Choose the BEST answer. Two points each.

1. The purpose of the Polymerase Chain Reaction is to
   a. determine the function of Taq polymerase in vitro
   b. inactivate polymerases to test wild type function.
   c. make numerous copies of a DNA fragment of interest.
   d. insert plasmid vectors into live E. coli.
   e. inspire nerdy music videos

2. Which of the following will cleave specific target sequences occurring throughout the genome (both within genes and in non-coding regions), fragmenting the genome into smaller strands of DNA?
   a. DNA polymerases
   b. exonucleases
   c. restriction endonucleases
   d. proteases
   e. inverted repeats

3. The most general term used to describe a small, rapidly replicating molecule that can be used to deliver a DNA fragment to a target location in recipient DNA is
   a. plasmid
   b. phage
   c. transgene
   d. vector
   e. clone

4. Which of the following terms is LEAST related to the others?
   a. genomics
   b. bioinformatics
   c. cDNA library
   d. expression vector
   e. reporter gene

5. In this type of organism, the genetically different cell types originate from more than one zygote.
   a. mosaic
   b. Turner Syndrome
   c. chimera
   d. polyploidy
   e. aneuploid

6. Because restriction enzymes cleave DNA in a species-specific manner, you must use a restriction enzyme extracted from a human cell to cleave human DNA.
   a. true
   b. false
   c. how speciesist

7. If you discovered a bacterial cell that contained no restriction endonucleases, which of the following would you expect to be true?
   a. the cell would be unable to replicate its DNA
   b. the cell would manufacture incomplete plasmids
   c. the cell would be easily infected and lysed by bacteriophages
   d. the cell would become an obligate parasite to survive
   e. the cell could never be indicted as a criminal suspect

8. A cDNA library
   a. a collection of cloned DNA of the same gene loci from different species
   b. a library of putative genes including promoters and operators
   c. a type of genomic library containing an organism's complete genome.
   d. a DNA library made up of DNA clones reconstructed from mRNA fragments
   e. is composed only of DNA sequences that are never expressed in the organism

9. Of the following substances, which would be most appropriate to use as a probe to locate an enzyme of interest that you have isolated on an electrophoresis gel?
   a. radioactive mRNA with a sequence encoding that enzyme's amino acid sequence
   b. a DNA fragment complementary to the enzyme's amino acid sequence
   c. a radioactive antibody with affinity for the enzyme
   d. labeled ribosomes with an appropriate Shine-Dalgarno sequence
   e. restriction sequences with "sticky ends" matching the enzyme’s amino acid sequence

10. You have a restriction endonuclease that cleaves the phosphodiester bond between two adjacent thymine nucleotides, but only when they occur in the exact sequence: 5'—TTGGCCAA—3'.
    You allowed the enzyme to cleave the following sequence: 5'—TTGGCCAA—3'
    3'—AACCGGTT—5'
    Which base sequence would comprise the actual "sticky ends" resulting from this cleavage?
    a. 5'--TGCGC--3'  
    b. 5'--TTGGCCAA--3'  
    c. 3'--AACCGGTT--5'  
    d. 3'--AACCGGTT--5'  
    e. 5'--TGGCCA--3'
11. Which of the following is used by forensic scientists as "DNA fingerprints"?
   a. Restriction Fragment Length Polymorphism  
   b. Variable Number Tandem Repeats  
   c. Highly Conserved Telomeric Sequences  
   d. chimeric DNA

**Use the following information to answer #12 - 15**

You have four reaction flasks in which you have provided all the raw materials (DNA template strands, DNA nucleotides, labeled primers, DNA polymerases, etc.) and physical conditions for DNA synthesis from a cloned template DNA strand you wish to sequence. To each of your flasks, you add radioactively labeled dideoxy nucleotide triphosphates (ddNTP's), as follows:

<table>
<thead>
<tr>
<th>Flask #1: ddATP</th>
<th>Flask #2: ddCTP</th>
<th>Flask #3: ddGTP</th>
<th>Flask #4: ddTTP</th>
</tr>
</thead>
</table>

12. The function of the ddNTP's is to
   a. facilitate DNA synthesis by activating DNA polymerases
   b. create a new DNA strand in which every nucleotide is radioactively labeled
   c. increase the reaction rate of DNA synthesis
   d. help generate a series of DNA fragments that differ in length by only one base pair
   e. More than one of the above

13. The purpose of the "dideoxy method" you have set up as described above is to
   a. quickly clone large quantities of DNA
   b. sequence a DNA strand
   c. create cloning vectors
   d. radioactively label nucleotides
   e. manufacture cDNA probes

14. After you allowed your DNA to react for an appropriate amount of time, you treated your samples to remove any residual single-stranded DNA, and then subjected them to electrophoresis. Once this was done, you were able to visualize the location of bands of radioactively labeled DNA by exposing them on x-ray film. This visualization technique is known as
   a. x-ray crystallography
   b. autoradiography
   c. DNA sequencing
   d. Giemsa staining
   e. dideoxy fragmentation

15. The diagram below represents the electrophoresis gel of the DNA fragments you obtained with the Sanger dideoxy method. The fragments moved from left to right during the process.

   | 3' A ||||| ||||| |
   | 3' C ||||| ||||| |
   | 3' G ||| ||||| |||| |
   | 3' T ||| ||||| |||| |

   What is the sequence of your DNA sample of interest?
   a. 3'-AGGGCTTAACCGTGGAAAACCGACT-5'  e. none of the above
   b. 5'-AGGGCTTAACCGTGGAAAACCGACT-3'
   c. 3'-TCCCGAATTGGCAACCTTTGGCTGA-5'
   d. 5'-TCCCGAATTGGCAACCTTTGGCTGA-3'

16. When the trp operon is working under [attenuator] control, the number of transcripts actually translated into the five trp-manufacturing enzymes is affected directly by
   a. the concentration of trp-manufacturing enzymes in the cell
   b. the concentration of tryptophan in the cell
   c. the speed at which the ribosome reads the three trp genes in the trp operon
   d. the stem loop configuration of the mRNA leader of the trp operon
   e. more than one of the above

17. This molecule acts as a co-repressor in its own operon system.
   a. lactose  
   b. arabinose  
   c. tryptophan  
   d. Ifg2  
   e. hybrid RNA

18. In *E. coli*, a mutation that inactivates the regulator gene of a repressible operon under negative control would be most likely to cause
   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. irreversible binding of the repressor to the operator
   d. inactivation of RNA polymerase
   e. both B and C
19. For a repressible operon to be transcribed, which of the following must be true?
   a. a corepressor must be present
   b. RNA polymerase and the active repressor must be present
   c. The repressor must be inactivated so that RNA polymerase can bind to the promoter
   d. RNA polymerase cannot be present, and the repressor must be inactive
   e. RNA polymerase must be bound to the repressor protein, removing it from the silencer

20. Transcription of the protein-coding genes in an *inducible* operon
   a. occurs all the time
   b. starts when the pathway's substrate is present
   c. starts when the pathway's product is present
   d. stops when the pathway's product is present
   e. does not produce functional enzymes

21. The lac repressor protein is capable of binding to
   a. allolactose and DNA
   b. DNA and mRNA transcripts of the lac operon
   c. Beta-galactosidase, permease, and transferase
   d. RNA polymerase and lactose
   e. more than one of the above

22. If a protein bound to the operator of an *E. coli* operon increases the affinity of the operon's
    promoter to RNA polymerase, you can say with absolute certainty that
    a. the operon is under positive control
    b. the operon is under negative control
    c. the operon is under attenuator control

23. A loss-of-function mutation a repressible operon’s operator would most likely result in ____________
    of the operon.
    a. repressible transcription
    b. constitutive transcription
    c. no translation
    d. attenuated translation
    e. no transcription

24. Control of gene expression at the protein activity level is most likely in genes whose product
    a. must be readily available in response to sudden environmental changes
    b. is constantly needed by the cell in its active form
    c. has a relatively short lifespan in the cell
    d. requires very little energy to produce
    e. is involved in the control of seasonal reproductive cycles

25. In *E. coli*, when the trp operon is working under attenuator control
    a. portions of the mRNA leader transcript may fold into stem loop structures
    b. none of the DNA coding for trp enzymes is transcribed
    c. the ribosome cannot attach to any part of the mRNA transcript
    d. the mRNA transcript has a much shorter half life than usual
    e. none of the above

26. The purpose of *attenuator control* in the trp operon of *E. coli* is to
    a. allow the bacterium to concentrate on the best sugar available
    b. allow fine control of trp anabolism by signaling trp concentration to the cell
    c. stop trp manufacture when the cell is starved for protein
    d. pause during trp manufacture to allow the cell to correct errors in translation
    e. keep the ribosomes busy so they won't hang out at the Golgi, causing trouble

27. In which of the following would you expect to find the greatest amount of highly methylated DNA?
    a. tandem arrays of ribosomal genes
    b. mitochondrial cytochrome genes
    c. inactivated mammalian chromosomes
    d. genes transcribed at a very high rate
    e. transposons

28. A eukaryotic transcription factor
    a. may have its DNA affinity modified by an effector molecule
    b. may bind to an enhancer or silencer
    c. may be an activator or a repressor
    d. is often an allosteric protein
    e. all of the above

29. Which of the following basic regulatory elements is found in *both* prokaryotes and eukaryotes?
    a. promoters
    b. enhancers
    c. operators
    d. silencers
    e. all of the above
30. In Mystery Snails, a wild type gene coding for green pigmentation (G) of the skin is maternally imprinted via a high degree of methylation. Which of the following is incorrect?
   a. A snail inheriting a mutant form of G from its father would lack green pigmentation.
   b. Wild type snails inherit functional green pigmentation enzymes from their mother.
   c. Wild type snails inherit functional green pigmentation enzymes from their father.
   d. Wild type snails express the G allele as if it were hemizygous
   e. More than one of the above is incorrect.

31. Which of the following may be involved in eukaryotic control of gene expression?
   a. change in a gene's exact position relative to a nucleosome
   b. binding of repressors to operators to stop mRNA transcription
   c. changing the protein composition of histones in the nucleosomes
   d. transcribing multiple adjacent genes from a single promoter
   e. eukaryotes may use more than one of the above in controlling gene expression.

32. Epigenetic inheritance
   a. occurs when an altered DNA sequence is inherited, but not expressed
   b. is usually a result of de-methylation of gene sequences
   c. is a result of altered DNA “packaging” without a change in DNA sequence
   d. is the reason that calico cats exhibit mosaic expression
   e. is the same as a pre-mutation

33. During normal oogenesis in human females, seven genes on the long arm of chromosome 15 are always silenced via methylation. Which of the following is TRUE?
   a. The father’s alleles will determine the phenotypic effect of these loci.
   b. The genes in question are maternally imprinted
   c. Mutant alleles of the maternally silenced genes will not be phenotypically expressed.
   d. Only the father will contribute functional version of the genes to his offspring.
   e. All of the above are true.

34. In eukaryotes, relatively inactive regions of the chromosomes are present as ____________, whereas transcriptionally active genes are usually found in less condensed ____________.
   a. methylation; heterochromatin  c. euchromatin; heterochromatine  e. Z-DNA; A-DNA
   b. heterochromatin; euchromatin  d. B-DNA; Z-DNA

35. Position effect variegation in Drosophila eyes is evidence that
   a. translocation mutations are almost always highly deleterious
   b. close proximity to heterochromatin usually results in very active transcription of a gene
   c. heterochromatin boundaries are not always strictly defined from cell to cell
   d. red pigmentation in the eyes of Drosophila is adaptive
   e. genes are frisky, and love to square dance.

36. Which of these will likely cause the most deleterious consequences in the individual expressing it?
   a. trisomy of the Y chromosome  d. monosomy of chromosome 2
   b. Klinefelter Syndrome  e. all of these are equally harmful
   c. monosomy of the X chromosome

37. Because the histone portions of nucleosomes are so highly conserved across species, they are not likely to be involved in gene expression control.
   a. true  b. false  c. I give up

38. A cell's location relative to an embryo's body axes is determined by molecular clues that control pattern formation. Which of the following contribute to early positional information in Drosophila?
   a. maternal effect genes  c. bicoid mRNA  e. more than one of the above
   b. tissue-specific proteins  d. morphogens

39. Transcription factors attach to
   a. signal molecules  c. rRNA  e. plasma membrane receptors
   b. ligands  d. DNA
40. Modification of gene structure without modification of nucleotide sequence can sometimes result in permanently heritable traits. This is type of inheritance is most generally defined as
a. macroevolution  c. epigenesis  e. maternal effect
b. epistasis  d. polymorphism

41. This protein, consisting of two alpha helices and a single-stranded "turn," may act as a transcription factor by physically binding to the major groove of the DNA double helix.
a. allolactase  c. scaffold protein  e. immunoglobin
b. homeo domain  d. actin

**Consider this diagram of sex determination in Drosophila to answer #42 – 45.**

42. In an individual in which X:A =1, dimers of the X gene products bind to the early promoter of the Sxl gene. In such an individual, what would be the most likely result of a nonsense mutation (i.e., insertion of a stop codon) just downstream of the Sxl early promoter?
a. the fly will develop into a normal female
b. the fly will develop into a metafemale
c. the fly will develop into a metamale
d. the fly will develop into a male
e. the mutation will be lethal

43. Judging from the developmental cascade shown, the "default" pathway in Drosophila is
a. Sxl ON  c. male  e. more than one
b. female  d. DSX-F of the above

44. Sex determination in Drosophila is guided primarily by
a. X and Y chromosomes
b. DNA splicing

c. maternal effect genes
d. ratio of specific X-linked genes to specific autosomal genes
e. The little Drosophila pope

45. The SXL, TRA, and DSX proteins encoded by the sxl, tra, and dsx genes are
a. ribozymes  c. homeotic  e. transcription factors
b. polymerases  d. mutagenic

46. The product of the bicoid maternal effect gene in Drosophila provides essential information about
a. which end of the embryo will be the head, and which end will be the tail
b. which side of the embryo will be dorsal, and which will be ventral
c. which sides will be right and left
d. whether the fly will be male or female  e. segmentation

47. Which of the following is **least** related to the others?
   a. gap genes  c. pair-rule genes  e. homeotic genes
   b. cyclin genes  d. segment-polarity genes

48. A mammalian embryonic stem cell is able to differentiate into any embryonic or adult cell except those forming the extra-embryonic membranes. Such a cell is most accurately described as
   a. totipotent  b. pluripotent  c. multipotent  d. germinal  e. controversial

49. Which of the following statements is true of homeotic genes?
   a. There is a sequence of 180 highly conserved nucleotides common to all of them.
   b. They are highly methylated, indicating that they are actively transcribed early in development.
   c. They determine the identity of body segments in eukaryotic organisms.
   d. More than one of the above are true of homeotic genes.
   e. They cause one to have strange and disturbing dreams

50. In Drosophila, which genes initiate an activation cascade that includes all other genes in the list?
   a. homeotic genes  c. pair-rule genes  e. segment polarity genes
   b. gap genes  d. maternal effect morphogens
BONUS QUESTIONS: No penalty for not answering. Just 2 extra points per correct answer.

51. The second syllable of the word "apoptosis" is pronounced
   a. "poh"     b. "pop"    c. "apo"      d. "poo"    e. ARGH

52. Which of the following is most likely to be involved in producing “hybrid vigor”? (Apply what you know about each of the choices to make an educated decision.)
   a. epigenetic inheritance  c. functional complementation  e. position effect
   b. histone remodeling      d. parental imprinting

53. Ubiquitin is a small polypeptide that, when attached to a protein, signals the cell to
   a. transport the protein to the proteasome for destruction
   b. protect that protein from enzymatic degradation
   c. use the protein as an enzyme to methylate/inactivate specific genes
   d. change the terminal amino acid on the histone of which that protein is a component
   e. explode on impact

54. In which of the following tissues/organs would you be likely to find a germline cell?
   a. testis   b. liver   c. zygote   d. meristem   e. a snotty nose

55. This form of DNA is the one originally described by Watson and Crick.

   Just because swans mate for life, I don’t think it’s that big of a deal. First of all, if you’re a swan, you’re probably not going to find a swan that looks that much better than the one you’ve got, so why not mate for life?

   Deep Thoughts by Jack Handey