Molecular Biology: From DNA to Protein (cont’d)

Transcription
- Purpose and sub-cellular compartment.
- Steps of transcription and the bio-molecules involved.
- Terminology: promoter and terminator DNA sequences

Genetic code
- The language of nucleic acids: letters and words (nucleotides and codons)
- Initiation and termination codons of translation

Translation or protein synthesis
- Purpose and sub-cellular compartment and its three steps.
- The interpreter the language of nucleic acids into the language of proteins

Mutation
- Definition, sources, impact the protein product

Use the genetic code table to translate a sequence of codons into a sequence of amino acids and the reverse as well as the sequence of normal and mutated proteins
Transcription

Producing copies of the genetic messages in the form of RNA
Transcription of a gene
1. DNA: double –stranded
2. Enzyme: RNA Polymerase
3. Monomers: RNA nucleotides
4. Steps:
   - Initiation- Starts at promoter sequence
   - Elongation
   - Termination- Stops at termination sequence

Figure 10.9B
– RNA polymerase
  • unwinds the two DNA strands
  • Uses one strand as a template strand
  • Polymerizes RNA nucleotides against the template strand following the base pairing rules

– Single-stranded messenger RNA (mRNA) peels away from the template strand

– The DNA strands rejoin

http://www.dnai.org/a/index.html
Template and coding strands of DNA

- The two strands of DNA have complementary sequences - (template and coding strand)

- RNA transcripts are single stranded and are made 5’ 3’

- Only one DNA strand, the template strand is copied into RNA

If given the sequence of one of the strands, predict the sequences of the other two using the base-pairing rule
In-Class Activity

Write down the sequence of the mRNA transcript of the following DNA sequence, given the information about the two strands

DNA:  5'...CCATGGATCTTAGCA...3' (template strand)
     3'...GGTACCTAGAATCGT...5’ (sense Strand)
THE FLOW OF GENETIC INFORMATION FROM DNA TO RNA TO PROTEIN

• The information carried by sequence of DNA bases constitutes an organism’s genotype.

• The DNA genotype is expressed as proteins, which provide the molecular basis for the phenotype.
Genetic information written in a code that is translated into amino acid sequences

The “words” of the DNA “language” are triplets of bases (3 bases long) called **codons**

Each **codons** in a gene specify one amino acid sequence of the polypeptide
Protein synthesis

Translation is the RNA–directed synthesis of a polypeptide

Translation of the language of nucleic acids into the language of proteins (amino acids)

One codon ------- one amino acid
Figure 10.7
The genetic code is the Rosetta stone of life

Nearly all organisms use exactly the same genetic code

Figure 10.8A
In-class activity/Genetic code

Use the genetic code table to answer the following:

1. How many codons are there for Leu (leucine)?
2. How many codons are there for Met (Methionine)?
3. How many codons are there for Phe (phenylalanine)?

Draw a conclusion about the number of codons for amino acids.

4. How many “stop” codons are there?

Answer the following questions using this genetic code:

5’-AUGACCCCUUUGUUAUACUAA-3’

5. How long is this message in nucleotides?

6. Is this the information present in DNA or in mRNA? Explain your answer

7. Write down the sequence of amino acids coded for by the above stretch of nucleotides.

how long is this polypeptide?
Translating the genetic code

Figure 10.8B

Transcription

Strand to be transcribed (template)

m-RNA 5’- A U G A A G U U U U A G - 3’

Translation

Start codon

Stop codon

Polypeptide

Met - Lys - Phe
- The coding sequence of mRNA is between the start codon, which marks the translation initiation and a stop codon, which marks the end of translation.
Translation

- Takes place in cytoplasm
- Involves:
  - Ribosomes: Two subunits (each made of many proteins & r-RNA)
  - mRNA
  - t-RNA (interpreter)
  - 20 amino acids
Transfer RNA molecules serve as interpreters during translation.
Each tRNA molecule is a folded molecule bearing a base triplet called an **anticodon** on one end.

A specific **amino acid** is attached to the other end.

Figure 10.11B
A ribosome attaches to the mRNA translates its message into a specific polypeptide aided by transfer RNAs (tRNAs)

Protein Synthesis animation
http://highered.mcgraw-hill.com/sites/0072437316/student_view0/chapter15/animations.html#

Translation Intro (Flash Animation)
Steps of protein Synthesis

1. **Initiation**
   a. Binding of mRNA to small ribosomal subunit
   b. Binding of Met-tRNA to the initiation codon AUG on mRNA
   c. Binding of large ribosomal subunit

2. **Elongation**

3. **Termination**
mRNA, a specific tRNA, and the ribosome subunits assemble during initiation.
Steps of protein Synthesis

1. **Initiation**
   - a. binding of mRNA to small ribosomal subunit
   - b. binding of Met-tRNA to AUG on mRNA
   - c. Binding of large ribosomal subunit

2. **Elongation**
   - a. binding of a second tRNA to next codon
   - b. formation of peptide bond
   - c. sliding of ribosome by one codon

   *Amino acids are added to the growing polypeptide chain until a stop codon is reached.*

3. **Termination**

   Disassembly of the protein synthesis machinery
Figure 10.14

Elongation steps

1. Codon recognition

2. Peptide bond formation

3. Translocation

- Polypeptide
- P site
- mRNA Codons
- mRNA movement
- Stop codon
- Anticodon
- Amino acid
- A site
- New Peptide bond

Figure 10.14
Review: The flow of genetic information in the cell is DNA→RNA→protein

The sequence of codons in DNA, via the sequence of codons in mRNA spells out the primary structure of a polypeptide
Mutations are changes in the DNA base sequence

- Caused by errors in DNA replication or recombination, or by mutagens

- [http://www.ygyh.org/](http://www.ygyh.org/)

![Diagram of normal and mutant hemoglobin DNA and mRNA](image)

**Figure 10.16A**

- Normal hemoglobin DNA
- Mutant hemoglobin DNA
- Normal hemoglobin
- Sickle-cell hemoglobin

<table>
<thead>
<tr>
<th>Normal hemoglobin DNA</th>
<th>Mutant hemoglobin DNA</th>
</tr>
</thead>
<tbody>
<tr>
<td>C T T T</td>
<td>C A T T</td>
</tr>
<tr>
<td>mRNA</td>
<td>mRNA</td>
</tr>
<tr>
<td>G A A</td>
<td>G U A</td>
</tr>
</tbody>
</table>

- Normal hemoglobin
  - Glu
  - Val

- Sickle-cell hemoglobin
  - Val
Substituting, inserting, or deleting nucleotides alters a gene with varying effects on the organism.

**Normal gene**

mRNA: AU G A A G U U U G G C G C A

Protein: Met Lys Phe Gly Ala

**Base substitution**

mRNA: AU G A A G U U U A G C G C A

Protein: Met Lys Phe Ser Ala

**Base deletion**

mRNA: AU G A A G U U U G G C G C A U

Protein: Met Lys Leu Ala His

Figure 10.16B