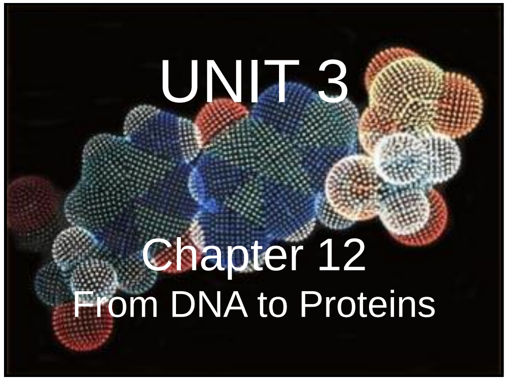
UNIT 3

Chapter 12
From DNA to Proteins



Chapter 12: From DNA to Proteins

I. Identifying DNA as the Genetic Material (8.1)

A. Griffith finds a “**transforming principle**”

1. Griffith experimented with the **bacteria** that cause pneumonia.

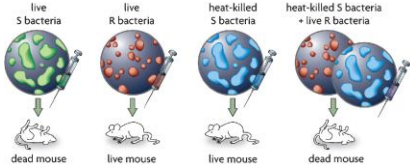
Pneumococcus ***bacteria***

2. He used **two forms** and injected them into mice

a. The S, or smooth form (**deadly**)

b. R form, or rough (**not deadly**).

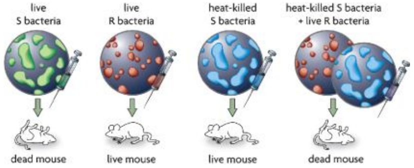
3. S form of bacteria **killed with heat** mice **unaffected**



4. Injected mice with **combination of heat-killed and live R bacteria**

a. **Mice died**

b. Griffith concluded that a **transforming material** passed from dead S bacteria to live R bacteria, making them deadly.



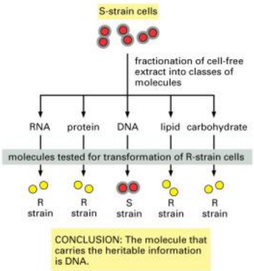
B. Avery identifies **DNA** as the **transforming principle**

1. Experimented with R bacteria and **extract** made from S bacteria

2. Allowed them to observe transformation of R bacteria

3. Developed process to **purify their extract**

a. Performed series of tests to find out if transforming principle was **DNA** or **protein**



b. Performed **chemical tests** that showed no proteins were present.

c. Test revealed that **DNA was present**

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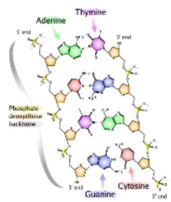
4. Performed tests with **Enzymes**

   a. Added enzymes to break down **proteins- transformation still occurred**.

   b. Added enzymes to break down **RNA- transformation still occurred**.



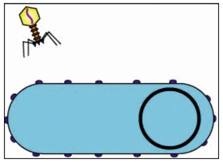
   c. Added enzymes to break down **DNA- transformation failed to occur**.

   d. **Concluded DNA was transforming factor**

C. Hershey and Chase confirm that DNA is the genetic material

   1. Alfred Hershey and Martha Chase provided conclusive evidence that **DNA was the genetic material** in 1952

   2. Studied **viruses** that infect bacteria (**bacteriophage**)



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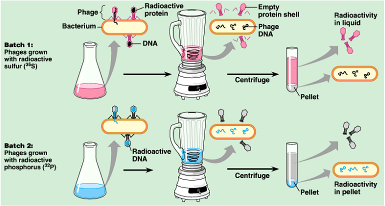
a. Bacteriophage is simple- **protein coat** surrounding **DNA core**

   1). **Proteins** contain **sulfur** buy **very little phosphorus**

   2). **DNA** contains **phosphorus** and **very little sulfur**



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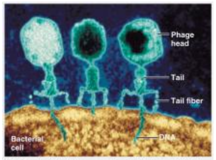
b. **Experiment No.1**- Bacteria infected with phages with **radioactive sulfur** atoms- **no radioactivity inside bacteria**

c. **Experiment No.2-** Bacteria infected with phages with **radioactive phosphorus** atoms- **radioactivity found inside bacteria**



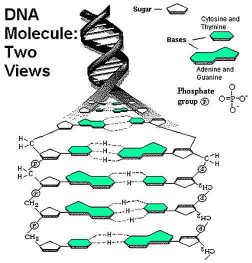
(a) T2 and related phages use their tail pieces to attach to the host cell and inject their genetic material (TEM).

d. Concluded phages **DNA** had entered bacteria but proteins had not. **Genetic material must be DNA**

II. Structure of DNA (8.2)

   A. **DNA** is composed of **four types of nucleotides**

DNA Molecule: Two Views



   1. **DNA** is long **polymer composed** of **monomers** called **nucleotides.**

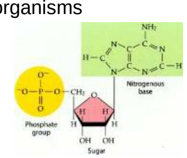
a. Each nucleotide has <u>three</u> parts

1). **Phosphate group**

2). Ring-shaped sugar called **deoxyribose**

3). **Nitrogen-containing base**

b. Scientists first believed that DNA was made of equal parts of four different nucleotides (same in all organisms



2. In 1950 Erwin Chargaff changed thinking by analyzing DNA of several different organisms

a. Found **same four bases** of DNA **in all organisms**

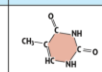
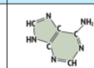
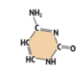
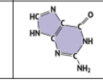
b. **Proportions** of 4 bases were **different** in organisms

Percentages of Bases in Four Organisms

Source of DNA	A	T	G	C
Streptococcus	29.8	31.6	20.5	18.0
Yeast	31.3	32.9	18.7	17.1
Herring	27.8	27.5	22.2	22.6
Human	30.9	29.4	19.9	19.8

c. Found amount of adenine equals thymine and amount of cytosine equals amount of guanine.

A = T and C = G (called **Chargaff's rules**)

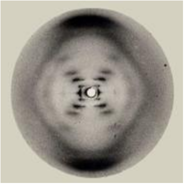
PYRIMIDINES = SINGLE RING			PURINES = DOUBLE RING		
Name of Base	Structural Formula	Model	Name of Base	Structural Formula	Model
thymine			adenine		
cytosine			guanine		

B. **Watson** and **Crick** developed accurate model of **DNA's three-dimensional structure**

1. Used previous work of other scientists and hypothesized that DNA might also be a helix

a. Rosalind **Franklin** and Maurice **Wilkins** used **x-ray crystallography** and suggested DNA **helical shape**

b. Work of Hershey, Chase, Chargaff, and Linus Pauling



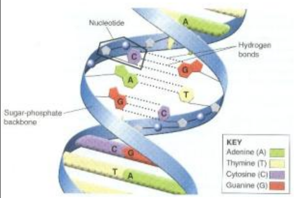
2. In **1953** Watson and Crick published their **DNA model** in a paper in the journal Nature

a. **DNA was double helix**

b. Strands are **complementary** (they fit together and are the opposites of each other- **pairing of bases according to Chargaff's rules**

3. Nucleotides always pair in the same way

a. **Backbone formed by** covalent bonds that connect sugar of one nucleotide to phosphate of another

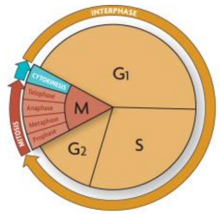


b. **Two sides** held together by **weak hydrogen bonds between bases**

c. **Base pairing rules- A with T** and **C with G**

III. DNA Replication (8.3)

A. Replication copies the genetic information



1. **Replication** creates **exact copies** of itself during the cell cycle

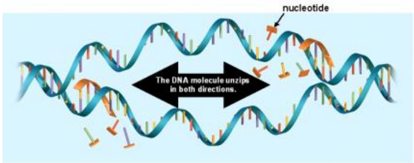
2. Replication assures every cell has complete set of identical genetic information

B. Proteins (**enzymes**) carry out the process of **replication**

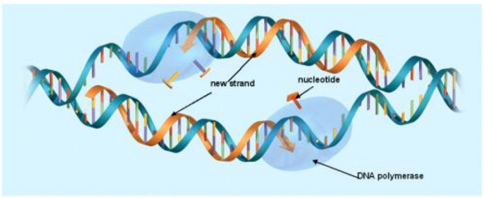
1. **Enzymes** begin to **unzip double helix** (DNA polymerases)

a. **Hydrogen bonds** are broken

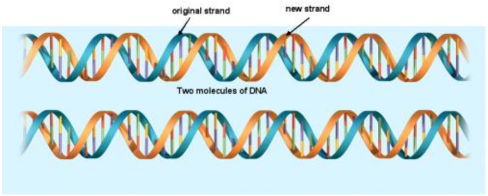
b. Molecule **separates** exposing bases



2. **Free-floating nucleotides** pair up one-by-one forming **complementary** strands to template



3. **Two identical molecules of DNA formed**

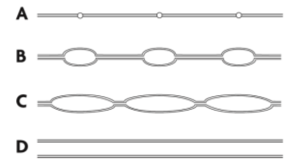


C. **Replication** is **fast** and **accurate**

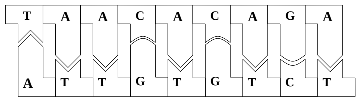
1. Process takes just a few hours

2. DNA replication **starts at many points** in eukaryotic chromosomes.

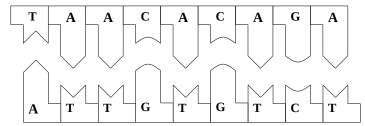
3. DNA polymerases can **find and correct errors**.

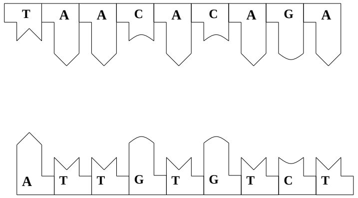


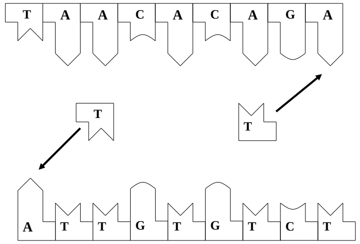
There are many origins of replication in eukaryotic chromosomes.



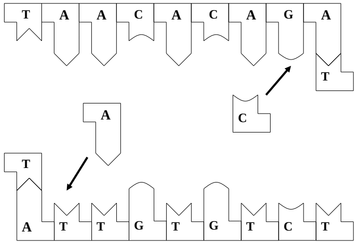
1. First the DNA must unzip: Enzymes split apart the base pairs and unwind the DNA.

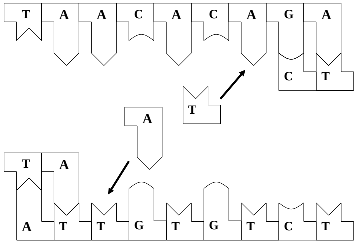


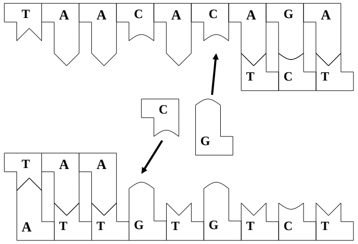




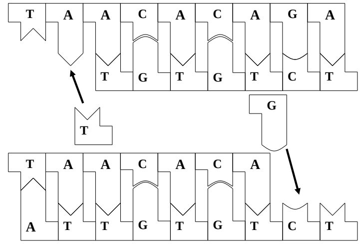
2. Bases pair up: Free nucleotides in the cell find their complementary bases along the original strand.

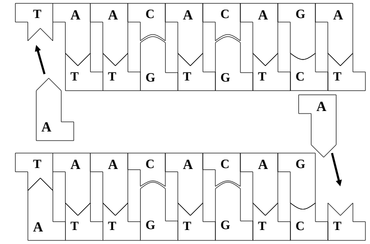


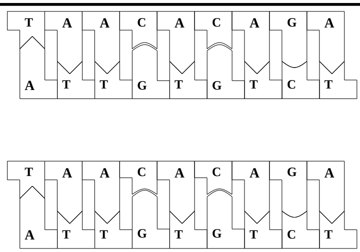




3. Backbone Bonds: The sugar-phosphate backbone is assembled to complete the DNA strand





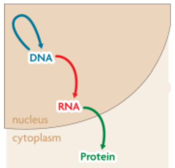


The DNA is now duplicated: The cell can now divide into two daughter cells.

IV. Transcription (8.4)

A. RNA carries DNA's instruction

1. Francis Crick defined the **central dogma of molecular biology**



a. **Replication copies DNA**

b. **Transcription converts DNA message into intermediate molecule, called RNA**

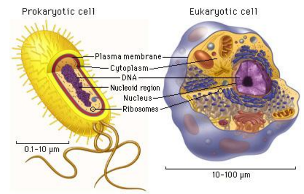
c. **Translation interprets an RNA message into string of amino acids, called polypeptide (protein)**

2. In **prokaryotic cells** processes take place in **cytoplasm**

3. In **eukaryotic cells** processes are separated

a. **Replication** and **Transcription** in **nucleus**

b. **Translation** occurs in **cytoplasm**



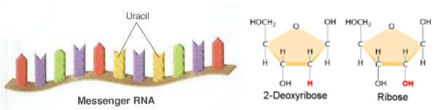
4. **RNA** acts as **messenger** between nucleus and protein synthesis in cytoplasm

5. RNA differs from DNA in three significant ways

a. Sugar in RNA is **ribose** not deoxyribose

b. RNA has the base **uracil** in place of thymine

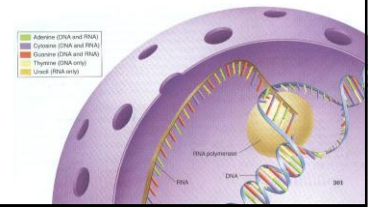
c. RNA is **single stranded** not double



B. Transcription makes three types of RNA

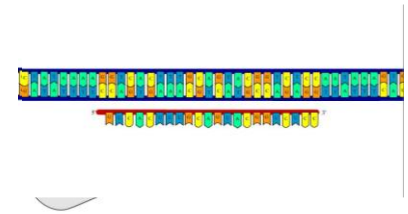
1. Transcription copies sequence of DNA (one **gene**) and is catalyzed by RNA polymerases

a. DNA begins to unwind at specific site (gene)



b. Using **one strand of DNA**, **complementary** strand of **RNA** is produced

c. RNA strand detaches and DNA reconnects

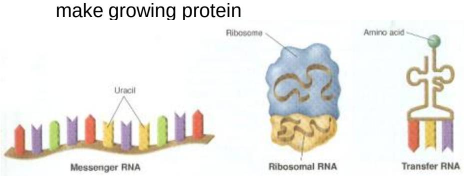


2. Transcription produces 3 kinds of RNA

a. **Messenger RNA (mRNA)-** code for translation

b. **Ribosomal RNA (rRNA)-** forms part of ribosome

c. **Transfer RNA (tRNA)-** brings amino acids from the cytoplasm to a ribosome to help make growing protein



3. The transcription process is similar to replication

a. Both occur in nucleus

b. Both involve unwinding of DNA

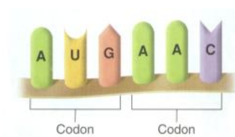
c. Both involve complementary base pairing

V. Translation (8.5)

A. **Amino acids** are **coded** by **mRNA base sequences**

1. Translation **converts mRNA** messages into **polypeptides**

2. A **codon** is a sequence of **three nucleotides** that codes for an **amino acid.**



a. RNA could code **64 different combinations**

b. Plenty to cover the **20 amino acids** used to build proteins in human body and most other organisms

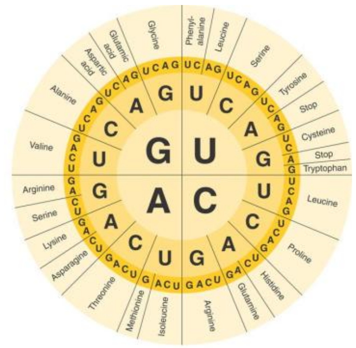
The genetic code matches each RNA **codon** with its amino acid or function.

First base	Second base U		Second base C		Second base A		Second base G		Third base
U	UUU	phenylalanine (Phe)	UCU	serine (Ser)	UAU	tyrosine (Tyr)	UGU	cysteine (Cys)	U
	UUC		UCC		UAC		UGC		C
	UUA	leucine (Leu)	UCA		UAA	STOP	UGA	STOP	A
	UUG		UCG		UAG	STOP	UGG	tryptophan (Trp)	G
C	CUU	leucine (Leu)	CCU	proline (Pro)	CAU	histidine (His)	CGU	arginine (Arg)	U
	CUC		CCC		CAC		CGC		C
	CUA		CCA		CAA	glutamine (Gln)	CGA		A
	CUG		CCG		CAG		CGG		G
A	AUU	isoleucine (Ile)	ACU	threonine (Thr)	AAU	asparagine (Asn)	AGU	serine (Ser)	U
	AUC		ACC		AAC		AGC		C
	AUA		ACA		AAA	lysine (Lys)	AGA	arginine (Arg)	A
	AUG	methionine (Met)	ACG		AAG		AGG		G
G	GUU	valine (Val)	GCU	alanine (Ala)	GAU	aspartic acid (Asp)	GGU	glycine (Gly)	U
	GUC		GCC		GAC		GGC		C
	GUA		GCA		GAA	glutamic acid (Glu)	GGA		A
	GUG		GCG		GAG		GGG		G

1 Find the first base, C, in the left column.

2 Find the second base, A, in the top row. Find the box where these two intersect.

3 Find the third base, U, in the right column. CAU codes for histidine, abbreviated as His.

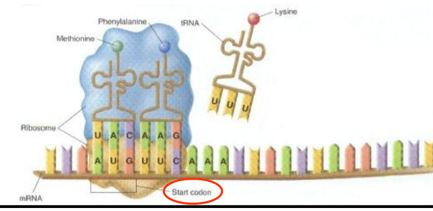


c. Many amino acids coded by more than one codon

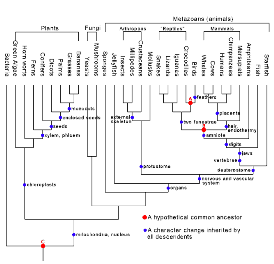
d. Also special codons

1). **Start codon**- signals start of translation

2). **Stop codon**- signals end of amino acid chain

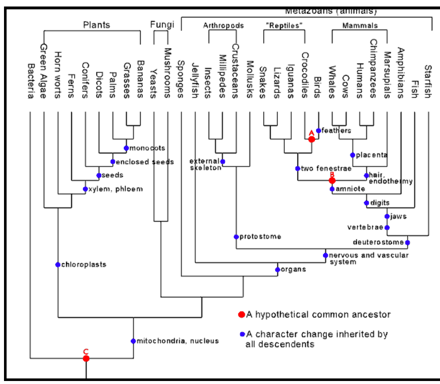


3. This **code is universal**- same in almost all organisms



a. Suggests **common ancestor**

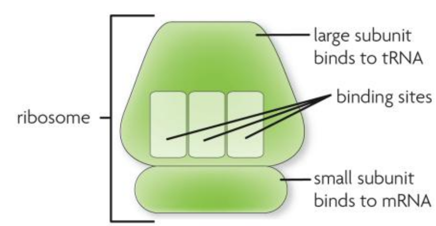
b. Means scientist can insert gene from one organism into another to make functional protein



B. **Amino acids** are <u>linked</u> to become a **protein**

1. Two important "tools" needed to translate a codon into an amino acid

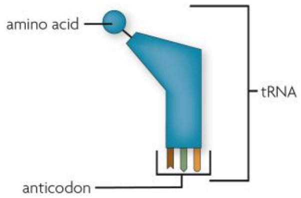
a. **Ribosome**- site of protein synthesis



b. **tRNA**- carries free-floating **amino acids** from cytoplasm to **ribosome**

1). tRNA attaches to specific **amino acid**

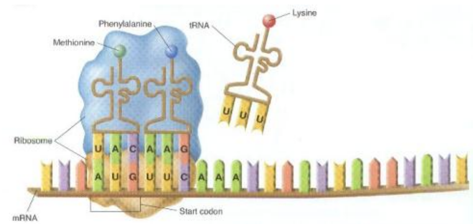
2). Has “3-letter” **anticodon** that recognizes a specific **condon**



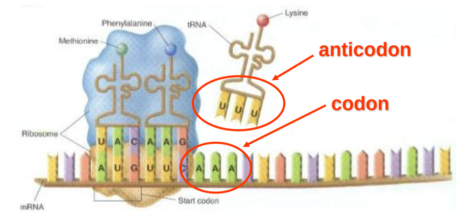
2. Translation occurs in cytoplasm of cell

a. **mRNA** binds to **ribosome**

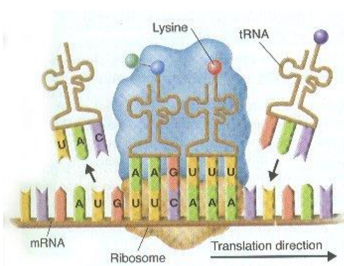
b. **Ribosome** pulls mRNA strand through **one codon at a time**



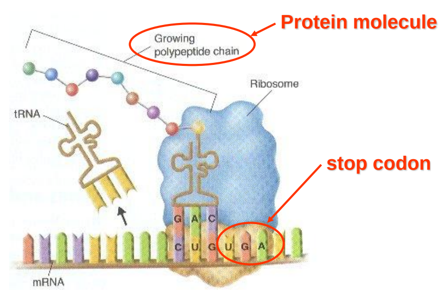
c. Exposed codon attracts **complementary tRNA** bearing an **amino acid**



d. **Amino acids bond together** and tRNA molecule leaves to find another amino acid



e. Ribosome moves down mRNA attaching more amino acids until reaches stop codon.



VI. Gene Expression and Regulation (8.6)

A. Your cells can control when gene is “turned on or off”

B. Different in prokaryotic and eukaryotic cells

C. Because cells are specialized in multicellular organisms, only certain genes are expressed in each type of cell.

VII. Mutations (8.7)

A. Some mutations affect a **single gene**, while others affect an **entire chromosome**

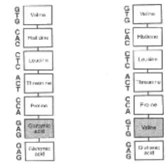
1. **Mutation**- a change in an organism's DNA

2. **Mutations** that affect a **single gene** usually happen during **replication**

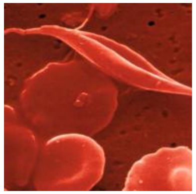
3. **Mutations** that affect **group of genes** or **chromosome** happen during **meiosis**

B. **Gene Mutations**

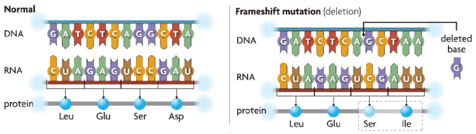
1. **Point mutation**- one nucleotide is substituted for another



Result of simple point mutation



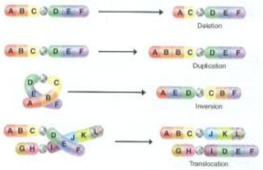
2. **Frameshift mutation**- involves insertion or deletion of a nucleotide in DNA sequence



3. **Chromosomal mutations**-

a. **Gene duplication**-exchange of DNA segments through crossing over during meiosis

b. **Gene translocation**- results from the exchange of DNA segments between nonhomologous chromosomes



C. **Mutations** <u>may or may not affect</u> **phenotype**

1. Impact on phenotype-

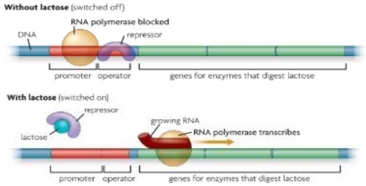
a. **Chromosomal mutations** affect many genes and have **big affect on the organism**

b. Some gene mutations **change** phenotype.

1. A mutation may cause a premature **stop codon.**

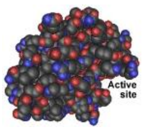
2. A mutation may change **protein shape** or the **active site**

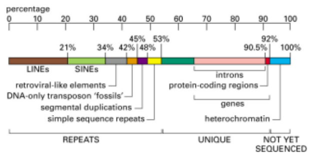
3. A mutation may change **gene regulation**



c. Some gene mutations **do not** affect phenotype

1. A mutation may be **silent**
2. A mutation may occur in a **noncoding region**
3. A mutation may not affect **protein folding** or the **active site**.





2. Mutations in **body cells** do not affect offspring.

3. Mutations in **sex cells** can be **harmful** or **beneficial** to offspring

4. **Natural selection** often removes mutant alleles from a population when they are less adaptive.

D. Mutations can be caused by several factors

1. **Replication errors** can cause mutations
2. **Mutagens**, such as UV ray and chemicals, can cause mutations
3. Some **cancer drugs** use **mutagenic properties** to kill cancer cells.