MULTIPLE CHOICE. Choose the one alternative that best completes the statement or answers the question.

1) In humans, the embryonic and fetal forms of hemoglobin have a higher affinity for oxygen than that of adults. This is due to
   A) the attachment of methyl groups to cytosine following birth, which changes the type of hemoglobin produced.
   B) pseudogenes, which interfere with gene expression in adults.
   C) identical genes that generate many copies of the ribosomes needed for fetal globin production.
   D) histone proteins changing shape during embryonic development.
   E) nonidentical genes that produce different versions of globins during development.

2) Which of the following experimental procedures is most likely to hasten mRNA degradation in a eukaryotic cell?
   A) methylation of C nucleotides
   B) removal of the 5’ cap
   C) removal of one or more exons
   D) memethylation of histones
   E) enzymatic shortening of the poly(A) tail

3) Which of the following statements is true about stem cells?
   A) Stem cell DNA lacks introns.
   B) Stem cells can differentiate into specialized cells.
   C) Stem cells are found only in the adult human brain.
   D) Stem cells can continually reproduce and are not subject to mitotic control.
   E) Stem cells are found only in bone marrow.

4) In eukaryotes, general transcription factors
   A) bind to other proteins or to a sequence element within the promoter called the TATA box.
   B) inhibit RNA polymerase binding to the promoter and begin transcribing.
   C) usually lead to a high level of transcription even without additional specific transcription factors.
   D) are required for the expression of specific protein-encoding genes.
   E) bind to sequences just after the start site of transcription.
A researcher has arrived at a method to prevent gene expression from Drosophila embryonic genes. The following questions assume that he is using this method.

5) The researcher measures the concentration of the polypeptides from different regions in the early embryo and finds the following pattern (darker shading = greater concentration):

![Regions 1 2 3 4 5]

Which of the following would be his most logical assumption?
A) The substance has moved quickly from region 5 to region 1.
B) The cytosol is in constant movement, dispersing the polypeptide.
C) Some other material in the embryo is causing accumulation in region 1 due to differential binding.
D) The substance must have entered the embryo from the environment near region 1.
E) The substance is produced in region 1 and diffuses toward region 5.

6) These genes form gradients and help establish the axes and other features of an embryo:
A) inducers
B) homeotic genes
C) egg-polarity genes
D) morphogens
E) segmentation genes

7) Cell differentiation always involves the
A) production of tissue-specific proteins, such as muscle actin.
B) movement of cells.
C) transcription of the myoD gene.
D) cell’s sensitivity to environmental cues such as light or heat.
E) selective loss of certain genes from the genome.

Use the following scenario to answer the following questions.

Suppose an experimenter becomes proficient with a technique that allows her to move DNA sequences within a prokaryotic genome.

8) If she moves the operator to the far end of the operon (past the transacetylase gene), which of the following would likely occur when the cell is exposed to lactose?
A) The repressor will no longer bind to the operator.
B) The operon will never be transcribed.
C) The structural genes will be transcribed continuously.
D) The repressor protein will no longer be produced.
E) The inducer will no longer bind to the repressor.
9) A genetic test to detect predisposition to cancer would likely examine the APC gene for involvement in which type(s) of cancer?
   A) lung only
   B) lung and prostate
   C) lung and breast
   D) small intestinal and esophageal
   E) colorectal only

10) One hereditary disease in humans, called xeroderma pigmentosum (XP), makes homozygous individuals exceptionally susceptible to UV-induced mutation damage in the cells of exposed tissue, especially skin. Without extraordinary avoidance of sunlight exposure, patients soon succumb to numerous skin cancers. Which of the following best describes this phenomenon?
   A) susceptibility to chemical carcinogens
   B) embryonic or fetal cancer
   C) inherited inability to repair UV-induced mutation
   D) inherited predisposition to mutation
   E) inherited cancer taking a few years to be expressed

11) Allolactose induces the synthesis of the enzyme lactase. An E. coli cell is presented for the first time with the sugar lactose (containing allolactose) as a potential food source. Which of the following occurs when the lactose enters the cell?
   A) Allolactose binds to the repressor protein.
   B) RNA polymerase attaches to the regulator.
   C) The repressor protein attaches to the regulator.
   D) The repressor protein and allolactose bind to RNA polymerase.
   E) Allolactose binds to the regulator gene.

12) A geneticist introduces a transgene into yeast cells and isolates five independent cell lines in which the transgene has integrated into the yeast genome. In four of the lines, the transgene is expressed strongly, but in the fifth there is no expression at all. Which is a likely explanation for the lack of transgene expression in the fifth cell line?
   A) A transgene integrated into a region of the genome characterized by high histone acetylation.
   B) A transgene integrated into a heterochromatic region of the genome.
   C) A transgene integrated into a euchromatic region of the genome.
   D) The transgene was mutated during the process of integration into the host cell genome.
   E) The host cell lacks the enzymes necessary to express the transgene.

13) The incidence of cancer increases dramatically in older humans because
   A) proteasomes become more active with age.
   B) as we age, normal cell division inhibitors cease to function.
   C) the Ras protein is more likely to be hyperactive after age sixty.
   D) tumor-suppressor genes are no longer able to repair damaged DNA.
   E) the longer we live, the more mutations we accumulate.
14) Proto-oncogenes can change into oncogenes that cause cancer. Which of the following best explains the presence of these potential time bombs in eukaryotic cells?
   A) Proto-oncogenes are mutant versions of normal genes.
   B) Proto-oncogenes first arose from viral infections.
   C) Cells produce proto-oncogenes as they age.
   D) Proto-oncogenes normally help regulate cell division.
   E) Proto-oncogenes are genetic "junk."

15) Which of the following mechanisms is (are) used to coordinately control the expression of multiple, related genes in eukaryotic cells?
   A) each of the genes sharing a common control element, allowing several activators to turn on their transcription, regardless of their location in the genome
   B) organizing the genes into large operons, allowing them to be transcribed as a single unit
   C) organization of the genes into clusters, with local chromatin structures influencing the expression of all the genes at once
   D) a single repressor able to turn off several related genes
   E) environmental signals that enter the cell and bind directly to their promoters

16) For a repressible operon to be transcribed, which of the following must occur?
   A) RNA polymerase must not occupy the promoter, and the repressor must be inactive.
   B) RNA polymerase and the active repressor must be present.
   C) A corepressor must be present.
   D) RNA polymerase cannot be present, and the repressor must be inactive.
   E) RNA polymerase must bind to the promoter, and the repressor must be inactive.

17) This is the site in the DNA located near the end of the final exon, encoding an RNA sequence that determines the 3' end of the transcript:
   A) terminator
   B) promoter
   C) enhancer
   D) activator
   E) repressor
A few decades ago, Knudsen and colleagues proposed a theory that, for a normal cell to become a cancer cell, a minimum of two genetic changes had to occur in that cell. Knudsen was studying retinoblastoma, a childhood cancer of the eye.

18) One of the human leukemias, called CML (chronic myelogenous leukemia) is associated with a chromosomal translocation between chromosomes 9 and 22 in somatic cells of bone marrow. Which of the following allows CML to provide further evidence of this multi-step nature of cancer?
   A) CML involves a proto-oncogene known as abl.
   B) The resulting chromosome 22 is abnormally short; it is then known as the Philadelphia chromosome.
   C) CML usually occurs in more elderly persons (late age of onset).
   D) The translocation requires breaks in both chromosomes 9 and 22, followed by fusion between the reciprocal pieces.
   E) CML can usually be treated by chemotherapy.

19) Which of the following is established prior to fertilization in *Drosophila* eggs?
   A) the position of the future segments
   B) the anterior-posterior and dorsal-ventral axes
   C) the position of the future wings, legs, and antennae
   D) A and B only
   E) A, B, and C

20) A lack of this nonprotein molecule would result in the inability of the cell to "turn off" genes:
   A) operon
   B) inducer
   C) repressor
   D) corepressor
   E) promoter

21) Altering patterns of gene expression in prokaryotes would most likely serve the organism's survival in which of the following ways?
   A) allowing the organism to adjust to changes in environmental conditions
   B) allowing environmental changes to alter the prokaryote's genome
   C) organizing gene expression so that genes are expressed in a given order
   D) allowing each gene to be expressed an equal number of times
   E) allowing young organisms to respond differently from more mature organisms

22) Steroid hormones produce their effects in cells by
   A) binding to intracellular receptors and promoting transcription of specific genes.
   B) activating translation of certain mRNAs.
   C) activating key enzymes in metabolic pathways.
   D) promoting the degradation of specific mRNAs.
   E) promoting the formation of looped domains in certain regions of DNA.
23) A cell that remains entirely flexible in its developmental possibilities is said to be
determined.
B) genomically equivalent.
C) totipotent.
D) epigenetic.
E) differentiated.

24) These genes map out the basic subdivisions along the anterior-posterior axis of the *Drosophila*
embryo:
A) egg-polarity genes
B) segmentation genes
C) inducers
D) homeotic genes
E) morphogens

25) The product of the *bicoid* gene in *Drosophila* provides essential information about
A) segmentation.
B) the anterior-posterior axis.
C) the left-right axis.
D) lethal genes.
E) the dorsal-ventral axis.

26) These genes are expressed by the mother, and their products are deposited into the developing egg:
A) homeotic genes
B) egg-polarity genes
C) inducers
D) morphogens
E) segmentation genes

27) Which of the following is characteristic of the product of the *p53* gene?
A) It causes cell death via apoptosis.
B) It is an activator for other genes.
C) It slows down the rate of DNA replication by interfering with the binding of DNA polymerase.
D) It speeds up the cell cycle.
E) It allows cells to pass on mutations due to DNA damage.

28) Eukaryotic cells can control gene expression by which of the following mechanisms?
A) histone acetylation of nucleosomes
B) repression of operons
C) induction of operators in the promoter
D) DNA acetylation
E) RNA induced modification of chromatin structure
29) Which of the following is most likely to have a small protein called ubiquitin attached to it?
   A) a cyclin that usually acts in G1, now that the cell is in G2
   B) a cell surface protein that requires transport from the ER
   C) an mRNA that is leaving the nucleus to be translated
   D) an mRNA produced by an egg cell that will be retained until after fertilization
   E) a regulatory protein that requires sugar residues to be attached

30) What would occur if the repressor of an inducible operon were mutated so it could not bind the operator?
   A) buildup of a substrate for the pathway controlled by the operon
   B) overproduction of catabolite activator protein (CAP)
   C) reduced transcription of the operon's genes
   D) irreversible binding of the repressor to the promoter
   E) continuous transcription of the operon's genes

31) If a particular operon encodes enzymes for making an essential amino acid and is regulated like the trp operon, then the
   A) enzymes produced are called inducible enzymes.
   B) amino acid acts as a corepressor.
   C) amino acid turns on transcription of the operon.
   D) repressor is active in the absence of the amino acid.
   E) amino acid inactivates the repressor.

32) A mutation that inactivates the regulatory gene of a repressible operon in an E. coli cell would result in
   A) continuous transcription of the structural gene controlled by that regulator.
   B) complete inhibition of transcription of the structural gene controlled by that regulator.
   C) continuous translation of the mRNA because of alteration of its structure.
   D) irreversible binding of the repressor to the operator.
   E) inactivation of RNA polymerase by alteration of its active site.

Use the following scenario to answer the following questions.

Suppose an experimenter becomes proficient with a technique that allows her to move DNA sequences within a prokaryotic genome.

33) If she moves the repressor gene (lac I), along with its promoter, to a position at some several thousand base pairs away from its normal position, which will you expect to occur?
   A) The repressor will no longer be made.
   B) The repressor will no longer bind to the inducer.
   C) The lac operon will be expressed continuously.
   D) The repressor will no longer bind to the operator.
   E) The lac operon will function normally.
34) Which of the following statements about the DNA in one of your brain cells is true?
   A) Most of the DNA codes for protein.
   B) Many genes are grouped into operon-like clusters.
   C) Each gene lies immediately adjacent to an enhancer.
   D) The majority of genes are likely to be transcribed.
   E) It is the same as the DNA in one of your heart cells.

35) You are given an experimental problem involving control of a gene’s expression in the embryo of a particular species. One of your first questions is whether the gene’s expression is controlled at the level of transcription or translation. Which of the following might best give you an answer?
   A) You explore whether there has been alternative splicing by examining amino acid sequences of very similar proteins.
   B) You assess the position and sequence of the promoter and enhancer for this gene.
   C) An analysis of amino acid production by the cell shows you that there is an increase at this stage of embryonic life.
   D) You measure the quantity of the appropriate pre-mRNA in various cell types and find they are all the same.
   E) You use an antibiotic known to prevent translation.

36) A researcher found a method she could use to manipulate and quantify phosphorylation and methylation in embryonic cells in culture. In one set of experiments she succeeded in decreasing methylation of histone tails. Which of the following results would she most likely see?
   A) increased chromatin condensation
   B) decreased binding of transcription factors
   C) inactivation of the selected genes
   D) decreased chromatin concentration
   E) abnormalities of mouse embryos

37) The lactose operon is likely to be transcribed when
   A) the cyclic AMP levels are low.
   B) the cyclic AMP and lactose levels are both high within the cell.
   C) the cAMP level is high and the lactose level is low.
   D) there is more glucose in the cell than lactose.
   E) there is glucose but no lactose in the cell.

38) Differentiation of cells is not easily reversible because it involves
   A) changes in the nucleotide sequence of genes within the genome.
   B) frameshift mutations and inversions.
   C) excision of some coding sequences.
   D) chemical modifications of histones and DNA methylation.
   E) changes in chromatin structure that make certain regions of the genome more accessible.
39) During DNA replication,  
A) methylation of the DNA is maintained because DNA polymerase directly incorporates methylated nucleotides into the new strand opposite any methylated nucleotides in the template.  
B) methylated DNA is copied in the cytoplasm, and unmethylated DNA in the nucleus.  
C) DNA polymerase is blocked by methyl groups, and methylated regions of the genome are therefore left uncopied.  
D) methylation of the DNA is maintained because methylation enzymes act at DNA sites where one strand is already methylated and thus correctly methylates daughter strands after replication.  
E) all methylation of the DNA is lost at the first round of replication.

40) The phenomenon in which RNA molecules in a cell are destroyed if they have a sequence complementary to an introduced double-stranded RNA is called  
A) RNA blocking.  
B) RNA targeting.  
C) RNA interference.  
D) RNA obstruction.  
E) RNA disposal.

41) Mutations in these genes lead to transformations in the identity of entire body parts:  
A) segmentation genes  
B) morphogens  
C) inducers  
D) egg-polarity genes  
E) homeotic genes

42) The MyoD protein  
A) is a target for other proteins that bind to it.  
B) can promote muscle development in all cell types.  
C) is a transcription factor that binds to and activates the transcription of muscle-related genes.  
D) magnifies the effects of other muscle proteins.  
E) was used by researchers to convert differentiated muscle cells into liver cells.

43) Which of the following is an example of post-transcriptional control of gene expression?  
A) the binding of transcription factors to a promoter  
B) the folding of DNA to form heterochromatin  
C) the addition of methyl groups to cytosine bases of DNA  
D) gene amplification during a stage in development  
E) the removal of introns and splicing together of exons

44) Within a cell, the amount of protein made using a given mRNA molecule depends partly on  
A) the presence of certain transcription factors.  
B) the degree of DNA methylation.  
C) the types of ribosomes present in the cytoplasm.  
D) the number of introns present in the mRNA.  
E) the rate at which the mRNA is degraded.
45) Genomic imprinting, DNA methylation, and histone acetylation are all examples of  
A) genetic mutation.  
B) karyotypes.  
C) epigenetic phenomena.  
D) chromosomal rearrangements.  
E) translocation.

46) What does the operon model attempt to explain?  
A) bacterial resistance to antibiotics  
B) how genes move between homologous regions of DNA  
C) horizontal transmission of plant viruses  
D) the mechanism of viral attachment to a host cell  
E) the coordinated control of gene expression in bacteria

Use the following scenario for the following questions.

A few decades ago, Knudsen and colleagues proposed a theory that, for a normal cell to become a cancer cell, a minimum of two genetic changes had to occur in that cell. Knudsen was studying retinoblastoma, a childhood cancer of the eye.

47) If there are two children born from the same parents, and child one inherits a predisposition to retinoblastoma (one of the mutations) and child two does not, but both children develop the retinoblastoma, which of the following would you expect?  
A) an earlier age of onset in child one  
B) decreased levels of DNA repair in child one  
C) a more severe cancer in child one  
D) increased levels of apoptosis in both children  
E) a history of exposure to mutagens in child one but not in child two

Use the following scenario to answer the following questions.

Suppose an experimenter becomes proficient with a technique that allows her to move DNA sequences within a prokaryotic genome.

48) If she moves the promoter for the lac operon to the region between the beta galactosidase gene and the permease gene, which of the following would be likely?  
A) RNA polymerase will no longer transcribe permease.  
B) Three structural genes will no longer be expressed.  
C) The cell will continue to metabolize but more slowly.  
D) The operon will no longer be inducible.  
E) Beta galactosidase will be produced.

49) The cancer-causing forms of the Ras protein are involved in which of the following processes?  
A) DNA repair  
B) cell-cell adhesion  
C) cell division  
D) DNA replication  
E) relaying a signal from a growth factor receptor
50) At the beginning of this century there was a general announcement regarding the sequencing of the human genome and the genomes of many other multicellular eukaryotes. There was surprise expressed by many that the number of protein-coding sequences is much smaller than they had expected. Which of the following accounts for most of the rest?
   A) non-protein coding DNA that is transcribed into several kinds of small RNAs with biological function
   B) DNA that is translated directly without being transcribed
   C) non-protein coding DNA that is transcribed into several kinds of small RNAs without biological function
   D) rRNA and tRNA coding sequences
   E) "junk" DNA that serves no possible purpose

51) The \textit{bicoid} gene product is normally localized to the anterior end of the embryo. If large amounts of the product were injected into the posterior end as well, which of the following would occur?
   A) The embryo would probably show no anterior development and die.
   B) The embryo would develop normally.
   C) The embryo would grow to an unusually large size.
   D) The embryo would grow extra wings and legs.
   E) Anterior structures would form in both sides of the embryo.

52) The process of cellular differentiation is a direct result of
   A) differential gene expression.
   B) differences in cellular genomes.
   C) apoptosis.
   D) cell division.
   E) morphogenesis.

53) Which of the following best describes siRNA?
   A) a double-stranded RNA that is formed by cleavage of hairpin loops in a larger precursor
   B) a molecule, known as Dicer, that can degrade other mRNA sequences
   C) a single-stranded RNA that can, where it has internal complementary base pairs, fold into cloverleaf patterns
   D) a portion of rRNA that allows it to bind to several ribosomal proteins in forming large or small subunits
   E) a short double-stranded RNA, one of whose strands can complement and inactivate a sequence of mRNA

54) A researcher found a method she could use to manipulate and quantify phosphorylation and methylation in embryonic cells in culture. In one set of experiments using this procedure in \textit{Drosophila}, she was readily successful in increasing phosphorylation of amino acids adjacent to methylated amino acids in histone tails. Which of the following results would she most likely see?
   A) decreased binding of transcription factors
   B) abnormalities of mouse embryos
   C) increased chromatin condensation
   D) decreased chromatin concentration
   E) inactivation of the selected genes
If a *Drosophila* female has a homozygous mutation for a maternal effect gene,  
A) her offspring will show the mutant phenotype only if they are also homozygous for the mutation.  
B) all of her offspring will show the mutant phenotype, regardless of their genotype.  
C) only her female offspring will show the mutant phenotype.  
D) she will not develop past the early embryonic stage.  
E) only her male offspring will show the mutant phenotype.

One of the hopes for use of recent knowledge gained about non-coding RNAs lies with the possibilities for their use in medicine. Of the following scenarios for future research, which would you expect to gain most from RNAs?  
A) creating knock-out organisms that can be useful for pharmaceutical drug design  
B) looking for a way to prevent viral DNA from causing infection in humans  
C) targeting siRNAs to disable the expression of an allele associated with autosomal recessive disease  
D) targeting siRNAs to disable the expression of an allele associated with autosomal dominant disease  
E) exploring a way to turn on the expression of pseudogenes

In animals, embryonic stem cells differ from adult stem cells in that  
A) embryonic stem cells are totipotent, and adult stem cells are pluripotent.  
B) embryonic stem cells are pluripotent, and adult stem cells are totipotent.  
C) embryonic stem cells have fewer genes than adult stem cells.  
D) embryonic stem cells are localized to specific sites within the embryo, whereas adult stem cells are spread throughout the body.  
E) embryonic stem cells have more genes than adult stem cells.

A researcher has arrived at a method to prevent gene expression from Drosophila embryonic genes. The following questions assume that he is using this method.

The researcher in question measures the amount of new polypeptide production in embryos from 2—8 hours following fertilization and the results show a steady and significant rise in polypeptide concentration over that time. The researcher concludes that  
A) the results are due to building new cell membranes to compartmentalize dividing nuclei.  
B) the resulting new polypeptides are due to translation of maternal mRNAs.  
C) the new polypeptides were inactive and not measurable until fertilization.  
D) polypeptides were attached to egg membranes until this time.  
E) his measurement skills must be faulty.
A few decades ago, Knudsen and colleagues proposed a theory that, for a normal cell to become a cancer cell, a minimum of two genetic changes had to occur in that cell. Knudsen was studying retinoblastoma, a childhood cancer of the eye.

59) In colorectal cancer, several genes must be mutated in order to make a cell a cancer cell, supporting Knudsen’s hypothesis. Which of the following kinds of genes would you expect to be mutated?
   A) genes that are especially susceptible to mutation
   B) genes coding for enzymes that act in the colon
   C) genes involved in control of the cell cycle
   D) the same genes that Knudsen identified as associated with retinoblastoma
   E) the genes of the bacteria that are abundant in the colon

60) In a series of experiments, the enzyme Dicer has been inactivated in cells from various vertebrates, and the centromere is abnormally formed from chromatin. Which of the following is most likely to occur?
   A) The DNA of the centromeres will no longer be able to replicate.
   B) The usual mRNAs transcribed from centromeric DNA will be missing from the cells.
   C) Centromeres will be euchromatic rather than heterochromatic and the cells will soon die in culture.
   D) Tetrads will no longer be able to form during meiosis I.
   E) The cells will no longer be able to resist bacterial contamination.