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• The SPO Virtual Classrooms offer many educational resources, including practice test questions, review questions, lecture PowerPoints, video tutorials, sample assignments and course syllabi. New materials are continually being developed, so check back frequently, or follow us on Facebook (Science Prof Online) or Twitter (ScienceProfSPO) for updates.

• Many SPO PowerPoints are available in a variety of formats, such as fully editable PowerPoint files, as well as uneditable versions in smaller file sizes, such as PowerPoint Shows and Portable Document Format (.pdf), for ease of printing.

• Images used on this resource, and on the SPO website are, wherever possible, credited and linked to their source. Any words underlined and appearing in blue are links that can be clicked on for more information. PowerPoints must be viewed in *slide show mode* to use the hyperlinks directly.

• Several helpful links to fun and interactive learning tools are included throughout the PPT and on the Smart Links slide, near the end of each presentation. You must be in *slide show mode* to utilize hyperlinks and animations.

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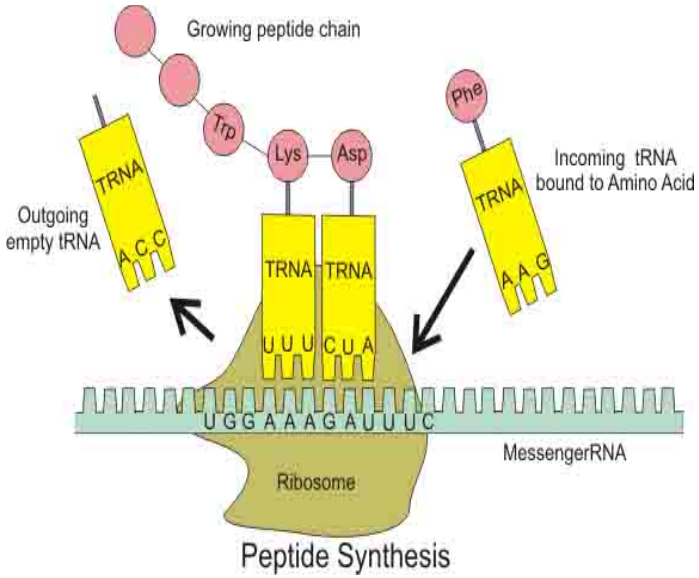
Image: Compound microscope objectives, T. Port

Molecular Genetics Basics



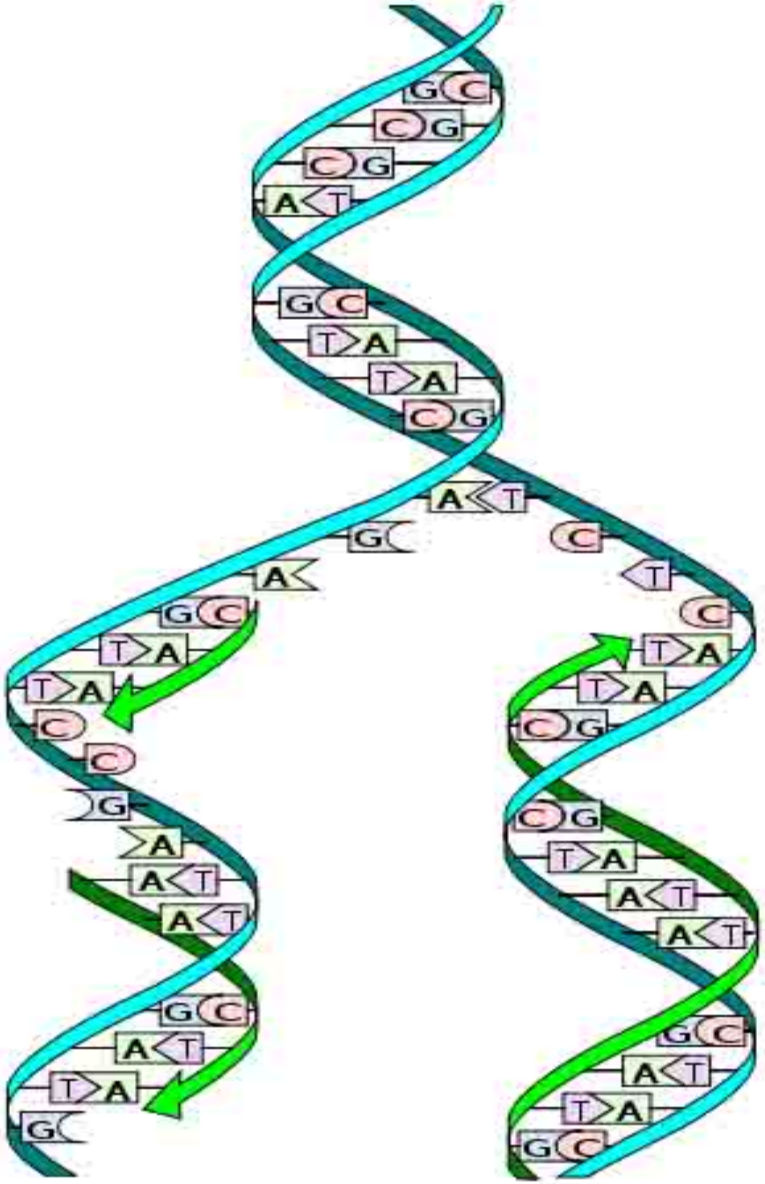


Image: Peptide Synthesis Diagram: Boumphreyfr, Wiki;
Replication Diagram: Madprime, Wiki

Prokaryotic Genomes

- Made of DNA
- Chromosomes can be circular or linear
- Genome floats freely within cytoplasm
- **Q:** Where is DNA found in prokaryotes?
  - _____
  - _____

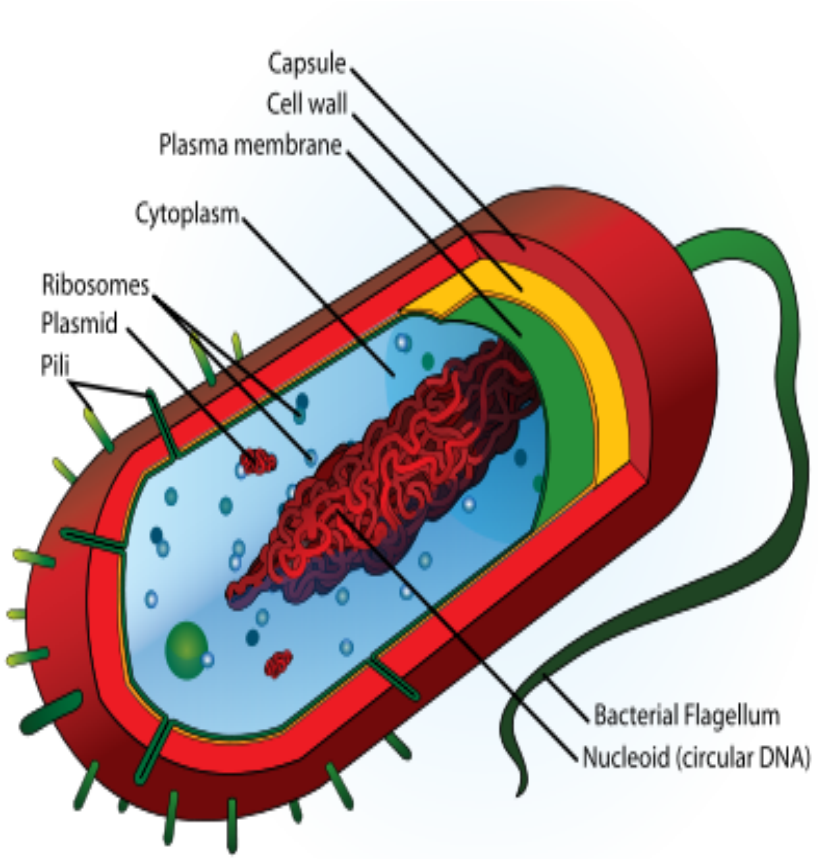


Image: Prokaryotic Cell Diagram: Mariana Ruiz

Eukaryotic Genomes

- Genomes of eukaryotic organisms made of DNA.

- Eukaryotic genomes frequently include many linear chromosomes within a membrane-bound nucleus

  (**Q**: How many do we have?).

- Where is DNA found in eukaryotes?
  - Nuclear DNA
  - Extranuclear DNA

    (**Q**: What is extranuclear DNA?)

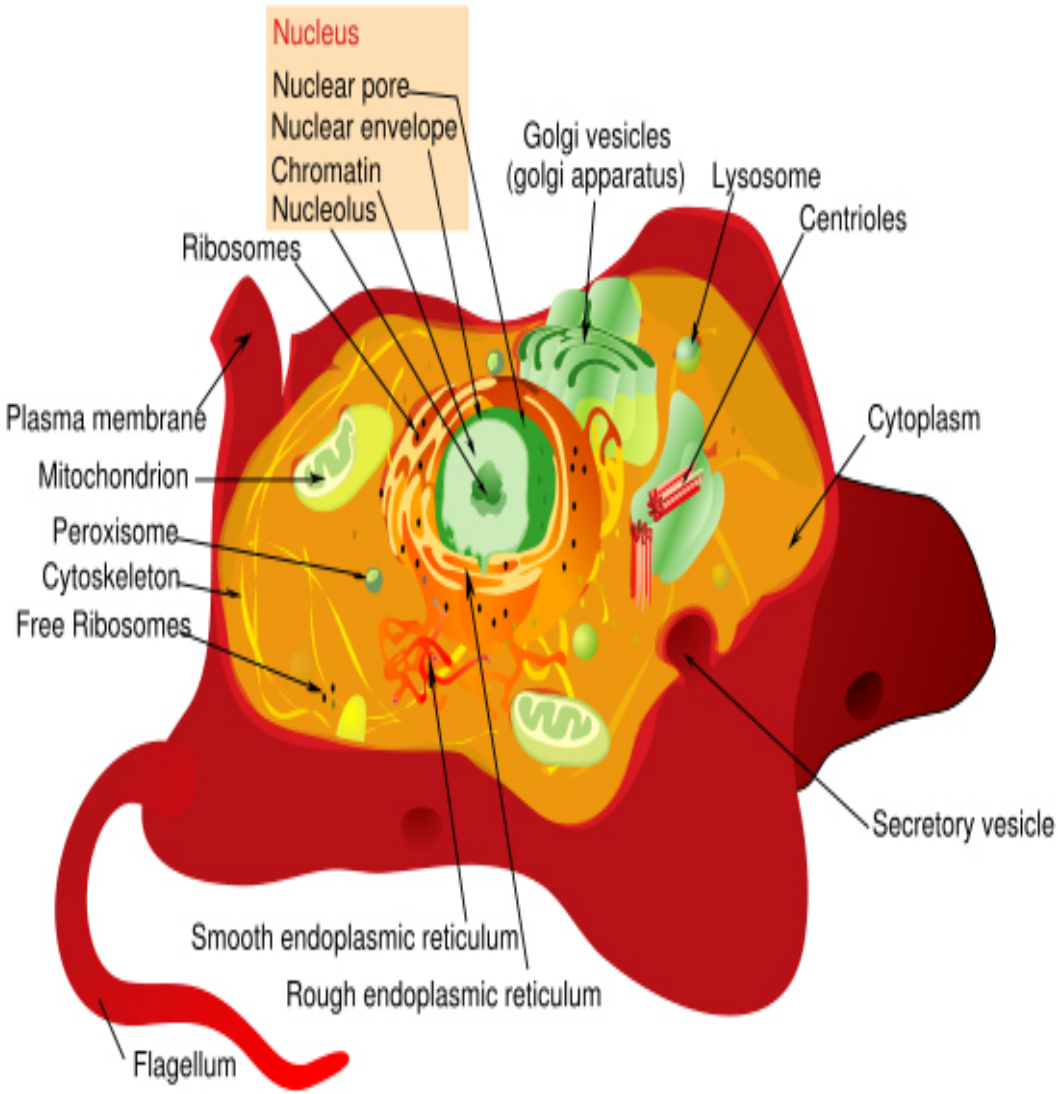


Image: Eukaryotic Cell Diagram, Mariana Ruiz

Chromosomes & Genes

- **Genome** - Complete complement of an organism's DNA.
- Cellular DNA is organized in **chromosomes**.
- **Genes** have specific places on chromosomes.

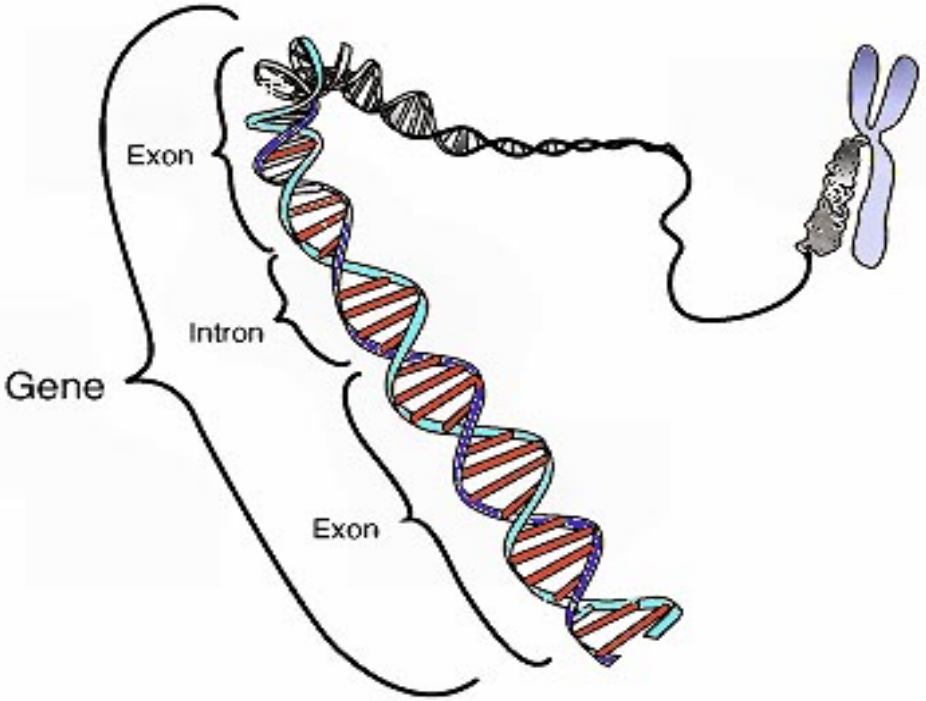


Image: Chromosome & gene, Graham Colm, National Human Genome Research Institute

Nucleotides and Nucleic Acids

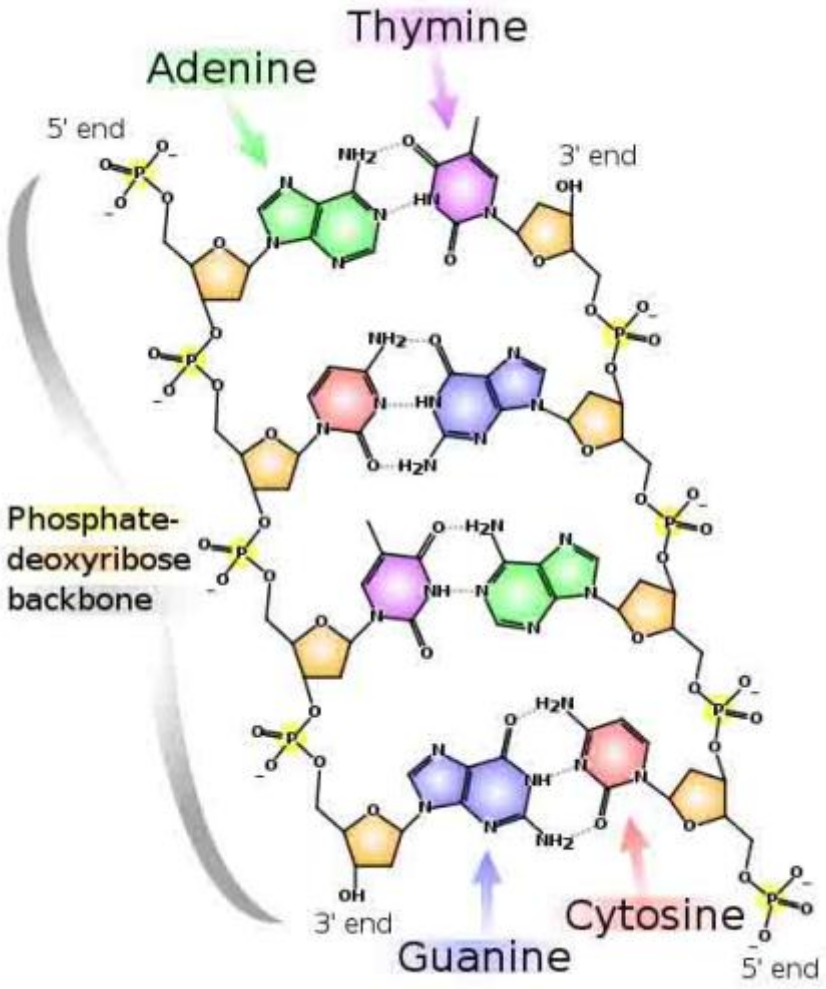


Image: DNA Detail Diagram: Madprime

Nucleic Acids

Q: What type of monomer are nucleic acids made of?

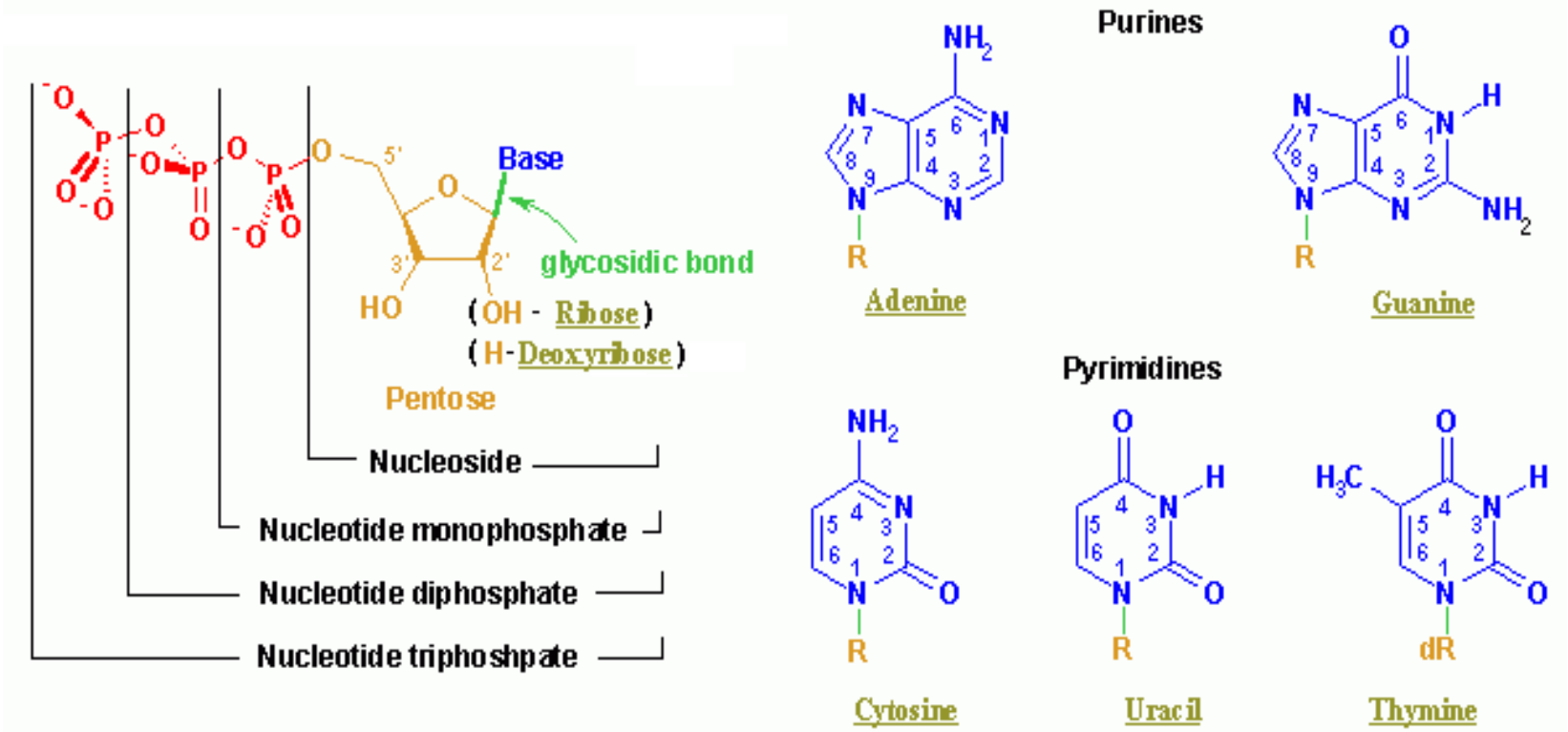


Image: Nucleotide Structure, Wikipedia

DNA Structure

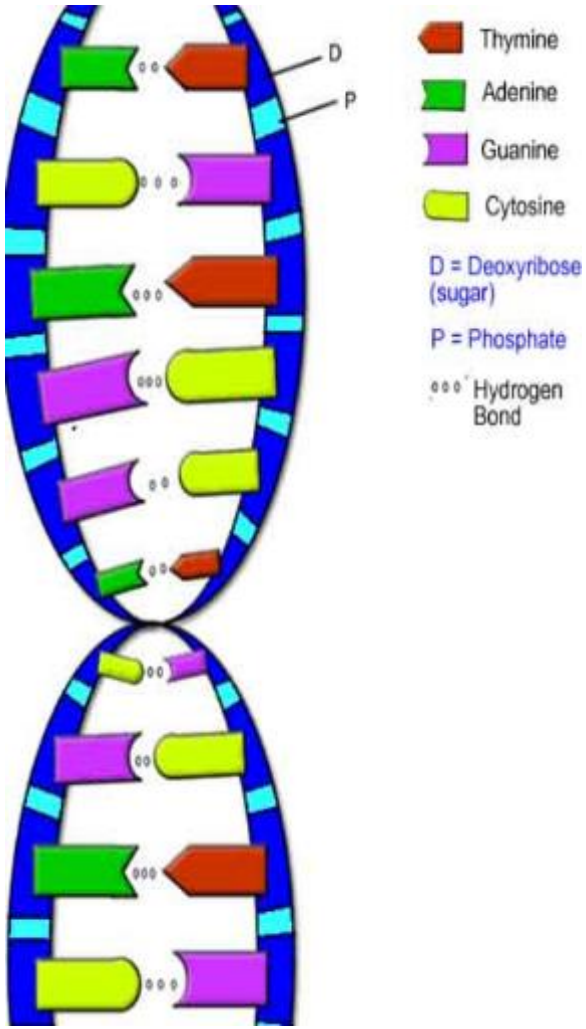
- Double stranded molecule, analogous to a spiral staircase:

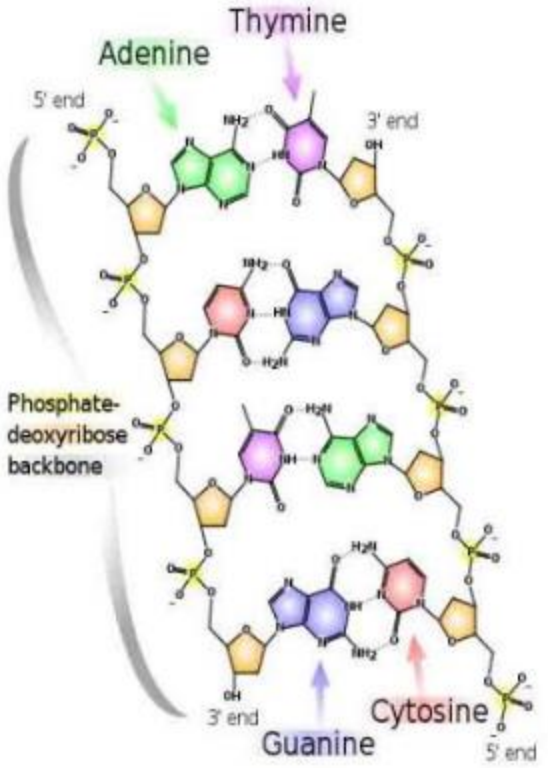
  - two deoxyribose-phosphate chains as the "**side rails**"

  - base pairs, linked by hydrogen bonds, are the "**steps**"

- **Purine Bases**
  (double ring)
  Adenine & Guanine

- **Pyrimidine Bases**
  (single ring)
  Cytosine & Thymine





Images: Model of DNA Molecule, Field Museum, Chicago, T. Port; DNA Detail Diagram: Madprime; DNA Molecule, Biology Corner

DNA molecule

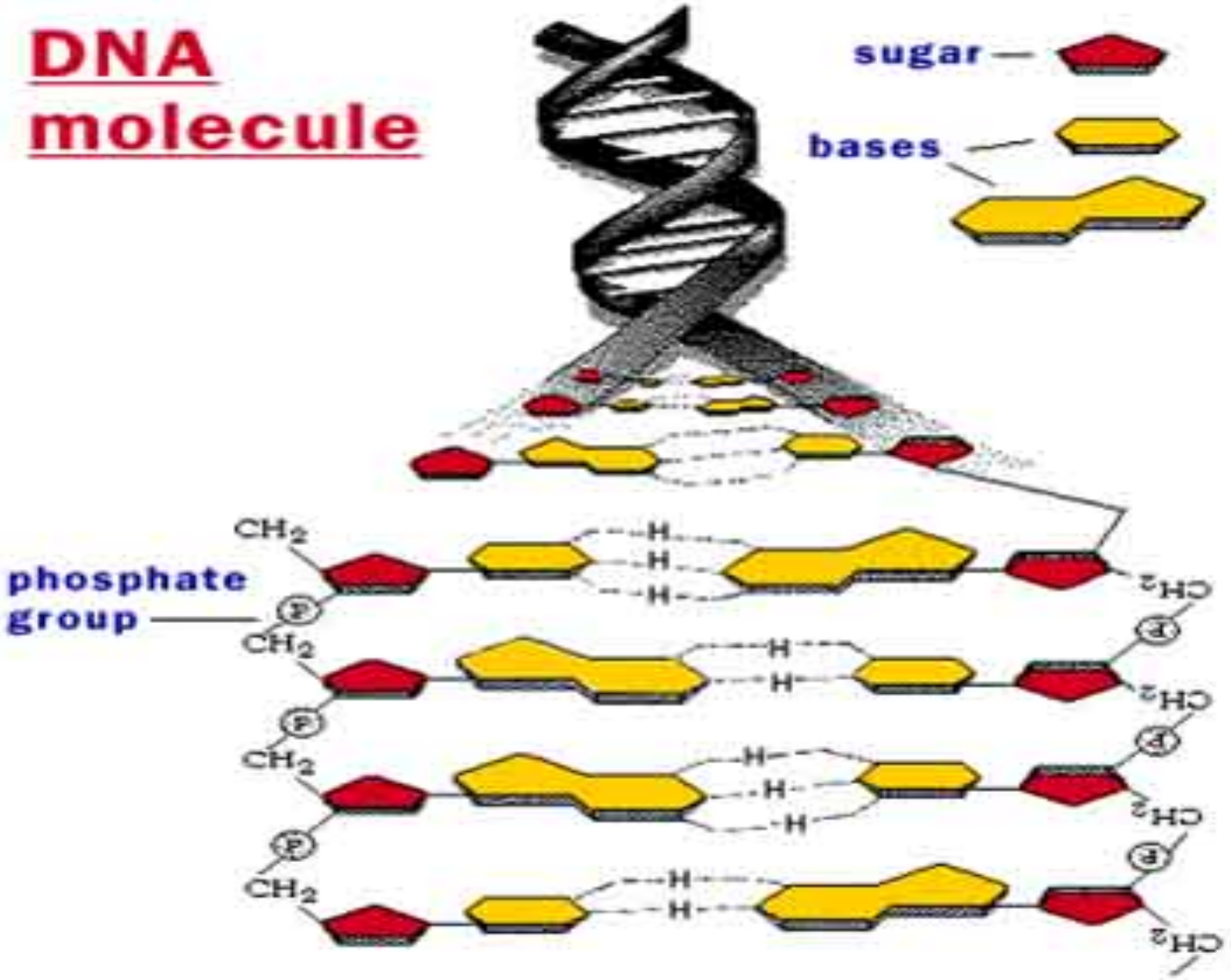


Image: DNA molecule, Why Files, NSF

DNA Replication

- **Copying** of a double-stranded DNA molecule.
- Each DNA strand holds the same genetic information, so each strand can serve as a template for the new, opposite strand.
- The **parent** (a.k.a. _____) strand is preserved and the **daughter** (a.k.a. _____) strand is assembled from nucleotides.
- This is called **semi-conservative** replication.
- Resulting double-stranded DNA molecules are identical.
- **Q: Why would a cell need to copy its DNA?**

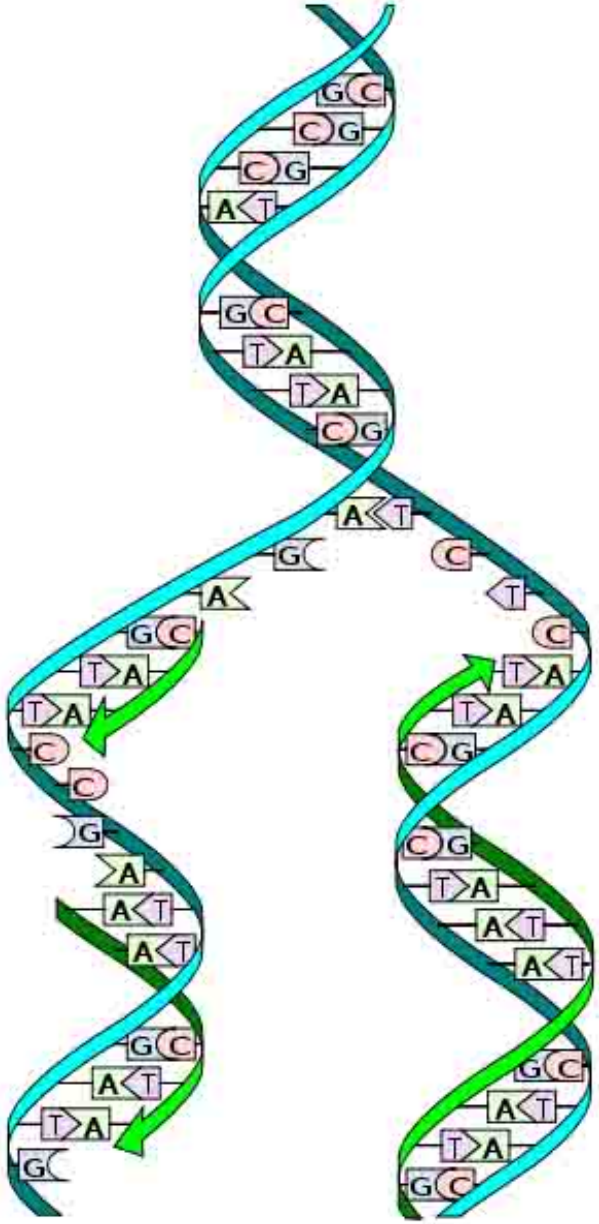
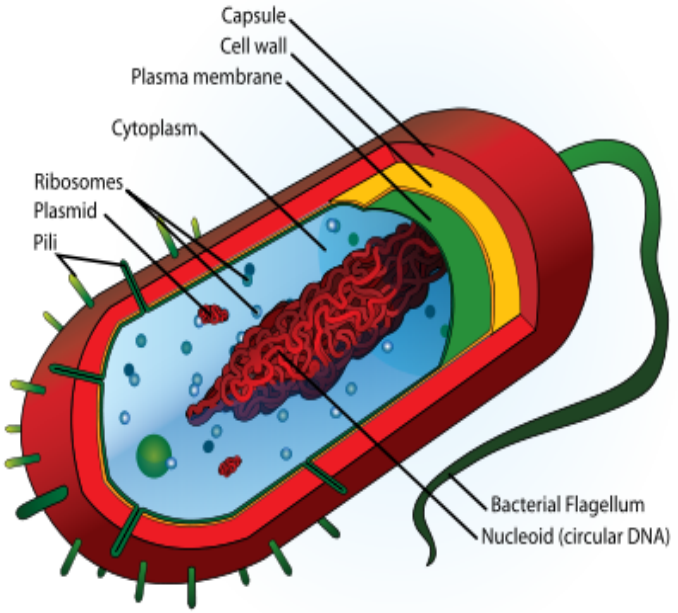


Image: Replication Diagram: Madprime, Wiki

DNA Replication

In a cell, DNA replication must happen before cell division.

- **Prokaryotes** replicate their DNA throughout the interval between cell divisions.
- In **eukaryotes**, timing of replication is highly regulated.



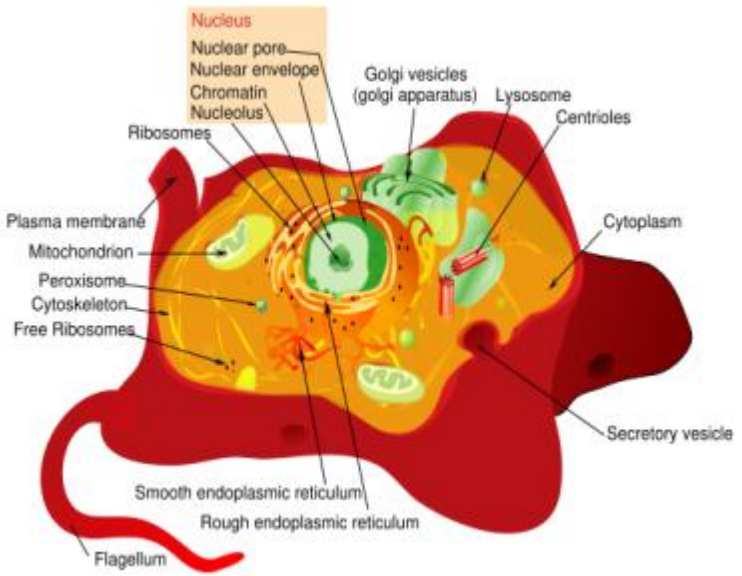
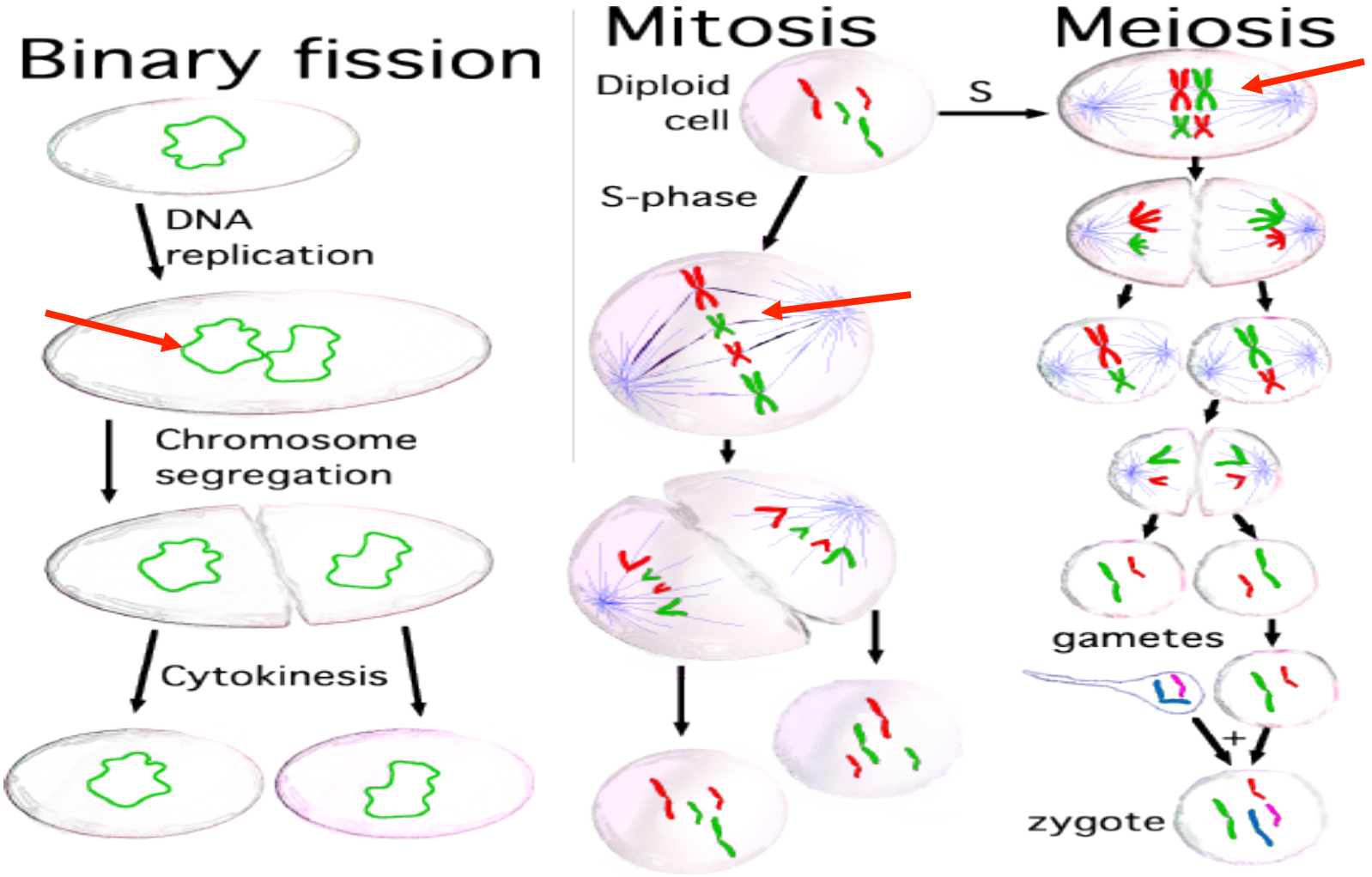


Image: Prokaryotic Cell Diagram & Eukaryotic Cell Diagram, Mariana Ruiz

DNA Replication



From the Virtual Biology Classroom on ScienceProfOnline.com

Image: Types of Cell Division, Saperaud Wiki

Reminder…Why is the DNA copied?

Replication occurs prior to cell division, because the new, daughter cell will also need a complete copy of cellular DNA.

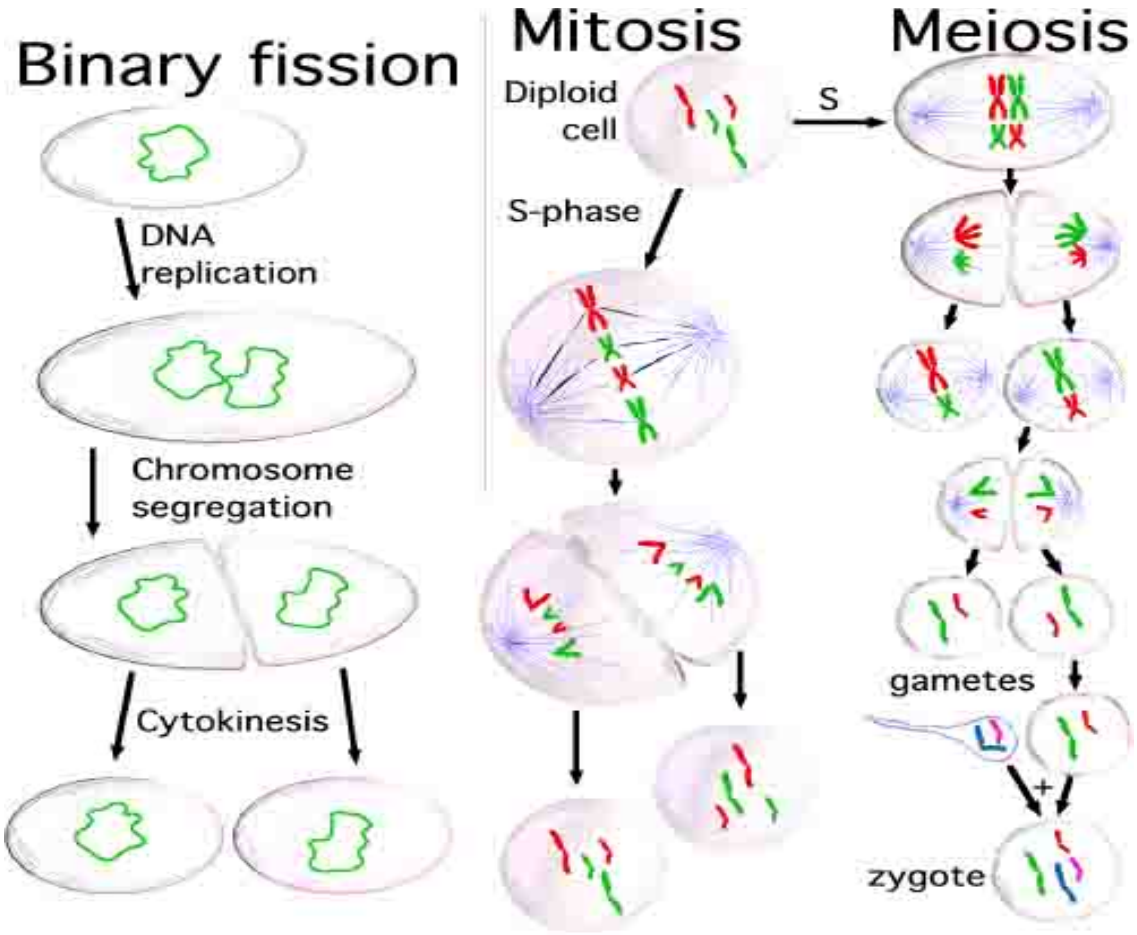


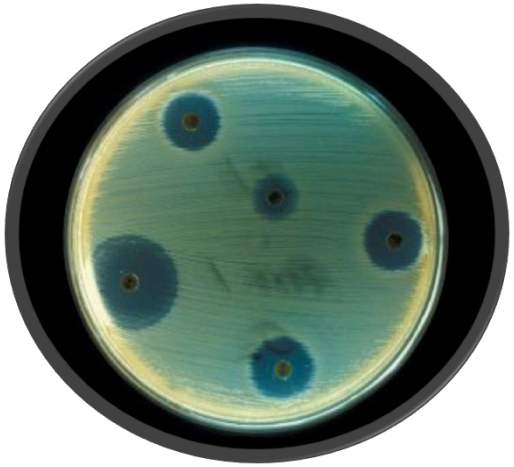
Image: Types of Cell Division, Saperaud Wiki

Replication Mistakes: Mutations of Genes

- Change in the nucleotide base sequence of a genome; rare.
- **The problem:** Wrong amino acid may result a non-functional Protein due to improper folding
- Almost always bad news, but...
- Rarely leads to a protein having a novel property that improves ability of organism and its descendants to survive and reproduce.

Images: Blinky & Bart, Matt Groening

Mutation and Bacterial Change



- _____ _____= **When a microorganism is able to survive exposure to an antibiotic.**
- Genetic mutation in bacteria can produce resistance to antimicrobial drugs (example: beta-lactamase).
- If those genes are on a plasmid, they can be transferred between bacteria by conjugation and other forms of horizontal gene transfer.
- If a bacterium carries several resistance genes, it is called multidrug resistant (MDR) or, informally, a superbug or super bacterium.
- Any use of antibiotics can increase selective pressure in a population of bacteria to allow the resistant bacteria to thrive and the susceptible bacteria to die off.

REVIEW!
Antibiotic Resistance Animation
from Sumanas

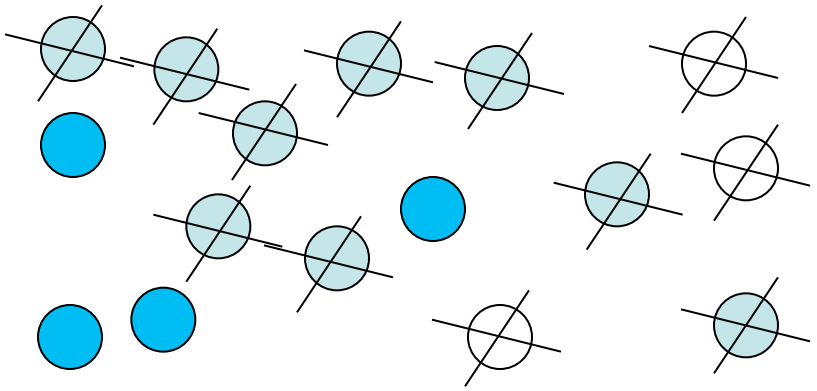


Image: ***Staphylococcus aureus* on antibiotic test plate**, **PHIL #2641**

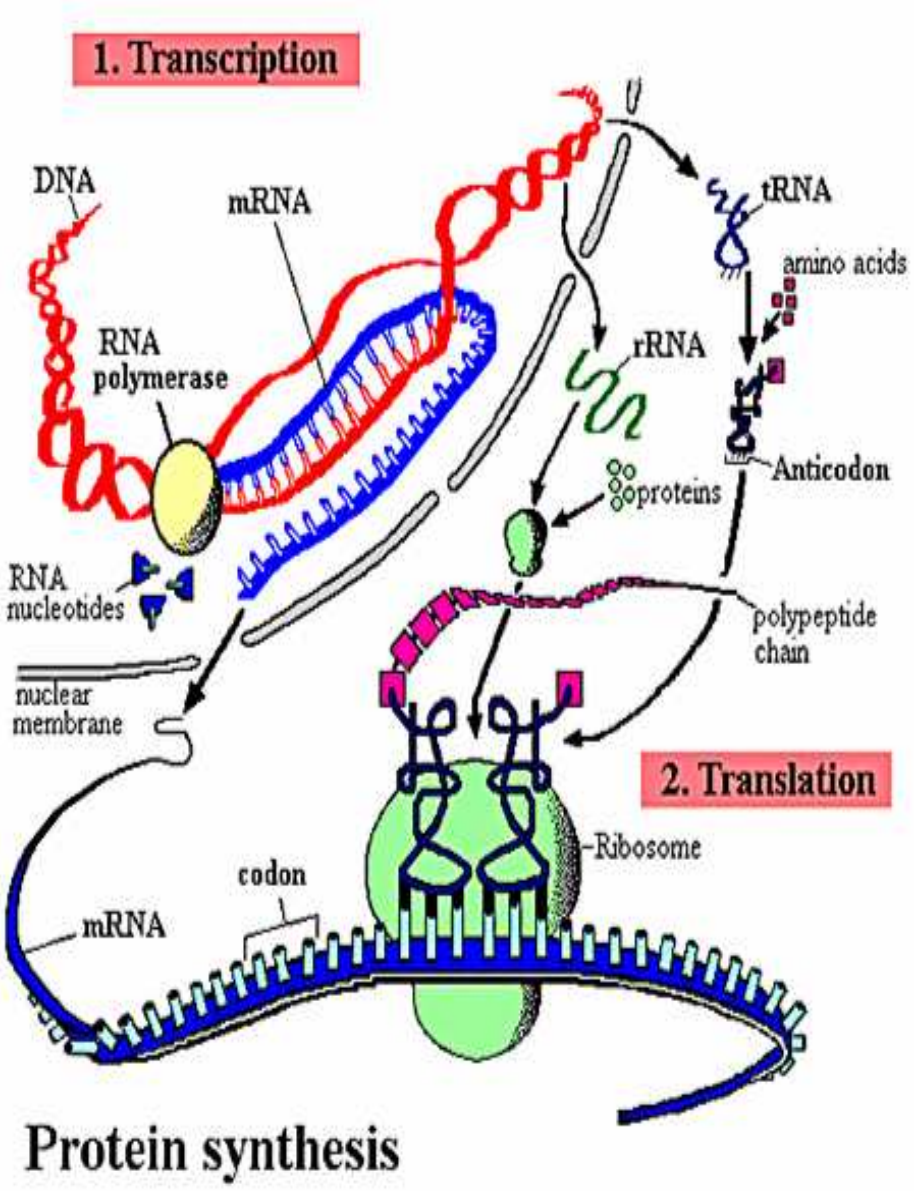
Gene Expression

Transcription

&

Translation

(Making Proteins)



Nucleic Acids: RNA Structure

RNA is typically a single-stranded molecule.

Purine Bases (double ring)
Adenine & Guanine

Pyrimidine Bases (single ring)
Cytosine & _____

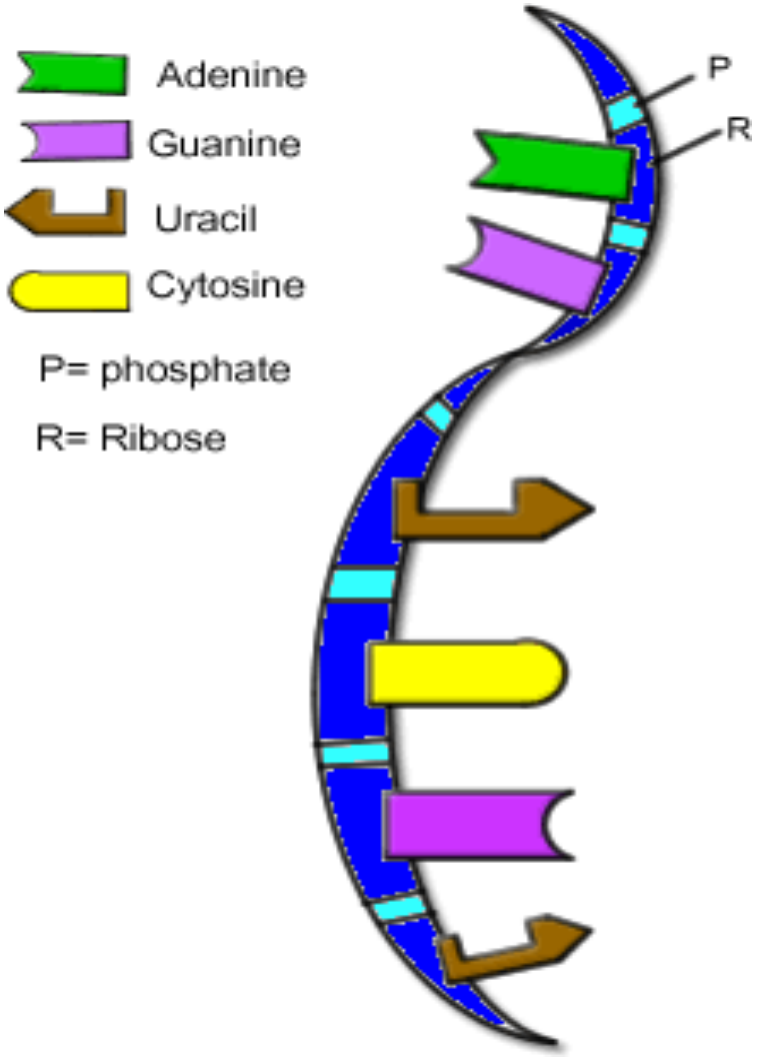
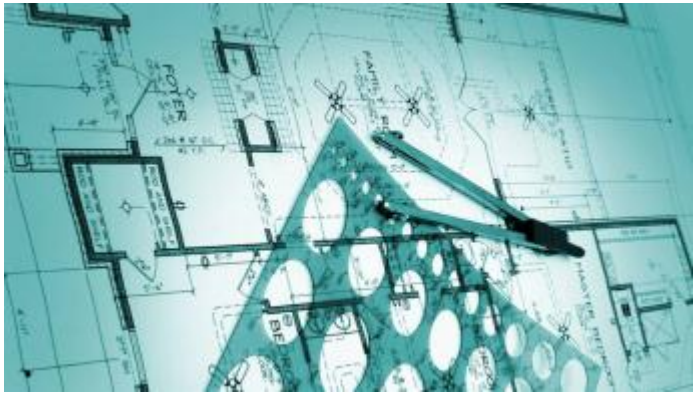


Image: RNA, Biology Corner

Types of RNA

Genetic information copied from DNA is transferred to 3 types of RNA:



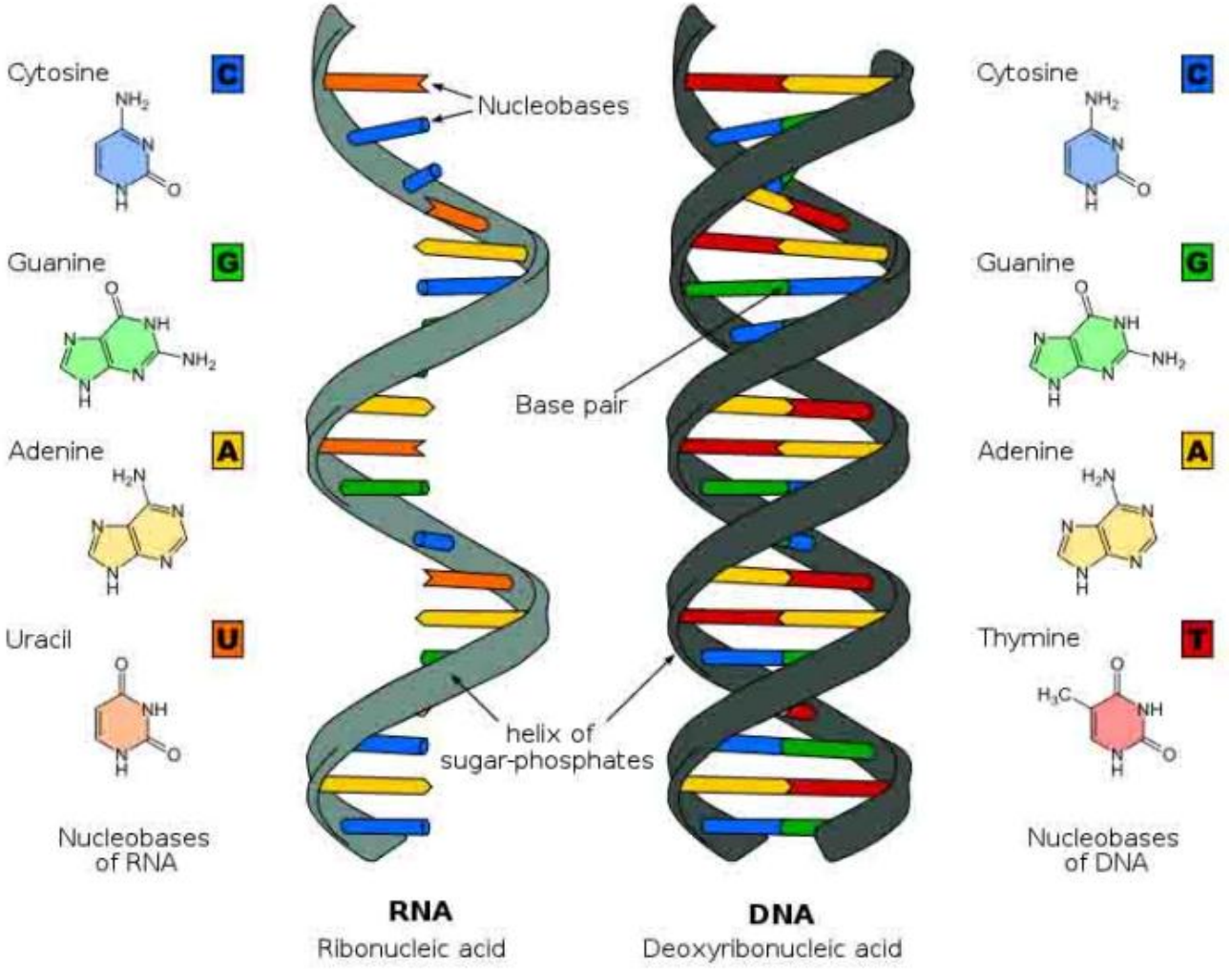
- **messenger** (mRNA) **is like a**
  Copy of information in DNA that is brought to the ribosome where the information is translated into a protein.

- **ribosomal** (rRNA) **is like a**
  The protein factories of the cells.

- **transfer** (tRNA) **are like a**
  Brings the amino acid to the ribosome.

Images: Blueprint, clipart; Factory, Andreas Praefcke; Truck, PRA; Ribosome translating protein, Xvazquez.

Nucleic Acid Structure



See SPO Class Notes article on [Nucleotides & Nucleic Acids](#).

Image: Comparison of DNA & RNA, Wiki Commons

Transcription

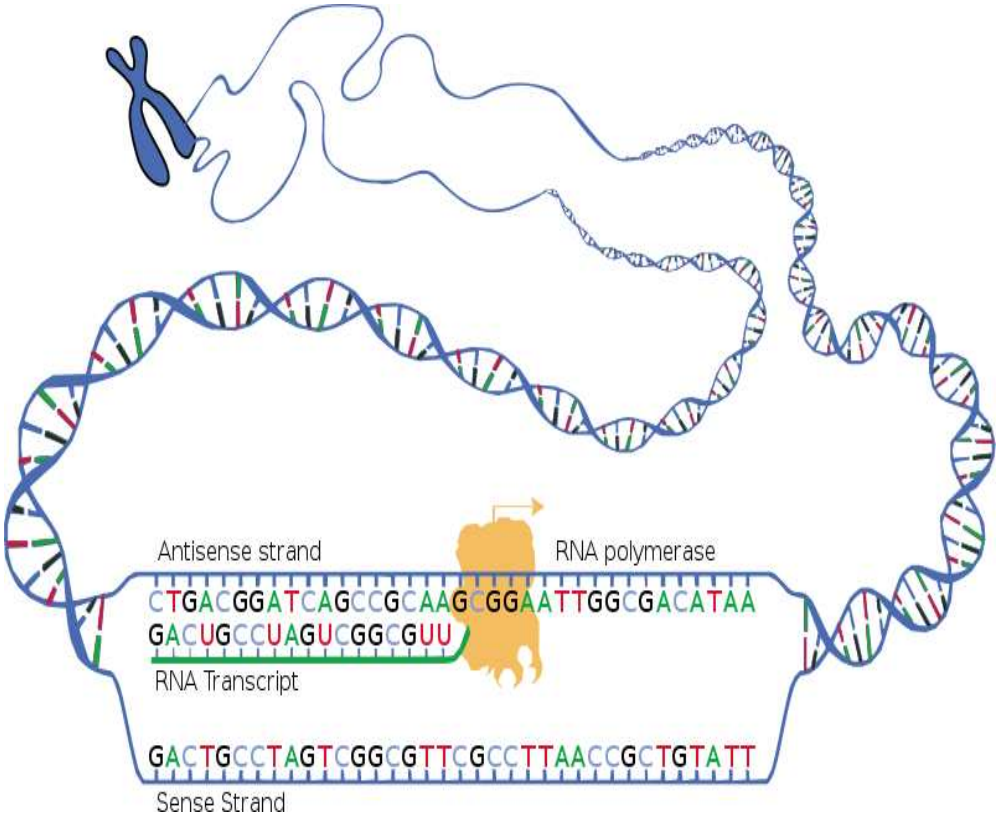
First Step of gene expression.

Process by which a DNA sequence is copied to produce a complementary mRNA strand.

In other words, it is the transfer of genetic information from DNA into RNA.

Like replication, but making RNA.

Beginning of the process that ultimately leads to the translation of the genetic code (via mRNA) into a protein.



REVIEW

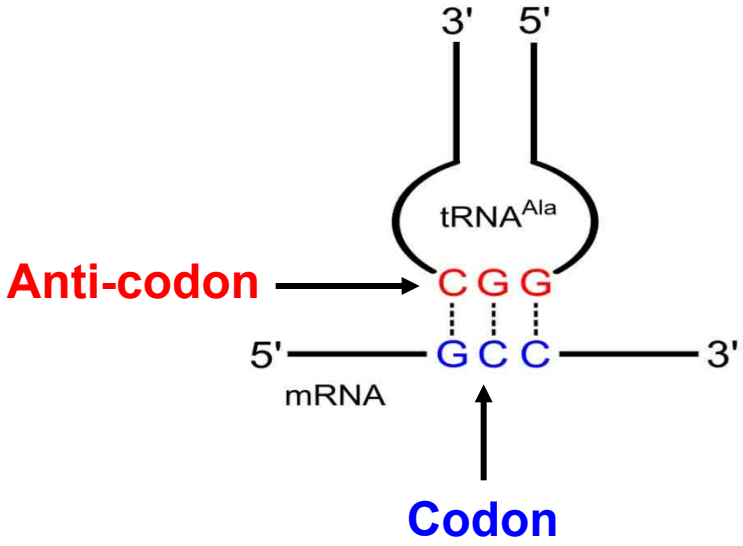
Transcription Animations

1. mRNA Synthesis from McGraw-Hill
2. Transcription from WH Freeman

Image: Transcription, National Human Genome Research Institute.

Translation

- Second Step of gene expression.
- Ribosomes *(which contain rRNA)* make proteins from the messages encoded in mRNA.
- The genetic instructions for a polypeptide chain are 'written' in the DNA as a series of 3-nucleotide 'words.'
- _____ on mRNA
- _____ on tRNA
- 'U' (uracil) replaces 'T' in RNA
- This is the **genetic code**.



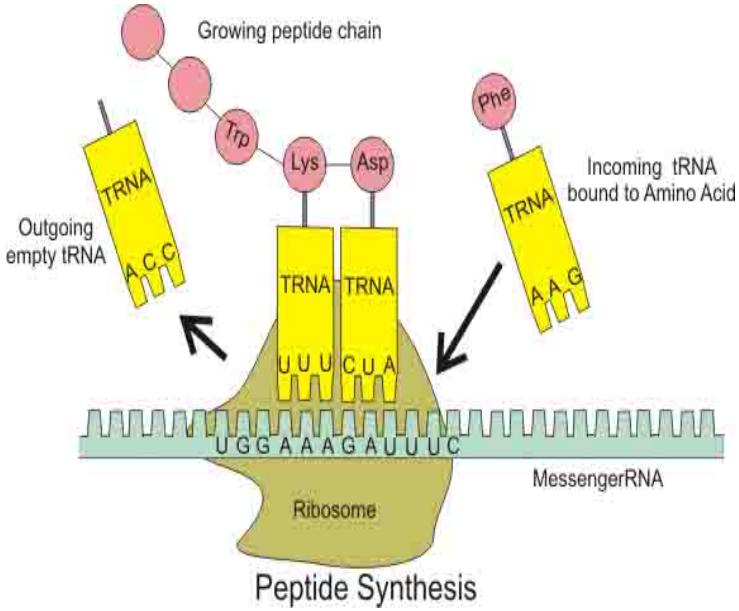
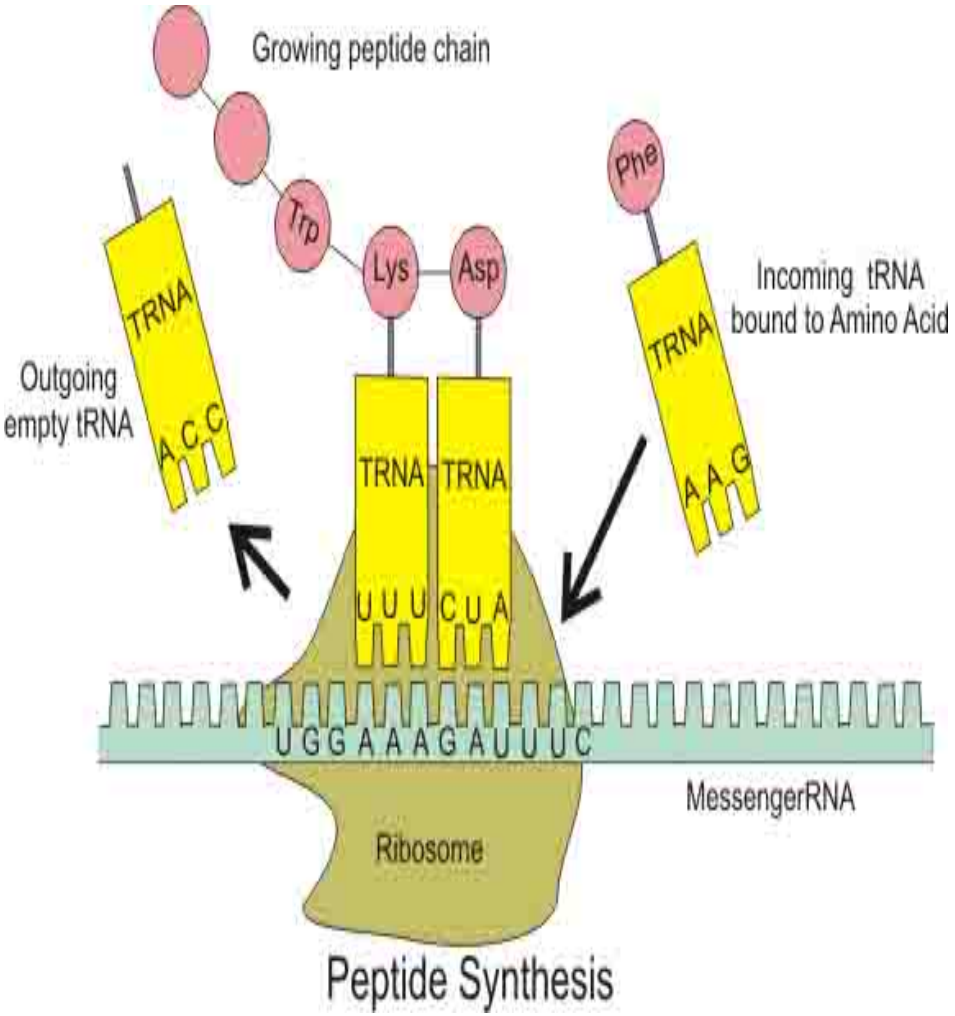


Image: Codon-Anticodon pairing, Yikrazuul, Wiki; Peptide Synthesis Diagram: Boumphreyfr, Wiki.

Translation



REVIEW

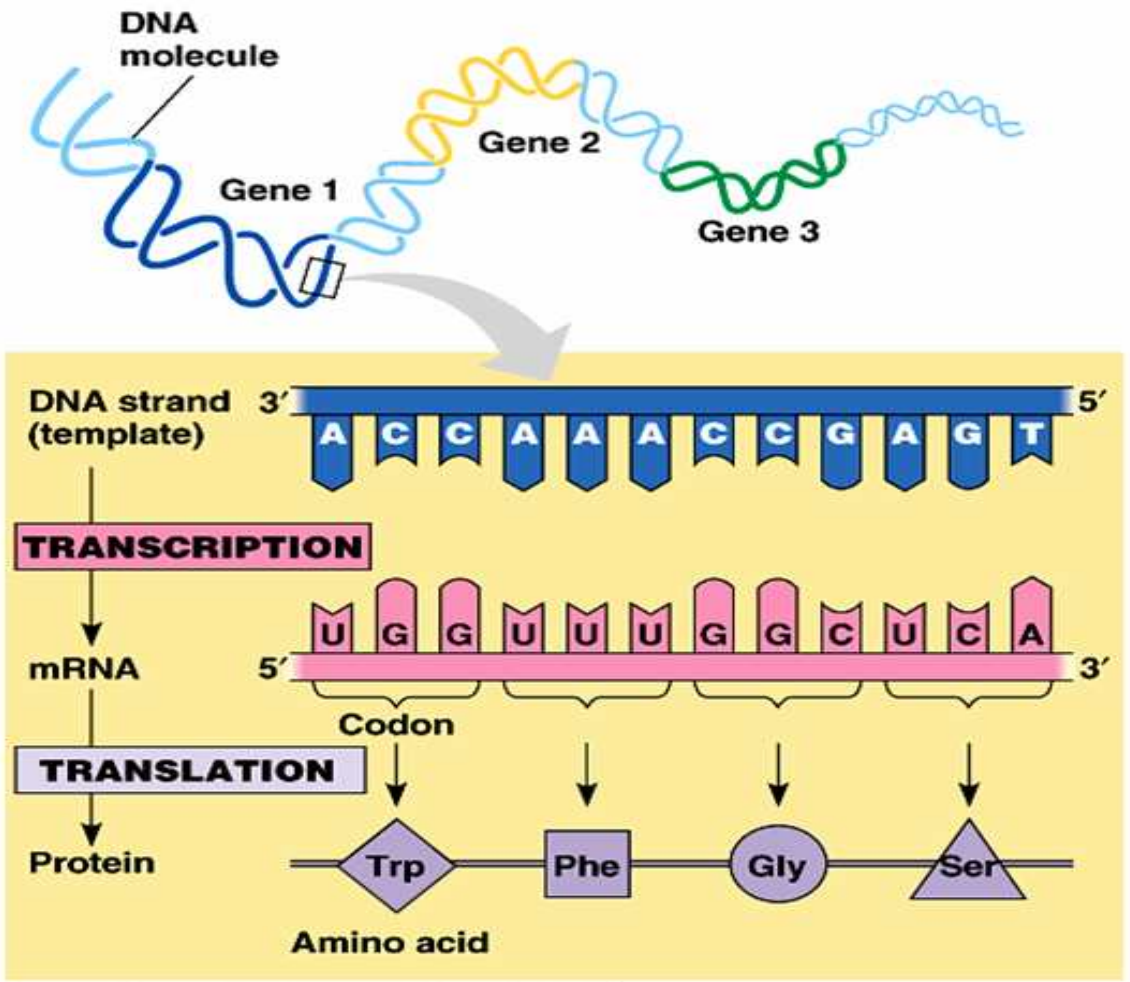
Translation Animations

1. How Translation Works
   from McGraw-Hill

2. Ribosome Building a Protein
   from Wikipedia

Image: Peptide Synthesis Diagram: Boumphreyfr, Wiki

Transcription & Translation Overview

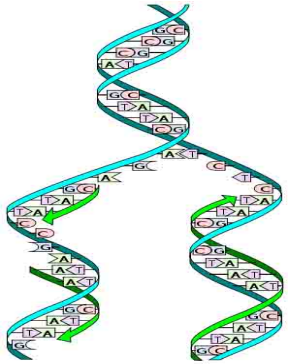


REVIEW

Interactive animation that allows you to transcribe and translate a gene!

See SPO Class Notes article on
DNA Function: Transcription & Translation.

Replication, Transcription, Translation

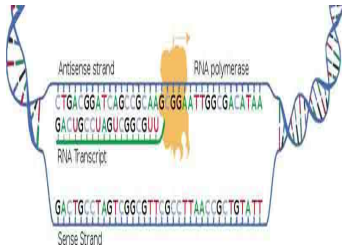


MAKING DNA

Making a copy of the genetic material = **Replication**

When you think "replication" think "duplication"

Q: Where does replication occur in prokaryotes? Eukaryotes?

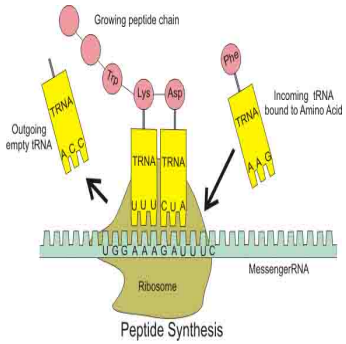


MAKING RNA

Transferring genetic code (DNA) to RNA = **Transcription**

Think of a medical transcriptionist copying the physicians words into another format.

Q: Where does transcription occur in prokaryotes? Eukaryotes?



MAKING PROTEINS

Making proteins = **Translation**

Think of how translation relates to languages.

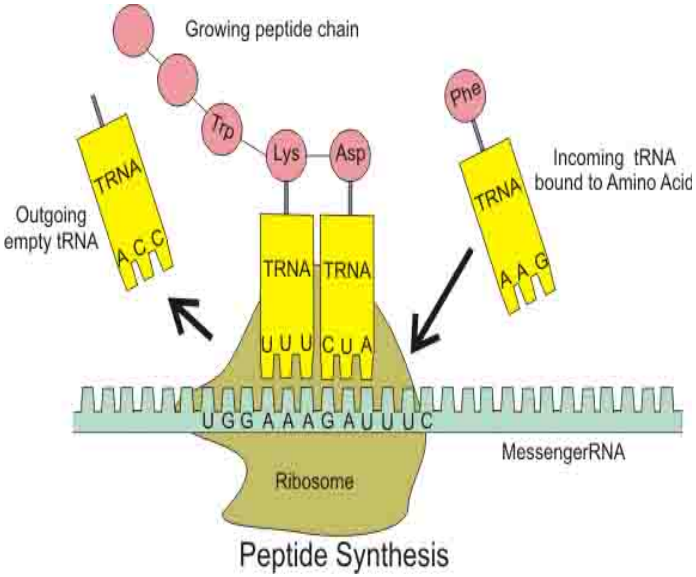
The translation of biology translates DNA information into proteins.

Q: Where does translation occur in prokaryotes? Eukaryotes?

Images: Replication Diagram: Madprime; Peptide Synthesis Diagram: Boumphreyfr, Wiki

Hereditary Diseases are due to DNA mutations

All inherited diseases arise from a mistake in the genetic code passed down from a person's parents, which leads to a defective protein.



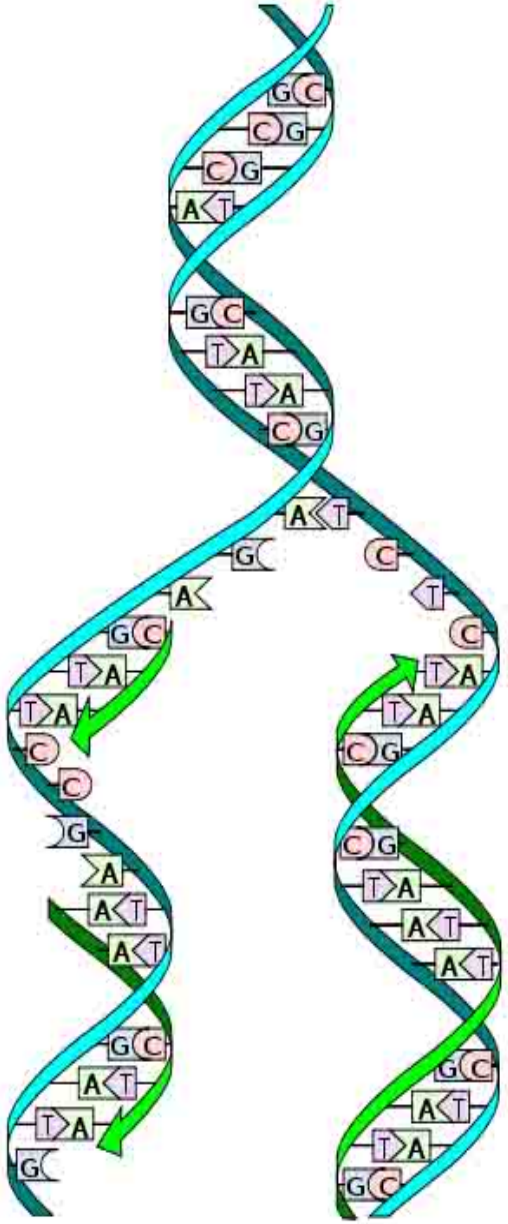


Image: Peptide Synthesis Diagram: Boumphreyfr, Wiki;
Replication Diagram: Madprime, Wiki

Genetic Disease: Cystic Fibrosis (CF)

Most common, fatal genetic disease in the US.

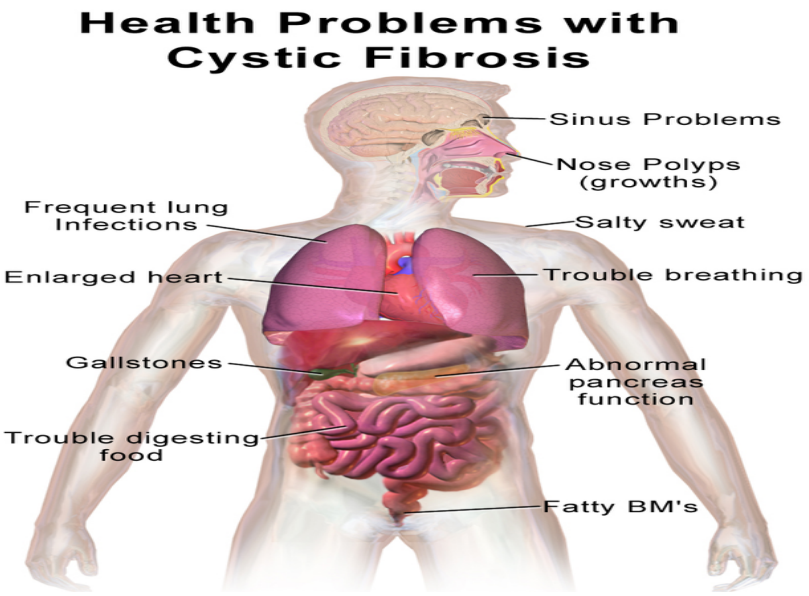
Causes body to produce thick mucus that:
- clogs the lungs
- leads to infections
- blocks pancreas from delivering digestive enzymes to intestine.

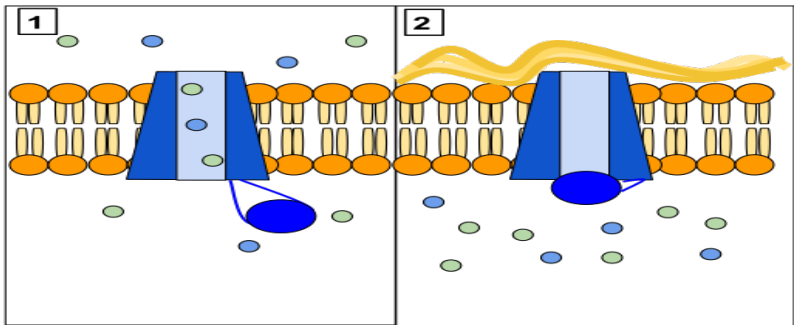
Results from mutations in a single gene: Cystic Fibrosis Transmembrane Regulator (CFTR) gene.

In normal cells, the CFTR channel protein allows cells to release chloride and other ions.

In people with CF, this protein is defective. Cells are not able to release chloride, resulting in an improper salt balance in the cells and thick, sticky mucus.

Medical research is focusing on ways to cure CF by correcting the defective gene, or correcting the defective protein.





CFTR channel protein controls flow of H_2O and Cl- inside the lungs. When this protein is working correctly (Panel 1) ions can flow in and out of the cells. But, when the CFTR protein is blocked (Panel 2) these ions cannot flow out of the cell.

Images: Health Problems of Cystic Fibrosis, Bruce Blaus Wiki, CFTR, Protein Channel, Wiki

Genetic Disease: Sickle Cell Disease

Most common inherited blood disorder in US.

Most prevalent among African Americans (~1 in 500) and Hispanic Americans (~1 in 1,000).

Hemoglobin is the molecule in red blood cells (RBCs) that delivers oxygen from the lungs to the body's cells.

Caused by a mutation in the hemoglobin-beta gene found on chromosome 11.

People with this disorder have atypical hemoglobin, which can distort red blood cells into a sickle, or crescent, shape.

Sickle shaped RBCs can pile up, rather than flow, causing blockages and damaging vital organs and tissue.

People who only carry one copy of sickle cell gene typically don't get the disease, but can pass that defective gene on to their children.

Children who get this trait from both parents get the disease (recessive trait).

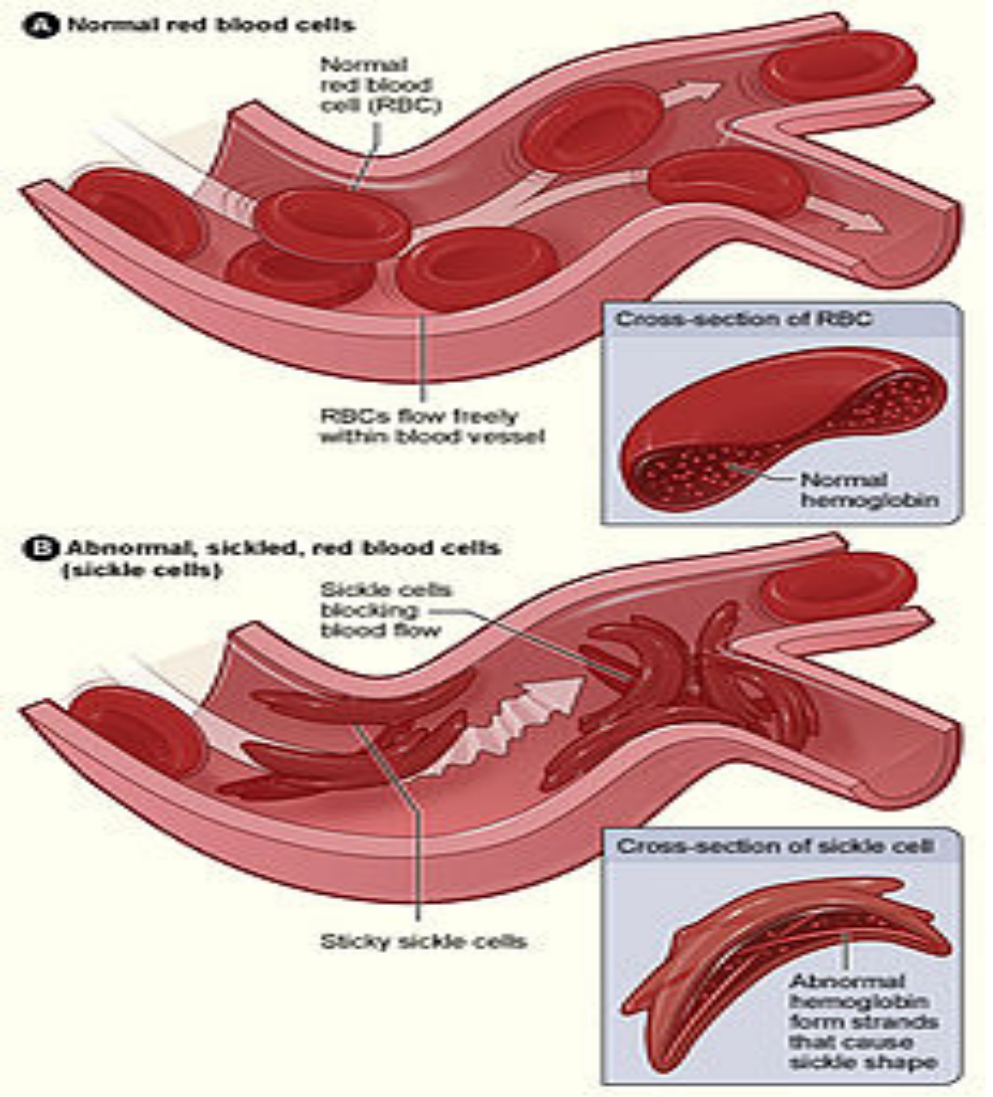


Image: Sickle Cell Diagram. Wiki

Confused?

Here are links to fun resources that further explain genetic transcription & translation:

- Molecular Genetics: Replication Main Page on the Virtual Cell Biology Classroom of Science Prof Online.
- "That Spells DNA" song by Jonathan Coulton.
- DNA Structure Cell Biology Animation from John Kyrk.
- Build a DNA Molecule from University of Utah.
- DNA Replication animation and review questions.
- DNA Replication Process animated video by FreeScienceLectures.com.
- DNA Replication step-through animation by John Kyrk.
- Transcription & Translation Main Page on the Virtual Cell Biology Classroom of Science Prof Online.
- DNA Transcription step-through animation by John Kyrk.
- Transcribe & Translate a Gene, from University of Utah.
- DNA Transcription and Protein Assembly animated movie by RedAndBrownPaperBag.
- Transcription and Translation animated movie from PBS production "DNA: The Secret of Life.

Smart Links

(You must be in PPT slideshow view to click on links.)