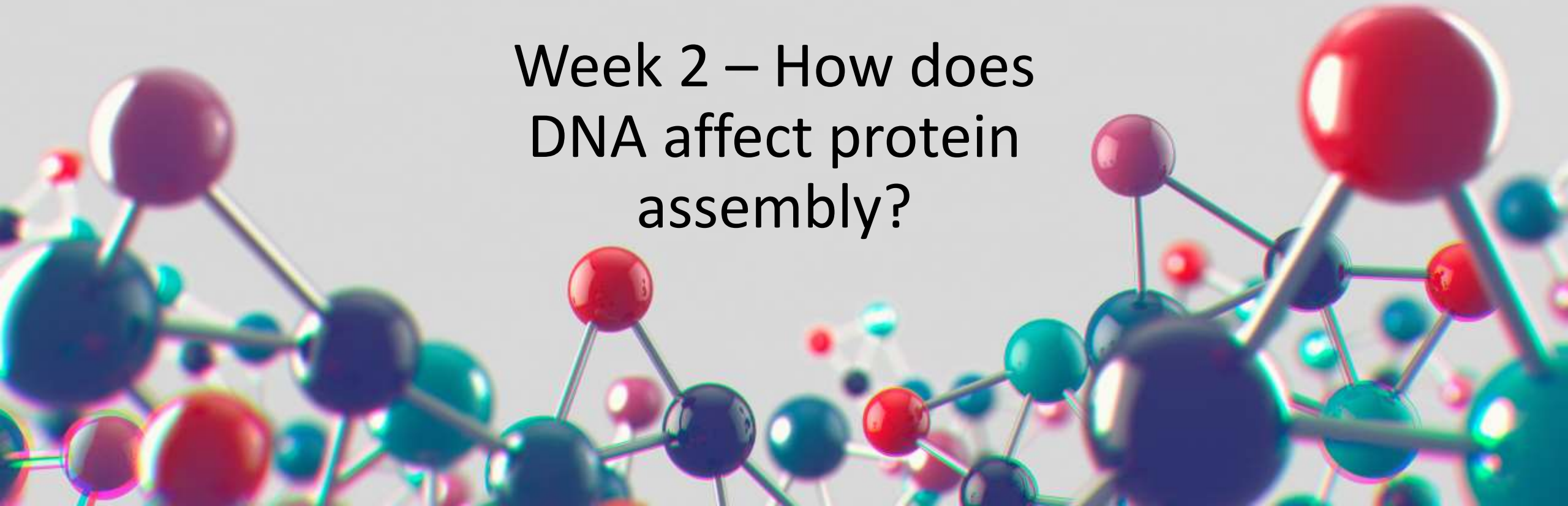
Waterford Biology

WUHS Biology: DNA & Proteins Unit

Week 2 – How does DNA affect protein assembly?



DNA & Proteins Unit – W2 Driving Questions

- **Driving Question: How does DNA affect protein assembly?**
- How is the information in DNA used to assemble amino acids?
- How does a cell “know” how to interpret the information stored within DNA?
- What is RNA and how is it both similar and different from DNA?

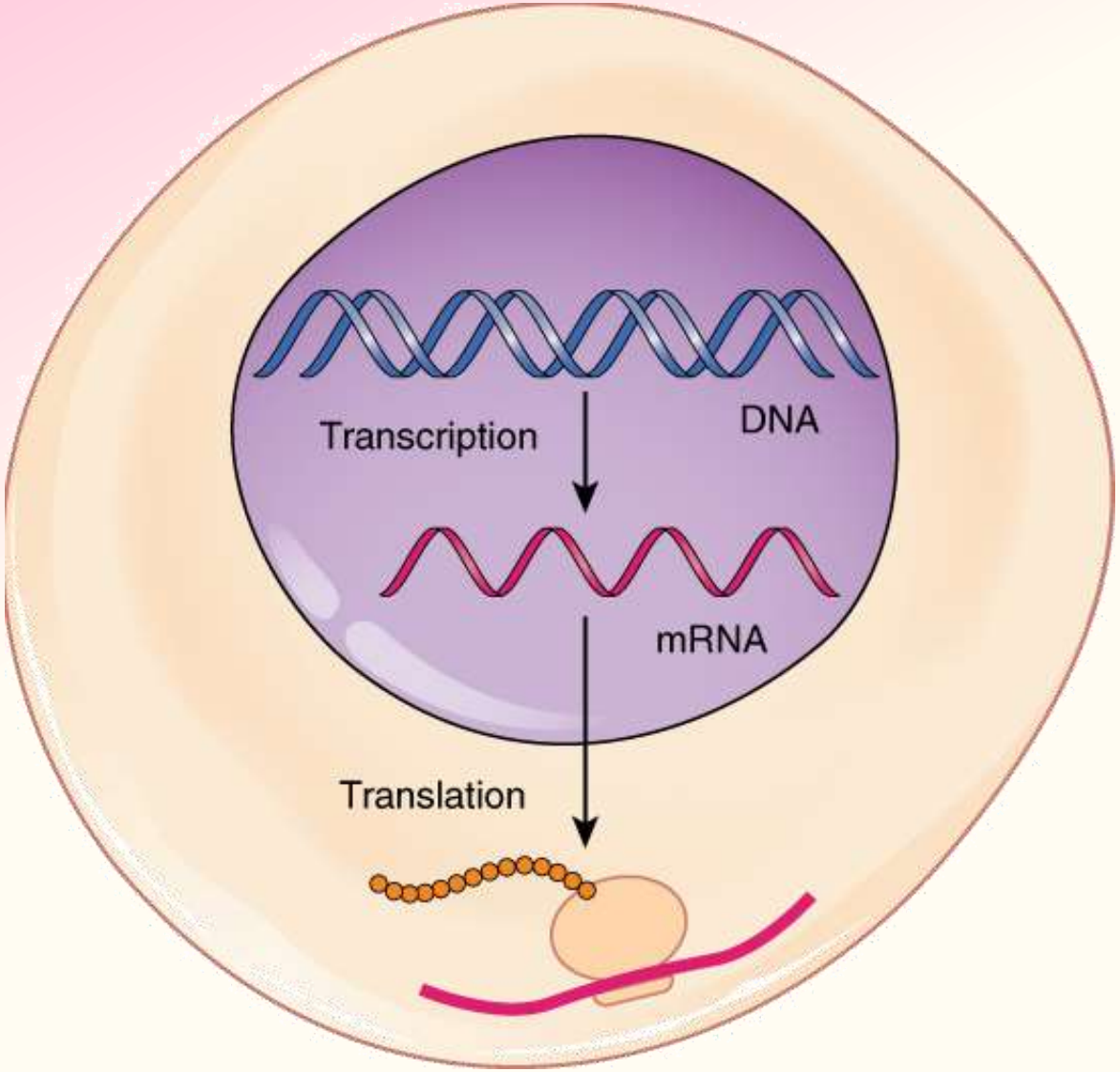


Image Source: Wikimedia

Recap of Week 1

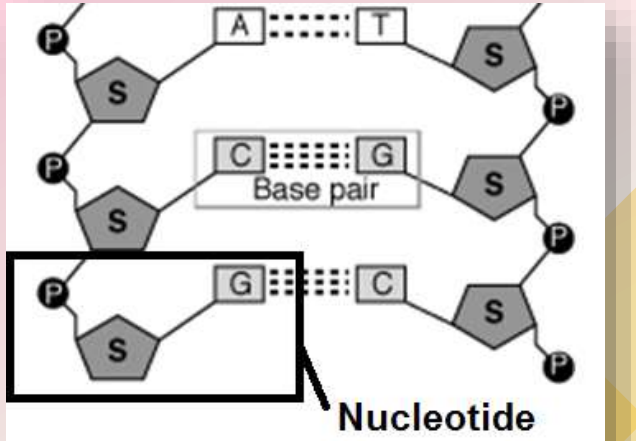
The primary function of DNA in all living organisms is to store information for how to assemble proteins.

DNA is a macromolecule (polymer) consisting of long chains of nucleotide molecules.

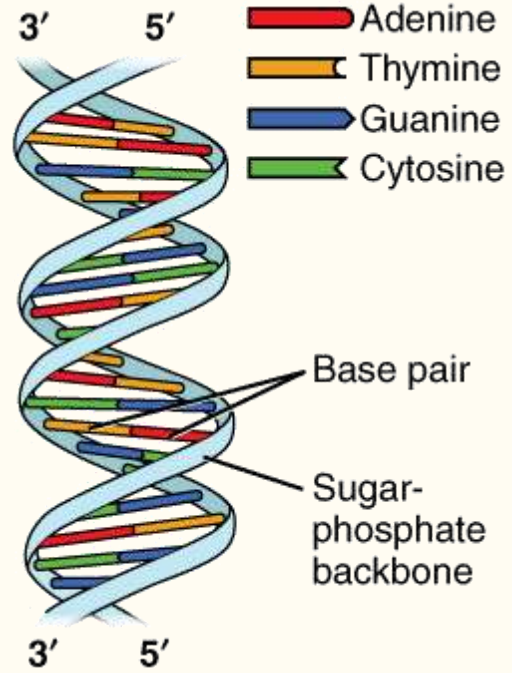
Each nucleotide has 3 parts: a phosphate, a sugar, and one of four bases.

Phosphate and sugar molecules provide structure to DNA; the base molecules are what code information for assembling proteins.

Due to differences in size and bonding sites, A only bonds with T, and G only bonds with C. These are called complementary base pairs.



A single nucleotide consists of a phosphate, a sugar, and a nitrogenous base.



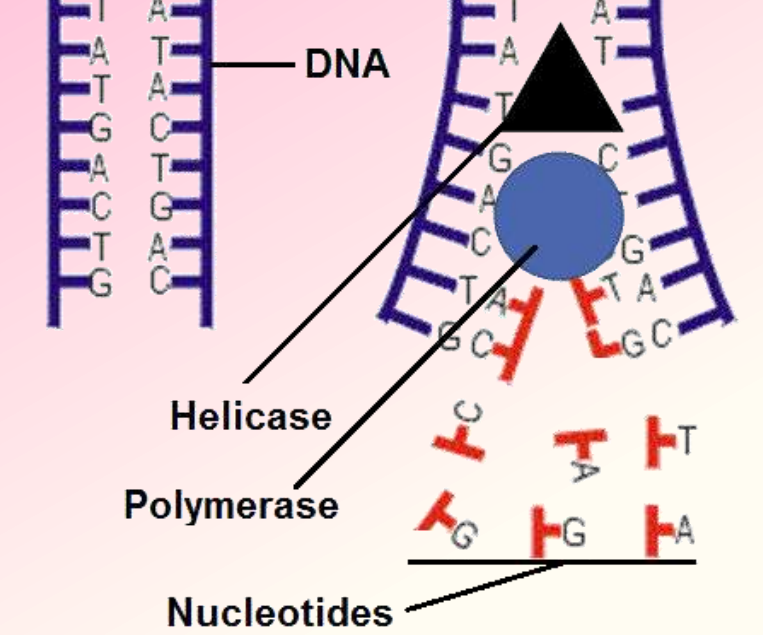
Recap of Week 1

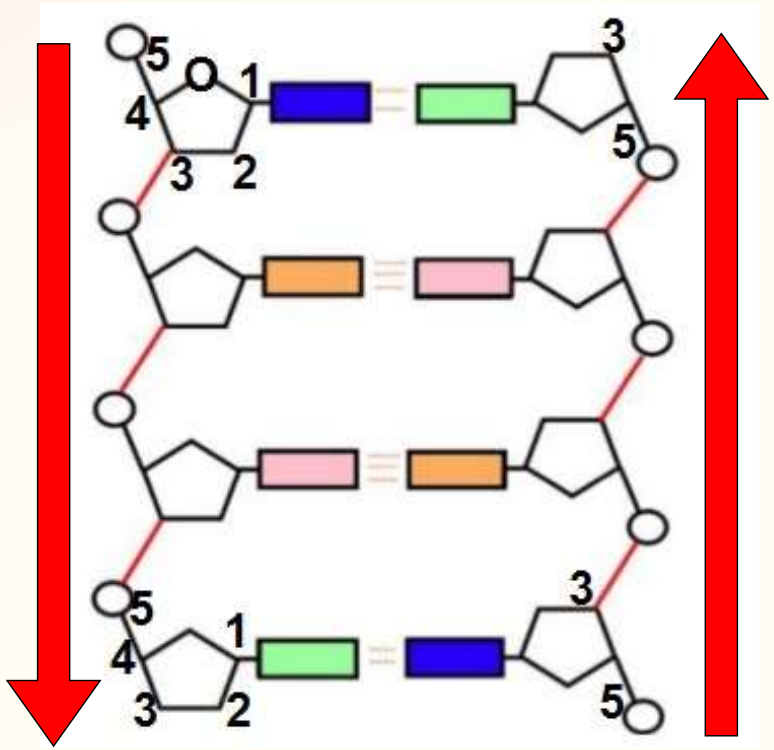
Helicase proteins separate the DNA strands, allowing polymerase proteins to add complementary bases to duplicate DNA.

DNA is always duplicated in a 5’ → 3’ direction (which refers to the carbon atoms on the sugar molecule).

The order of codons (3 bases) in a gene determines the order of amino acids in a protein. This determines the kind of protein that is assembled.

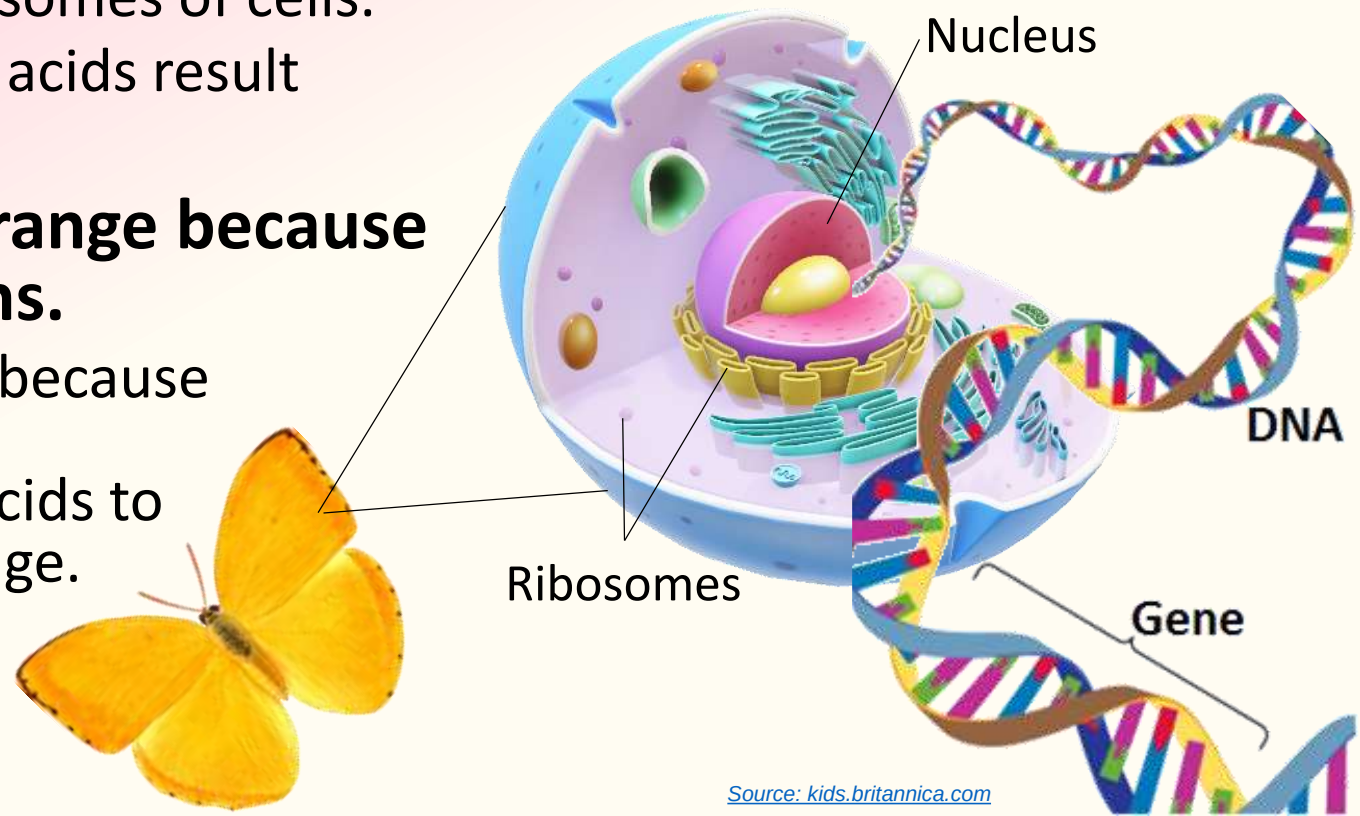
The way in which a protein is assembled determines the trait that is expressed. Species are classified based on their traits.





DNA → Proteins → Traits

- **The traits of living organisms are determined by the proteins produced in their cells.**
  - Cells produce proteins based on the instructions stored within their DNA.
  - DNA is stored within the nucleus of a cell.
  - Proteins are produced in the ribosomes of cells.
  - Different arrangements of amino acids result in different kinds of proteins.
- **For example, this butterfly is orange because its cells produce orange proteins.**
  - Its cells produce orange proteins because their DNA contains a gene with instructions to assemble amino acids to make a protein that appears orange.

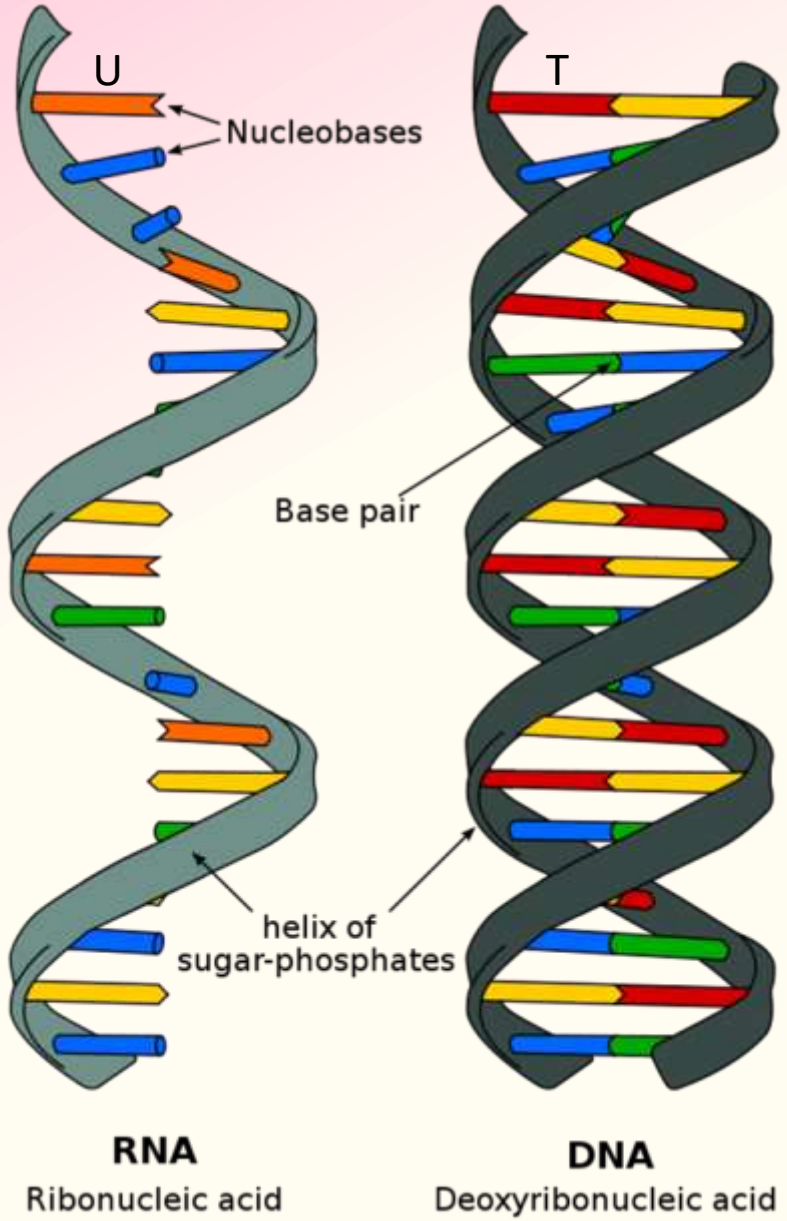


Source: kids.britannica.com

Image Source: SVG

DNA vs. RNA

- **Genes are segments of DNA that provide the instructions for building specific proteins.**
  - However, a gene does not directly assemble a protein.
- **A separate molecule, called RNA, serves as a link between the information stored in DNA and the assembly of proteins.**
  - DNA must remain inside the nucleus where it can be protected from damage.
- **As a macromolecule, RNA is very similar to DNA except for three key differences.**
  - DNA is double stranded, but RNA is single stranded.
  - The bases in DNA are G, C, A, and T; however, the bases in RNA are G, C, A, and U.
  - The sugar molecule in RNA is slightly different from the sugar molecule in DNA.



Source: biobook.nerinxhs.org

DNA vs. RNA Summary

- **DNA and RNA are both macromolecules made of repeating chains of nucleotides.**

- **Unlike DNA, RNA is 1) single stranded, 2) uses Uracil (U) instead of Thymine (T), and 3) has a different sugar molecule.**

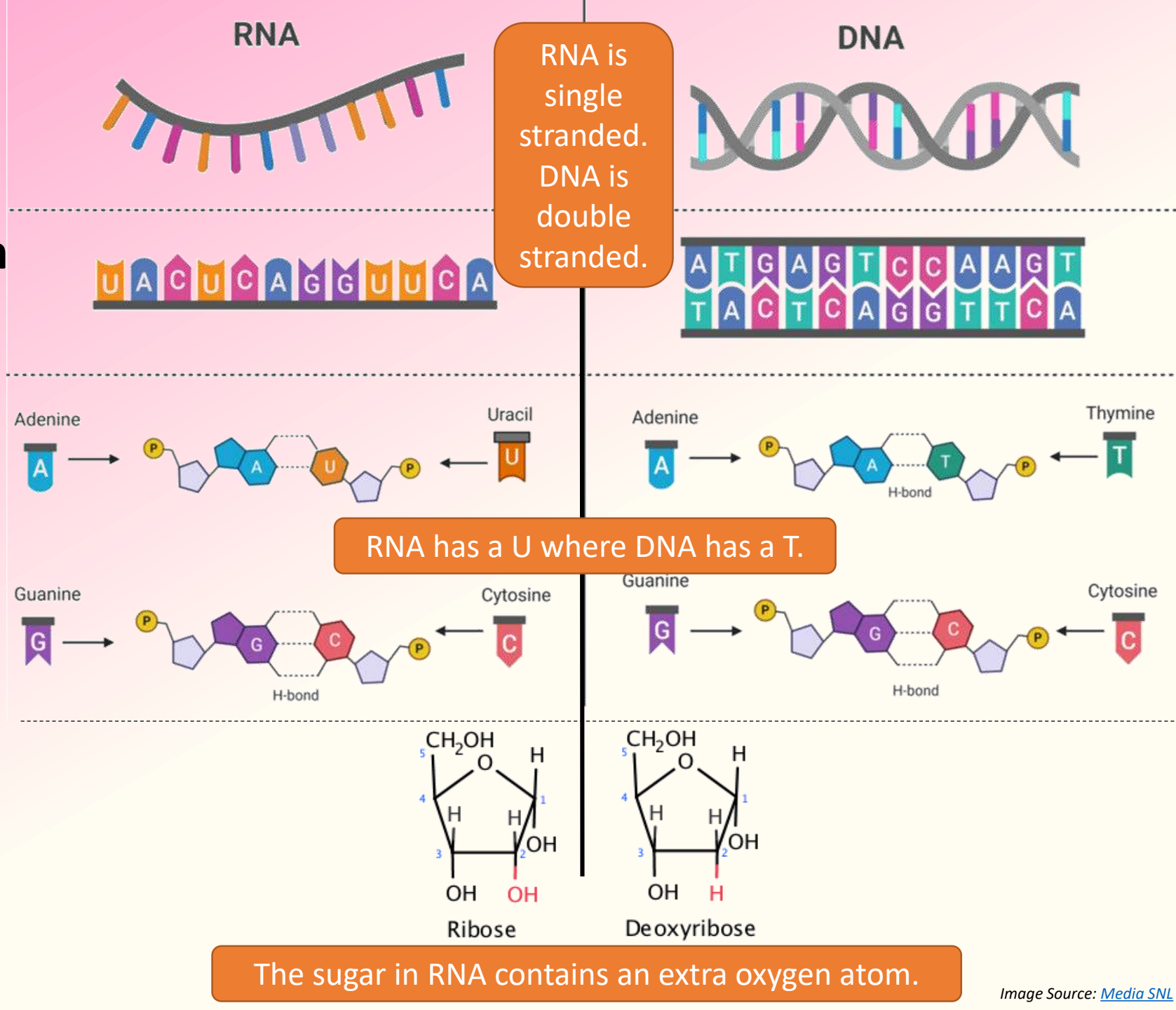


Image Source: Media SNL

Transcription & Translation

- **To assemble a protein using the information in DNA, two key processes are needed: transcription and translation.**
  - Transcription is the process of producing an RNA copy of a gene in the DNA.
  - Translation is the assembly of a protein using info from the RNA copy.

- **Transcription produces an RNA copy of DNA.**
  - A "transcript" is a copy of something (*e.g., a transcript of your grades is a copy of your grades*).
  - During transcription, the cell produces a copy of DNA known as mRNA (short for *messenger RNA*).

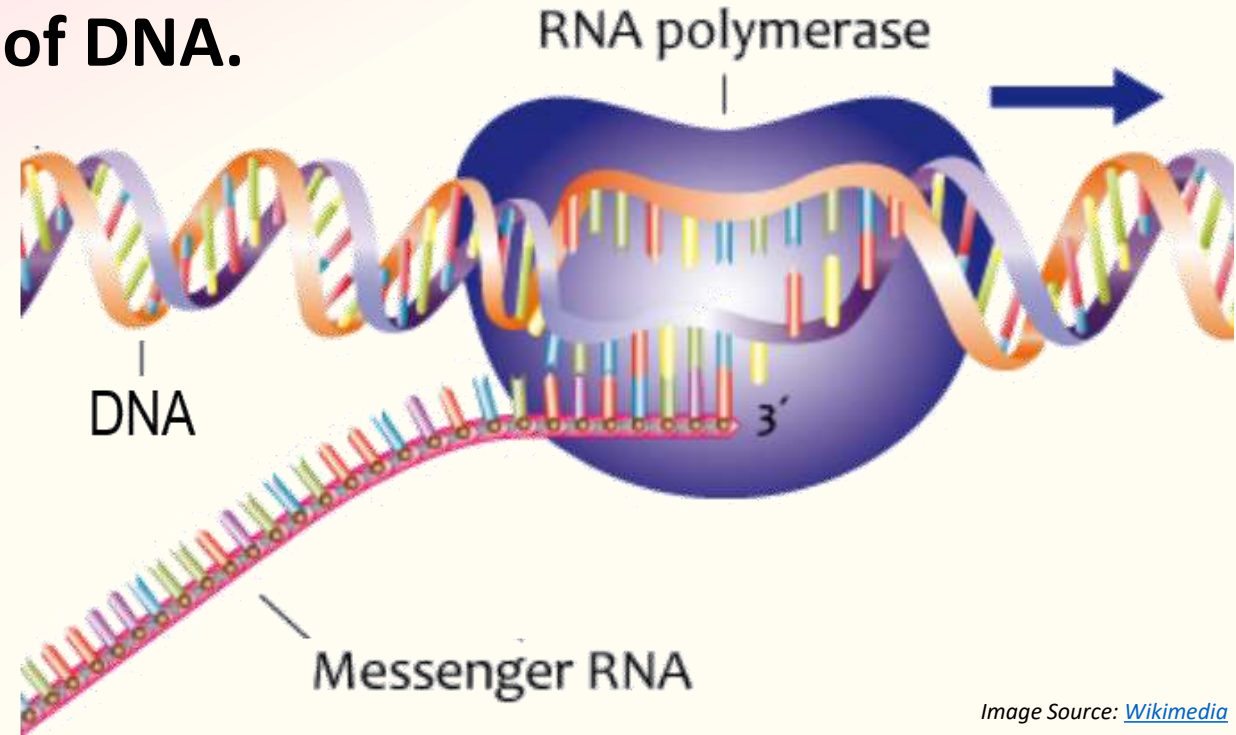


Image Source: Wikimedia

Transcription

- **Transcription begins when a protein called RNA polymerase attaches to a gene within DNA.**
  - RNA polymerase is the enzyme that creates the mRNA copy.
  - A *gene* is a segment of DNA that codes for the assembly of a specific protein.

- **RNA polymerase then creates the mRNA copy of DNA.**
  - The mRNA copy will have a complementary base for each base in DNA.
  - For example, if a sequence in DNA was: **3' - G - C - T - 5'** …

    …then the sequence in the mRNA copy would be: **5' - C - G - A - 3'**

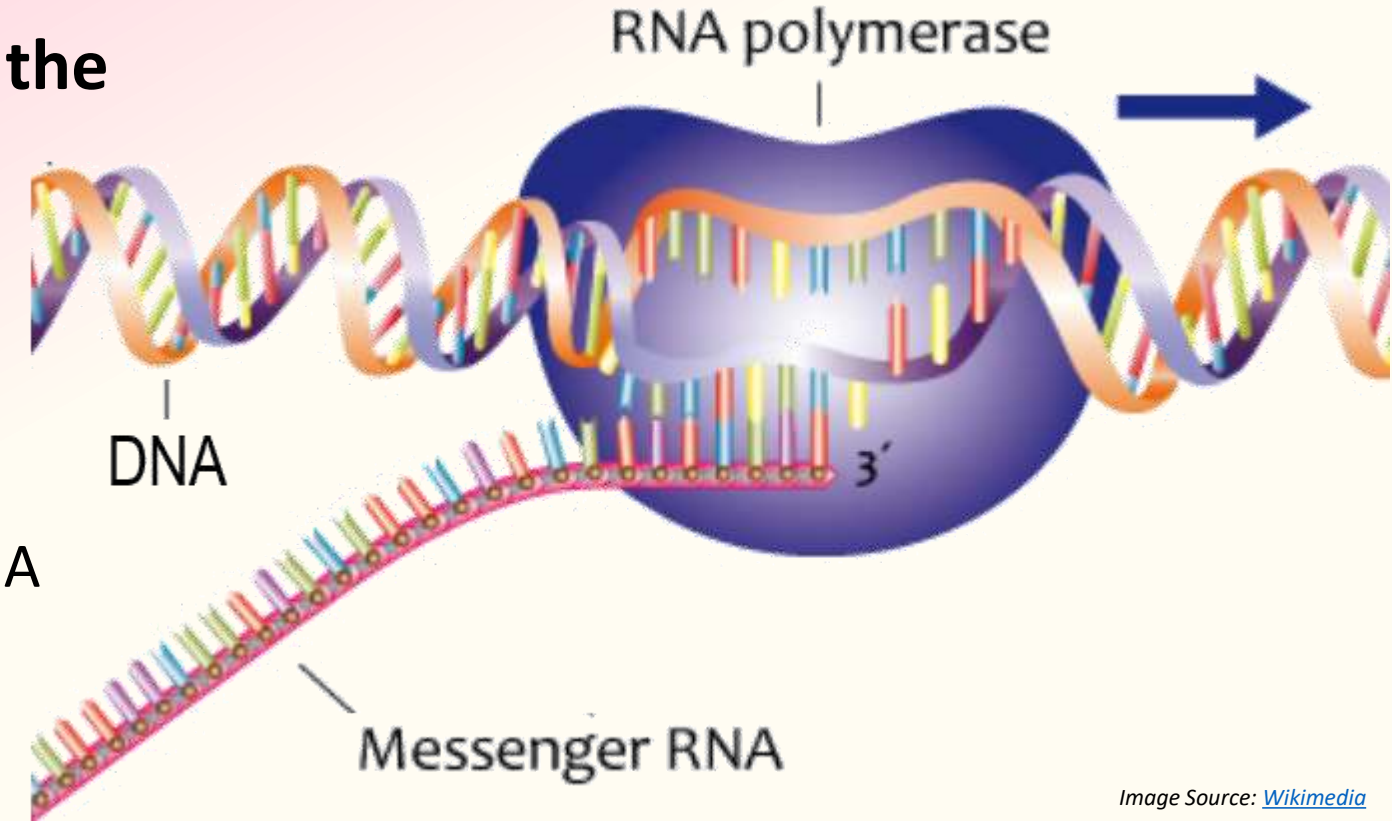


Image Source: Wikimedia

U's, not T's

- **Both DNA polymerase and RNA polymerase make copies of DNA.**
  - DNA polymerase makes an identical duplicate copy of DNA.
  - RNA polymerase makes a *complementary* RNA copy (w/ opposite bases).
- **Unlike DNA polymerase, RNA polymerase adds a U (instead of a T) as the complementary base to A.**
  - For example, if RNA polymerase encountered a 3' - A – T – G - 5' codon, it would create a 5' - U - A - C - 3' codon in the mRNA.

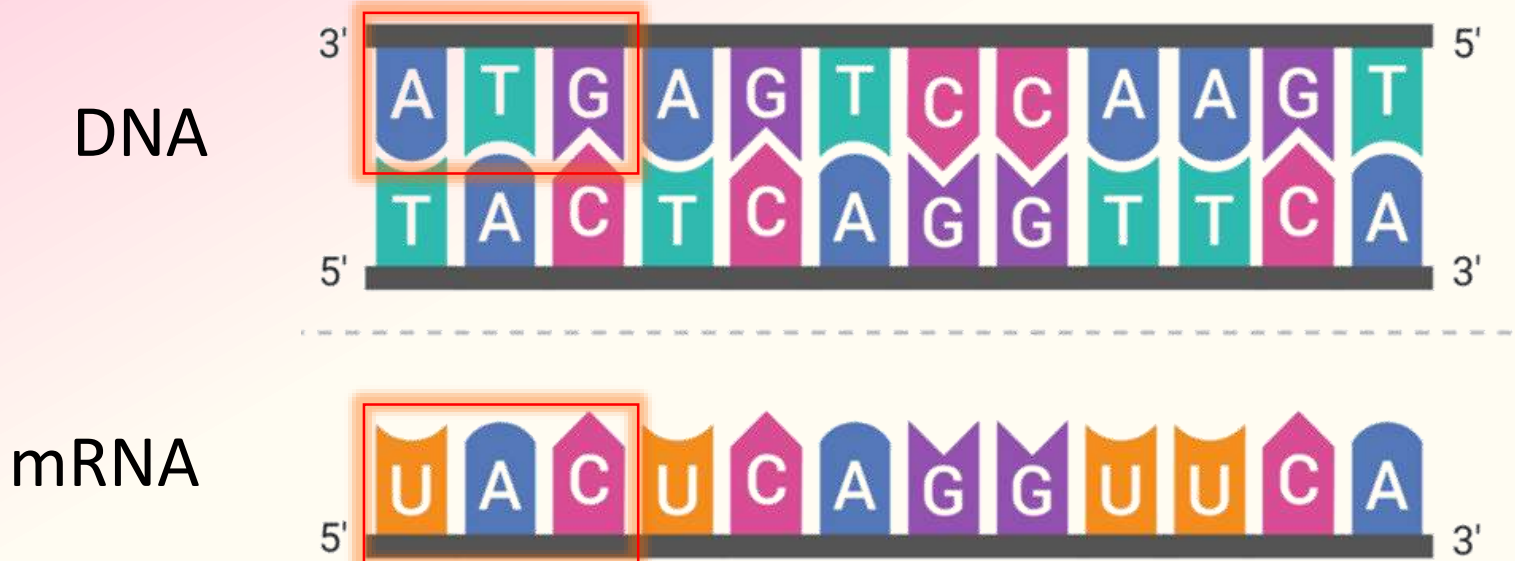


Image Source: SML

Translation

- **Next, the mRNA copy is used to assemble a protein (translation).**
  - The mRNA copy of a gene leaves the nucleus and moves to a structure called a ribosome.
- **Ribosomes (made from rRNA) are like molecular factories that assemble proteins from amino acids.**
  - The mRNA copy moves through the ribosome one codon (3 bases) at a time.
  - The mRNA indicates the order in which amino acids should be added to make a protein.
  - tRNA delivers amino acids to the ribosome to make proteins.

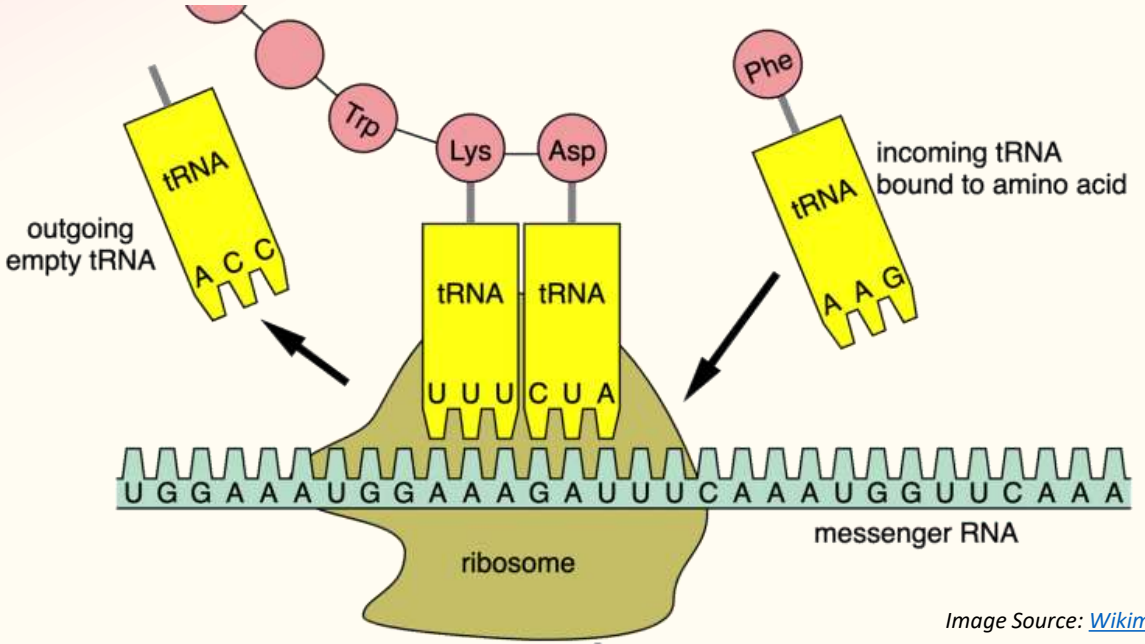
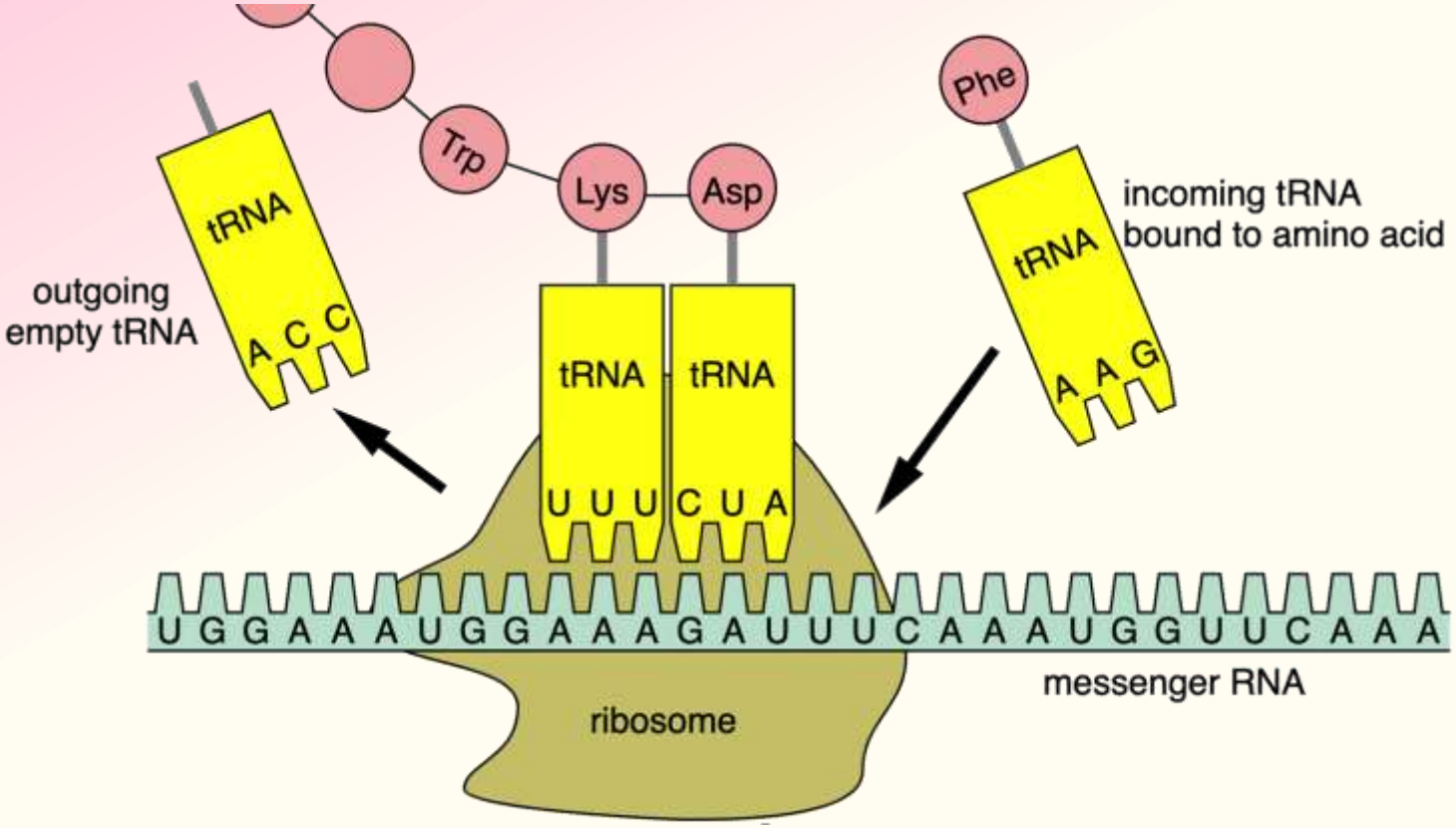


Image Source: Wikimedia

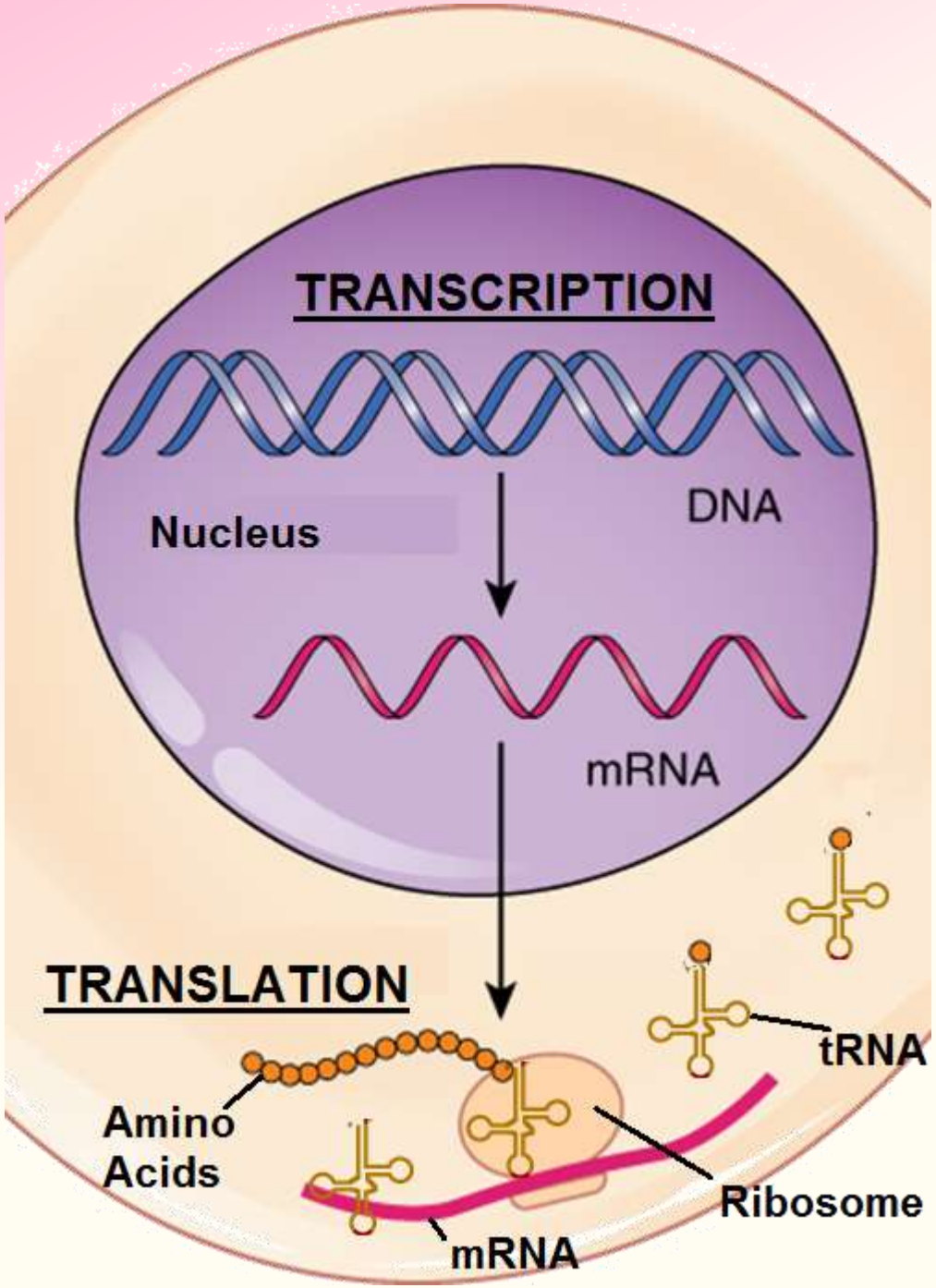
tRNA & Amino Acids

- **tRNA delivers amino acids to the ribosome based on the codons in mRNA.**
  - Once a tRNA attaches to a complementary mRNA codon, it releases its amino acid.
- **For example, if the first mRNA codon was AUG, the complementary tRNA codon would be UAC.**
  - When tRNA attaches to mRNA, it adds its amino acid to the growing protein.
  - The amino acid chain will increase in length as the mRNA moves through the ribosome.



Summary

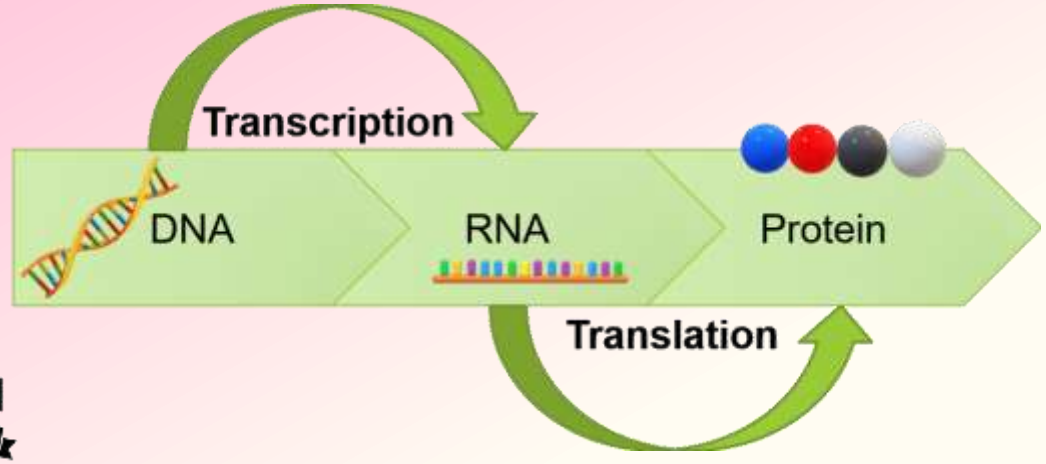
- **Transcription is when an mRNA copy of DNA is made in the nucleus by RNA polymerase.**
- **Translation is when tRNA delivers amino acids to the ribosome based on the information in mRNA to assemble a specific protein.**
- **Once assembled, the protein will leave the ribosome to perform its specific function.**



Source: oerpub.github.io

Baking Analogy

- **Transcription and translation are sort of like making a recipe.**
  - *Transcription* is like the process of making a copy of the family recipe that you want (to avoid damage to the original cookbook, you must make a copy).
  - *Translation* is like the process of using the recipe to combine the needed ingredients in the correct order and quantities.



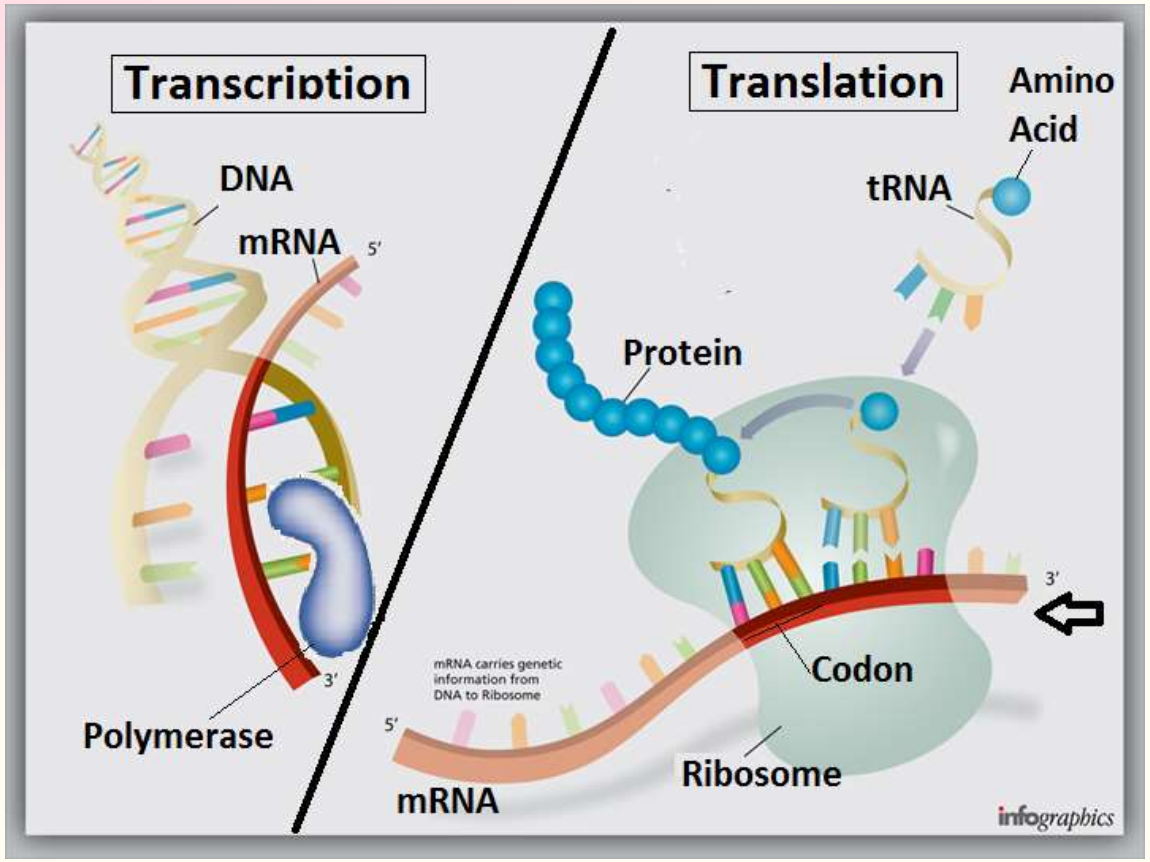
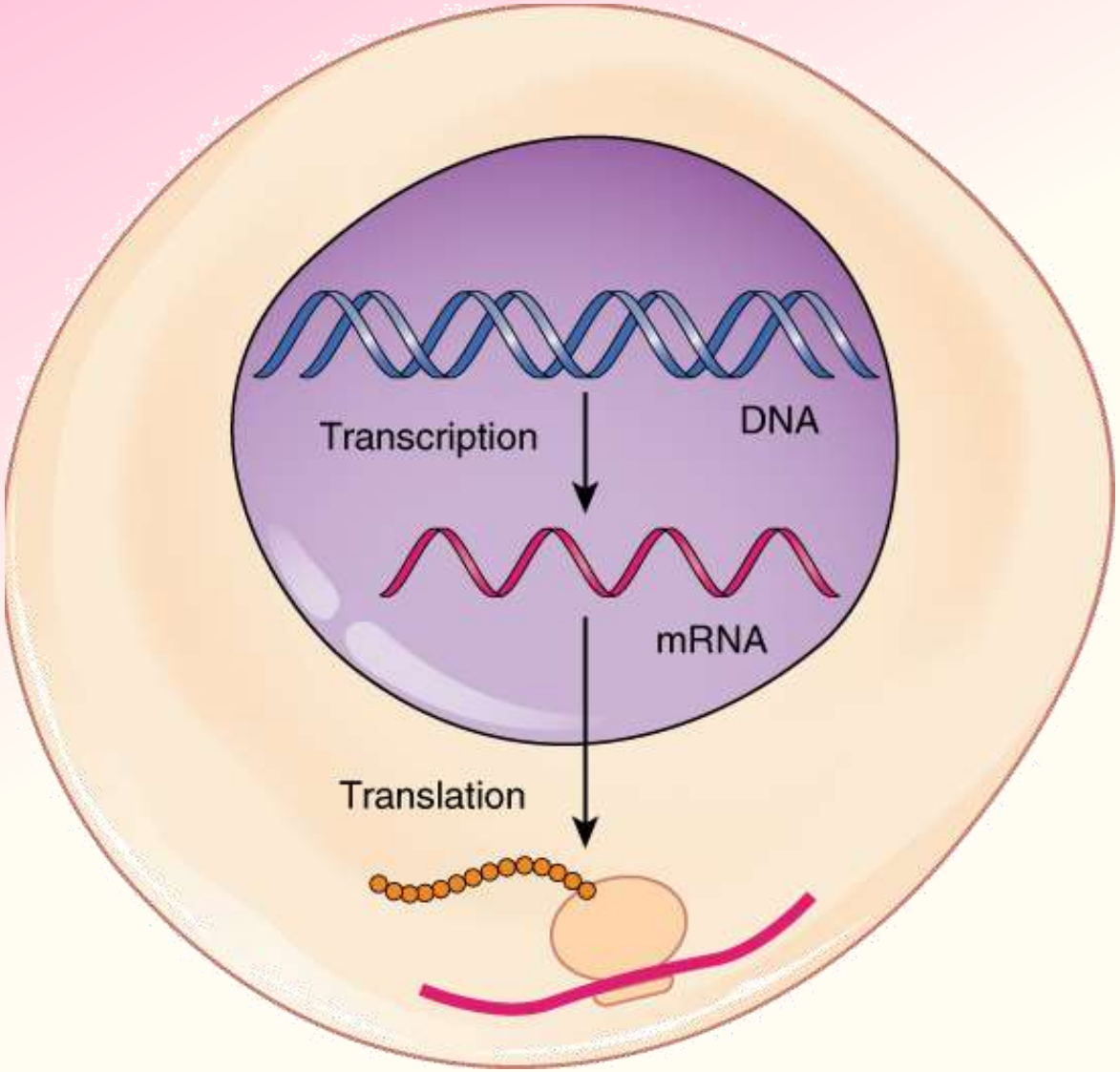


Image Source: Wikimedia

Source: http://www.ignyc.com/wp-content/uploads/2012/11/transcription-translation.png

Revising Our Claims

- **Revisit your ideas from Part 1. How could you improve your responses to our Driving Questions?**
- **How does DNA affect protein assembly?**
- How is the information in DNA used to assemble amino acids?
- How does a cell “know” how to interpret the information stored within DNA?
- What is RNA and how is it both similar and different from DNA?



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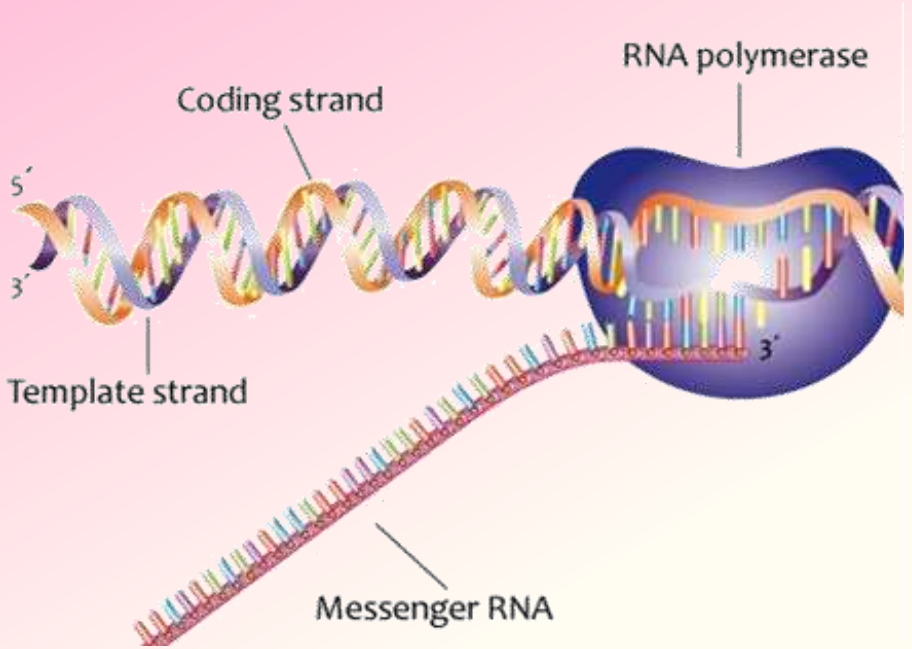
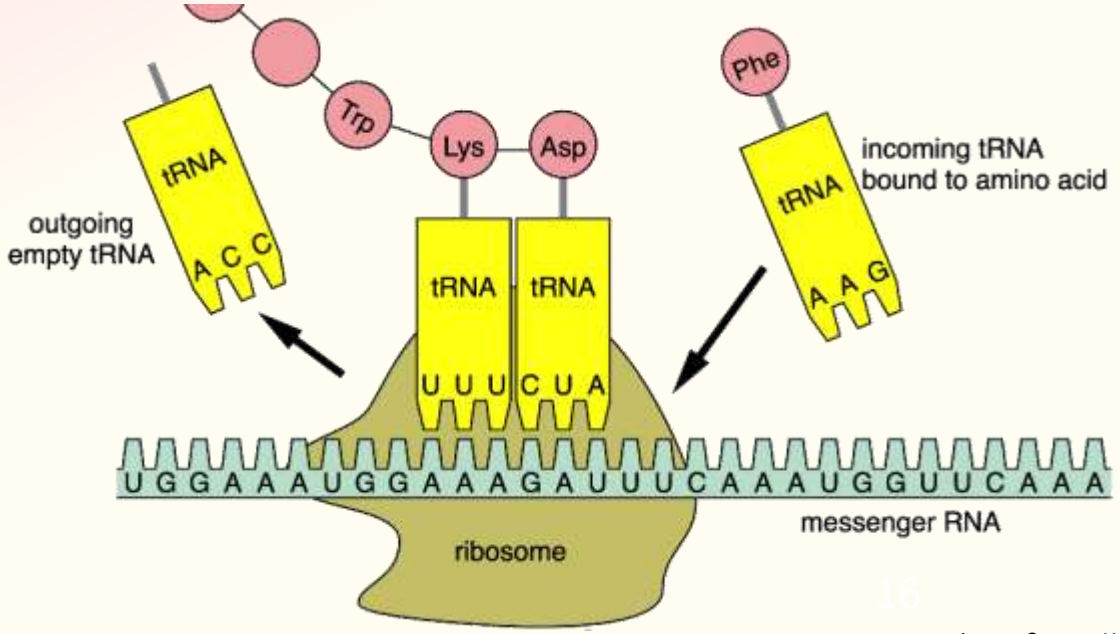
Looking Ahead: Part 3 Investigation

- **In Part 3 you will start by using a metaphorical story to explain how transcription and translation function. You will then use 2D or 3D models to demonstrate your comprehension.**





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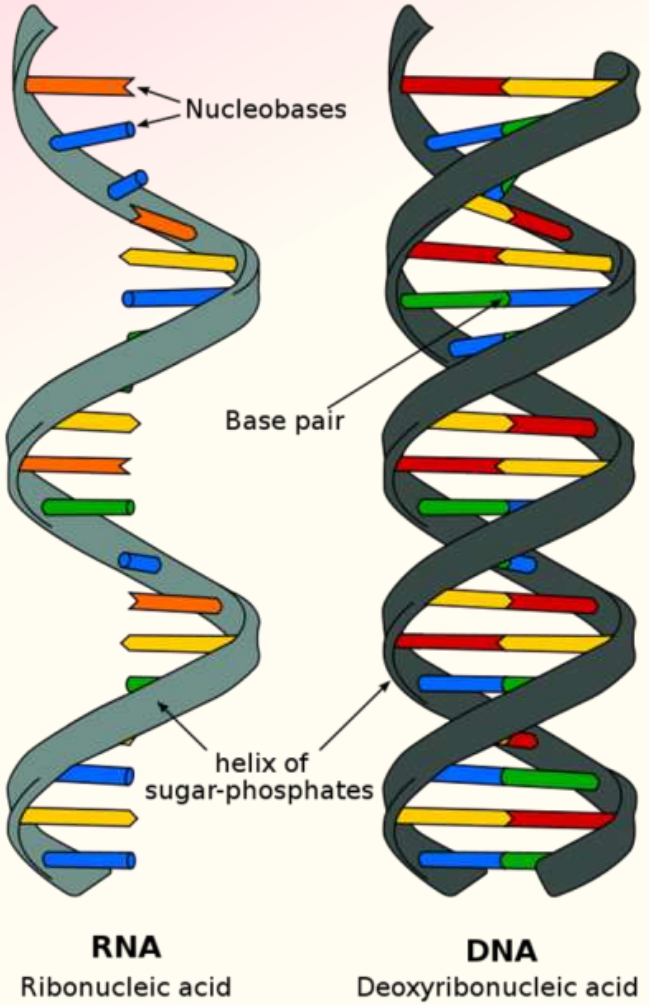
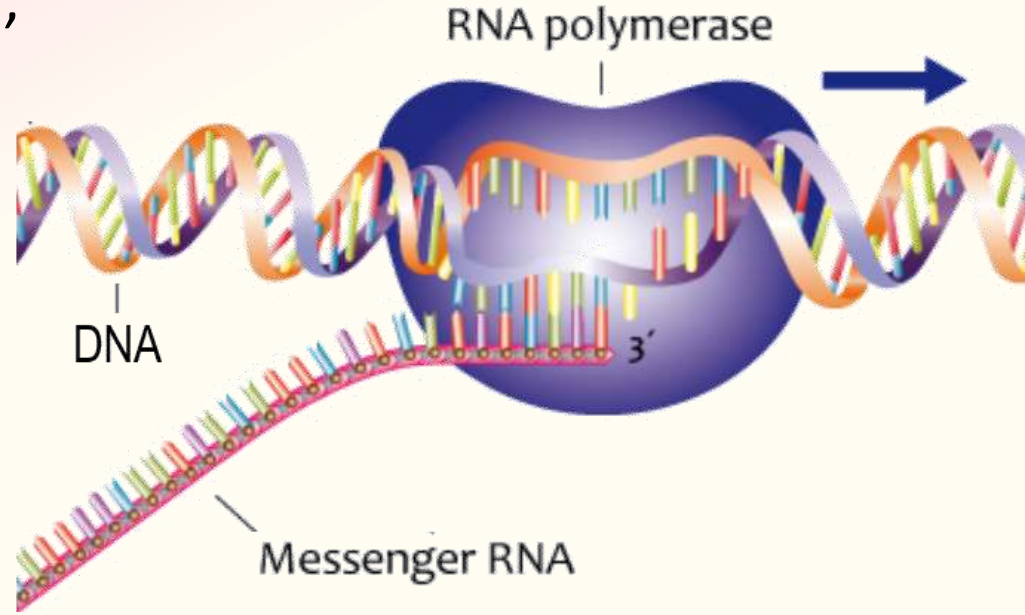
Key Points

- **A molecule called RNA serves as a link between the information stored in DNA and the assembly of proteins.**
- **Unlike DNA, RNA is 1) single stranded, 2) has a different sugar molecule, and 3) uses U instead of T.**
- **To get from information stored in DNA to the production of a protein, RNA is involved in two key processes: transcription and translation.**
  - Transcription produces an RNA copy of DNA known as mRNA (short for messenger RNA).
  - Translation is the actual assembly of a protein using the mRNA copy.



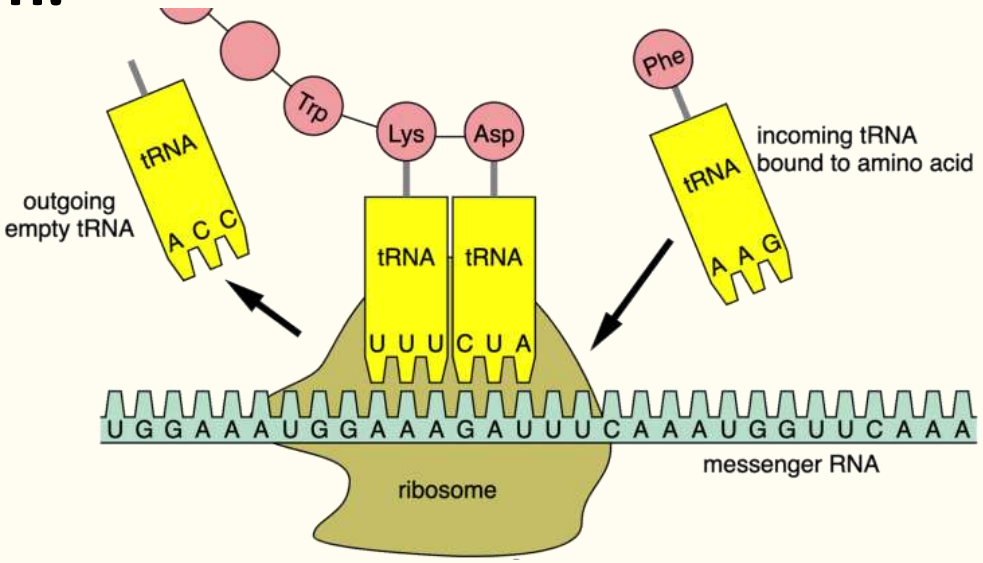
Key Points

- **<u>RNA polymerase</u> is the enzyme that creates the mRNA copy. Transcription begins when mRNA attaches to the needed gene.**
- **RNA polymerase creates the mRNA copy of DNA.**
  - If a DNA codon was: 3’ - G - C - T - 5’,
    RNA polymerase would create: 5’ - C - G - A - 3’
- **RNA polymerase adds a U (instead of a T) as the complementary base to A.**
  - E.g., a ATG in DNA becomes UAC in mRNA.



Key Points

- **Translation occurs when protein is assembled from amino acids based on the information in mRNA.**
- **Ribosomes (made from rRNA) function like molecular factories that assemble proteins from amino acids.**
- **As mRNA moves through the ribosome, tRNA delivers amino acids to the ribosome based on each mRNA codon.**
  - tRNA delivers amino acids to the ribosome based on the codons in mRNA.
- **Once assembled, the protein will leave the ribosome to perform its specific function.**



Key Terms

- **RNA: a single-stranded macromolecule made from nucleotides that serves as a link between the information stored in DNA and the assembly of proteins.**
- **Transcription is the process of producing a mRNA copy of a gene in the DNA.**
- **Translation is the actual assembly of a protein using the mRNA copy.**
- **mRNA: short for messenger RNA; acts as a copy of a gene and delivers information needed for protein assembly to a ribosome.**
- **RNA polymerase: the enzyme that creates the mRNA copy.**
- **Ribosomes: molecular structures that assemble proteins from amino acids; made from ribosomal RNA (rRNA).**
- **tRNA: delivers amino acids to the ribosome based on info in mRNA.**