DNA and Genes
Roles of RNA and DNA

• **DNA** is the MASTER PLAN

• **RNA** is the BLUEPRINT of the Master Plan
RNA Differs from DNA

- RNA has a sugar ribose
- DNA has a sugar deoxyribose
Other Differences

- RNA contains the base uracil (U)
  DNA has thymine (T)
- RNA molecule is single-stranded
  DNA is double-stranded
Structure of RNA

Base is uracil instead of thymine.
Central Dogma of Biology

DNA codes for RNA which guides the synthesis of proteins!
Three Types of RNA

- **Messenger RNA (mRNA)** copies DNA’s code & carries the genetic information to the ribosomes
- **Ribosomal RNA (rRNA)**, along with protein, makes up the ribosomes
- **Transfer RNA (tRNA)** transfers amino acids to the ribosomes where proteins are synthesized
mRNA

rRNA

Uracil

Messenger RNA

amino acid attachment site

anticodon

tRNA
Central Dogma of Biology

DNA codes for RNA which guides the synthesis of proteins!

Step 1

Transcription

Translation

DNA

mRNA

Protein
TRANSCRIPTION IS HAPPENING AT THE SAME TIME AS DNA REPLICATION!
Transcription - 1

- A portion of the DNA molecule unzips
- Recall: DNA helicase is the enzyme responsible for this!
Transcription - 2

- RNA polymerase joins RNA nucleotides using the DNA strand as a template
- This new strand of RNA is the mRNA strand
DNA

G C A T

CGTA

RNA

G C A U

CGTA

base pairing during DNA replication

base pairing during transcription
Transcription - 3

- After the DNA is transcribed into RNA, editing must be done to the nucleotide chain to make the RNA functional.
Transcription - 3

- **Introns**, non-functional segments of DNA are **snipped out** of the chain

- **Exons**, segments of DNA that code for proteins, are then rejoined by the enzyme **ligase**
Result of Transcription

Introns and Exons (1)

Exon (coding region)         Intron (noncoding region)

DNA: 1 2 3 4 5 6 7

5' cap Transcription 3' poly-A-tail

Primary RNA transcript Intron are cut out and coding regions are spliced together

Mature mRNA transcript

New Transcript Cap Tail

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mRNA Transcript - 4

- mRNA leaves the nucleus through its pores and goes to the ribosomes
The Genetic Code

- A **codon** designates an **amino acid**
- An amino acid may have **more than one codon**
- There are 20 amino acids, but **64 possible codons**
- Some codons tell the ribosome to **stop translating**

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The Genetic Code

- Use the code by reading from the center to the outside
- Example: AUG codes for Methionine
Name the Amino Acids

- GGG?
- UCA?
- CAU?
- GCA?
- AAA?
Remember the Complementary Bases

On DNA:
- A - T
- C - G

On RNA:
- A - U
- C - G

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Question:

What would be the complementary RNA strand for the following DNA sequence?

DNA  5’-GCGTATG-3’
Answer:

- DNA  5’-GCGTATG-3’
- RNA  3’-CGCAUAC-5’
Central Dogma of Biology

mRNA creates proteins
Translation

• Translation is the process of decoding the mRNA into a polypeptide chain to create proteins (amino acids)

• Ribosomes read mRNA three bases or 1 codon at a time and construct the proteins
Transcription

Translation

codon 1 codon 2 codon 3

- N - C - C - N - C - C - N - C - C

arginine tyrosine tryptophan

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Ribosomes

- Composed of rRNA and proteins
- Have two sites for tRNA attachment --- P and A
- The P site is the first to read the mRNA
Step 1

- mRNA transcript start codon **AUG** must be read
- This signals to the ribosome to start making proteins
Ribosomes

P Site

A Site

mRNA

AUGCUUACUCGC

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Step 2

- As ribosome moves, two tRNA with their amino acids move into site A and P of the ribosome
aa1

1-tRNA

U A C

anticodon

codon

mRNA

G AU U C G A

2-tRNA

aa2

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Ribosomes move over one codon
peptide bonds

2-tRNA

3-tRNA

4-tRNA

aa1

aa2

aa3

aa4

mRNA

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mRNA

\[\text{A} \quad \text{U} \quad \text{G} \quad \text{C} \quad \text{U} \quad \text{A} \quad \text{C} \quad \text{U} \quad \text{U} \quad \text{C} \quad \text{G} \quad \text{A} \quad \text{A} \quad \text{C} \quad \text{U}\]

Ribosomes move over one codon

peptide bonds

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peptide bonds

aa1 → aa2 → peptide bonds → aa3 → aa4 → peptide bonds → aa5

3-tRNA (GAA) → 4-tRNA (GCU)

mRNA: GCUAACCUCGAAACCU

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Ribosomes move over one codon
Termination

primary structure of a protein

mRNA

AA1

AA2

AA3

AA4

AA5

AA200

AA199

200-tRNA

terminator or stop codon

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End Product - The Protein!

- The end products of protein synthesis is an amino acid chain that makes up a protein.
Messenger RNA (mRNA)

Amino Acid Chain

- methionine
- glycine
- serine
- isoleucine
- glycine
- alanine

peptide bonds

start codon

stop codon
Beadle & Tatum Hypothesis

• One GENE codes for one POLYPEPTIDE (protein)