Gene Expression
Transcription and Translation

Transcription

- copy a set of ingredients/instructions from a cookbook to create a recipe

Translation

- use the recipe to create a dish

- BIO*300/CMPSC*300 – SPRING 2016
- CRASH COURSE IN MOLECULAR BIOLOGY
The Central Dogma of Molecular Biology

Proteins provide structure and carry out many essential activities in a cell.
Transcription

- **Transcribe** specific regions of DNA – genes
  - Human genome ~25,000 genes (just 1.5% of genome)
- **RNA** is the direct **product** of transcribing a gene
  - same language (nucleotides)

- **Transfer RNA (tRNA)**
- **Ribosomal RNA (rRNA)**
- **Messenger RNA (mRNA)**
RNA vs DNA

- RNA – uracil replaces thymine (no Ts in RNA)
- RNA – single stranded (one backbone, no basepairs)
- (RNA – slightly different sugar)
Antisense and Sense Strands of DNA – relative to the gene being transcribed.
Genes exists on both strands of DNA....

.....transcription occurs on the strand containing the gene that is needed.

The strand containing the gene is the antisense strand.

The RNA transcript is the complement of the antisense strand.
Genes have beginnings and ends - promoters and terminators

Transcription is initiated at a promoter sequence and ends at a terminator sequence. The transcript is synthesized in a 5’-to-3’ direction.

Both DNA strands serve as templates for transcription.
RNA polymerase binds at promoter

RNA polymerase – enzyme that reads gene (DNA) and creates transcript (RNA)
Transcription

- Strands of DNA are separated – transcription bubble
- RNA synthesis
  - DNA template “read” in 3’ -> 5’ direction
  - RNA synthesized in 5’ -> 3’ direction
Transcription Video

• [https://www.dnalc.org/resources/3d/12-transcription-basic.html](https://www.dnalc.org/resources/3d/12-transcription-basic.html)

• Watch video and read text below

• “other factors” – no responsible for details, just watch process

• Know the role of RNA polymerase
Splicing of some RNA sometimes...

Eukaryotic pre-mRNA contains exons and introns*

*some pre-mRNAs contain only one exon
Add 2 eggs *bhgty* to the flour *qwtzptlrbn* and stir.
Add 2 eggs *bhgty* to the flour *qwtzptlrbn* and stir.

Introns do not contain the message and are removed from the RNA after transcription but prior to translation.
An image of a DNA transcription process is shown. The DNA sequence is illustrated on two strands: the antisense strand and the sense strand. The transcribed RNA sequence is indicated below the DNA sequence.
Translation

• Reading transcript (RNA) and creating protein (amino acids)
  – new language!
Proteins are made of amino acids
### Genetic Code

**“nucleotide to amino acid dictionary”**

<table>
<thead>
<tr>
<th>First base of codon</th>
<th>Second base of codon</th>
<th>Third base of codon</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>G</td>
<td>A</td>
</tr>
<tr>
<td>UUU UUC</td>
<td>Phenylalanine</td>
<td>Valine</td>
</tr>
<tr>
<td>UAU UUG</td>
<td>Urea</td>
<td>G</td>
</tr>
<tr>
<td>C</td>
<td>A</td>
<td>A</td>
</tr>
<tr>
<td>CUU CUC CUA CUG</td>
<td>Leucine</td>
<td>Methionine (start codon)</td>
</tr>
<tr>
<td>A</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>AUG</td>
<td>Isoleucine</td>
<td>Threonine</td>
</tr>
<tr>
<td>G</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>GUU GUC GUA GUG</td>
<td>Valine</td>
<td>Alanine</td>
</tr>
<tr>
<td>A</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>AGU AGC AGA AGG</td>
<td>Aspartic acid</td>
<td>Glutamic acid</td>
</tr>
<tr>
<td>G</td>
<td>U</td>
<td>C</td>
</tr>
<tr>
<td>GGU GCC GGA GGG</td>
<td>Asparagine</td>
<td>Glutamine</td>
</tr>
<tr>
<td>A</td>
<td>C</td>
<td>A</td>
</tr>
<tr>
<td>AUU AUC AUA AUG</td>
<td>Serine</td>
<td>Arginine</td>
</tr>
<tr>
<td>C</td>
<td>G</td>
<td>G</td>
</tr>
<tr>
<td>CCC CCA CCG</td>
<td>Serine</td>
<td>Arginine</td>
</tr>
<tr>
<td>G</td>
<td>U</td>
<td>C</td>
</tr>
<tr>
<td>UAU UAC UUG UGC</td>
<td>Tyrrosine</td>
<td>Cysine</td>
</tr>
<tr>
<td>A</td>
<td>U</td>
<td>A</td>
</tr>
<tr>
<td>UAA UAG</td>
<td>STOP codon</td>
<td>STOP codon</td>
</tr>
<tr>
<td>G</td>
<td>U</td>
<td>G</td>
</tr>
</tbody>
</table>
The Genetic Code

- **Triplet code**
  - Combinations of three nucleotides code for one amino acid
  - Three nucleotides = codon

- **Redundancy**
  - Sometimes >1 codon codes for same amino acid
  - 20 amino acids, 64 possible codons

- **Start and Stop codons**
  - First codon of many transcripts is “AUG”, which codes for methionine
  - Codons UAA, UAG, and UGA indicate the end of the transcript
Translation

• Reading transcript (RNA) and creating protein (amino acids)
  – new language!

• Translation machinery:
  – Transfer molecules - bring correct amino acid to ribosome
  – Ribosome – factory that builds joins amino acids to build a protein
Translation

- Transfer molecule brings next amino acid to complex.
- Amino acid is specific – based on codon of RNA
- Ribosome builds the protein by joining the amino acids
Translation Videos

• [https://www.youtube.com/watch?v=8dsTvBaUMvw](https://www.youtube.com/watch?v=8dsTvBaUMvw)

• Translation process is generic – specificity comes from the gene that was transcribed.

• [https://www.youtube.com/watch?v=h5mJbP23Buo](https://www.youtube.com/watch?v=h5mJbP23Buo)
  – Fun review of entire process of gene expression (transcription and translation)
Genes vs Gene Expression

all genes are present, only expressed when needed

Of the many recipes in the cookbook...

....only transcribe and translate 4th of July recipes in July

Of the many recipes in the cookbook...

....only transcribe and translate the Thanksgiving turkey recipe in November