1. In eukaryotic cells the transcript of a gene must be processed into mRNA. Describe briefly but specifically the three processing steps.

   **Capping** - a 7'-methyl-guanosine nucleotide is added to the 5' end of the hnRNA molecule, 5' to 5'

   **Tailing** - a poly(A) tail is added to the 3' end of the hnRNA molecule

   **Splicing** - the introns are cut out of the hnRNA molecule and the exons are joined, producing the finished mRNA molecule

2. How many ATPs does it cost to put one amino acid into a protein? Describe one step that requires ATP or GTP somewhere in the process.

   **It costs 10 ATPs to put one amino acid into a protein.**

   Starting with the DNA it costs 6 ATPs to put 3 bases (a codon) into DNA
   The equivalent of 2 ATPs are used in charging a tRNA molecule with the correct amino acid
   One GTP is required to position a tRNA in the A site of the ribosome
   One GTP is required to translocate the ribosome to the next codon
3. In the accompanying diagram of a tRNA indicate where the following would be located:

   the amino acid
   the anti-codon

   The amino acid is on the 3' end of the tRNA and the anti-codon is at on the lower loop of the molecule - see p. 687 of your text

What effect would there be on the sequence of proteins synthesized in an *E. coli* cell that has a mutated tRNA such that its anti-codon has been changed from:

   \[ \text{3' UGC 5'} \]

   to

   \[ \text{3' UGU 5'} \]

There would be no effect on the protein synthesized because the codon \[ \text{5'ACG 3'} \]

could be served by either of these tRNAs due to wobble at the 5' position and both would carry threonine since ACG and ACA are part of the same family
4. Eukaryotic cells have three different RNA polymerases. Why is a mutation in any one of them sufficient to prevent the cell from being able to carry out the process of translation?

Each RNA polymerase transcribes a different category of RNAs, transfer RNA, messenger RNA and ribosomal RNA. All three types of RNAs are required for translation to take place, mRNA to be read, rRNA to form part of the ribosome structure and tRNA to bring the appropriate amino acids to the ribosomes. If any one of these components is missing, protein could not be synthesized.

5. A biologist inserted a gene from a human liver cell into the chromosome of a bacterium. The bacterium then transcribed this gene into mRNA and translated the mRNA into protein. The protein produced was useless; it contained many more amino acids than the protein made by the eukaryotic cell, and the amino acids were in a different sequence. Explain why.

The mRNA from the eukaryotic gene contained introns and exons. The introns needed to be spliced out and the exons joined to produce the functional mRNA molecule. Since the bacterium didn’t know how to do the splicing it tried to translate the entire transcript, including the intron regions. This resulted in many more bases being read as codons from the intron regions and probably introduced frameshifts in the base sequence that would cause different codons (and thus different a.a.) to be introduced into the protein.
6. The base sequence of the template strand of an unusual gene, which codes for an extremely short polypeptide, is:

   There are two possible answers; either orientation would work

   3' CTACGCTAGGCCTATTCAT 5'  or  
   5' CTACGCTAGGCCTATTCAT 3'

Which is the 5' end of this DNA sequence? How do you know?

   In the first example above, the coding strand complementary to this template strand has the start codon for translation (AUG) near the left end of the strand, one base in, and translation always proceeds from the 5' to the 3' end

   or

   In the second example an AUG occurs at the very beginning of the coding strand

What would be the base sequence of the mRNA transcribed from this gene?

   5' G AUG CGA UCC GCA UAA GUA  3'

   or

   5' AUG AAU ACG CCU AGC GUA G  3'

Using the genetic code below, give the amino acid sequence of the polypeptide translated from this mRNA.

   met - arg - ser - ala

   or

   met - asn - thr - pro - ser - val