Multiple Choice
Identify the choice that best completes the statement or answers the question.

1. Why did the original “one-gene, one-enzyme” hypothesis have to be modified?
   a. Not all proteins are coded by genes.
   b. Some RNAs have catalytic activity.
   c. Some enzymes are made up of more than one polypeptide.
   d. Not all enzymes are coded for by genes.

2. Sickle-cell disease and hemoglobin C disease are both caused by point mutations, resulting in glutamic acid being replaced by _______ and _______, respectively.
   a. lysine; arginine
   b. valine; glycine
   c. serine; cysteine
   d. valine; lysine

3. Which of the following is required for the initiation of transcription?
   a. DNA polymerase
   b. Ribonucleoside triphosphates
   c. The start codon AUG
   d. Promoter DNA

4. Put the following four steps of eukaryotic gene expression in order, from beginning to end.
   (1) Pre-mRNA is processed to make mRNA.
   (2) Ribosomes translate the mRNA message to make proteins.
   (3) mRNA is transported to the cytoplasm.
   (4) DNA is used as a template make pre-mRNA.
   a. 1; 4; 3; 2
   b. 1; 2; 4; 3
   c. 4; 3; 1; 2
   d. 4; 1; 3; 2

5. RNA polymerases differ from DNA polymerases in that
   a. only DNA polymerases are processive.
   b. RNA polymerases are less effective at proofreading than DNA polymerases.
   c. RNA polymerases do not require a template.
   d. DNA polymerases use ribonucleoside triphosphates as substrates.

6. Which of the following statements about pre-mRNA splicing is false?
   a. It removes introns.
   b. It is performed by small nuclear ribonucleoprotein particles (snRNPs).
   c. It is common in prokaryotes.
   d. It is directed by consensus sequences.

7. Which component of transcribed RNA in eukaryotes is present in the primary transcript but is removed before translation occurs?
   a. 5’ cap
   b. Poly A tail
   c. Intron
   d. Exon
8. In eukaryotes, the first amino acid in a growing polypeptide chain is always _______ because the only codon for this amino acid is also the _______ codon.
   a. alanine; stop
   b. tryptophan; start
   c. tryptophan; stop
   d. methionine; start

9. Which of the following single-base substitutions in the template strand of DNA would result in the premature termination of translation?
   a. GAG to TAG
   b. CTG to CTT
   c. ATG to ATT
   d. CAA to CAG

10. UAU and UAC both code for tyrosine. A change from UAU to UAC would thus be a(n) _______ mutation; a change from UAU to UAG would be a(n) _______ mutation.
    a. silent; nonsense
    b. nonsense; silent
    c. silent; missense
    d. frame-shift; missense

11. Ribosomes
    a. carry out translation.
    b. are not found in prokaryotes.
    c. have no role in the fidelity of mRNA and tRNA interactions.
    d. contain RNA only.

12. The mRNA codon for leucine is 5´-UUG-3´, and the tRNA anticodon is
    a. 5`-UUG-3`
    b. 3`-AAC-5`
    c. 5`-AAC-3`
    d. 3`-UUG-5`

13. Which of the following statements about tRNAs is false?
    a. tRNAs have an anticodon at their 5’ end and an amino acid attachment site at their 3’ end.
    b. Specific enzymes bind amino acids to their corresponding tRNAs.
    c. ATP is required for the charging of tRNAs with amino acids.
    d. tRNAs interact with mRNA.

14. During protein synthesis, ribosomes
    a. translate mRNA into polypeptides.
    b. transcribe mRNA to proteins.
    c. translate mRNA into DNA.
    d. translate mRNA into tRNA.

15. At the initiation of translation in eukaryotes,
    a. the anticodon of tRNA charged with methionine binds to mRNA associated with the small ribosomal subunit.
    b. the complex of mRNA and the large ribosomal subunit are formed.
    c. the poly A tail of mRNA is directly involved.
    d. the large ribosomal subunit binds to mRNA, causing the release of the small subunit.
16. In the elongation stage of translation,
   a. rRNA plays a passive role.
   b. rRNA is catalytically active.
   c. peptidyl transferase activity is catalyzed by a ribosomal protein.
   d. the message is read in the 3'-to-5' direction.

17. A protein destined for a lysosome carries a signal peptide for the
   a. plasma membrane.
   b. lysosome.
   c. rough ER.
   d. mitochondria.

18. Posttranslational alterations of proteins
   a. can affect the activity of an enzyme.
   b. may include addition of phosphate groups.
   c. may include the addition of polysaccharides to proteins.
   d. may include the cleavage of signal sequences.
   e. All of the above

19. Predict the intracellular destinations of the following proteins: DNA polymerase; pyruvate kinase; rubisco; citrate synthase.
   a. Nucleus; cytoplasm; chloroplast; mitochondrion
   b. Mitochondrion; chloroplast; nucleus, cytoplasm
   c. Cytoplasm; chloroplast; nucleus; mitochondrion
   d. Nucleus; mitochondrion; chloroplast; cytoplasm

20. Gene expression can be
   a. regulated before transcription.
   b. during transcription.
   c. after transcription but before translation.
   d. at or after translation.
   e. All of the above

21. ______ genes are expressed all of the time.
   a. Activator
   b. Clustered
   c. Inducible
   d. Constitutive

22. Bacterial viruses (phage)
   a. require a host cell to replicate.
   b. are alive.
   c. have a plasma membrane.
   d. can reproduce on their own.

23. Regulation of gene expression during the phage lytic cycle does not include
   a. stimulation of viral late gene transcription.
   b. enhancement of the host’s gene transcription.
   c. binding of a host RNA polymerase to a viral promoter.
   d. down regulation of the host’s gene transcription.

24. A retrovirus
   a. has a double-stranded DNA genome.
25. Structural genes
   a. are absent in eukaryotes.
   b. are always constitutively expressed.
   c. code for structural proteins.
   d. specify the primary structure (amino acid sequence) of proteins.

26. Operons
   a. consist of structural genes only.
   b. consist of a promoter, an operator, and two (or more) structural genes.
   c. include inducer genes.
   d. consist of a promoter, an operator, structural genes, and a repressor gene.

27. A(n) ______ operon is turned on unless not needed.
   a. repressible
   b. constitutive
   c. inducible
   d. clustered
   e. None of the above

28. The expression of the lac structural genes is ______ when lactose is absent from the culture medium and is ______ when lactose is added because lactose binds to the ______ and inactivates it.
   a. low; high; lac repressor
   b. low; high; lac promoter
   c. low; high; lac operator
   d. high; low; lac inducer

29. ______ are present in prokaryotes and bind to and direct the polymerase to specific promoters.
   a. Ribosomes
   b. Proteases
   c. Sigma factors
   d. Reverse transcriptases

30. Prokaryotes and eukaryotes differ in transcription in that
   a. there are three RNA polymerases in eukaryotes.
   b. initiation of transcription is simpler in prokaryotes.
   c. structural genes for a pathway are more likely to be clustered in prokaryotes.
   d. eukaryotic promoters have a TATA box.
   e. All of the above

31. Which of the following statements about RNA polymerase is true?
   a. Bacteria contain more regulatory sequences than eukaryotes.
   b. Eukaryotes use RNA polymerase III to transcribe ribosomal RNA.
   c. In eukaryotes, RNA polymerase II binds directly to the DNA promoter and initiates transcription.
   d. Eukaryotes use different RNA polymerases to transcribe rRNA and mRNA.

32. In the initiation of the transcription of protein-coding genes in eukaryotes, ______ cannot bind directly to the _______. Initiation requires ______ and other regulatory proteins called “______.”
   a. TFIID; RNA polymerase I; initiation site; transcription factors
b. RNA polymerase II; initiation site; TFIID; transcription factors
c. RNA polymerase I; TATA box; TFIID; transcription factors
d. RNA polymerase III; initiation site; TFIID; initiation factors

33. Which of the following are not involved in the process of transcription?
   a. Transcription factors
   b. RNA polymerase
   c. TATA box
   d. Ribosomes

34. DNA methylation
   a. is important in the development of mammalian embryos.
   b. may repress the transcription of genes.
   c. involves the modification of the pyrimidine cytosine.
   d. is abundant in promoters.
   e. All of the above

35. Epigenetics may be defined as changes in the expression of a gene or set of genes by _______ and _______.
   a. DNA methylation; chromosomal protein alteration
   b. transcription factors; DNA methylation
   c. promoters; DNA methylation
   d. promoters; chromosomal protein alteration

36. Which of the following does not regulate gene expression after transcription?
   a. MicroRNA
   b. Translational repressor proteins
   c. Modifications to the G cap
   d. Alternative splicing
   e. All of the above regulate gene expression.

37. Predict what would happen to the synthesis of the enzyme HMG CoA reductase (an enzyme that catalyzes an initial step in the synthesis of cholesterol) if trichostatin A, a histone deacetylase inhibitor, is added to liver cells.
   a. The amount of HMG CoA reductase increases.
   b. The amount of HMG CoA reductase decreases.
   c. The HMG CoA reductase levels do not change.
   d. The HMG CoA reductase undergoes a conformational change and loses function.
   e. None of the above

38. Which of the following statements about determination is false?
   a. Most cells are determined early in their life cycle.
   b. A determined cell will keep its determination no matter where it is placed in an embryo.
   c. Determination precedes differentiation.
   d. Fates of cells become more restricted during development.

39. The process of morphogenesis
   a. is the shaping of differentiated cells into the multicellular body and its organs.
   b. sets the developmental fate of a cell.
   c. is the process by which different cell types arise.
   d. is the increase in body size.
   e. All of the above
40. Although plants may be cloned from _______ somatic cells, animals have so far been cloned using either _______ cells or by _______ with _______ eggs.
   a. differentiated; transformation; cell fusion; enucleated
   b. differentiated; nuclear transfer; cell fusion; enucleated
   c. embryonic; transformation; nuclear transfer; nucleated
   d. determined; nuclear transfer; cell fusion; enucleated

41. The cloning of the first mammal, Dolly, a Dorset sheep,
   a. used rapidly dividing cells as the donor of the nucleus.
   b. showed that differentiated animal cells may be totipotent.
   c. was accomplished using an embryonic cell as the donor of the nucleus.
   d. used a differentiated cell as a recipient of the nucleus.

42. Stem cells are
   a. present in all parts of a mature plant.
   b. totipotent in animals.
   c. found in just a few animal tissues.
   d. multipotent in animals.

43. Induced pluripotent stem cells
   a. are genetic transformants.
   b. may be produced from skin cells in vitro.
   c. can be induced to form many different tissues.
   d. offer some advantages over embryonic stem cells for therapeutic use.
   e. All of the above

44. In a vertebrate embryo,
   a. cell division and differentiation may be mutually exclusive.
   b. arrest of the cell cycle blocks differentiation.
   c. transcription factors result in differential gene expression.
   d. rapid growth by cell division favors differentiation.
   e. Both a and c

45. The fate of a cell during development is
   a. not altered by reagents that interfere with microtubule formation.
   b. influenced by cytoplasmic determinants.
   c. entirely controlled by nuclear gene expression.
   d. independent of gene expression.

46. Which of the following statements about inducer molecules is false?
   a. Inducer molecules can activate transcription factors.
   b. Inducers bind to receptors on the plasma membrane of target cells.
   c. Inducers molecules are generally produced by the same cells they affect.
   d. Inducer molecules act through signal transduction pathways.

47. Apoptosis
   a. is not an important process in the development of nematodes.
   b. is random cell death.
   c. occurs by similar mechanisms in both nematodes and humans.
   d. is not an important process in neuronal development of humans.

48. The genes that determine the fate of cells in the _______ of a flowering plant’s shoot apex are called _______ genes. These genes code for _______. 
49. Location of a cell may be critical in the determination of its ultimate fate during development, as in the development of vertebrate limbs. This fact arises from
   a. a gradient in the concentration of the morphogen, Sonic hedgehog.
   b. the unequal distribution of transcription factors.
   c. expression of organ identity genes.
   d. a gradient in the concentration of ZPA.

50. In *Drosophila*, the *bicoid* and *nanos* genes
   a. have no effect on the expression of the *hunchback* gene.
   b. are expressed even before fertilization.
   c. are expressed late in the development of the embryo.
   d. determine the dorsal–ventral axis of the embryo.

51. The anterior and posterior ends of a *Drosophila* embryo are determined by _______ genes that are active _______ fertilization and result in a gradient of the protein _______.
   a. segmentation; before and after; Bicoid
   b. organ identity; before and after; Nanos
   c. maternal effect; before; Hunchback
   d. maternal effect; before and after; Hunchback

52. What is the correct order of expression of the genes listed below in the determination of segmentation in *Drosophila*?
   (1) Segment polarity genes
   (2) Gap genes
   (3) Pair rule genes
   a. 1, 2, 3
   b. 2, 3, 1
   c. 3, 1, 2
   d. 3, 2, 1

53. Which of the following is the last set of genes to turn on in the *Drosophila* embryo?
   a. Gap genes
   b. Pair rule genes
   c. Segment polarity genes
   d. Homeotic genes

54. A homeobox
   a. is a DNA sequence present in many transcription factors.
   b. is another name for a homeodomain.
   c. binds to DNA.
   d. is not present in plants.

55. Which of the following principles of evo-devo is *not* stated properly?
   a. Developmental mechanisms have evolved to be responsive to environmental cues.
   b. New developmental mechanisms, rather than modifications of existing mechanisms, account for morphological evolution.
   c. Development is modular.
   d. Even distantly related organisms share similar molecular mechanisms for development.
56. Hox genes
   a. control dorsal–ventral pattern formation in *Drosophila*.
   b. code for enzymes.
   c. are clustered in a similar way in both *Drosophila* and mouse embryos.
   d. code for termination factors.

57. Developmental modularity
   a. allows one part of an animal’s body to change independent of another part.
   b. is controlled by a single “switch.”
   c. is a consequence of the action of the genetic toolkit.
   d. does not involve spatial differences in gene expression.
   e. Both a and c

58. Major morphological changes can result from
   a. mutations in developmental regulatory genes.
   b. short-term environmental changes.
   c. alterations in the time or place of expression of genes.
   d. Both a and c
   e. All of the above

59. Conserved developmental genes can lead to _______ evolution.
   a. divergent
   b. convergent
   c. parallel phenotypic
   d. linear
   e. None of the above

60. Evolutionary modifications
   a. generally occur in large steps.
   b. are facilitated by the conservation of the genes that regulate development.
   c. such as wings, likely evolved independently in insects and vertebrates.
   d. usually result in entirely new anatomical features over a short time period.