Vocabulary

Gene: A sequence of DNA that instructs a cell to produce a particular protein

Promoter – a control sequence near the start of a gene

Coding sequence – the sequence of nucleotide bases on the DNA that are transcribed into RNA which are in turn translated into protein

Intron – part of a gene that is transcribed but is excised from the mRNA before translation into protein

Exon – part of a gene that encodes amino acids

Genetic code – the correspondence between specific RNA triplets and the amino acids they specify

Codon – a continuous triplet of mRNA that specifies a particular amino acid

Start codon – AUG, methionine, the amino acid on the mRNA that signals the start of protein synthesis

Stop codon – UGA, UAA, and UAG on mRNA; amino acids that signal the end of the synthesis of a protein

RNA – ribonucleic acid, a nucleic acid whose bases are A, C, U, and G

mRNA – messenger RNA; a molecule of RNA complementary in sequence to the template strand of a gene that specifies a protein product

tRNA – transfer RNA; a type of RNA that connects mRNA to amino acids during protein synthesis

rRNA – ribosomal RNA; RNA that, with proteins, comprises ribosomes

Mutation – a change in a protein-encoding gene that affects the phenotype and affects less than one percent of a population

Frameshift – a mutation that alters a gene’s reading frame

Missense – a single base change mutation that alters an amino acid

Nonsense – a point mutation that changes an amino-acid-coding codon into a stop codon, prematurely terminating synthesis of the encoded protein

Silent – a mutation that does not result in any identifiable problems, does not change the outcome of the type of amino acid produced

Transcription – manufacturing RNA from DNA

RNA polymerase – an enzyme that adds RNA nucleotides to a growing RNA chain
Template strand – the DNA strand carrying the information to be transcribed

Non template (coding) strand – the DNA strand whose sequence is identical to the RNA strand except with thymine in the place of uracil

5’ cap – a short sequence of modified nucleotides, several backwardly inserted guanine that attracts an enzyme that adds methyl groups; called a methylated cap it is a recognition site for protein synthesis

3’ polyA tail – about 200 adenines added to the 3’ end of the RNA, necessary for protein synthesis to begin, might possible stabilize the mRNA

RNA processing – after the mRNA is transcribed the ends are modified, introns removed, and proofreading done

Transcription factor – a protein that activates the transcription of certain genes

Central Dogma – described the relationship between nucleic acids and proteins as a directional flow of information

Translation – assembly of an amino acid chain according to the sequence of base triplets in a molecule of mRNA

Ribosome – an organelle consisting of RNA and protein that is a scaffold for protein synthesis

Small subunit – part of the initiator complex, bonds to mRNA at the start of protein synthesis

Large subunit – during the elongation stage of protein synthesis, the large subunit attaches to the initiation complex.

Charged RNA – a tRNA that has its appropriate amino acid attached

Reading frame – the grouping of DNA base triplets encoding an amino acid sequence

Initiator RNA – the tRNA that carries the amino acid methionine

A site – the site on the ribosome that hold the next amino acid to be added to the chain

P site – the site on the ribosome that holds the growing amino acid chain

E site – exit site

Initiation complex – formed when a small ribosomal subunit, with the mRNA bonded to it and the initiator tRNA with its attached methionine come together at the appropriate AUG codon on the mRNA

Anticodon – a three-base sequence on one loop of a transfer RNA molecule that is complementary to an mRNA codon, and brings together the appropriate amino acid and its mRNA
Protein – a type of macromolecule that is the direct product of genetic information; a chain of amino acids

Amino acid – a small organic molecule that is protein building block

Polypeptide – a substance that contains two or more amino acids

Primary structure – the amino acid sequence of a protein

Secondary structure – folds in a polypeptide caused by attractions between amino acids close together in the primary structure

Tertiary structure – folds in a polypeptide caused by interactions between amino acids and water. This draws together amino acids that are far apart in the primary structure

Quaternary structure – a protein that has more than one polypeptide subunit

Chaperone – a protein that binds a polypeptide and guides folding

Proteosome – a multiprotein structure in a cell shaped like a barrel through which misfolded proteins pass and are refolded or dismantled

Peptide bond – bonds formed between amino acids

Review questions

1. Explain how complementary base pairing is responsible for

   a. the structure of the DNA double helix – hydrogen bonds hold the complementary base pairs together; the double helix is formed when the antiparallel, base-paired stands twist about one another in a regular fashion

   b. DNA replication – the bases on each strand of DNA is able to pair up with their complements in order to duplicate the DNA

   c. transcription of RNA from DNA – a mRNA is made by aligning nucleotide base pairs up with the particular section of a DNA’s nucleotide sequence

   d. the attachment of mRNA to a ribosome – the leader sequence of the mRNA forms hydrogen bonds with a short sequence of rRNA

   e. codon/anticodon pairing – the codon is on the mRNA, which is three consecutive base pairs, the amino acids have complementary bases, anticodons, these are carried on the tRNA to pair up with the mRNA in the formation of protein

   f. tRNA conformation – some of tRNA’s nucleotide bases weakly bond to each other folding the tRNA into loops forming a characteristic cloverleaf appearance
2. A retrovirus has RNA as its genetic material. When it infects a cell, it uses enzymes to copy its RNA into DNA, which then integrates into the host cell’s chromosome. Is this flow of genetic information consistent with the central dogma? Why or why not? It is not consistent with the central dogma. The central dogma describes a directional flow of information from DNA to RNA to protein.

3. What are the functions of these proteins?
   a. RNA polymerase – an enzyme used in the synthesis of RNA from the template strand of DNA
   b. ubiquitin – a protein used to tag misfolded proteins
   c. a chaperone protein – a protein that stabilizes partially folded areas of a protein
   d. a transcription factor – proteins that are instructed to bind certain areas of DNA to initiate transcription of RNA

4. Explain where a hydrogen bond forms and where a peptide bond forms. – Hydrogen bonds form between nucleotide base pairs, peptide bonds form between amino acids.

5. List the differences between RNA and DNA. – DNA is double stranded, has thymine as a base, has deoxyribose as a sugar, maintains protein-encoding information, and cannot function as an enzyme. RNA is usually single stranded, has uracil as a base, has ribose as a sugar, carries protein-encoding information and controls how information is used, and can function as an enzyme.

6. Where in a cell do DNA replication, transcription, and translation occur? – In eukaryotes DNA replication and transcription take place in the nucleus, translation takes place in the cytoplasm. Prokaryotes do not have a nucleus so replication, transcription and translation takes place in the cytoplasm.

7. How does transcription control cell specialization? – Only the particular genes that relate to the particular cell function are transcribed producing the proteins that the cell uses for its particular function.

8. How can the same mRNA codon be at an A site on a ribosome at one time, but at a P site at another time? – As the amino acids are added the ribosome moves down the mRNA, the next codon becomes the new A site and the old A site is now the P site.

9. Describe the events of transcription initiation. – transcription factors and RNA polymerase are attracted to a promoter of a gene

10. List the three major types of RNA and their functions. – mRNA carries the information that specifies a particular protein. rRNA associate with certain proteins to form ribosomes. tRNA carries amino acids to mRNA

11. Describe three ways RNA is altered after it is transcribed. – a cap is put on the 5’ end, a poly A tail is put on the 3’ end, and introns are removed.
15. Explain how protein misfolding conditions and illnesses that result from abnormal transcription factors might each produce many different symptoms. – Many different proteins could be affected thereby causing different symptoms depending on what proteins are affected.

18. How do a protein’s primary, secondary, and tertiary structures affect conformation? Which is the most important determinant of conformation? – Primary structures are most important, errors in this one will in turn affect the other structures. Primary structure is a sequence of amino acids, it is a chain. Secondary structure is caused by chemical attractions between amino acids that fold the chain. Tertiary structure are formed by winding of secondary structures as more widely separated amino acids are attracted or repelled by water molecules.

**Applied Questions**

3. List 3 different mRNA sequences that could encode the following amino acid sequence:

Histidine-alanine-arginine-serine-leucine-valine-cysteine

CAU-GCU-AGU-CUU-GUU-UGU

CAC-GCC-CGC-CUC-GUC-UGC

CAU-GCA-CGA-UCA-CUA-GUA-UGU

**Case Study**

12. Five patients meet at a clinic for families in which several members have early onset Parkinson disease. This condition causes rigidity, tremors, and other motor symptoms. Only 2 percent of cases of Parkinson disease are inherited. The five patients all have mutations in a gene that encodes the protein parkin, which has 12 exons. For each patient, indicate whether the mutation shortens, lengthens, or does not change the size of the protein.

   a. Manny Filipo’s parkin gene is missing exon 3. - shortens
   b. Frank Myer’s parkin gene has a duplication in intron 4. – does not change
   c. Theresa Ruzi’s parkin gene lacks six contiguous nucleotides in exon 1. - shortens
   d. Elyse Fitzsimmon’s parkin gene has an altered splice site between exon 8 and intron 8. - lengthens
   e. Scott Shapiro’s parkin gene is deleted. – protein is absent

**Second Look**

3. Discuss how the use of an animal model provided information on Marfan syndrome that was not easily or ethically available from people. - The life span of mice is considerably less than humans monitoring how the mice’s lungs and heart are affected by the fibrillin factor is easier to determine.
1. Use the following DNA molecule to answer the following questions.

a. Using the bottom strand as the template (bold) for RNA polymerase, what is the sequence of mRNA?

5'- ACC TTA AAA ATG TAT CCT GCC ACC TTA AAA CTT CGA TAG-3'

3'- TGG AAT TTT TAC ATA GGA CGG TGG AAT TTT GTT GCT ATC-5'

mRNA 5’ ACC UUA AAA AUG UAU CCU GCC ACC UUA AAA CAA CGA UAG 3’

b. Using the codon chart in your book provide what is the amino acid sequence of the polypeptide made using this mRNA?

methionine-tyrosine-proline-alanine-threonine-leucine-lysine-glutamine-arginine-stop

c. What is the consequence of mutation A? Show the amino acid sequence of the polypeptide A. What type of mutation is this?

mut A 5'- ACC TTA TAA ATG TAT CCT ACC ACC TTA AAA CTT CGA TAG-3'

3'- TGG AAT TTT TAC ATA GGA TGG TGG AAT TTT GTT GCT ATC-5'

mRNA 5’ UCC UUA AAA AUG UAU CCU GCC ACC UUA AAA CAA CGA UAG

methionine-tyrosine-proline-threonine-threonine-leucine-lysine-glutamine-arginine-stop

A missense mutation

The consequence is the wrong amino acid is placed within the polypeptide

d. What is the consequence of mutation B? Show the amino acid sequence of the polypeptide B. What type of mutation is this?

Mut B

5'- ACC TTA AAA -TG TAT CCT GCC ACC TTA AAA CTT CGA TAG-3'

3'- TGG AAT TTT -AC ATA GGA GGG TGG AAT TTT GTT GCT ATC-5'

5’ ACC UUA AAA –UG UAU CCU GCC ACC UUA AAA CAA CGA UAG

The protein is never started because of the missing codon for methionine

A frameshift mutation
2. Draw the Central Dogma include the steps between transcription and translation and steps following translation.