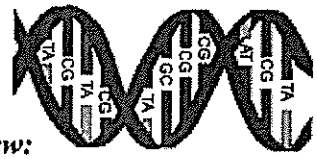
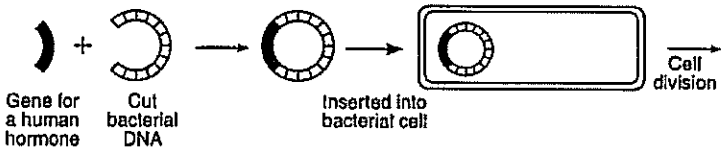
GENETICS





Overview:

Living organisms have a set of genetic instructions that determine the characteristics of their structures and functions. The genetic instructions are passed from parent to offspring through a process of reproduction. During inheritance of these traits, the genetic instructions can be changed leading to variation. Genetic instructions are found in the form of a code within DNA molecules. Each set of genetic codes or DNA is unique to each individual organism.

Humans have used artificial techniques to alter genetic information. Through breeding practices and biotechnology, humans are developing new combinations of genes and new varieties of organisms.

Organization Relationship: Cell → Nucleus → Chromosome → DNA → Gene → Molecular Bases (A,T,C,G)

Essential Information:

DNA's Role – In all living organisms, cells store coded genetic information in the form of *DNA*. DNA is composed of *nucleotides*, which consist of sugar, phosphate, and *molecular bases* that form genetic sequences. These molecular bases are represented by letters that are the beginning of their molecular names: A = Adenine, T = Thymine, C = Cytosine, G = Guanine. Molecular bases form complimentary pairs: A with T and C with G. These bases form sequences within DNA called genes, which code for specific proteins that determine an organism's traits or characteristics. Genetic material is organized in the cell for efficient replication practices as well as protein synthesis. DNA is coiled and packed into structures known as chromosomes. *Chromosomes* are located within a nucleus or genetic area within a cell.

DNA's *double helix* structure allows it to serve as a *template* for *DNA replication*. DNA "unzips" using enzymes, and new *nucleotides* attach to exposed strands forming two new identical DNA strands. This process allows for continuity of genetic material to be passed from parent to offspring. This process is an essential part of asexual as well as sexual reproduction. *Asexual reproduction* results in offspring that are identical to the parent, while *sexual reproduction* results in offspring that resemble but are not identical to the parent. The processes of mitosis and meiosis rely on the replication of DNA. *Mitosis* is the process of cell division that produces identical daughter cells for growth and repair, whereas *meiosis* is the process of cell division that produces sex cells or gametes. Each process uses DNA replication. DNA also serves to store the codes for the production of proteins, which are vital to the proper functioning of cells and all living things. Within the cell, *protein synthesis* occurs when coded genetic information is copied and transferred from the nucleus to *ribosomes*.

RNA's Role – The copy and transfer of genetic information involves a second nucleic acid, RNA. RNA is single stranded and uses a molecular base represented by U instead of T, making the complimentary pairs: A with U and C with G. In the ribosome, amino acids are assembled into chains forming a protein molecule. The sequence of the amino acids is determined by the sequence of molecular bases on the copied RNA strand. A sequence of three bases on RNA, known as a codon, codes for a particular amino acid. A universal chart allows geneticists and researchers to convert RNA code into an amino acid. The original code for every protein begins with DNA. Each protein has a specific shape that determines its function, all based on the sequence of those amino acids.

Expression of Genes – When gene sequences in DNA are accessed to make specific proteins, those genes are said to be expressed. The phrase "genes are turned on" may also be used to describe *gene expression*. Gene expression is regulated or controlled by several factors. There are internal controls that allow genes to be expressed when proteins are needed. The environment can also influence gene expression. Factors such as sunlight and temperature can determine whether genes may be expressed.

Mutations – Changes in genetic sequences are known as mutations. A gene sequence can be changed through *deletion* – where a portion of the genetic code is lost or missing; through *addition* – where a section of genetic code has been added to the existing sequence; or through *substitution* – a process where information from one chromosome is traded with another chromosome. During meiosis, closely aligned chromosomes may trade sections in a process known as *crossing over*. This results in a new genetic makeup in the chromosome. Some mutations may promote genetic variation, becoming either beneficial or detrimental to a population. There are many *mutagenic agents* that can cause mutations within DNA, including chemicals, UV rays, X–rays, and other types of radiation exposure. In order for a mutation to be passed from one generation to another, the DNA in a sex cell (egg or sperm) must be changed. Mutation to DNA in body cells will not result in a mutation being passed to the next generation.

Gene Manipulation – Humans have altered genetic information through *selective breeding* to create enhanced varieties of plants and animals. By choosing organisms with the most desired traits and breeding them, farmers and breeders have created many new varieties. With greater knowledge of DNA and genes, humans can now use *genetic engineering* to manipulate DNA to produce new traits within existing organisms. By using *restriction enzymes* that cut DNA, scientists can cut, copy, and move DNA segments from one individual organism to another. When the DNA segment is inserted into the DNA of another organism, such as bacteria, the altered DNA will then contain a foreign DNA segment and also express it. For example, the human hormone insulin is now genetically engineered using bacteria (see diagram 5). Researchers have also been able to *clone* organisms by inserting a whole set of genetic instructions for an organism into an egg cell. Cloned organisms will contain genetic information identical to the donor parent organism.

Using these techniques and their increasing knowledge of genetics, researchers have been able to locate disease-causing genes and develop preventative measures to help fight those diseases. Researchers have also genetically engineered hormones and enzymes that could provide economical advantages and produce fewer side effects when used in medicines. Other genetic techniques such as gel electrophoresis (see diagram 6) are used to identify individuals as well as determine paternity, based on the genetic information available. The use of genetic engineering so far has led to advances in agriculture and medicine that have benefited mankind.

Additional Information:

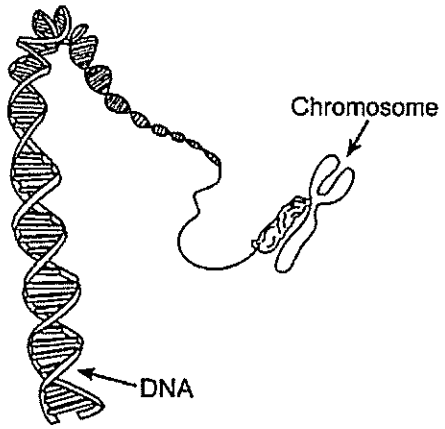
- Many genetic disorders are a result of a change in the genetic sequence of a gene. This change may lead to a disruption in the synthesis of necessary proteins. Several genetic disorders include cystic fibrosis, hemophilia, and sickle cell anemia.
- Identical twins are genetically identical, having the same DNA, and are always the same sex. But different environmental influences throughout their lives affect which genes are switched on or off. Thus, the twins will show different characteristics based on that environmental effect on gene expression.

Additional Information: (continued)

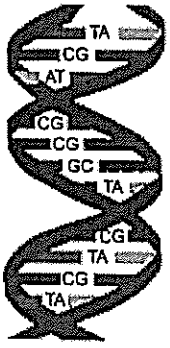
- RNA has several forms. mRNA is utilized to transcribe or copy the genetic code and bring it to the ribosome. tRNA brings amino acids to the ribosome to be assembled into proteins based on genetic code.
- Sometimes chromosomes fail to separate during the process of meiosis, resulting in gametes that have either an additional chromosome or a missing chromosome. This is known as non-disjunction. When these gametes are joined during fertilization, the resulting offspring will have one extra or one less chromosome from the normal species chromosome number. A person who has an extra chromosome (number 21) has Down syndrome, a disorder that exhibits some health abnormalities.
- Many environmental disruptions that have been caused by man can lead to genetic mutation. This is especially true in places that have had serious nuclear disasters, like the Chernobyl nuclear power plant, located in Russia and the Fukushima Daiichi nuclear power plant, located in Japan.
- Because DNA is unique to each individual, it has become useful in many biotechnological procedures as well as in forensic investigation.
- Scientist have successfully mapped the human genetic code. This mapping called The Humane Genome Project and can provide valuable information to researchers and geneticists.

Diagrams:

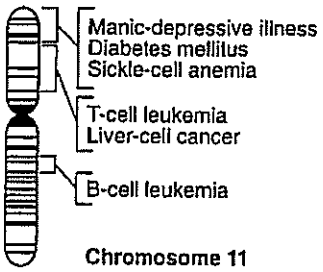
1. **Organization of Genetic Material** – This diagram shows the organization of genetic material found within a chromosome. This double helix of DNA is wound and tightly coiled within the structure of a chromosome. Chromosomes are found within a nucleus of a cell.



2. **DNA Double Helix Structure** – The DNA double helix structure acts to store genetic information and serves as a template for DNA replication. Shown are molecular base sequences, which are paired with complimentary bases (A – T and C – G). Sequences of these molecular bases represent genes that can code for a particular protein and genetic trait.



3. **Human Gene** – The accompanying diagram represents the gene pattern for human chromosome 11. Some of the genes are identified and labeled as causing certain illnesses or diseases. Research into the arrangement and location of specific genes on chromosomes has led to many discoveries for correcting genetic defects.



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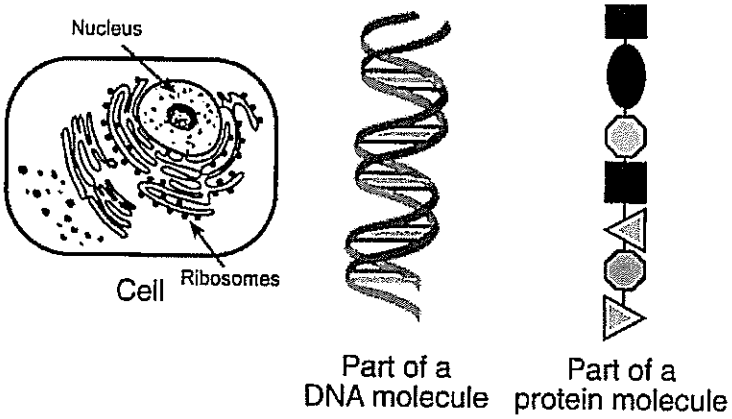
4. **Protein Synthesis** – DNA, which is found in the nucleus of the cell, stores genetic information that can be copied and transferred from the nucleus to the ribosomes of a cell. At the ribosomes, the coded instructions will be converted into a protein. This process is known as protein synthesis and takes place in every cell.



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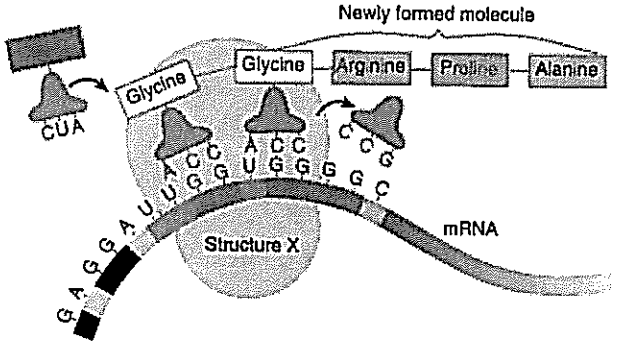
5. **Protein Synthesis in a Ribosome** – This diagram illustrates the process of protein synthesis as it occurs within the ribosome, Structure X. The newly formed molecules are amino acids that are aligned together in sequence to create proteins based on the code from mRNA. Notice the complimentary pairs in RNA, *A* with *U* and *C* with *G*.



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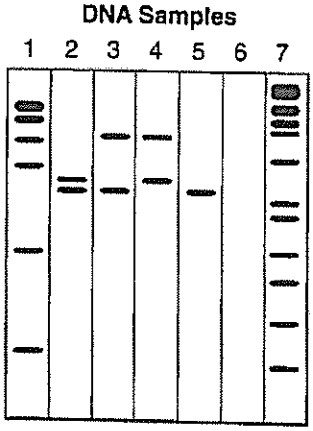
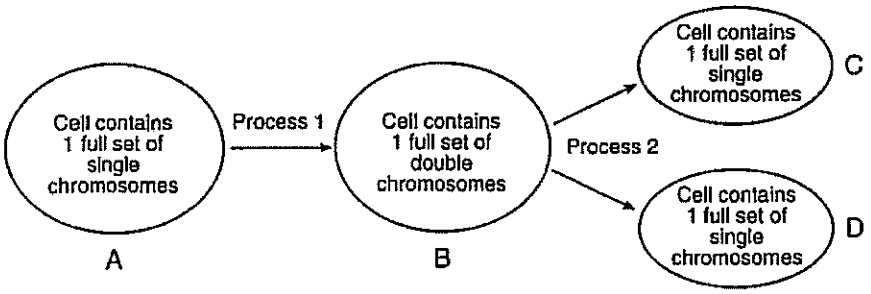
6. **Gel Electrophoresis** – This diagram represents the results of gel electrophoresis, a process where DNA fragments are separated and moved by electric current to identify or look for relationships between living organisms. DNA molecules are cut into fragments of various lengths by enzymes and then loaded into a gel. Electric currents cause these fragments to migrate through the gel at varying distances and speeds. Smaller pieces move farther than larger ones. The patterns that develop as a result of this process can be used in crime investigations and evolutionary determinations.





7. **Mitotic Cell Division in Asexual Reproduction** – In this diagram, a single cell organism, such as paramecium, is undergoing asexual reproduction. Process 1 is replication in which the DNA structure is being copied. In process 2, the cell divides producing two identical cells, each with a full set of single chromosomes. Process 1 and 2 are directly involved in mitotic cell division. This results in the genetic content of *C* and *D* being identical to parent cell *A*.

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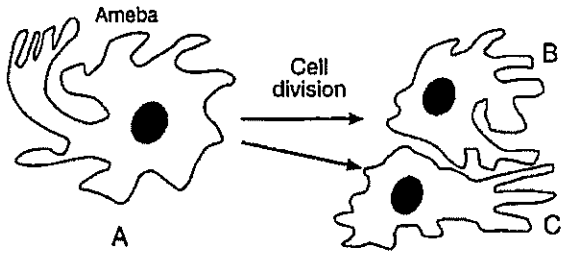
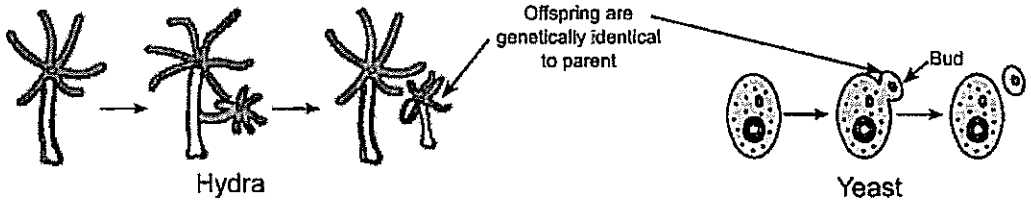
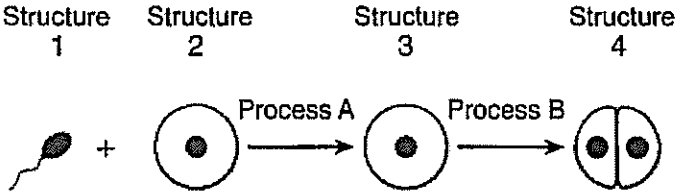
8. **Genetic Information in Asexual Reproduction** – This ameba is undergoing asexual reproduction. Daughter cells *B* and *C* will contain the same genetic information as cell *A*. In asexual reproduction, resulting offspring are identical to the parent.

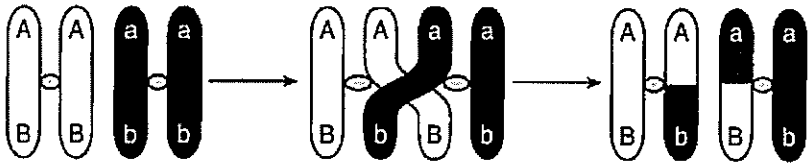


The offspring of these organisms will also have the same genetic information as the parent. No genetic variation will occur because the offspring is a result of the asexual process of budding.

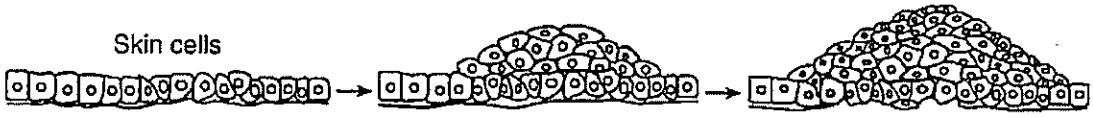




9. **Meiosis and Genetic Information** – During the process of meiosis, sperm (Structure 1) and egg cell (Structure 2) are produced with half the genetic information of the parent cells. During fertilization (Process *A*), genetic information from sperm and egg combine and provide a full set of genetic instructions in the resulting cell (Structure 3). This cell undergoes mitosis (Process *B*) in order to grow and develop into a complete organism.



10. **Chromosome Crossing Over** – The diagram represents the process of crossing over, which occurs during meiosis. Genetic material is exchanged between chromosomes, and new genetic combinations are created resulting in genetic variation within the offspring.



11. **Uncontrolled Cell Growth** – The diagram above shows the effect of genetic mutations that occur in skin cells when mitotic division proceeds uncontrollably. These cells may result in a tumor or form of cancer.

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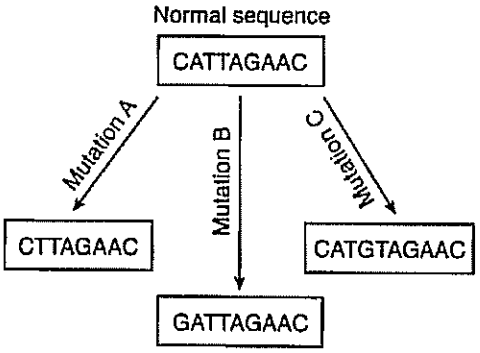
12. **Mutation** – This diagram shows a normal gene sequence and three mutated sequences of a segment of DNA. Mutation *A* is *deletion* where the first *A* in the normal sequence has been deleted. Mutation *B* is *substitution* where *G* has taken the place for *C*. Mutation *C* is *addition* where a *G* has been inserted between the two *T*'s.



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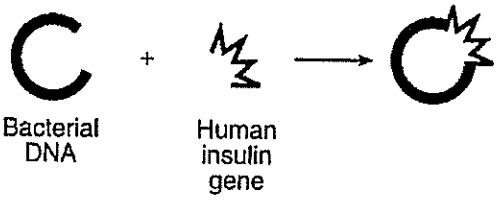
13. **Genetic Engineering** – The process of genetic engineering is represented by this diagram. Enzymes are used to cut open a ring of bacterial DNA as well as to cut out an insulin gene from human DNA. The human insulin gene is then inserted into the bacterial DNA, resulting in a new genetic combination. This newly combined bacterial DNA will now produce human insulin.



DNA base sequence → Amino acid sequence → Protein shape → Protein function → Trait

14. **DNA and the Expression of Genetic Traits** – The sequence in this diagram represents the relationship between DNA and the expression of a genetic trait. DNA code provides the template that determines the order of linked amino acids. Specific sequences of amino acids build proteins that have specific shapes and functions that are expressed as a trait.

Vocabulary Refresher

Group A *Directions* - Match the correct definition for the following terms:

1. _____DNA
2. _____ Chromosome
3. _____Gene
4. _____Protein
5. _____Trait
6. _____Molecular bases
7. _____Double helix
8. _____Template
9. _____DNA replication
10. _____Nucleotide
11. _____Protein synthesis
12. _____Deletion
13. _____Crossing over
14. _____Gene expression

A. Four molecules (represented by A, T, C, and G) that provide the codes for amino acids and ultimately, proteins within living organisms. These molecules are complimentary to each other with A binding to T and C binding with G.

B. Building block of DNA consisting of a sugar, a phosphate group, and a molecular base (A, C, T, or G).

C. A process where a genetic code found in DNA is copied and converted into a chain of amino acids.

D. A pattern that provides the basis for an identical copy to be made.

E. A sequence of molecular bases within a DNA molecule that code for a particular protein.

F. A tightly packed coil of DNA that is found in the nucleus of a cell.

G. A process where the genetic information found within DNA is changed into a functional product like a protein. This protein may take the form of a physical feature or a functional chemical.

H. A characteristic (structure or function) that an organism exhibits as a result of the genetic code within its DNA.

I. A twisted ladder-like structure with a backbone of sugar and phosphate and internal rungs made of complimentary molecular bases.

J. The process where chromosomes overlap and sections of these chromosomes are exchanged during meiosis resulting in genetics variations.

K. A process where two identical DNA molecules are synthesized from an original DNA molecule.

L. An organic molecule that contains a unique genetic code within the sequences of its molecular bases for each living organism.

M. An organic molecule that is composed of a sequence of amino acids that plays a vital role in the function of all living organisms. An example is an enzyme.

N. A mutation where part of the genetic code is missing or incomplete.

Vocabulary Refresher

Group B *Directions* - Match the correct definition for the following terms:

1. _____Asexual reproduction
2. _____Sexual reproduction
3. _____Mitosis
4. _____Meiosis
5. _____Ribosome
6. _____Amino acid
7. _____Mutation
8. _____Mutagenic agent
9. _____Selective breeding
10. _____Restriction enzyme
11. _____Genetic engineering
12. _____Clone
13. _____RNA

A. Molecules that when arranged in specific sequences act as the building blocks of proteins. There are 20 different types of these.

B. A form of cell division that takes place within the sex organs of organisms and results in the formation of gametes (sex cells), having one-half the original chromosomes of the parent cell.

C. Any factor such as chemicals or radiation, that leads to a change in the genetic code.

D. A process where a parent organism divides into two new genetically identical offspring. Examples include budding and binary fission.

E. A sudden change in the genetic code or sequence of molecular bases within DNA.

F. An enzyme that locates a particular gene sequence on DNA and "cuts" the DNA at that site, creating DNA fragments of various sizes. These enzymes are used in many biotech processes.

G. An exact genetic copy. The process can be applied to a cell or to a whole organism.

H. A form of cell division where two daughter cells are produced from a parent cell that are genetically identical to the parent cell.

I. A single stranded nucleic acid which contains the molecular bases, A, U, C and G. This molecule plays a vital role in the synthesis of proteins.

J. A process involving two parent organisms that produce offspring, which may resemble but are genetically different from the parent organism.

K. A process where organisms with desirable traits are bred to enhance or maintain a trait, or increase variety.

L. A cell organelle that serves as the site for protein synthesis.

M. A process where a gene from one organism is inserted into the DNA of another organism. The new recombinant DNA will express that inserted gene.

1. The instructions for the traits of an organism are coded in the arrangement of

   (1) glucose units in carbohydrate molecules
   (2) bases in DNA in the nucleus
   (3) fat molecules in the cell membrane
   (4) energy-rich bonds in starch molecules

   1_____

2. Scientific studies show that identical twins who were separated at birth and raised in different homes may vary in height, weight, and intelligence. The most probable explanation for these differences is that

   (1) original genes of each twin increased in number as they developed
   (2) one twin received genes only from the mother while the other twin received genes only from the father
   (3) environments in which they were raised were different enough to affect the expression of their genes
   (4) environments in which they were raised were different enough to change the genetic makeup of both individuals

   2_____

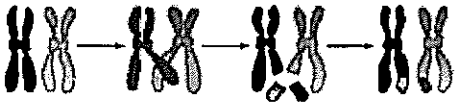
3. For centuries, certain animals have been crossed to produce offspring that have desirable qualities. Dogs have been mated to produce Labradors, beagles, and poodles. All of these dogs look and behave very differently from one another. This technique of producing organisms with specific qualities is known as

   (1) gene replication
   (2) natural selection
   (3) random mutation
   (4) selective breeding 3_____

4. Which process will increase variations that could be inherited?

   (1) mitotic cell division
   (2) active transport
   (3) recombination of base subunit sequences
   (4) synthesis of proteins 4_____

5. The diagram below shows a process that can occur during meiosis.

   The most likely result of this process is

   (1) a new combination of inheritable traits that can appear in the offspring
   (2) an inability to pass either of these chromosomes on to offspring
   (3) a loss of genetic information that will produce a genetic disorder in the offspring
   (4) an increase in the chromosome number of the organism in which this process occurs 5_____

6. Which statement best describes human insulin that is produced by genetically engineered bacteria?

   (1) This insulin will not function normally in humans because it is produced by bacteria.
   (2) This insulin is produced as a result of human insulin being inserted into bacteria cells.
   (3) This insulin is produced as a result of exposing bacteria cells to radiation, which produces a mutation.
   (4) This insulin may have fewer side effects than the insulin previously extracted from the pancreas of other animals.

   6_____

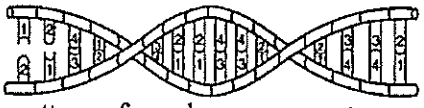
7. Individual cells can be isolated from a mature plant and grown with special mixtures of growth hormones to produce a number of genetically identical plants. This process is known as

(1) cloning
(2) meiotic division
(3) recombinant DNA technology
(4) selective breeding 7_____

8. Which statements best describe the relationship between the terms chromosomes, genes, and nuclei?

(1) Chromosomes are found on genes. Genes are found in nuclei.
(2) Chromosomes are found in nuclei. Nuclei are found in genes.
(3) Genes are found on chromosomes. Chromosomes are found in nuclei.
(4) Genes are found in nuclei. Nuclei are found in chromosomes. 8_____

9. The diagram below represents a section of a molecule that carries genetic information.



The pattern of numbers represents

(1) a sequence of paired bases
(2) the order of proteins in a gene
(3) folds of an amino acid
(4) positions of gene mutations 9_____

10. Asexually reproducing organisms pass on hereditary information as

(1) sequences of A, T, C, and G
(2) chains of complex amino acids
(3) folded protein molecules
(4) simple inorganic sugars 10_____

11. In sexually reproducing species, the number of chromosomes in each body cell remains the same from one generation to the next as a direct result of

(1) meiosis and fertilization
(2) mitosis and mutation
(3) differentiation and aging
(4) homeostasis and dynamic equilibrium

11_____

12. Enzymes are used in moving sections of DNA that code for insulin from the pancreas cells of humans into a certain type of bacterial cell. This bacterial cell will reproduce, giving rise to offspring that are able to form

(1) human insulin
(2) antibodies against insulin
(3) enzymes that digest insulin
(4) a new type of insulin 12_____

13. A change in the base subunit sequence during DNA replication can result in

(1) variation resulting from changes within the genetic code
(2) rapid evolution of an organism
(3) synthesis of antigens to protect the cell
(4) recombination of genes within the cell

13_____

14. Plants inherit genes that enable them to produce chlorophyll, but this pigment is not produced unless the plants are exposed to light. This is an example of how the environment can

(1) cause mutations to occur
(2) influence the expression of a genetic trait
(3) result in the appearance of a new species
(4) affect one plant species, but not another

14_____

15. If the ribosomes of a cell were destroyed, what effect would this most likely have on the cell?

(1) It would stimulate mitotic cell division.
(2) The cell would be unable to synthesize proteins.
(3) Development of abnormal hereditary features would occur in the cell.
(4) Increased protein absorption would occur through the cell membrane. 15_____

16. Which statement describes asexual reproduction?

(1) Adaptive traits are usually passed from parent to offspring without genetic modification.
(2) Mutations are not passed from generation to generation.
(3) It always enables organisms to survive in changing environmental conditions.
(4) It is responsible for many new variations in offspring. 16_____

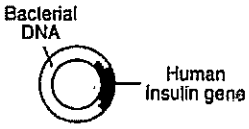
17. A change in the order of DNA bases that code for a respiratory protein will most likely cause

(1) the production of a starch that has a similar function
(2) the digestion of the altered gene by enzymes
(3) a change in the sequence of amino acids determined by the gene
(4) the release of antibodies by certain cells to correct the error 17_____

18. In sexually reproducing organisms, mutations can be inherited if they occur in

(1) the egg, only
(2) the sperm, only
(3) any body cell of either the mother or the father
(4) either the egg or the sperm 18_____

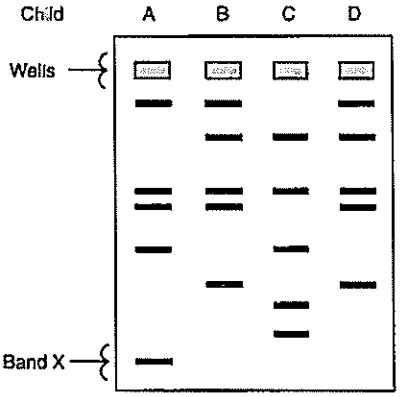
19. A product of genetic engineering technology is represented.



Which substance was needed to join the insulin gene to the bacterial DNA as shown?

(1) a specific carbohydrate
(2) a specific enzyme
(3) hormones
(4) antibodies 19_____

20. DNA samples were collected from four children. The diagram below represents the results of a procedure that separated the DNA in each sample.



Band *X* represents the

(1) largest fragment of DNA that traveled the fastest
(2) smallest fragment of DNA that traveled the fastest
(3) largest fragment of DNA that traveled the slowest
(4) smallest fragment of DNA that traveled the slowest 20_____

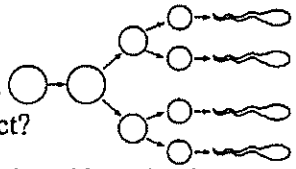
21. Which process can produce new inheritable characteristics within a multicellular species?

(1) cloning of the skin cells
(2) mitosis in muscle cells
(3) gene alterations in gametes
(4) differentiation in nerve cells 21_____

22. Offspring that result from meiosis and fertilization each have

(1) twice as many chromosomes as their parents
(2) one-half as many chromosomes as their parents
(3) gene combinations different from those of either parent
(4) gene combinations identical to those of each parent 22_____

23. Which statement concerning the reproductive cells in the diagram is correct?



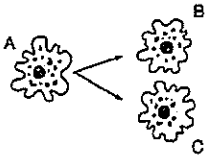
(1) The cells are produced by mitosis and contain all the genetic information of the father.
(2) If one of these cells fertilizes an egg, the offspring will be identical to the father.
(3) Each of these cells contains only half the genetic information necessary for the formation of an offspring.
(4) An egg fertilized by one of these cells will develop into a female with the same characteristics as the mother.

23_____

24. A mutation that can be inherited by offspring would result from

(1) random breakage of chromosomes in the nucleus of liver cells
(2) a base substitution in gametes during meiosis
(3) abnormal lung cells produced by toxins in smoke
(4) ultraviolet radiation damage to skin cells 24_____

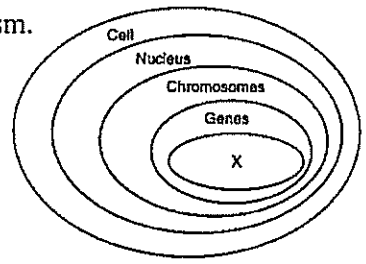
25. The diagram below represents single-celled organism *A* dividing by mitosis to form cells *B* and *C*. Cells *A*, *B*, and *C* all produced protein *X*. What can best be inferred from this observation?



(1) Protein *X* is found in all organisms.
(2) The gene for protein *X* is found in single-celled organisms, only.
(3) Cells *A*, *B*, and *C* ingested food containing the gene to produce protein *X*.
(4) The gene to produce protein *X* was passed from cell *A* to cells *B* and *C*.

25_____

26. The diagram below represents levels of organization within a cell of a multicellular organism.



The level represented by *X* is composed of

(1) four types of base subunits
(2) folded chains of glucose molecules
(3) twenty different kinds of amino acids
(4) complex, energy-rich inorganic molecules 26_____

27. A chemical known as 5-bromouracil causes a mutation that results in the mismatching of molecular bases in DNA. The offspring of organisms exposed to 5-bromouracil can have mismatched DNA if the mutation occurs in

(1) the skin cells of the mother
(2) the gametes of either parent
(3) all the body cells of both parents
(4) only the nerve cells of the father

27_____

28. Sexually produced offspring often resemble, but are not identical to, either of their parents. Explain why they resemble their parents but are not identical to either parent.

_____

_____

29. If 20% of a DNA sample is made up of cytosine, C, what percentage of the sample is made up of adenine, A? _____ %

30. Arrange the following structures from largest to smallest.

a chromosome **a nucleus** **a gene**

Largest _____

↓ _____

Smallest _____

Base your answers to question 31 on the information and chart below.

Amino Acid	Abbreviation	DNA Code
Phenylalanine	Phe	AAA, AAG
Tryptophan	Try	ACC
Serine	Ser	AGA, AGG, AGT, AGC, TCA, TCG
Valine	Val	CAA, CAG, CAT, CAC
Proline	Pro	GGA, GGG, GGT, GGC
Glutamine	Glu	GTT, GTC
Threonine	Thr	TGA, TGG, TGT, TGC
Asparagine	Asp	TTA, TTG

In DNA, a sequence of three bases is a code for the placement of a certain amino acid in a protein chain. The table above shows some amino acids with their abbreviations and DNA codes.

31. *a*) Which amino acid chain would be produced by the DNA base sequence below?

C-A-A-G-T-T-A-A-A-T-T-A-T-T-G-T-G-A

(1) Val–Glu–Phe–Asp–Thr–Asp (3) Val–Glu–Phe–Asp–Asp–Thr

(2) Val–Pro–Phe–Asp–Asp–Thr (4) Val–Glu–Phe–Thr–Asp–Asp a _____

b) Identify one environmental factor that could cause a base sequence in DNA to be changed to a different base sequence. _____

c) Describe how a protein would be changed if a base sequence mutates from GGA to TGA.

_____

Base your answers to question 32 on the information below.

Scientists are increasingly concerned about the possible effects of damage to the ozone layer.

32. Damage to the ozone layer has resulted in mutations in skin cells that lead to cancer. Will the mutations that caused the skin cancers be passed on to offspring? Support your answer.

Answer:_____ Supporting statement:_____

_____

33. A child is born with a genetic disorder to parents who show no symptoms of the disorder. Explain the type of information a genetic counselor might provide to these parents. In your answer, be sure to:

a) explain why the child exhibits symptoms of the genetic disorder even though the parents do not

_____

b) identify one technique that can be used to detect a genetic disorder

_____

c) identify one genetic disorder _____

34. Scientists have successfully cloned sheep and cattle for several years. A farmer is considering the advantages and disadvantages of having a flock of sheep cloned from a single individual. Discuss the issues the farmer should take into account before making a decision. Your response should include:

a) how a cloned flock would be different from a noncloned flock

_____

b) one advantage of having a cloned flock

_____

c) one disadvantage of having a cloned flock

_____

d) one reason that the farmer could not mate these cloned sheep with each other to increase the size of his flock

_____

e) one reason that the offspring resulting from breeding these sheep with an unrelated sheep would not all be the same

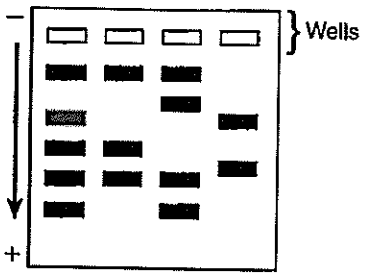
_____

35. Identical twins have the same genetic material, but they may develop slightly different characteristics. State one reason that would cause this.

_____

Base your answers to question 36 on the information and diagram.

The four wells represented in the diagram were each injected with fragments that were prepared from DNA samples using identical techniques.



36. *a*) This laboratory procedure is known as

_____.

b) The arrow represents the direction of the movement of the DNA fragments. What is responsible for the movement of the DNA in this process?

_____

c) The four samples of DNA were taken from four different individuals. Explain how this is evident from the results shown in the diagram.

_____

d) Identify the substance that was used to treat the DNA to produce the fragments that were put into the wells. _____

37. Rabbits eat plants and in turn are eaten by predators such as foxes and wolves. A population of rabbits is found in which a few have a genetic trait that gives them much better than average leg strength.

a) Predict how the frequency of the trait for above average leg strength would be expected to change in the population over time. Explain your prediction.

Frequency: _____

Explanation: _____

b) State what is likely to happen to the rabbits in the population that do not have the trait for above average leg strength.

_____

38. The segments of DNA below were extracted from two different species of plants. The segments represent the same region of DNA that codes for a particular pigment (color) in these species.

Plant Species *A*: A C C G C A G G G A T T C G C
Plant Species *B*: A C C G G A G C G A T T C G C

A restriction enzyme is used to cut the DNA from species *A* and *B*. The enzyme binds to the sequence G G G A T T and cuts between *G* and *A*. State how many cuts will be made in the DNA sequences of each species when this enzyme is used.

Plant species *A* cuts: _____ Plant species *B* cuts: _____

39. The table shows the number of individual molecules obtained when a DNA molecule from a bacterial species is broken down.

Molecules from Bacterial DNA

Molecule	Number
sugar	4.6 million
phosphate	4.6 million
adenine (A)	1.75 million
cytosine (C)	0.55 million
guanine (G)	0.55 million
thymine (T)	1.75 million

a) What data in the data table indicate that adenine pairs with thymine in a DNA molecule?

_____

_____

b) Explain how the data table would differ if the molecular data reflected bacterial RNA instead of DNA.

_____

_____

40. The work of a cell is carried out by the many different types of molecules it assembles. Most of these molecules are proteins. Explain how the cell is able to make the many different proteins it needs. Your response should include:

a) identify where in the cell the information necessary to construct a particular protein is located and the specific molecule that contains this information

Where: _____ Specific molecule: _____

b) identify *both* the cellular structure that assembles these proteins and the kinds of molecules that are used as the building blocks of the proteins

Cellular structure: _____

Molecules: _____

41. Discuss the process used by scientists to insert a gene from one organism into the DNA of another. Your response should include:

a) identify the scientific technique used to insert a gene from one organism into another.

_____

b) describe the function of a gene

_____

c) identify the type of molecule used to cut the gene from the DNA of an organism

_____

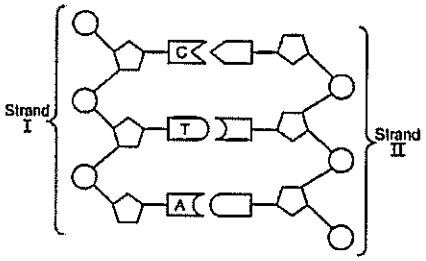
d) state *one* benefit of this technique to humans

_____

1. Meiosis and fertilization are important processes because they may most immediately result in

   (1) many body cells
   (2) immune responses
   (3) genetic variation
   (4) natural selection 1 _____

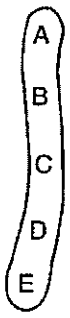
2. In the diagram below, strands I and II represent portions of a DNA molecule.



   Strand II would normally include

   (1) AGC (3) TAC
   (2) TCG (4) GAT 2 _____

3. The letters in the diagram represent genes on a particular chromosome. Gene *B* contains the code for an enzyme that cannot be synthesized unless gene *A* is also active. Which statement best explains why this can occur?



   (1) A hereditary trait can be determined by more than one gene.
   (2) Genes are made up of double-stranded segments of DNA.
   (3) All the genes on a chromosome act to produce a single trait.
   (4) The first gene on each chromosome controls all the other genes on the chromosome. 3 _____

4. In Siamese cats, the fur on the ears, paws, tail, and face is usually black or brown, while the rest of the body fur is almost white. If a Siamese cat is kept indoors where it is warm, it may grow fur that is almost white on the ears, paws, tail, and face, while a Siamese cat that stays outside where it is cold, will grow fur that is quite dark on these areas. The best explanation for these changes in fur color is that

   (1) the gene for fur color is modified by interactions with the environment
   (2) the location of pigment-producing cells determines the DNA code of the genes
   (3) skin cells that produce pigments have a higher mutation rate than other cells
   (4) an environmental factor influences the expression of this inherited trait 4 _____

5. Which statement best describes a chromosome?

   (1) It is a gene that has thousands of different forms.
   (2) It has genetic information contained in DNA.
   (3) It is a reproductive cell that influences more than one trait.
   (4) It contains hundreds of genetically identical DNA molecules 5 _____

6. Which statement is true of both mitosis and meiosis?

   (1) Both are involved in asexual reproduction.
   (2) Both occur only in reproductive cells.
   (3) The number of chromosomes is reduced by half.
   (4) DNA replication occurs before the division of the nucleus 6 _____

7. What determines the kind of genes an organism possesses?

(1) type of amino acids in the cells of the organism
(2) sequence of the subunits *A*, *T*, *C*, and *G* in the DNA of the organism
(3) size of simple sugar molecules in the organs of the organism
(4) shape of the protein molecules in the organelles of the organism 7____

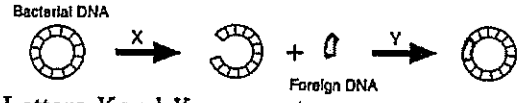
8. If a set of instructions that determines all of the characteristics of an organism is compared to a book, and a chromosome is compared to a chapter in the book, then what might be compared to a paragraph in the book?

(1) a starch molecule
(2) an egg
(3) an amino acid
(4) a DNA molecule 8____

9. People with cystic fibrosis inherit defective genetic information and cannot produce normal CFTR proteins. Scientists have used gene therapy to insert normal DNA segments that code for the missing CFTR protein into the lung cells of people with cystic fibrosis. Which statement does not describe a result of this therapy?

(1) Altered lung cells can produce the normal CFTR protein.
(2) Altered lung cells can divide to produce other lung cells with the normal CFTR gene.
(3) The normal CFTR gene may be expressed in altered lung cells.
(4) Offspring of someone with altered lung cells will inherit the normal CFTR gene. 9____

10. The diagrams below represent some steps in a procedure used in biotechnology.



Letters *X* and *Y* represent

(1) hormones that stimulate the replication of bacterial DNA
(2) biochemical catalysts involved in the insertion of genes into other organisms
(3) hormones that trigger rapid mutation of genetic information
(4) gases needed to produce the energy required for gene manipulation 10____

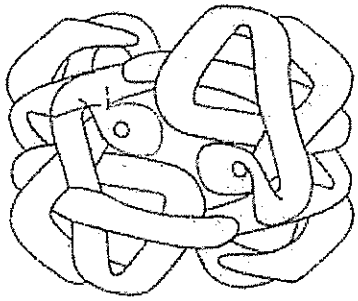
11. Plants in species *A* cannot fight most fungal infections. Plants in species *B* make a protein that kills many fungi. One possible way for humans to produce species *A* plants with the ability to synthesize this protein would be to

(1) mutate fungal DNA and introduce the mutated DNA into species *B* using a virus
(2) add DNA from species *B* into the soil around species *A*
(3) insert the gene for the protein from species *B* into a chromosome in species *A*
(4) cross species *A* and a fungus to stimulate the synthesis of this protein 11____

12. A small amount of DNA was taken from a fossil of a mammoth found frozen in glacial ice. Genetic technology can be used to produce a large quantity of identical DNA from this mammoth's DNA. In this technology, the original DNA sample is used to

(1) stimulate differentiation in other mammoth cells
(2) provide fragments to replace certain human body chemicals
(3) act as a template for repeated replication
(4) trigger mitosis to obtain new base sequences 12____

13. The diagram below represents a protein molecule present in some living things.

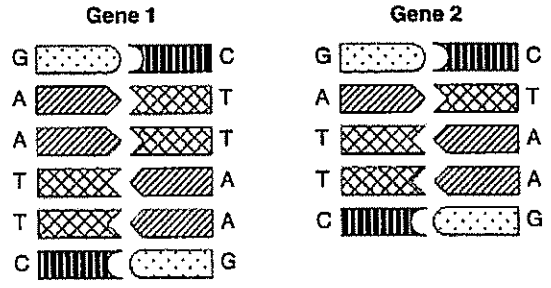


This type of molecule is composed of a sequence of

(1) amino acids arranged in a specific order
(2) simple sugars alternating with starches arranged in a folded pattern
(3) large inorganic subunits that form chains that interlock with each other
(4) four bases that make up the folded structure

13_____

14. The diagrams below represent portions of the genes that code for wing structure in two organisms of the same species. Gene 1 was taken from the cells of a female with normal wings, and gene 2 was taken from the cells of a female with abnormal wings.



The abnormal wing structure was most likely due to

(1) an insertion
(2) a substitution
(3) a deletion
(4) normal replication

14_____

15. Which situation would most directly affect future generations naturally produced by a maple tree?

(1) Ultraviolet radiation changes the DNA sequence within some leaves of the tree.
(2) Ultraviolet radiation changes the DNA sequence within the gametes of some flowers of the tree.
(3) An increase in temperature reduces the number of cell divisions in the roots.
(4) Rapidly growing cells just under the bark are exposed to radiation, causing changes in genetic material.

15_____

16. Some steps involved in DNA replication and protein synthesis are summarized in the table below.

Step A	DNA is copied and each new cell gets a full copy.
Step B	Information copied from DNA moves to the cytoplasm.
Step C	Proteins are assembled at the ribosomes.
Step D	Proteins fold and begin functioning.

In which step would a mutation lead directly to the formation of an altered gene?

(1) *A*
(2) *B*
(3) *C*
(4) *D*

16_____

17. During meiosis, crossing-over (gene exchange between chromosomes) may occur. Crossing-over usually results in

(1) the production of an extra amino acid
(2) the formation of an extra chromosome
(3) the formation of identical twins
(4) new combination of inheritable traits

17_____

18. Which phrases best identify characteristics of asexual reproduction?

(1) one parent, union of gametes, offspring similar to but not genetically identical to the parent
(2) one parent, no union of gametes, offspring genetically identical to parents
(3) two parents, union of gametes, offspring similar to but not genetically identical to parents
(4) two parents, no union of gametes, offspring genetically identical to parents

18 _____

19. To determine the identity of their biological parents, adopted children sometimes request DNA tests. These tests involve comparing DNA samples from the child to DNA samples taken from the likely parents. Possible relationships may be determined from these tests because the

(1) base sequence of the father determines the base sequence of the offspring
(2) DNA of parents and their offspring is more similar than the DNA of nonfamily members
(3) position of the genes on each chromosome is unique to each family
(4) mutation rate is the same in closely related individuals

19 _____

20. One way to produce large numbers of genetically identical offspring is by

(1) cloning
(2) fertilization
(3) changing genes by agents such as radiation or chemicals
(4) inserting a DNA segment into a different DNA molecule

20 _____

21. The diagram below shows a process that affects chromosomes during meiosis.

This process can be used to explain

(1) why some offspring are genetically identical to their parents
(2) the process of differentiation in offspring
(3) why some offspring physically resemble their parents
(4) the origin of new combinations of traits in offspring

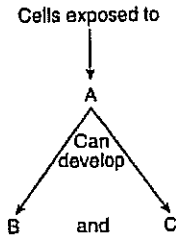
21 _____

22. Even though human proteins are synthesized from only 20 different amino acids, there are thousands of different proteins found in human cells. This great variety of proteins is possible because the

(1) size of a specific amino acid can vary within a protein
(2) chemical composition of a specific amino acid can vary
(3) sequence and number of amino acids can be different in each protein
(4) same amino acid can have many different properties

22 _____

23. The diagram can be used to illustrate cellular changes.



Which row of terms in the chart below best completes the diagram?

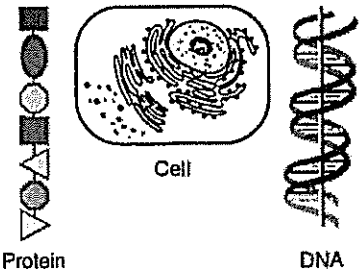
Row	A	B	C
(1)	atmospheric oxygen	mutations	increased mitochondria
(2)	radiation	cancer	mutations
(3)	salt water	more cytoplasm	two nuclei
(4)	less sunlight	extra genes	decreased mutations

23 _____

24. Mustard gas removes guanine (G) from DNA. For developing embryos, exposure to mustard gas can cause serious deformities because guanine

(1) stores the building blocks of proteins
(2) supports the structure of ribosomes
(3) produces energy for genetic transfer
(4) is part of the genetic code 24 ____

25. Three structures are represented in the diagram below.



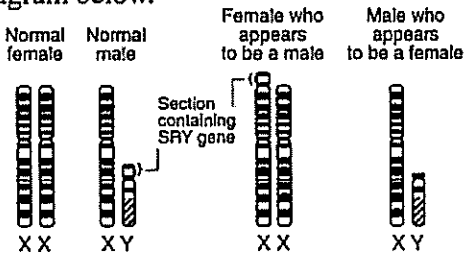
What is the relationship between these three structures?

(1) DNA is made up of proteins that are synthesized in the cell.
(2) Protein is composed of DNA that is stored in the cell.
(3) DNA controls the production of protein in the cell.
(4) The cell is composed only of DNA and protein. 25 ____

26. The human liver contains many specialized cells that secrete bile. Only these cells produce bile because

(1) different cells use different parts of the genetic information they contain
(2) cells can eliminate the genetic codes that they do not need
(3) all other cells in the body lack the genes needed for the production of bile
(4) these cells mutated during embryonic development 26 ____

27. The *Y*-chromosome carries the SRY gene that codes for the production of testosterone in humans. Occasionally a mutation occurs resulting in the SRY gene being lost from the *Y*-chromosome and added to the *X*-chromosome, as shown in the diagram below.



Based on the diagram, which statement is correct?

(1) The production of testosterone influences the development of male characteristics.
(2) Reproductive technology has had an important influence on human development.
(3) Normal female characteristics develop from a single *X*-chromosome.
(4) Male characteristics only develop in the absence of *X*-chromosomes. 27 ____

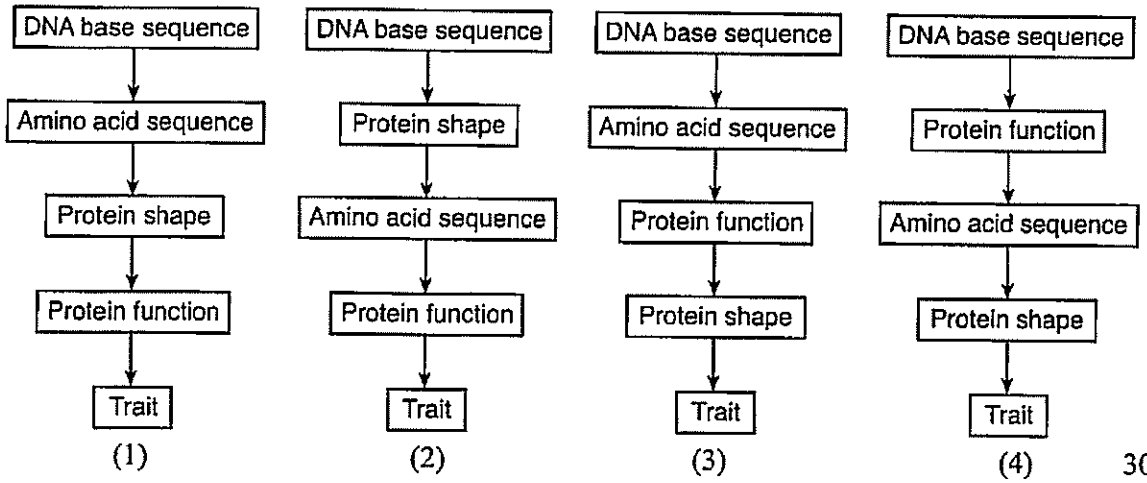
28. The sequence of subunits in a protein is most directly dependent on the

(1) region in the cell where enzymes are produced
(2) DNA in the chromosomes in a cell
(3) type of cell in which starch is found
(4) kinds of materials in the cell membrane 28 ____

29. If 15% of a DNA sample is made up of thymine, T, what percentage of the sample is made up of cytosine, C?

(1) 15% (3) 70%
(2) 35% (4) 85% 29 ____

30. Which sequence best represents the relationship between DNA and the traits of an organism?



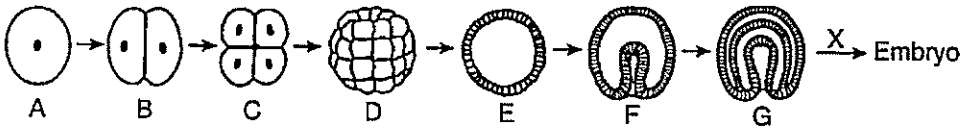
30_____

31. Which row in the chart best describes what happens when some DNA bases are deleted from a gene?

Row	Gene	Trait Controlled By the Original DNA
(1)	is not changed	is never changed
(2)	is not changed	may be changed
(3)	is changed	is never changed
(4)	is changed	may be changed

31_____

32. The diagram represents stages in the development of an embryo. The process of mitosis is involved in all shown steps.



If cell *A* has 46 chromosomes, how many chromosomes will most likely be found in each cell of stage *G*?

(1) 23 (2) 46 (3) 69 (4) 92

32_____

33. Four different segments of a DNA molecule are represented.

There is an error in the DNA molecule in

(1) segment 1, only
(2) segment 3, only
(3) segments 2 and 3
(4) segments 2 and 4

Segment 1	Segment 2
T–A–G–G–C	G–G–T–G–A
A–T–C–C–G	C–C–A–C–T
Segment 3	**Segment 4**
G–A–T–T–A	C–A–A–T–G
C–C–A–A–T	G–T–T–A–C

33_____

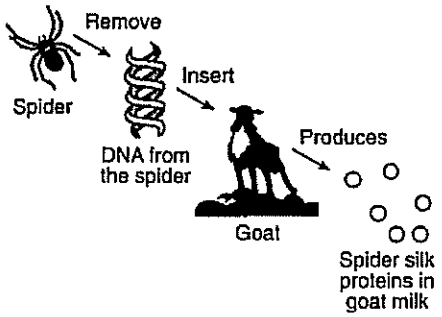
34. DNA replication occurs in preparation for

(1) mitosis, only
(2) meiosis, only
(3) both mitosis and meiosis
(4) neither mitosis nor meiosis

34 ____

35. Give an appropriate title for the accompanying diagram.

_____



36. Place the correct phase number inside the appropriate box of the flowchart below.

Phase 1 – Increased chance of cancer
Phase 2 – Exposure of cells to radiation
Phase 3 – Increase rate of mutation

Base your answers to question 37 on the statement below.

Selective breeding has been used to improve the racing ability of horses.

37. *a*) Define selective breeding and state how it would be used to improve the racing ability of horses.

Selective breeding: _____

Improvement: _____

b) State one disadvantage of selective breeding.

_____

38. Compare asexual reproduction to sexual reproduction. In your comparison, be sure to include:

a) Which type of reproduction results in offspring that are usually genetically identical to the previous generation and explain why this occurs.

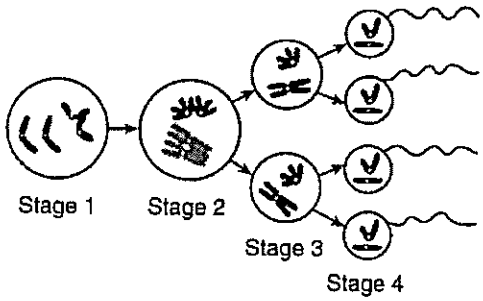
Type of reproduction: _____

Explanation: _____

b) Give one other way these methods of reproduction differ.

_____

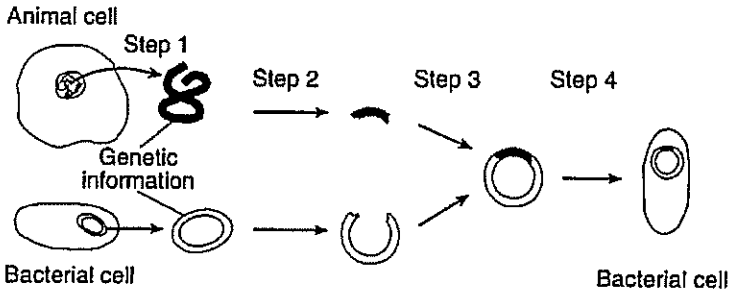
39. The diagram illustrates some of the changes that occur during gamete formation. Give a statement on the amount of DNA in stage 1 cell compared to the amount of DNA in stage 4 cell.



_____

_____

Base your answers to question 40 on the diagram below, which illustrates some steps in genetic engineering.



40. *a*) What is the result of step 3? _____

b) State one way that enzymes are used in step 2. _____

_____

c) State one possible reason why a gene for the production of a human hormone would be placed in bacterial DNA.

_____

Base your answers to question 41 on the information below.

To demonstrate techniques used in DNA analysis, a student was given two paper strip samples of DNA. The two DNA samples are shown below.

Sample 1: ATTCCGGTAATCCCGTAATGCCGGATAATACTCCGGTAATATC

Sample 2: ATTCCGGTAATCCCGTAATGCCGGATAATACTCCGGTAATATC

The student cut between the C and G in each of the shaded CCGG sequences in sample 1 and between the As in each of the shaded TAAT sequences in sample 2. Both sets of fragments were then arranged on a paper model of a gel.

41. *a*) The action of what kind of molecules was being demonstrated when the DNA samples were cut?

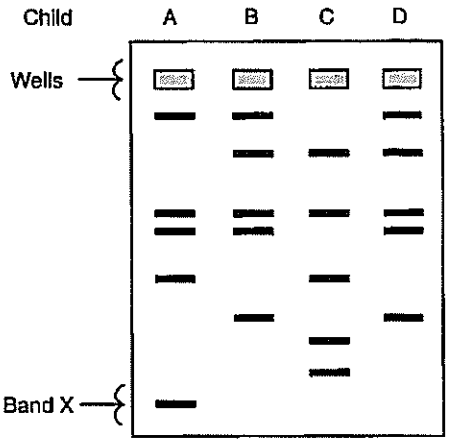
_____

b) State one way the arrangement of the two samples on the gel model would be different.

_____

Base your answers to question 42 on the information and diagram below.

DNA samples were collected from four children. The accompanying diagram represents the results of a procedure that separated the DNA in each sample.



42. *a*) Identify the procedure used to obtain these results.

_____

b) Band *X* represents the
(1) largest fragment of DNA that traveled the fastest
(2) smallest fragment of DNA that traveled the fastest
(3) largest fragment of DNA that traveled the slowest
(4) smallest fragment of DNA that traveled the slowest

b _____

c) The DNA is most similar in which two children? _____ and _____

Support your answer. _____

_____

d) State one way information obtained from this procedure can be used.

_____

e) Identify another substance other than DNA that can be analyzed by this technique.

_____

43. A sample of body cells and samples of sex cells received from four members of a species are screened for the presence of a specific gene mutation. The results of the gene-testing procedure conducted on the cells are shown in the table below.

Species Member Tested	Type of Cells Tested and the Result (+ = mutation present, – = mutation absent)		
	Body Cells	Sperm	Egg
1	+		+
2	+	+	
3	–		+
4	+	–	

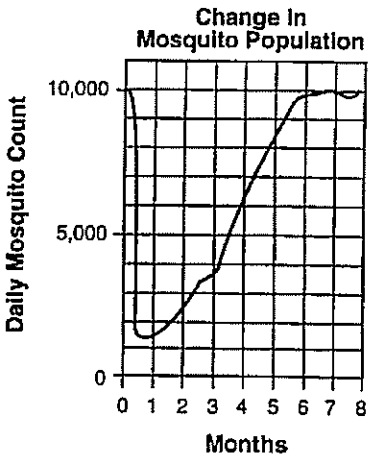
Which species member would be unlikely to pass the gene mutation on to its offspring? _____

Explain your choice: _____

44. In the past, diabetics used horse or cow insulin to control their glucose levels. Today, as a result of genetic engineering, human insulin can be synthesized by bacteria. State one advantage for a person with diabetes to receive genetically engineered insulin rather than insulin taken from a horse or cow.

_____

45. A small village that is heavily infested with mosquitoes was sprayed with an insecticide once a week for several months. Changes in the size of the mosquito population are shown in the accompanying graph.



State one way that the population of mosquitoes present 7 months after spraying differs genetically from the population of mosquitoes present before the spraying began.

_____

_____

Base your answers to question 46 on the information below.

The sequences below represent the same portions of a DNA molecule from the same gene used by a student to study the relationship between two plant species. A biological catalyst that recognizes the CCGG site is used to cut the DNA molecules into pieces. The catalyst cuts the DNA between the C and G of the site.

46. *a*) Draw lines in the sequences below for species 1 and species 2 to show where the catalyst would cut the DNA.

Species 1: T A C C G G A T T A G T T A T G C C G G A T C G

Species 2: T A C G G A T G C C G G A T C G G A A A T T C G

b) Complete the data table below to show the results of the action of the catalyst.

Results of Catalyst Action

	Number of Cuts	Number of Resulting Pieces of DNA
Species 1		
Species 2		

c) Are the two species of plants closely related? _____

Support your answer. _____

_____

47. An alteration of genetic information is shown below.

A-G-T-A-C-C-G-A-T → A-G-T-G-A-T

This type of alteration of the genetic information is an example of _____

48. Explain how using cloning to produce a single crop could actually lead to a loss of the entire crop.

_____

Genetics
Answers
Set 1

1. 2 The genetic code for all living things is found within the molecular bases of DNA. Each molecular base forms a sequence that can code for a particular protein. These proteins will be made during the process of protein synthesis.

2. 3 Many environmental factors can influence whether a gene is read (transcribed and translated). Identical twins, whose DNA is identical, may show variance in height, weight, intelligence, etc., due to differences in gene expression resulting from environmental differences, such as diet and education.

3. 4 The process of choosing animals with desirable characteristics or traits for breeding purposes is called selective breeding. This process is used to produce not only dog breeds but many desirable agricultural animals and plants.

4. 3 By recombining genes through fertilization, new combinations of genetic information can occur. These new gene combinations may result in genetic variation and may be inherited through gametes during sexual reproduction.

5. 1 During the process of meiosis, crossing over can lead to a chromosomal change. This process can lead to new variations through different genetic combinations found in the offspring.

6. 4 Genetically engineered insulin is produced as a result of the human insulin gene being inserted into circular rings of DNA within the bacteria. The bacteria then reads this inserted DNA and produces human insulin. The insulin produced is much less likely to produce side effects because it is genetically human based.

7. 1 Cloning is the production of identical organisms from one cell. By removing a cell from a mature plant and promoting growth of the cell into mature plants, the process of cloning can be achieved.

8. 3 Within a cell's nucleus are found thin strands of genetic material known as chromosomes. These chromosomes are composed of many smaller segments known as genes.

9. 1 This molecule represents a double helix of DNA. The patterned number sequences represent paired molecular bases (A-T, C-G). The patterns or sequences of these bases set up the genetic code for all living things.

10. 1 In asexual reproducing organisms, hereditary information is passed from a parent organism to resulting offspring through DNA. DNA consists of coded instructions using sequences of 4 molecular bases – A,T,C, and G. The sequence of these four bases determines the structure of proteins in new organisms.

11. 1 Meiosis is the process which allows for the production of sperm and egg. During this process, the chromosome number reduces to half that of the original body cell amount. When the genetic information found in the chromosomes of the sperm and the egg unite during fertilization, the original chromosome number is restored in the next generation.

12. 1 The process of genetic engineering allows for the transfer of a section of DNA encoded for a specific protein into another cell, usually a bacteria. Upon insertion, this section of DNA is now part of the bacterial DNA. When the bacteria reproduces (asexually), it will produce new bacteria with exact copies of DNA found in parent cell. The new cells will be able to produce the protein coded for by the inserted section of DNA, in this case insulin.

13. 1 A change in base unit sequence (like TAA → TAC) will lead to a change in the DNA and may alter proteins. These alterations or mutations can lead to genetic variation.

14. 2 Genes can be "turned on" so that particular genetic traits can be expressed. Environmental factors can trigger this expression of genes. In plants, the environmental factor of light triggers production of chlorophyll.

15. 2 Within a cell, protein synthesis occurs when coded genetic information is copied and transferred from nucleus to ribosomes. In the ribosomes, amino acids are assembled, based on the copied code, into particular sequences that make up a specific protein. This would not occur if the ribosomes were damaged or destroyed.

16. 1 Asexual reproduction produces offspring that are genetically identical to the parent. This is accomplished by various types of cell divisions where the chromosomes in offspring are exact copies of the parent. Therefore, under normal circumstances, there would be no genetic variations.

17. 3 The sequence of molecular bases in DNA code for specific amino acids. When the genetic code is changed, it will change the sequence of amino acids that are linked together to form a protein. Therefore, a change in DNA could lead to a change in a respiratory protein.

18. 4 In sexual reproduction, when a change or alteration occurs in the egg or sperm, and if fertilization occurs, the change will be expressed as a new trait within the offspring of that species.

19. 2 During genetic engineering, the insertion of a gene into another organism or into another organism's DNA is aided by the action of specific enzymes that join two segments of DNA together with the portion of the inserted gene at a particular location.

20. 2 During this procedure, known as gel electrophoresis, DNA fragments that are positioned in the wells are moved through a gel using electric currents. The smallest fragments travel the farthest and fastest; this would be the DNA fragment band X.

21. 3 Inheritable characteristics must be passed through sex cells known as gametes. When a change or alteration occurs in genes passed on by the gametes, these alterations will be expressed as new characteristics within the offspring of that species.

22. 3 Meiosis produces gametes or sex cells that contain only half the amount of genetic information as the parent. When combined at fertilization, these two half amounts of genetic material (chromosomes) will restore the original chromosome number for that species, but contain different combinations of genetic information.

23. 3 The reproductive cells represented in this diagram are sperm cells. Sperm cells are produced by a division process known as meiosis where the resulting cells contain half the chromosome number as the parent cell. When fertilization takes place, the sperm will provide half the genetic material, and the egg will provide the other half.

24. 2 Inheritance of a mutation must take place through a change in the DNA in a sex cell or gamete. A DNA base substitution in gametes that occurred during meiosis would be carried to the offspring by that gamete. All other choices relate to types of body cells that do not take part in reproduction or inheritance of genes.

25. 4 During asexual reproduction, genetic information from the parent cell (*A*) is passed to daughter cells (*B* and *C*) through mitosis. The genes for protein *X* were present in cell *A*, and when mitosis occurred, the gene for protein *X* got passed to each new cell *B* and *C*.

26. 1 Letter X represents the four molecular bases (A,T,C,G) that form different sequences known as genes. These genes are found within the DNA of chromosomes. Chromosomes are located in the nucleus of a cell.

27. 2 In order for a mutation to be passed from parent to offspring, the change must occur in the gametes or sex cells of the parent. The mismatched DNA (a mutation) found in a sperm or egg would be transfered from parent to offspring. All other choices relate to types of body cells that do not take part in reproduction or inheritance of genes.

28. Answer: Offspring are not identical to either parent because they receive:
genetic material from each parent *or* half of their genes or DNA
or chromosomes from each parent *or* genetic information from each parent

Explanation: The recombination of genetic information that occurs during fertilization of egg by sperm leads to variation and explains why offspring resemble but are not identical to either parent. Each sex cell has genetic material from one parent.

29. Answer: 30%

Explanation: In a DNA sequence, C is linked with G and A is linked with T. Therefore, C and G must constitute 40% of the sample (20% + 20%). The remaining 60% must be A and T, of which A will be 30%.

30. Answer:

Largest	nucleus
↓	chromosome
Smallest	gene

Explanation: See answer for question #26.

31. *a*) Answer: 3

Explanation: Based on the information presented in the chart, we can convert the DNA base sequence given into its representative amino acids. Amino acids are coded using a group of three molecular bases known as a codon. Taking the first three bases of the given code, CAA, and using the chart, one can determine that CAA codes for valine (Val). The second group of three bases, GTT, codes for glutamine (Glu), and continuning with the rest of the base code sequence, leads to a chain of amino acids (Val –Glu –Phe – Asp – Asp – Thr).

b) Answer: ultraviolet light *or* radiation *or* x-rays *or* chemicals.

Explanation: All of the above are considered environmental mutagenic agents. Mutagenic agents have the ability to alter the base sequence in the DNA code, leading to a mutation – a sudden change in the genetic code.

c) Acceptable responses include but are not limited to: The amino acid sequence would be changed. *or* The protein would contain threonine instead of proline. *or* The shape of the protein would change. *or* The protein produced may not function properly or function at all.

Explanation: The base sequence of DNA determines what the identity of a protein is, its shape, and its function. If the original code or base sequence is altered, then the amino acid sequence will also be changed, and therefore the protein produced. If the protein is changed, its original shape and function may not be the same.

32. Answer: No

Supporting statement: Any mutation to skin cells will not be passed on to offspring. Gametes are the only cells responsible for the passing of genetic information. The mutation would have to occur to these sex cells in order to get passed to the offspring.

33. Acceptable responses include, but are not limited to:

a) Nondisjunction could have occurred. *or* A mutation might have taken place.
or The child may have inherited two recessive alleles (genes).
or A mutation or genetic change in a parent's DNA could be passed through a gamete or sex cell to the offspring during sexual reproduction and then be reflected in its genetic makeup.

Explanation: Both parents could carry the recessive gene, but it would not be expressed. If their child inherited this pair of recessive genes, that recessive disorder would then be fully expressed.

b) amniocentesis *or* karyotyping *or* blood screening *or* electrophoresis

Explanation: All of these processes involve the removal and analysis of genetic material. Through that analysis, geneticists can determine if a child may have inherited a genetic disorder.

c) Acceptable responses include, but are not limited to:
down syndrome *or* sickle-cell anemia *or* hemophilia (Other answers are possible.)

Explanation: Genetic disorders occur when a gene sequence is altered and the proteins that are normally coded for are not synthesized, leading to deficiencies. Disorders can also occur when there are irregular numbers of chromosomes due to nondisjunction – a failure of chromosomes to separate during meiosis.

34. Acceptable responses include, but are not limited to:

a) There would be no variation. *or* All would be identical genetic copies, unlike noncloned herds, where much genetic diversity would be present. *or* All sheep would be the same.

Explanation: Cloning is a process using biotechnology where the resulting offspring are genetically identical to the organism that donated its DNA to be cloned.

b) All sheep would have one or more desired trait that the original individual possessed.

Explanation: By choosing the donor DNA cell, farmers and researchers can clone organisms with desired genetic traits. All cloned organisms would have that trait.

c) Because all are the same, the entire flock could be lost if a disease to which they have no resistance were to infect them. *or* The sheep may have a genetic flaw. *or* shorter life span

Explanation: When there is no variation, the flock could be susceptible to a disease or illness, because they may lack a genetic variation that may allow them to fight that disease. The identical clones would all be affected by that disease or illness. This could result in death of the animals and monetary loss for the farmer.

d) They would all be the same sex, so they could not mate with each other.

Explanation: When sheep or cattle are cloned, the donor genetic material will determine what the sex of the clones will be. All clones will be the same gender as the donor, so sexual reproduction between cloned members would be impossible.

e) Both parents contribute genes to the offspring. *or* Different gene combinations will result.

Explanation: The unrelated sheep would have a different genetic makeup than that of the cloned sheep, so when an unrelated sheep and a cloned sheep reproduce, new genetic variations occur through the recombination of each animal's genetic material.

35. Answer: environmental factors

Explanation: The expression of genetic material can be influenced by outside factors such as the environment. These factors can "turn on" or "turn off" genes so that their information will be expressed or not expressed. Twins, while having the same genetic makeup, could express different characteristics if they were exposed to different factors. For example, if one twin is exposed to sunlight and the other gets no exposure, the twin with sun exposure will exhibit a darkening of the skin that the other twin will not.

36. *a*) Answer: gel electrophoresis

Explanation: Gel electrophoresis is a procedure in which samples of DNA are placed into wells situated in a thin layer of gel. An electrical current is passed through the gel separating the DNA fragments, causing them to migrate through the gel. This procedure has many applications including criminal/forensic work, evolutionary relationships, and even identification of bodies.

b) Answer: electrical current *or* attraction of negative DNA fragments to positive pole *or* charges on DNA *or* DNA has negative charge

Explanation: The electrophoresis equipment has a negative and positive end. Electrical current is run through the gel creating this difference in charge. DNA with its negative charge will move from the negative end (wells) to the positive end.

c) Answer: bands in different positions in each column *or* different banding patterns *or* different number of bands in columns

Explanation: Each individual has DNA that is unique and different from everyone else. When DNA is broken into fragments and runs through the gel, these different fragments create different patterns, with fragments moving to different positions for each individual.

d) Answer: Enzymes *or* restriction enzymes

Explanation: Enzymes, derived from bacteria, are used to cut sections of DNA at a specific site. Each enzyme has a particular point upon which it acts.

37. *a*) Frequency: The above average leg strength trait would increase in frequency.

Explanation: If rabbits with stronger legs can escape predators, they will be available to reproduce and pass that favorable leg trait on to their offspring. Rabbits without the stronger trait may be preyed upon more often and not be as reproductively successful. Over time, the successful stronger leg trait frequency will increase within a population.

b) Answer: These rabbits will start to decrease in numbers. *or* They will be eaten by predators.

Explanation: The rabbits without the leg strength trait will be preyed upon more easily and will decrease in number.

38. Answer: Plant species *A* cuts: 1 Plant species *B* cuts: 0

Explanation: Plant species *A* will be cut by the restriction enzyme once at the recognized sequence: ACCGCAGGG/ATTCGC

Plant Species *B* does not contain the recognized sequence and therefore will receive 0 cuts.

39. *a*) Answer: Adenine and Thymine are present in equal numbers. *or* There is the same number of molecule.

Explanation: Adenine (*A*) and Thymine (*T*) are complimentary base pairs. Due to this pairing, the amount of each base in the pair would be equal.

b) Answer: The molecule Uracil (U) would replace the thymine (T) molecule in the chart.

Explanation: RNA molecules contain the molecular base Uracil (U), in place of Thymine (T), and would pair with Adenine (A). The chart numbers would remain unchanged as U and A are complimentary base pairs.

40. *a*) Where: nucleus
Specific molecule: DNA – where the information is found
or
Where: chromosome
Specific molecule: DNA

Explanation: Genetic information, composed of DNA, is stored within the nucleus of cells, tightly coiled into chromosome structures for integrity. This organization allows for continuity in DNA replication and error-free transcription or copying of the DNA code into RNA for protein synthesis.

b) Cellular structure: ribosomes
Molecules: amino acids

Explanation: Protein synthesis occurs in the cellular organelle known as the ribosome. During this process in the ribosome, amino acids are assembled into proteins. The original genetic code found in DNA will determine the sequence of the amino acid chain and ultimately, the structure and function of that protein.

41. *a*) Acceptable responses include, but are not limited to:
genetic engineering *or* genetic recombination *or* genetic manipulation *or* gene splicing
Note: No credit for biotechnology. It is a field of science, not a technique.

Explanation: Genetic engineering is a process that allows for the manipulation or movement of DNA from one organism into another. DNA is commonly cut and inserted using enzymes specific to DNA.

b) Acceptable responses include, but are not limited to: a segment of DNA that codes for a protein *or* Genes control traits. *or* Genes carry genetic information from one generation to the next.

Explanation: A gene is a section of DNA that codes for an amino acid sequence which becomes a protein. That protein will have a specific structure and function based on the order of amino acids.

c) Acceptable responses include, but are not limited to:
enzyme *or* restriction enzyme *or* biological catalyst

Explanation: Restriction enzymes cut DNA at specific locations. They are used to remove desirable genes from one organism as well as cut the DNA of another organism receiving that gene. They then allow for the insertion of the gene into the other organism.

d) Acceptable responses include but are not limited to: make medicines for humans
or increase the yield of crops *or* introduce new traits/characteristics into an organism
or use plants to produce vaccines *or* produce needed hormones (chemicals) for humans

Explanation: The insertion of desirable genes into other organisms allow for the production of medicines such as hormones, insulin, antibiotics and vaccines. Organisms such as plants can be genetically manipulated to have become resistant to disease, pests or severe environmental factors such as heat, cold or drought.