

BIOL 200 (Section 921)

Lecture # 4-5

June 22/23, 2006

UNIT 4: BIOLOGICAL INFORMATION FLOW - from DNA (gene) to RNA to protein

Reading: ECB (2nd Ed.) **Chap 7**, pp. 229-262; **Chap 8**, pp. 267-286 (focus only on parts covered in lecture). Related questions 7-8, 7-9, 7-11, 7-12, 7-14, 7-16, 7-17, 8-5a,b,d;
or

ECB (1st ed.) **Chap 7**, pp. 211-240; 263-4; **Chap 8**, pp. 257-270 (focus only on parts covered in lecture). Related questions 7-9, 7-10, 7-12, 7-13, 7-15, 7-18, 7-19; 8-7b,c,e.

I. TRANSCRIPTION, RNA

Learning Objectives

- Understand the structural differences between DNA and RNA, and the directionality of transcription.
- Understand the structure of a eukaryotic gene.
- Describe the general mechanism of transcription, including binding, initiation, elongation and termination. Discuss factors regulating transcription.
- Describe processing for all three types of RNA, and discuss why it must occur.

Main Points:

- **Transcribe=copy** --> implies the same language-language of nucleotides.

Transcription - the process of using the DNA sequence as a template and make a faithful RNA copy.

Differential gene expression: e.g. of 30,000 genes in a typical mammalian cell, only about 5,000 are being transcribed at any time. Which 5000 depends on the cell type. Some are housekeeping genes, all cells transcribe them; some are specific to cell function, such as red blood cells where 95% of protein in cell is hemoglobin.

- Transcription units (genes) contain the transcribed information and all associated regulatory sequences for the production of an RNA transcript.
- Structure of eukaryotic gene: (i) Promoter region, DNA elements that bind transcription regulatory proteins; (ii) 5' untranslated region; (iii) coding region (exons); (iv) noncoding regions (introns); (v) 3' untranslated region
- Transcription is carried out by RNA polymerase, a multi-protein complex that assembles on the promoter region of the transcription unit and proceeds to transcribe the DNA information to form an RNA transcript.
- Both eukaryotic and prokaryotic genes are transcribed when RNA Polymerase binds to the the promotor region of the gene upstream of the coding region.
Prokaryotes-initiation of transcription simpler, genes controlled by repressor (turn off) or activator (turn on). Genes occur in groups called "operons", that are transcribed as a single mRNA (turned on together). (**Fig. 7-12**). Sigma factor (a subunit of the polymerase recognizes the promoter)
Eukaryotes-initiation of transcription is more complex. RNA Polymerase II requires

large set of general transcription factors, and gene regulatory proteins binding to DNA before it can bind and initiate transcription.

- Transcription always occurs in the same direction relative to the copied strand, but may occur in either direction on the chromosome, depending on which of the DNA strands is copied.
- **MECHANICS OF TRANSCRIPTION:** involves 4 steps; Binding step, Initiation step, Elongation step and Termination step (Details given in Figs. 7-7, 7-9, and will be discussed in class).

II. RNA TRANSCRIPT PROCESSING

Learning Objectives

- Describe the processing of mRNA and ribosomal RNAs
- Describe the structural features of ribosomes.

Question: Why is the processing of mRNA important?

Answer: Because the modifications help stabilize the mRNA and prevent its degradation. In addition, the modifications help prepare the mRNA for export from the nucleus and for use during the protein synthesis process.

Main Points

- RNAs of all classes are processed before they are allowed out of the nucleus.
- Processing (modifications) help stabilize the mRNA and prevent degradation, help prepare the mRNA for export from the nucleus and for use during the protein synthesis process.
- Processing involves removal of RNA sequences from transcripts and or modification of bases or the base sequence.
- Transcripts are complexed with proteins during the processing process.
- In the case of mRNAs the most important processing event is excision of introns via interaction with proteins that recognize specific sequences (exon/ intron boundaries) and that excise introns.
- The 5' Cap, composed of a guanosine containing an extra methyl group. The 'CAP' protects the mRNA from exonucleases that chew from the 5' end of the molecule. This protection makes the mRNA more stable. The 'CAP' also aids mRNA alignment during protein synthesis.
- The 3' polyA tail: The 3' modification is the addition of poly adenylate (A)(100-200 adenylyl units) to the 3' end of the mRNA. The poly A protects the mRNA from getting degraded by 3' exonucleases.
- Differential processing of transcripts may produce different final products in different tissues or developmental stages.
- Precursors of Ribosomal RNA and Transfer RNA also undergo processing

III. GENETIC CODE, TRANSLATION

Learning Objectives

- Describe the genetic code and how it is related to the mechanisms of transcription and translation.
- Describe the coupling of tRNA and discuss the specificity of amino acid tRNA synthetases.
- Describe the general mechanism of translation including binding, initiation, elongation and termination.

The word **translation** implies changing from the language of nucleic acids (nucleotides) to that of proteins (amino acids). Remember transcription was rewriting (copying) the information from DNA, i.e. language of nucleic acids, into the language of RNA, also nucleic acids.

Translation is the transfer of biological information from the 4 nucleotide language of nucleic acids into the 20 amino acid language of proteins using the rules of the genetic code.

Main points

- The genetic code is a triplet code, readable in three different readings frames.
- The reading frame to be used is determined by the position of the initiator codon (AUG).
- Matching of codons with amino acids occurs through a system of two adapters: tRNA molecules and the matching aminoacyl transferase enzymes that join them to the appropriate amino acid. They are 'bifunctional' RNAs that use its ANTICODON to recognize the mRNA codon and they also carry amino acids on 3' OH.
- Ribosomes act as a platform for protein synthesis
- Mechanism of translation – involves 3 steps: Initiation, Elongation and Termination [details given in Figs. 7.33, 7.34; and will be discussed in class].