several generations of lemon trees and performing several cross-pollinations, with no guarantee that it will be successful.

An advantage of genetically engineering the desired lemon tree is that, assuming the gene(s) for growth in cooler climate can be isolated and introduced into a gamete, there is a good chance it will be successful. It will take less time than the many generations required for artificial selection. A disadvantage is that the process is likely to be much more expensive than artificial selection.

**34. (a)** Slipper limpets, which form stacks attached to seashore rocks, can change gender from male to female if necessary. When in a stack, the slipper limpet's gender is determined by a hormone which is constantly produced by the female. When the female dies, or becomes too old and stops producing the hormone, the male at the bottom of the stack will develop ovaries and become female. The process takes approximately 60 days. The genetic process that accounts for this is thought to be a protein that activates a particular gene. This gene codes for proteins that either form or stimulate hormones to change the male into a female, and begin producing eggs.

**(b)** Accept all reasonable responses. An example hypothesis is: If no female is present, one or more slipper limpets in an all-male stack will develop into females. An example of an experiment to test this hypothesis is: Place five adult male slipper limpets into one salt-water aquarium with suitable rock habitat. Put four adult males and one adult female into a similar aquarium. Mark the back of the shell of the female with non-toxic paint. The limpets should automatically organise themselves into a stack. Check the sexes of the limpets sixty days from the point of stack formation. If the hypothesis is correct, one or more males in the "all-male" stack should have developed into females. The sexes of the "four male–one female" stack should remain the same, with the original marked limpet still being the female.

**35. (a)** An amniocentesis may be performed as a prenatal screening, in which amniotic fluid containing some fetal cells is withdrawn from the amniotic sac. The cells are cultured, and the DNA can be tested to determine if the dwarfism gene is present. They may also opt for chorionic villi sampling, a technique that removes fetal cells for testing from the chorionic villus at the placenta. Ultrasound, which uses a high frequency sound that produces an image, will only show major growth aspects of fetal development and may, or may not, be helpful.

**(b)** The ethical question that accompanies prenatal screening is "What is the purpose of the screening?" If a screening determines that a fetus has a condition that results in an early death or a poor quality of life, the question of terminating the pregnancy is a possibility.

**36.** Liver, brain, and all somatic cells of the same individual that have a nucleus will have the same DNA because they originate from the same fertilized egg. The exception to this is that in females one of the X chromosomes of each cell is inactivated as a Barr body. So in effect, female tissues are a "mosaic" containing one of the two original X chromosomes in each cell.

## Answers to Making Connections Questions

**37.** The flowchart or graphic organizer should contain the flowing points:

- Cigarette smoke contains several carcinogens.
- Smoking brings carcinogens into contact with the lining of the respiratory tract.
- Long term exposure to carcinogens increases the risk of them adversely affecting the cells of the respiratory tract.
- Carcinogens may cause cells that are actively reproducing to develop point mutations in their DNA.
- Over time, repeated DNA mutations may upset the genetic control of the cell cycle.
- A tumour may develop if the tissues repeatedly reproduce without a check on their growth.
- Tumours often interfere with the normal functions of the tissue.
- Cancer cells that become malignant in the original tissue may spread (metastasize) to other tissues and form secondary tumours.
- Localized lung tumours may be treated by surgical removal of the affected tissue.

**38.** Suggested possible answers are:

**(a)** It is not possible to change your genetic make-up, but with the correct information you can make wise lifestyle choices that will keep you as healthy as possible.

**(b)** Five headings could potentially be:

Introduction; Genetic Make-up; Diet; Exercise; and, Conclusion.

**(c)** The points under each heading may include:

- Introduction: After genes, it is environmental influences that count most.
- Genetic Make-up: Can you know your genetic make up? What is your family history? Do you have a genetic condition that you wish you did not? Could you pass that condition on to your children?
- Diet: Are we "what we eat?" Is a balanced diet enough? Can I be healthy being a vegan, a vegetarian, or …? New research was just released, and what was OK last week should be avoided this week—how to decide? What are trans fats, LDLs, HDLs, and good and bad cholesterol? Is there any "good" junk food?
- Exercise: Do I need a personal trainer? Should I belong to a gym? How much exercise and how often? What is right for me?
- Conclusion: Fish, fruits, vegetables, and exercise—will that do it? Will keeping healthy in these ways reduce my chances of mutations occurring in my DNA? What other things could I do to stay healthy and reduce my risks?

**39. (a)** The significance of the discovery of the herbicide-resistant weed depends on the genetic relationship and interaction between the weed and the canola. Will the presence of the weed make it difficult to grow canola? If this is the case, are there other herbicides that are safe to use with canola that are effective against the weed? How did the weed acquire resistance to the herbicide? Could the original research that produced the transgenic canola have predicted the occurrence of the herbicide resistant weed?

**(b)** Possible points that students may write are:

- The farmer worries if the weed will affect the quality and quantity of her canola crop. She worries

how she can control the weed without using herbicides that will reduce the market value of the canola.

- An official from the genetic engineering corporation that created the transgenic canola expresses his/her regrets that this happened. The company will work on a solution but that may be years away. The farmer is reimbursed for the cost of her canola seed and potential crop loss.
- The owner of a nearby organic farm is concerned about the possible use of herbicides on canola. If the herbicide should drift to his/her neighbouring crops, it may result in the loss of his/her organic crop designation.
- A consumer organization opposed to the development of genetically modified organisms wants the public to be informed about the health risks of consuming GMO food products. The organization is concerned whether the developers of the transgenic herbicide-resistant canola have researched the long term health effects of this product.
- A genetics researcher wants a grant from the genetic engineering corporation to study the weed and how it developed resistance to the herbicide.

**40.** Mendel would have likely become frustrated at the difficulties of using cats as a subject for investigating inheritance. Raising peas in significant numbers is much easier than raising cats. Finding observable traits in cats is more difficult than in pea plants. For example, the inheritance of colour in cats involves multiple alleles, and is far more complex than the traits selected in pea plants. Using a plant subject for studies in inheritance is much easier and more manageable than a vertebrate subject. It is doubtful that his studies would have had the same impact on our knowledge of inheritance had he used cats.

**41.** A detailed DNA analysis of a species can determine how biologically diverse it is. Such knowledge may help researchers determine if the species is more likely to become endangered in the future.

Several projects are also underway that collect and preserve eggs, semen, embryos, and DNA from endangered mammals, birds, and reptiles. The genetic material collected is saved for potential use in breeding projects aimed at reintroducing the species at risk.

**42. (a)** Optics, biochemistry and physics have opened genetics to analysis that was not possible until the past two centuries. Optics and the development of microscopes have permitted observation of chromosomes and their behaviour during mitosis and meiosis. Photography has allowed the production of karyotypes and helped determine the structure of DNA. Biochemistry and physics have made possible the separation of molecules in a protein gel that has an electric current applied to it.

**(b)** An understanding of gene interactions and the role of proteins in initiating and regulating gene expression would do much to further our present understanding of genetics.

Perhaps the unrelated field of electrochemistry would provide an understanding of what attracts proteins to certain genes and turns them on, while in other instances proteins turn genes off, or suppress their action. Accept any reasonable answer.

**43.** Genomics is the comprehensive study of the sequences, functions, and interactions of genes. Knowledge of biological diversity at the whole genome level may provide an understanding of the origins of individual traits and disease. Genetics refers to the study of single genes and their patterns of inheritance. It is less complex than genomics, which studies gene interactions. Human genetics provides an insight into specific genes and their role in human inheritance that can be used to further understanding and treatment of disease.

**44. (a)** The following are some questions that students may raise in terms of social effects of this technology: Should we invest in people who have more genetic potential or should we compensate those who have possibly less genetic potential? Would parents abort their child if knew that their developing embryo did not have genetic potential in terms of intelligence? Would they pay for gene therapy to insert this gene into the child's genome? Would this technology be used to create a "master" race? Would altering the gene for intelligence inadvertently alter or impact other genes? Is it ethical to value some traits over others? Could this technology lead to gene pollution – irreversibly altering this gene in the human population? Could this technology be used to treat people with brain injuries and/or dementia?

**(b)** Student answers will depend on their interests, values, and spirituality. For example, some will think that this type of biotechnology is playing "God" and that governments should make laws preventing this type of research. Other students may feel that the benefits of this type of research outweigh the risks and that governments should allow this type of research to continue while others simply will not care one way or the other. You may even find students note that most of the decision makers in government are not scientists and many will base their decision on emotion rather than on fact. Accept all reasonable answers.

**(c)** It is difficult to assess how students will respond to this question. Once again, you can expect a range of answers that depend on individual points of view. Some students may indicate that legislation should be enacted right away to prevent biotechnology research that involves humans. Others may indicate that educating individuals is important in making them

aware of the pros and cons of this type of research. Accept all reasonable answers.

**45.** Students' answers will reflect their beliefs. An example answer might be: Transgenic crops $0, gene therapy $60 million, cell cycle regulation $40 million. Transgenic crops have too many potential negative effects on the ecosystem. Gene therapy holds promise for treating genetic diseases. Cell cycle regulation holds promise of understanding and treating cancer and stopping the spread of malignant tumours.

**46.** Example answers are given:

| Using transgenic pigs as organ donors | Benefits | Risks |
|---|---|---|
| To individual people | – treatment of disease | – long term use of anti-rejection drugs and side-effects are unknown |
| To society | – can help people live longer, and/or have a better quality of life | – ethical challenges might arise<br>– possibility of infectious disease transferring from pigs to humans |
| To the economy | – less cost to care for people that are in ill health<br>– they remain productive members of society<br>– makes more money available for other medical research | – bearing the cost of potential adverse effects |
| To other species | – none | – none |
| To the environment | – none | – none |

**47.** The structure and function of DNA is conserved across all species. Only the DNA of mitochondria and chloroplasts show variation in the genetic code.

**48.** Students' answers will reflect their beliefs. The application of molecular genetics for human use—either with transgenic organisms, or for the treatment of human diseases and conditions—may raise difficult and ethical questions about the appropriateness of the research and its subsequent application.

Molecular genetics and its manifestation in the great number of proteins and their complex interactions that occur in a cell and an organism may give one pause to ask, "Are these interactions all that there is to life?" We know that without these interactions there is no life. Yet seeds may remain dormant, but viable for thousands of years, and when exposed to the right conditions of water, nutrients, and sunlight, they germinate and grow. Viruses are often described as on the borderline between life and non-life. Are they nature's most complex molecules or nature's simplest life forms? They are mostly protein and nucleic acid. Without the conditions inside a cell, they are biologically inert, and are unable to convert molecules into a useable form of cellular energy or reproduce independently. They are, nevertheless, very much connected to the living world in a genetic and an evolutionary way. It is possible to appreciate the wonder and complexities of life without having a complete understanding of what it is.