03 Transcription

Chapter 10
From DNA to Proteins:
Transcription ~~and~~
~~RNA Processing~~

Chapter 10 Opener
Genetics Essentials: Concepts and Connections, Second Edition
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The death cap mushroom, *Amanita phalloides*
α-amanitin

Fig. 10.1a: Structure of an RNA strand

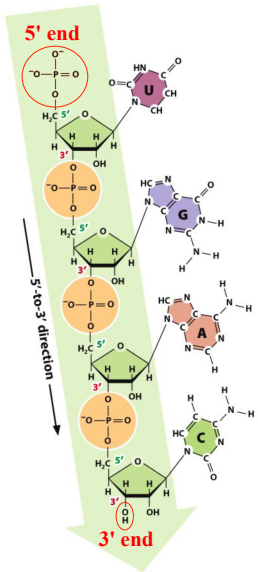


Fig. 10.1b: Secondary structure of an RNA strand

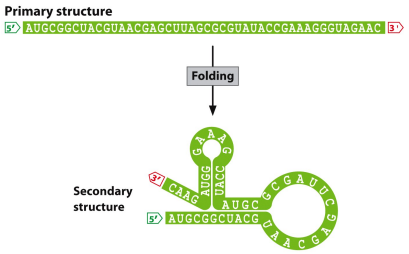


Table 10.1 The structures of DNA and RNA compared

Characteristic	DNA	RNA
Composed of nucleotides	Yes	Yes
Type of sugar	Deoxyribose	Ribose
Presence of 2′-OH group	No	Yes
Bases	A, G, C, T	A, G, C, U
Nucleotides joined by phosphodiester bonds	Yes	Yes
Double or single stranded	Usually double	Usually single
Secondary structure	Double helix	Many types
Stability	Stable	Easily degraded

Table 10.2 Location and functions of different classes of RNA molecules

Class of RNA	Cell type	Location of function in eukaryotic cells*	Function
Ribosomal RNA (rRNA)	Bacterial and eukaryotic	Cytoplasm	Structural and functional components of the ribosome
Messenger RNA (mRNA)	Bacterial and eukaryotic	Nucleus and cytoplasm	Carries genetic code for proteins
Transfer RNA (tRNA)	Bacterial and eukaryotic	Cytoplasm	Helps incorporate amino acids into polypeptide chain
Small nuclear RNA (snRNA)	Eukaryotic	Nucleus	Processing of pre-mRNA
Small nucleolar RNA (snoRNA)	Eukaryotic	Nucleus	Processing and assembly of rRNA
MicroRNA (miRNA)	Eukaryotic	Cytoplasm	Inhibits the translation of mRNA
Small interfering RNA (siRNA)	Eukaryotic	Cytoplasm	Triggers the degradation of other RNA molecules

*All eukaryotic RNAs are transcribed in the nucleus.

DNA carries genetic information in its linear sequence of its nucleotides (Fig. 10.14)

Partial nucleotide sequence of a human gene

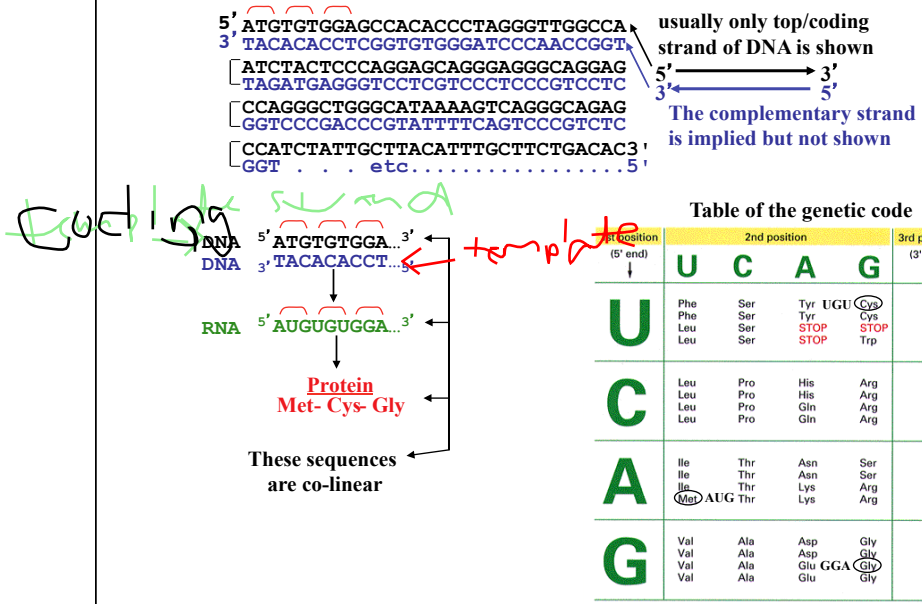
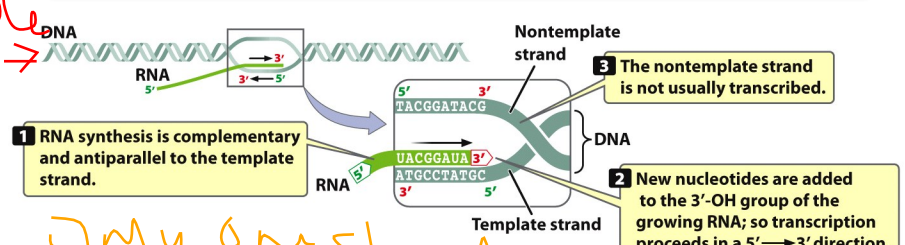


Table of the genetic code

1st position (5' end)	2nd position U	2nd position C	2nd position A	2nd position G	3rd position (3' end)
U	Phe	Ser	Tyr	UGU Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	STOP	STOP	A
	Leu	Ser	STOP	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met AUG	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	GGA Gly	A
	Val	Ala	Glu	Gly	G

Double

Fig. 10.4: RNA synthesis from a DNA template



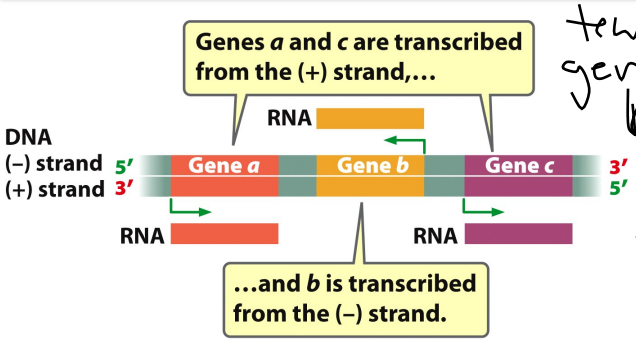
Only One strand of double stranded is transcribed

The synthesis of RNA is complementary and antiparallel to the DNA template strand

The initiation of RNA synthesis (transcription) does NOT require a pre-existing primer

Unlike DNA initiation by polymerase must have

Fig. 10.5: Transcription of genes from a region of genomic DNA



template strand of gene a & c is the bottom strand (+) 5'-3'

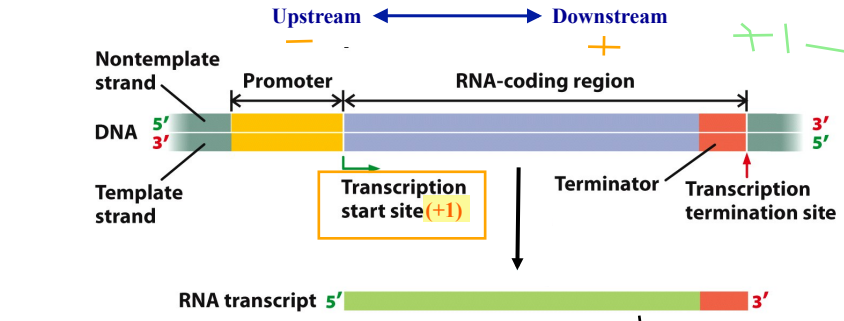
Template of 'b' is top (-) 3'-5'

The template strand of a gene can be on either strand within a region of genomic DNA

3 transcripts

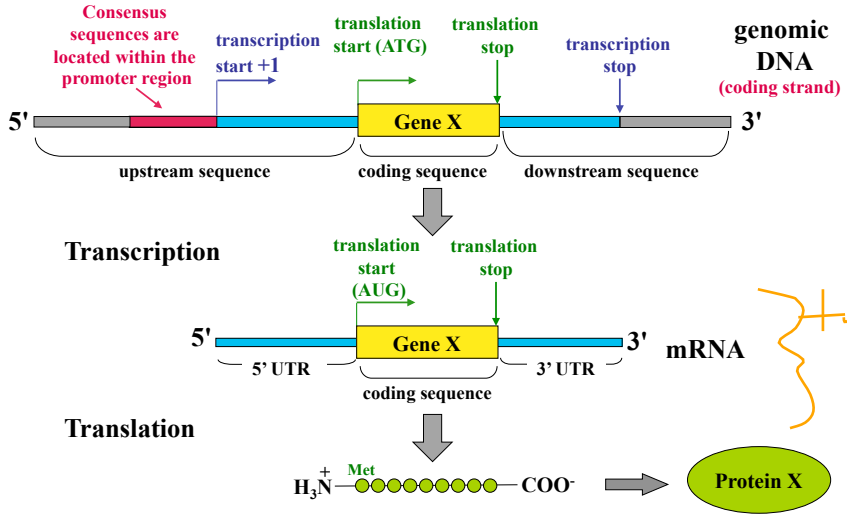
'Same sequence' as MRNA → contains the codons if read DNA 5'→3' will look like strand 2 but 5'→3' and U=T

Fig. 10.6: Components of a transcriptional unit



terminator only in bacteria
Motor allows downstream to transcribe

Replaces Fig. 10.6: Components of a gene

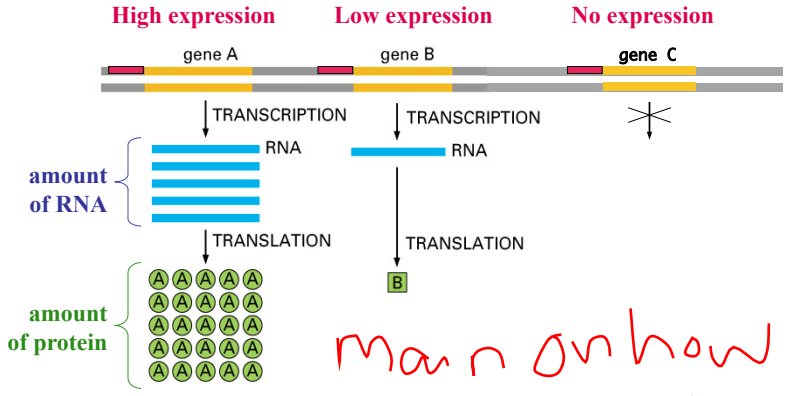


transcribed but not translated

transcription - mRNA
translation - protein from MRNA

Genes can be transcribed (expressed) with different efficiencies

Different promoter sequences → Different promoter strengths → Different numbers of transcription initiations at a specific promoter over a fixed period of time



main on how much is promoter (and how much)

Prokaryotes (*E. coli*) have a single type of RNA pol

α1 α2 + β β' 4 subunits in core enzyme + σ (sigma factor)

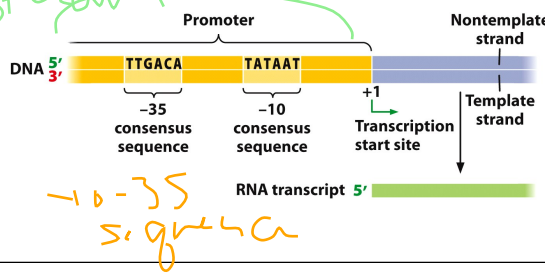
polypeptide

Only one type of core enzyme but several types of σ factors are available

- different σ used by the enzyme to recognize different "promoters"
- A promoter is a region that "tells" RNA pol where to sit on the DNA to start transcription

Fig. 10.10: The standard bacterial promoter consists of -10 and -35 consensus sequences (also see Fig. 10.9)

upstream



bind before transcribe

-10 -35 sigma

The process of bacterial transcription
(read section 10.3 in textbook)

Initiation

Elongation

Termination

hairpin structure falls back on itself

Table 10.3 Eukaryotic RNA polymerases

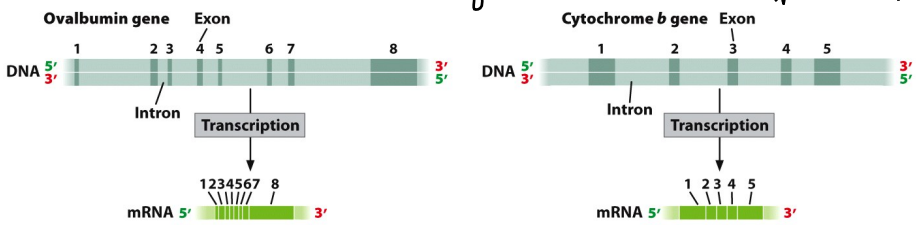
Type	Present in	Transcribes
RNA polymerase I	All eukaryotes	Large rRNAs
RNA polymerase II	All eukaryotes	Pre-mRNA, some snRNAs, snoRNAs, some miRNAs
RNA polymerase III	All eukaryotes	tRNAs, small rRNAs, some snRNAs, some miRNAs
RNA polymerase IV	Plants	Some siRNAs
RNA polymerase V	Plants	RNA molecules taking part in heterochromatin formation

MOST SENSETIVE to α-amanitin

α-amanitin – poison from mushrooms

Fig. 10.16: The coding sequence of some eukaryotic genes are disrupted by non-coding introns

introns & exons initially transcribed (pre-mRNA)



Introns: Intervening or Interrupting sequences
Exons: Expressed sequences

Both the introns and exons of a gene are initially transcribed (as a pre-mRNA) but the introns are removed/excised (RNA splicing) before the mature mRNA is translated

fig 10.20 consensus sequence for intron removal at 5', 3', branch point in between

Modifications of eukaryotic mRNAs
(read section 10.5 in textbook)

Addition of specialized cap structure to 5' end

— on phone

Addition of poly(A) tail to 3' end

Removal of introns

all processes occur in the nucleus before the mRNA is exported to the cytoplasm