Multiple Choice Review – Gene Expression

Questions #1-2 refer to the following diagram:

1. The diagram illustrates the lac operon. The top picture shows the operon in the absence of lactose and the bottom picture shows the operon in the presence of lactose. What is the green shape, labeled “2”?
   a. Repressor
   b. Promoter
   c. RNA polymerase
   d. Operator

2. What type of operon does this portray?
   a. Repressible
   b. Inducible
   c. Co-repressible
   d. Allosteric

3. After transcription, mRNA goes through processing in eukaryotic cells. Why do prokaryotic cells not use mRNA processing?
   a. Prokaryotes do not possess hydrolytic enzymes against which processing protects.
   b. In prokaryotes, operons are used to regulate mRNA.
   c. mRNA processing only evolved in eukaryotes.
   d. Prokaryotes have no nucleus so gene expression occurs all together.

4. During chromosomal replication, DNA is built in the 5’→3’ direction. Why does this occur?
   a. Building from 5’→3’ conserves energy.
   b. The replication fork runs in this direction.
   c. Okazaki fragments prevent building in the opposite direction.
   d. Nucleotides are added to the –OH end (the 3’ end) of the sugar backbone.

5. Alternative splicing is a process that enables the number of proteins produced by an organism to be vastly greater than its number of genes. How is this possible?
   a. Codons can code for more than one amino acid.
   b. Recombinant technology is able to translate different proteins from the same gene.
   c. Depending on what sections are treated as introns and exons, different proteins can be made from the same gene.
   d. The anticodon of tRNA has a wobble effect that allows a variety of translations per gene.

6. Which of the following is not an example of a point mutation?
   a. Silent mutation
   b. Nonsense mutation
   c. Missense mutation
   d. Frameshift mutation

Questions #7-8 refer to the following experiment:

Frederick Griffith was a scientist who worked with two different strands of Streptococcus pneumonia. The S bacteria caused pneumonia while the R bacteria had no effect. Griffith treated mice with four different injections, shown below.

<table>
<thead>
<tr>
<th>Injection</th>
<th>Mice died</th>
<th>Mice survived</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living S bacteria</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Living R bacteria</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Dead S bacteria</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Dead S bacteria mixed with living R bacteria</td>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

7. What do the results of this experiment indicate?
   a. The deadly gene from the S bacteria was taken up and used by the R bacteria.
   b. The R bacteria used the components of the dead S bacteria to make themselves stronger.
   c. DNA is the agent of heredity, not proteins.
   d. R bacteria become activated in the presence of S bacterial enzymes.

8. If Griffith’s experiment had included a control group, of what would that group consist?
   a. Mice injected with dead S and dead R bacteria.
   b. Mice receiving no injections.
   c. Mice injected with living S and living R bacteria.
   d. Mice injected with dead R bacteria mixed with living S bacteria.
Questions #9-10 refer to the following diagram:

9. The top strand of DNA is able to be replicated in a continuous line while the bottom strand is replicated in small strands that are later connected. The top red strand is referred to as what?
   a. Template strand  
   b. Leading strand  
   c. Parental strand  
   d. Lagging strand

10. For the replication illustrated in the diagram, how many RNA primers were necessary?
    a. 0  
    b. 1  
    c. 2  
    d. 3

11. Codons are triplet nucleotide sequences that play an essential role in translation. Where are codons located?
    a. tRNA  
    b. mRNA  
    c. DNA template strand  
    d. rRNA

12. Prokaryotic genes are often clustered into operons. Which of the following is not part of an operon?
    a. Genes  
    b. Operator  
    c. Exon  
    d. Promoter

13. DNA technology has enabled scientists to identify many human genetic disorders, such as hemophilia and cystic fibrosis. They are able to do this by conducting PCR using primers that target these genes. When the gene has been amplified, the DNA is sequenced to determine whether the individual has the disease. If scientists decide to create a test for a new genetic disease, what must first occur before PCR can be used to test for that disease?
    a. The genome must be run through gel electrophoresis.  
    b. The gene for the disease must be located in the genome.  
    c. A polymerase specific to the gene must be created in the lab.  
    d. It must be recombined into a bacterial cell.
14. Which of the following does not correctly pair a process with the location where that process occurs in eukaryotes?
   a. Replication - nucleus
   b. Translation - cytosol
   c. Transcription - nucleus
   d. mRNA processing – cytosol

15. A graph showing the amount of DNA produced per cycle of PCR is shown below. What type of growth does this portray?

![PCR Cycle Number vs. Amount of DNA](http://pathmicro.med.sc.edu/pcr/PCR_Reaction_graph1.htm)

   a. Linear
   b. Parabolic
   c. Exponential
   d. Logarithmic

16. DNA is the genetic material of all living organisms. Which of the following describes a difference between prokaryotic DNA and eukaryotic DNA?
   a. Eukaryotic DNA is antiparallel while prokaryotic DNA is not.
   b. Prokaryotic DNA uses uracil while eukaryotic DNA uses thymine.
   c. Prokaryotic DNA is haploid while eukaryotic DNA is diploid.
   d. Prokaryotic DNA is circular while eukaryotic DNA is linear.

17. During transcription, if the template strand reads 5’-ACCAAACCG-3’, what will the newly formed strand read?
   a. 3’-TGGTTTGGC-5’
   b. 3’-CGGGTTGGT-5’
   c. 3’-UGGUUUGGC-5’
   d. 3’-CGGUUUGGU-5’

18. Which of the following molecules is not involved in translation?
   a. Nucleotides
   b. tRNA
   c. DNA
   d. mRNA
19. DNA polymerase and RNA polymerase have similar functions. Which statement is an incorrect description of these enzymes?
   a. Both enzymes require a primer.
   b. DNA polymerase is used in replication while RNA polymerase is used in transcription.
   c. Both enzymes add nucleotides to the 3’ end of a chain.
   d. The binding of RNA polymerase is preceded by the binding of transcription factors.

20. Fireflies are able to glow because they produce an enzyme called luciferase. The luciferase gene can be isolated and put into a tobacco plant. The result is shown below:

![Glowing tobacco plant](http://en.wikipedia.org/wiki/File:Glowing_tobacco_plant.jpg)

This phenomenon is possible because of what type of technology?
   a. Recombinant DNA technology
   b. Stem cells
   c. Alternative RNA splicing
   d. X-ray diffraction

21. Which of the following scientists is incorrectly matched with his/her contribution to the field of biology?
   a. Watson-Crick: helped to discover the structure of DNA
   b. Griffith: discovered the phenomenon of transformation
   c. Hershey-Chase: took x-ray diffraction picture of DNA
   d. Avery: determined that transformation occurred via DNA

22. All biological components have structures that directly correspond with their functions. Which of the following is a correct statement regarding chromosomal structure?
   a. Histones and scaffolds condense DNA into a size that fits into the nucleus.
   b. Chromosomes are composed of DNA and specialized carbohydrates.
   c. When DNA is condensed, it is called a chromatid.
   d. The loci refers to the location where two chromatids touch.
Questions #23-26 refer to the following codon table:

<table>
<thead>
<tr>
<th>First letter</th>
<th>Second letter</th>
<th>Third letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>UU UUC UUA UUG</td>
<td>Phe Leu</td>
</tr>
<tr>
<td></td>
<td>UCU UCC UCA UCG</td>
<td>Ser</td>
</tr>
<tr>
<td>C</td>
<td>CU CUC CUA CUG</td>
<td>Leu</td>
</tr>
<tr>
<td></td>
<td>CCA CCC CCA CCG</td>
<td>Pro</td>
</tr>
<tr>
<td>A</td>
<td>AU AUC AUA AUG</td>
<td>Ile Met</td>
</tr>
<tr>
<td></td>
<td>ACC ACA ACG</td>
<td>Thr</td>
</tr>
<tr>
<td></td>
<td>GGU GUC GUA GUG</td>
<td>Val</td>
</tr>
<tr>
<td>G</td>
<td>GU GCC GCA GCG</td>
<td>Ala</td>
</tr>
</tbody>
</table>

Source: [http://commons.wikimedia.org/wiki/File:06_chart_pu3.gif](http://commons.wikimedia.org/wiki/File:06_chart_pu3.gif)

23. A section of mRNA reads as follows: 5’ – AUGAAUUGG – 3’. How would this be translated?
   a. Trp-Asn-Met
   b. Ile-Asn-Stop
   c. Met-Asn-Trp
   d. Start-Asn-Stop

24. This codon chart shows that there is redundancy but not ambiguity in the genetic code. How can this statement be explained?
   a. One codon can code for several amino acids.
   b. Any mistakes are corrected during the proofreading process.
   c. Individual amino acids can have more than one codon, but each codon only translates one amino acid.
   d. The same 20 amino acids are used repeatedly, but in different combinations, to create different proteins.

25. A section of mRNA reads as follows: 5’ – AUGGUGACGUUUUAG – 3’. For how many amino acids does this code?
   a. 3
   b. 4
   c. 5
   d. 6

26. During gene expression, an error creates a mutation in the codon GUU. Which of the following is not an example of what could have replaced GUU in order to create a silent mutation.
   a. GUC
   b. UGA
   c. GUA
   d. GUG
27. Frameshift mutations are the result of what occurrence?
   a. Insertions or deletions that are not a multiple of three.
   b. A mutation that changes an amino acid codon to a stop codon.
   c. A mutation that changes one amino acid to another.
   d. A nucleotide-pair substitution.

28. Recombinant DNA technology has allowed scientists to produce human hormones in the laboratory to fight diseases. Which of the following is not used in recombinant DNA technology?
   a. Polymerase chain reaction
   b. Operons
   c. Restriction enzymes
   d. Gel electrophoresis

Questions #29-30 refer to the following information:
Telomeres are nucleotide sequences that are found at the ends of chromatids. They are small, non-coding sections of nucleotides that are repeated several times. For example, in humans, the sequence TTAGGG can be repeated between 100 and 1,000 times. The purpose of telomeres is to protect the ends of chromosomes from deterioration.

29. During replication, a primer attaches to the 3’ end of the template strand. After replication is complete, the primer is removed. However, the piece of DNA to which the primer was attached was not replicated. As a result, chromosomes become shorter with each round of replication. How do telomeres help chromosomes manage this situation?
   a. Telomeres build additional nucleotide sequences at the short ends of DNA.
   b. Telomeres bind to the primers and make them a permanent part of the DNA.
   c. Telomeres create binding sites for primase in the next round of replication.
   d. The non-coding telomere sequences protect the chromosomes from losing coding sections of DNA.

30. Telomeres are only located in eukaryotes. Using the information from question #36, postulate why they not found in prokaryotes.
   a. Prokaryotes have circular DNA and so are able to replicate their entire genome.
   b. Telomeres evolved in eukaryotes and so are not present in prokaryotes, who evolved earlier.
   c. Prokaryotes do not use a primase during replication.
   d. Prokaryotes do not live long enough to experience chromosomal deterioration.

31. The two strands that compose a DNA molecule run anti-parallel to each other. What does this indicate?
   a. Purines always pair with pyrimidines.
   b. During replication, each daughter molecule is composed of one parental strand and one new strand.
   c. One strand runs in the 3’ → 5’ direction while the other runs in the 5’ → 3’ direction.
   d. The sugar-phosphate backbone is always on the outside while the bases are always on the inside.
32. The result of transcription is a pre-mRNA molecule that goes on to be processed into an mRNA molecule. Which of the following is not something that occurs during mRNA processing?
   a. Poly-A tail is added to 3’ end.
   b. Introns are joined together.
   c. 5’ cap is added to 5’ end.
   d. Noncoding regions are spliced out.

33. A DNA strand that originally reads 5’-GATATC-3’ undergoes a mutation that changes it to 5’-GATCATC-3’. This is an example of what type of mutation?
   a. Insertion
   b. Point mutation
   c. Nonsense mutation
   d. Deletion

34. Shown below is a karyotype from a diploid eukaryote. What can be deduced from this picture?

![Karyotype Image](http://medicalschool.tumblr.com/post/29291280332/human-chromosomes)

   a. One chromosome is missing.
   b. There are 23 homologous chromosomes.
   c. The organism is probably male.
   d. The genome is incomplete.

35. If a section of RNA reads 5’-GCAUGA – 3’, from what template strand was this transcribed?
   a. 5’-TCATGC-3’
   b. 5’-UCAUGC-3’
   c. 5’-CGTACT-3’
   d. 5’-CGUACU-3’

36. The genetic code is universal, which means that gene expression is also universal. What is a difference between prokaryotic and eukaryotic gene expression?
   a. Prokaryotes use the base uracil while eukaryotes use thymine.
   b. In prokaryotes, each step of gene expression occurs in the cytoplasm.
   c. In eukaryotes, each step of gene expression occurs in the nucleus.
   d. Prokaryotes do not follow the central dogma.
37. To what are the two arrows pointing?
   a. Origin of replication
   b. Okazaki fragment
   c. Replication fork
   d. Leading strand

38. At the locations indicated by the arrows, molecules work to unwind DNA and to keep it in this unwound position for the duration of replication. Which of the following molecules does not help with this task?
   a. DNA ligase
   b. Helicase
   c. Single-strand binding proteins
   d. Topoisomerase

39. In recombinant DNA technology, the genes from one organism are spliced into the genome of another organism. How is it that the other organism can produce proteins from a foreign gene?
   a. During the procedure, all the components of the necessary protein are added to the solution.
   b. The wobble effect allows flexibility in the genetic code.
   c. All organisms use the same genetic code.
   d. The genetic code is ambiguous.

40. Translation involves the coordination of several different molecules. Which of the following pairs is incorrectly matched in terms of function?
   a. Small rRNA subunit – binds to mRNA
   b. tRNA – brings the nucleotides to be added to the polypeptide
   c. A site on rRNA – houses the next nucleotide to be added
   d. mRNA – contains the anticodons to be translated
1. A common human telomere consists of 5'–GGTTAG-3' repeated up to 2,000 times at the ends of each chromosome. During each cycle of mitosis, approximately 100 base pairs are lost from each telomeric end. If a chromosome consists of 1,500 repeats of the sequence at each end, how many mitotic divisions can occur before the telomeres are completely gone?

2. Insulin is one of the smallest proteins in the human body, consisting of two chains that interact via disulfide bridges. Based on the image of insulin below, calculate how many nucleotides compose the codons necessary to translate this protein. Do not include the nucleotides used in start or stop codons.

![Human Insulin Diagram](http://www.bio.davidson.edu/courses/molbio/molstudents/spring2005/dresser/my%20favorite%20protein.html)

3. The following chart shows how many strands of DNA are present after \( n \) cycles of PCR. Typical PCR experiments run through 25 cycles. At the end of 25 cycles, how many strands of DNA are present? Write your answer with two significant figures.

<table>
<thead>
<tr>
<th># of cycles</th>
<th># of DNA strands</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>16</td>
</tr>
<tr>
<td>8</td>
<td>256</td>
</tr>
<tr>
<td>10</td>
<td>1024</td>
</tr>
</tbody>
</table>
4. A group of scientists conduct a transformation experiment inserting human plasmids into E. coli. During the course of the experiment, the scientists spread 5 µg of DNA onto the agar plates. At the end of the experiment, they count 6,000 colonies growing on the plates. They now want to determine how effective they were in getting the new plasmids into the E. coli cells. Using the formula below, calculate the transformation efficiency of this experiment.

\[
\text{Transformation efficiency} = \frac{\text{Total # of colonies growing on agar plates}}{\text{Amount of DNA spread on agar plates (in µg)}}
\]

5. If a protein is created via the translation of 705 nucleotides, including a start and a stop codon, how many amino acids are included in the final product?

6. PCR is a technique that amplifies DNA strands. Using the information gained in question #3, how many cycles of PCR have been completed if 512 strands of DNA are present?
ANSWER KEY

1. A  
2. B  
3. D  
4. D  
5. C  
6. D  
7. A  
8. B  
9. B  
10. D  
11. B  
12. C  
13. B  
14. D  
15. C  
16. D  
17. C  
18. C  
19. A  
20. A  
21. C  
22. A  
23. C  
24. C  
25. B  
26. B  
27. A  
28. B  
29. D  
30. A  
31. C  
32. B  
33. A  
34. B  
35. A  
36. B  
37. C  
38. A  
39. C  
40. D  
1. 90  
2. 153  
3. 3.4 x 10^7  
4. 1.0 x 10^3  
5. 233  
6. 9