

## Nucleic Acid Structure & Functions



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### DNA- Deoxyribonucleic Acid

- Stores genetic information
- Is copied and passed from generation to generation
- All living organisms have DNA and it is identical in structure and function in all organisms

#### RNA-Ribonucleic Acid

Is another nucleic acid molecule found in cells

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### DNA and RNA: Polymers of Nucleotides

- RNA is a nucleic acid very similar to DNA (it functions with DNA to make proteins)
  - They both consist of chemical sub-units (monomers) called **nucleotides**
  - The nucleotides are joined by a sugar-phosphate backbone

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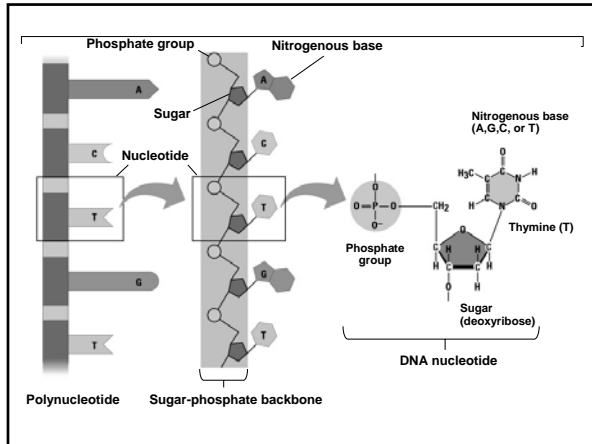
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## NUCLEOTIDES

- There are five different nucleotides
- Three are found in both DNA and RNA:
  - cytosine (C)
  - adenine (A)
  - guanine (G)
- One is found only in DNA:
  - thymine (T)
- RNA has uracil (U) in place of thymine

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## Rosalind Franklin



- She earned her doctorate in physical chemistry from Cambridge University in 1945
- Rosalind Franklin did the X-ray crystallography work which elucidated the structure of DNA
- Watson and Crick used her X-ray crystallography data to make a model of DNA
- James Watson, Francis Crick, and Maurice Wilkins received a Nobel Prize for the double-helix model of DNA in 1962, four years after Franklin's death at age 37 from ovarian cancer.

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## Watson and Crick's Model of the Double Helix



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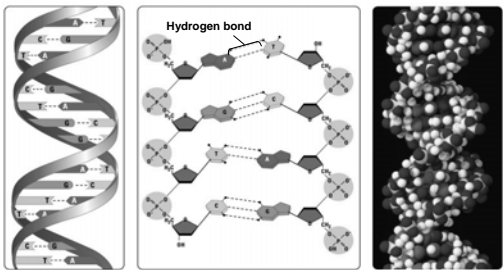
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- Notice that the bases pair in a **complementary** fashion **A=T** or **A=U (RNA)**, **G=C**
- **Hydrogen bonds** hold bases together
- **Three for G-C, two for A-T**

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## FUNCTIONS of the NUCLEIC ACIDS

- DNA has two functions:
  - Replication (for mitosis and meiosis)
  - Stores the codes for proteins in its sequence
- RNA has one major function:
  - Plays **THREE** key roles in protein synthesis

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## DNA Replication

- When a cell or organism reproduces, a complete set of genetic instructions must pass from one generation to the next
- This replication of DNA occurs during interphase (S) of the cell cycle.

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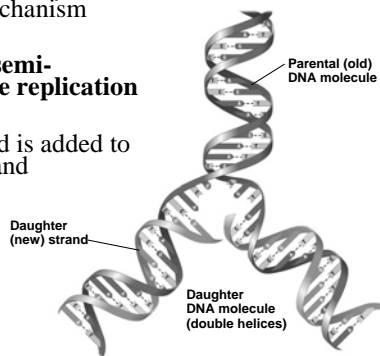
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- DNA replicates by a template mechanism

- This is call **semi-conservative replication**

- A new strand is added to each old strand



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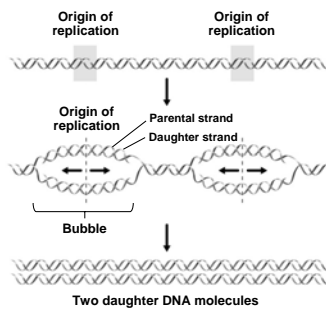
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## DNA REPLICATION

- Begins at specific sites on a double helix

- Proceeds in both directions



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**THE FLOW OF GENETIC INFORMATION FROM DNA TO RNA TO PROTEIN**

- DNA functions as the inherited directions for a cell or organism
  - How are these directions carried out?

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**How an Organism's DNA Genotype Produces Its Phenotype**

- An organism's genotype, its genetic makeup is the sequence of nucleotide bases in DNA
  - The phenotype is the organism's specific traits
  - Traits are determined by the types of proteins an organism has in its cells
  - DNA and RNA function together to produce proteins

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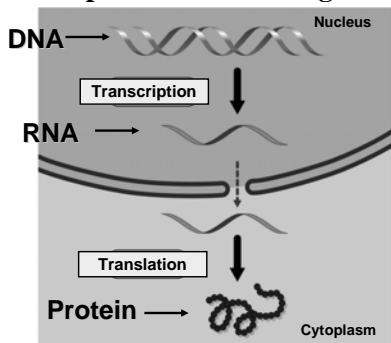
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**DNA specifies the synthesis of proteins in two stages**



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## From Nucleotide Sequence to Amino Acid Sequence

- The information, or “language,” in DNA is ultimately translated into the language of polypeptides (proteins)
- The order in which the base pairs are arranged creates a “message” called a gene
- Genes code for proteins

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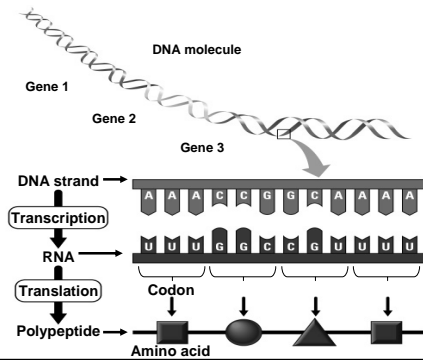
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- What is the language of nucleic acids?
  - In DNA, it is the linear sequence of nucleotide bases




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## The Genetic Code

- Triplets of bases called codons determine which amino acids are in the protein

		Second base							
		U	C	A	G				
First base	U	UUU } Phenylalanine (Phe) UUC } UUA } Leucine (Leu) UUG }	UCU } Serine (Ser) UCC } UCA } UCG }	UAU } Tyrosine (Tyr) UAC } UAA } Stop UAG } Stop	UGU } Cysteine (Cys) UGC } UGA } Stop UGG } Tryptophan (Trp)	U	C	A	G
	C	CUU } Leucine (Leu) CUC } CUA } CUG }	CCU } Proline (Pro) CCC } CCA } CCG }	CAU } Histidine (His) CAC } CAA } Glutamine (Gln) CAG }	CGU } Arginine (Arg) CGC } CGA } CGG }	C	A	G	
	A	AUU } Isoleucine (Ile) AUC } AUA } AUG } Met or start	ACU } Threonine (Thr) ACC } ACA } ACG }	AUU } Asparagine (Asn) AAC } AAA } Lysine (Lys) AAG }	AGU } Serine (Ser) AGC } AGA } Arginine (Arg) AGG }	A	C	A	G
	G	GUU } Valine (Val) GUC } GUA } GUG }	GCU } Alanine (Ala) GCC } GCA } GCG }	GAU } Aspartic acid (Asp) GAC } GAA } Glutamic acid (Glu) GAG }	GGU } Glycine (Gly) GGC } GGA } GGG }	G	U	C	A

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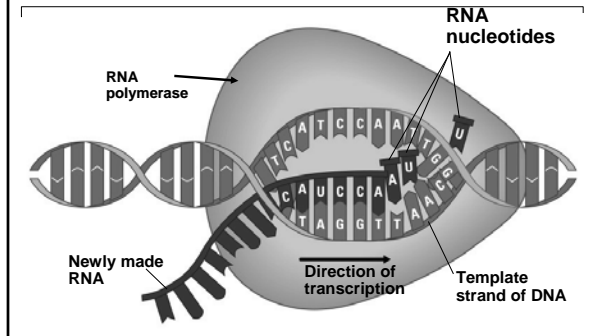
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## TRANSCRIPTION: From DNA to RNA




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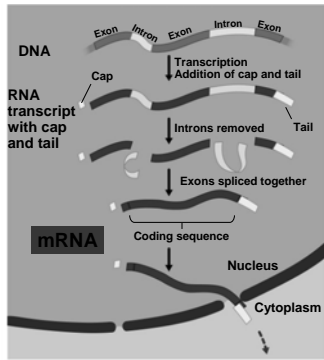
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## RNA PROCESSING IN EUKARYOTES

- Adding a cap and tail
- Removing introns
- Splicing exons together
- Final product is mRNA




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## Translation: The Players

- Translation
  - Is the conversion from the nucleic acid language to the protein language
  - A new protein molecule is made

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*There are three kinds of RNA that play a role in translation*

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

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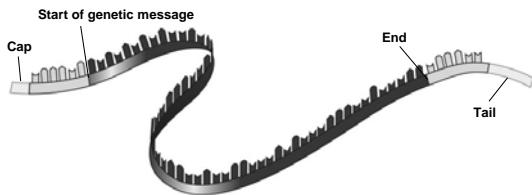
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### *Messenger RNA (mRNA)*



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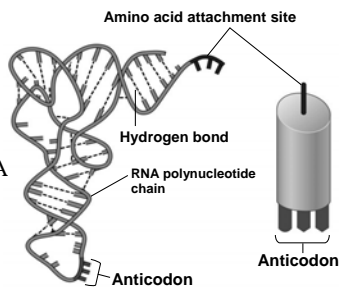
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### *Transfer RNA (tRNA)*

- Carries amino acids
- Matches amino acids with codons in mRNA using anticodons



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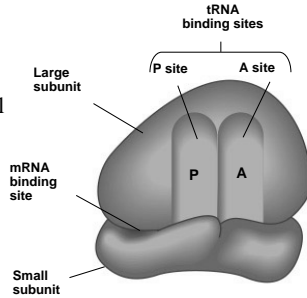
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## Ribosomes (rRNA)

- Are organelles that make polypeptides
- Are made up of protein and ribosomal RNA (rRNA)




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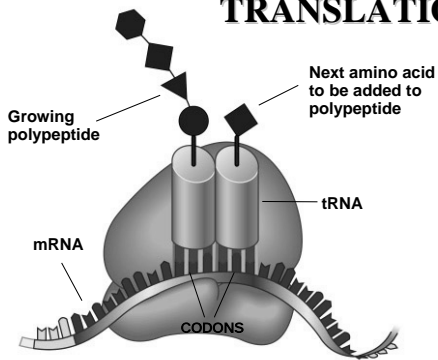


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## TRANSLATION




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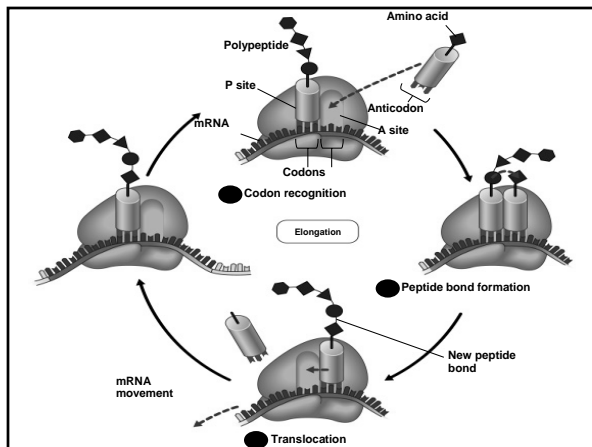
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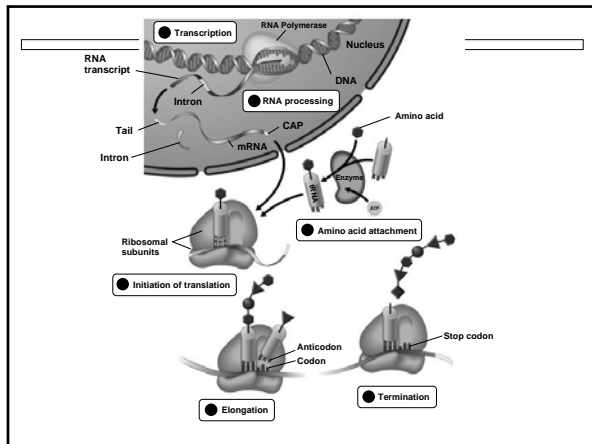
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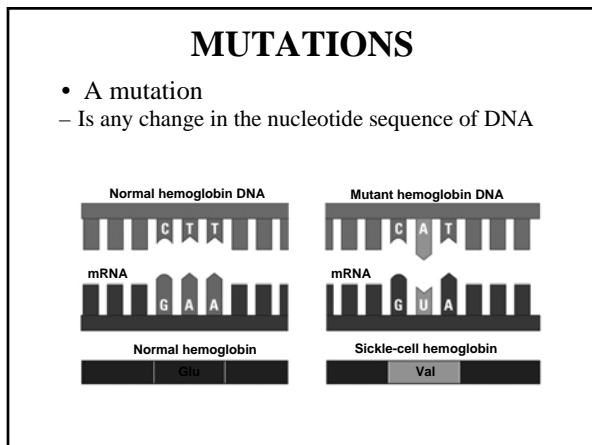
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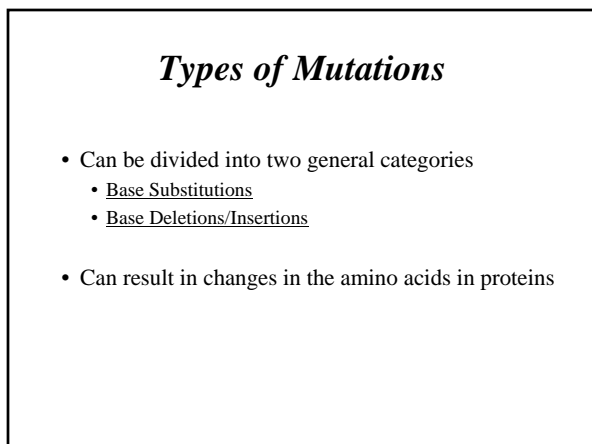
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## BASE SUBSTITUTIONS



Base substitution




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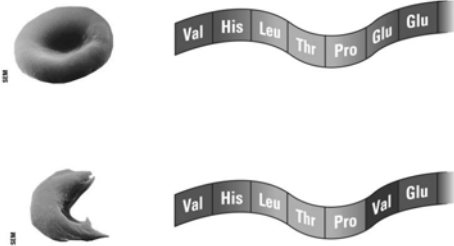
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## Sickle Cell Anemia



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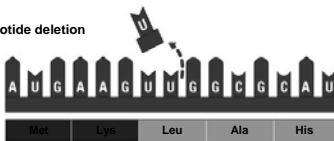
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## INSERTIONS AND DELETIONS

- Usually have disastrous effects
- Change the reading frame of the genetic message



Nucleotide deletion




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## ***MUTAGENS***

- Mutations may result from
  - Errors in DNA replication
  - Physical or chemical agents called mutagens



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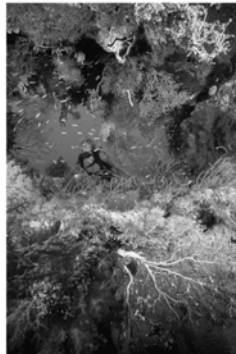
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## **Although mutations are often harmful**

- They are the source of the rich diversity of genes in the living world
- They contribute to the process of evolution by natural selection



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## **DNA Technologies**

- DNA Finger printing (VNTR)
- Recombinant DNA Technologies

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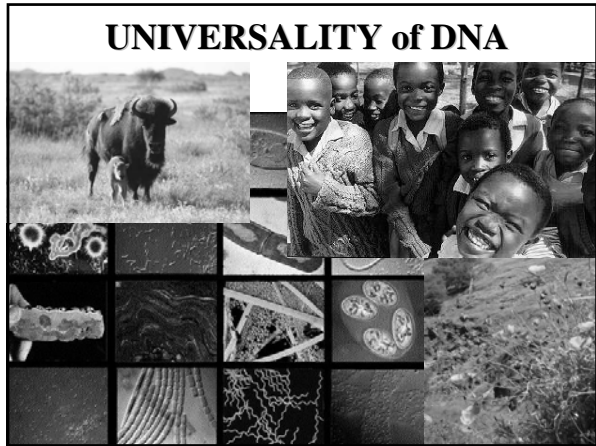
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- Notice that the bases pair in a **complementary** fashion **A=T** or **A=U (RNA)**, **G=C**
- **Hydrogen bonds** hold bases together
- **Three for G-C, two for A-T**

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### Restriction enzymes

Some enzymes can cut DNA at specific sequences

$\downarrow$   
 ....CGCCTAGGAT....  
 ....CGGGATCCTA....  
 $\uparrow$

....CGCCTAG                      GAT....  
 ....CGG                              GATCCTA....

RESTRICTION ENDONUCLEASES  
 E.g. EcoRI, HindIII, XbaI

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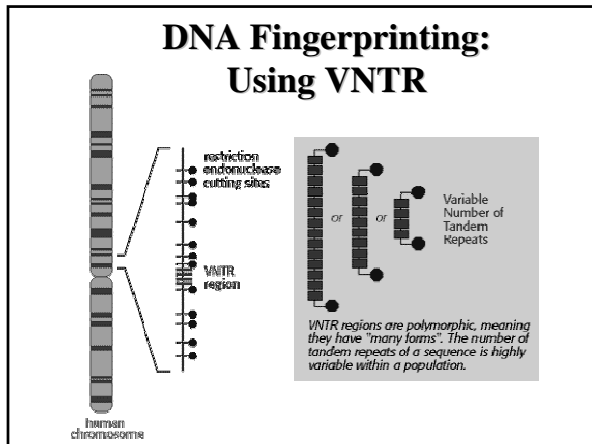
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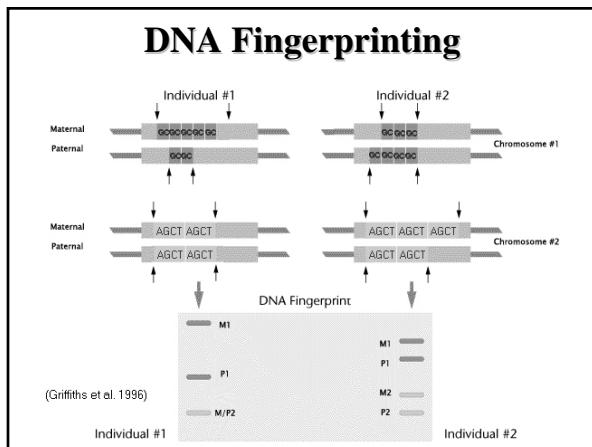
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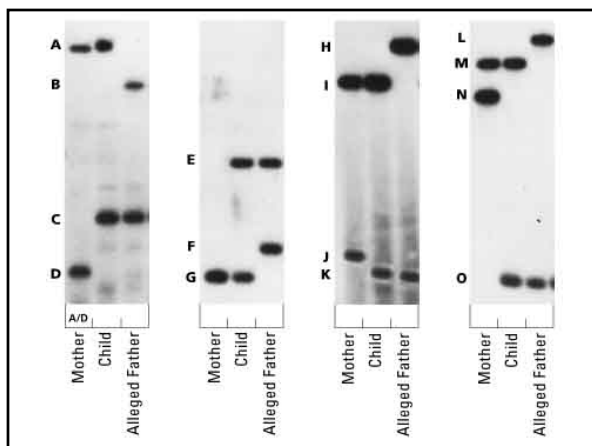
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# Recombinant DNA Technology: Transgenics

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**Restriction enzymes**  
Some enzymes can cut DNA at specific sequences

↓  
....CGCCTAGGAT....  
....CGGGATCCTA....  
↑

....CGCCTAG                      GAT....  
....CGG                              GATCCTA....

RESTRICTION ENDONUCLEASES  
E.g. EcoRI, HindIII, XbaI

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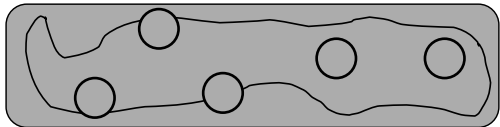
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**PLASMIDS**



*Escherichia coli*

The diagram shows a rod-shaped bacterium with a large, irregularly shaped nucleus and several smaller, circular plasmids scattered throughout the cytoplasm.

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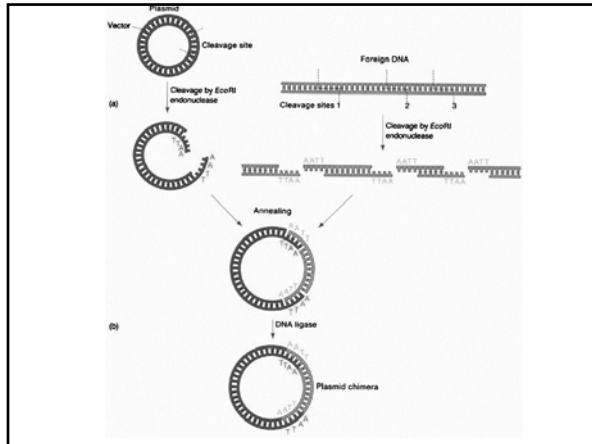
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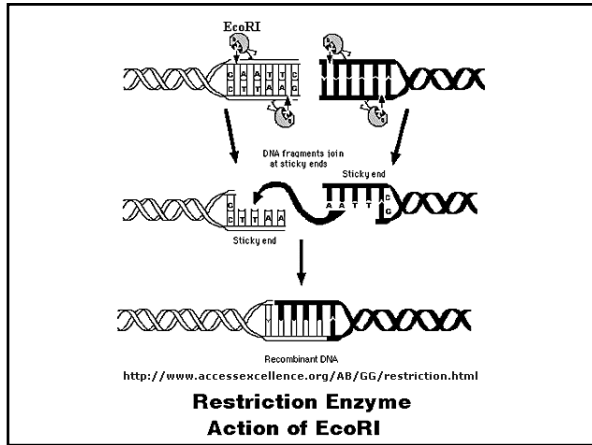
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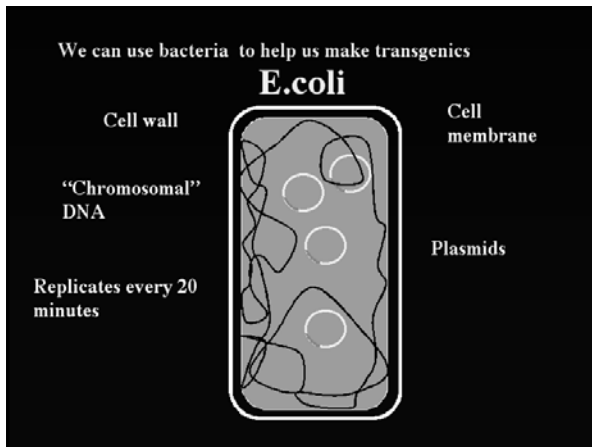
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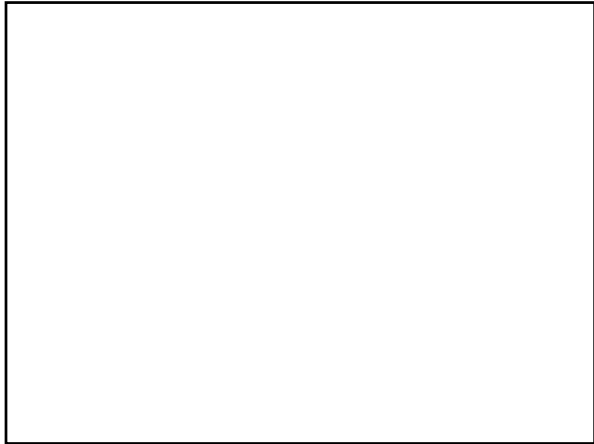
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## Products of Recombinant DNA



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## Human Genetics

Gregor Mendel



1822 - 1884

© Michael Cummings, Institute of Health, Genomics and Biotechnology, University of Liverpool

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## Mendel's Laws of Heredity

- Law of Segregation
- Law of Independent Assortment

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Law of Segregation –Part 1:

### Alternative versions of genes account for variations in inherited characters

ALLELES- Alternative versions of the same gene

GENOTYPE- The set of alleles that an organism has for a trait

PHENOTYPE- The physical characteristics/traits that result from the genotype. Phenotype is always a combination between genes and environment.

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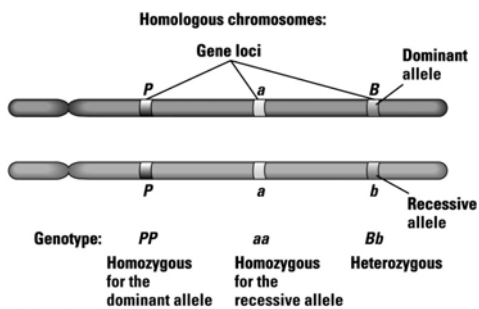
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Law of Segregation –Part 2:

### An organism inherits two alleles for each trait, one from each parent



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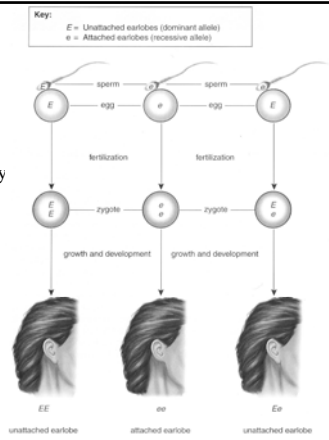
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Law of Segregation- Part 3:

If the two alleles differ, then one, the dominant allele, is fully expressed in the organism's appearance; the other, the recessive allele, has no noticeable effect on the organism's appearance




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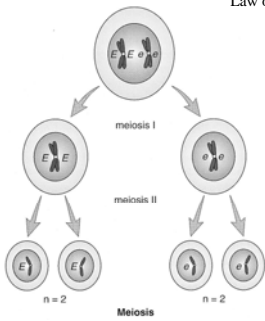
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Law of Segregation - Part 4

The two genes for each character segregate during gamete production



**Figure 18.3 Gametogenesis.** Because the pairs of chromosomes separate during meiosis, which occurs during gametogenesis, the gametes have only one allele for each trait.

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Law of Independent Assortment

- the emergence of one trait will not effect the emergence of another
- More on this in lab...

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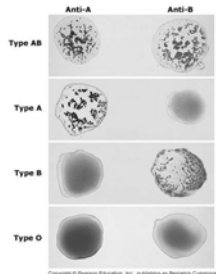
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## Beyond Mendel



**Co-dominance**- both alleles are expressed



**Incomplete Dominance**- intermediate forms occur

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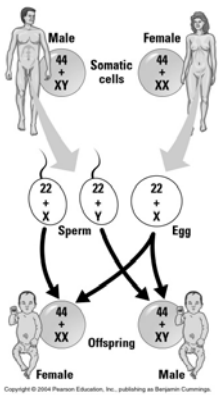
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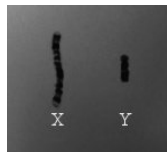
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## Sex-Linked Traits



The X and Y chromosomes carry genes for things besides gender.




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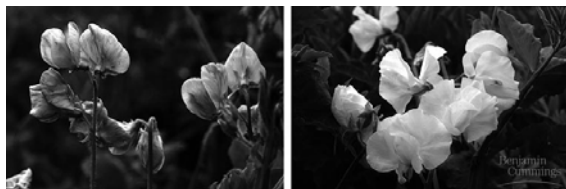
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## How Did Mendel Work it Out?

He studied sexual reproduction in Pea plants




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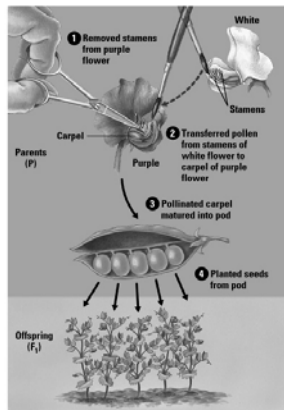
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# How Do Plants Have Sex, anyway?



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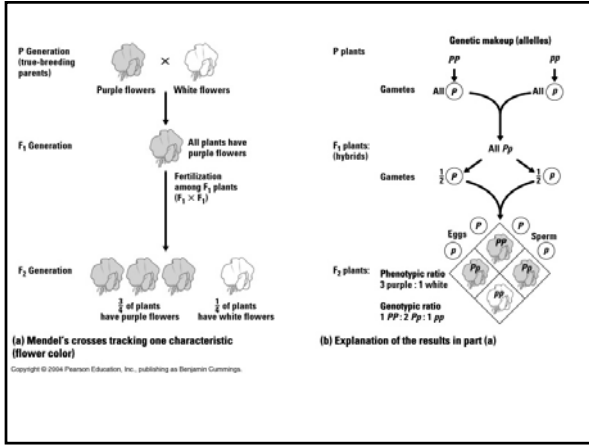
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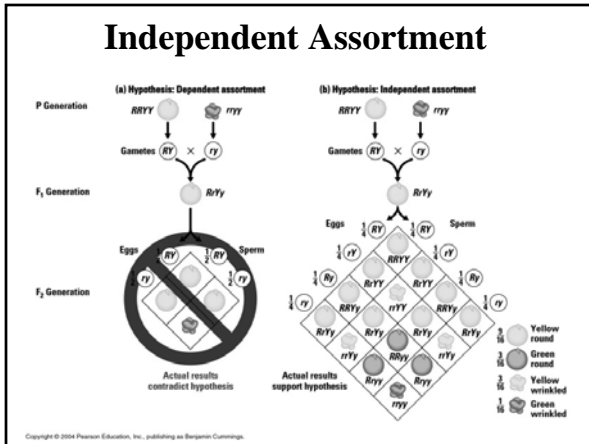
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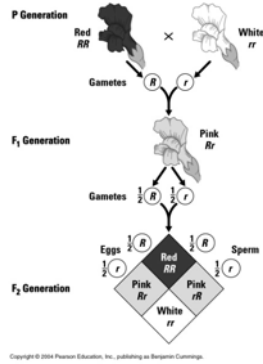
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# Incomplete Dominance



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Testcross:

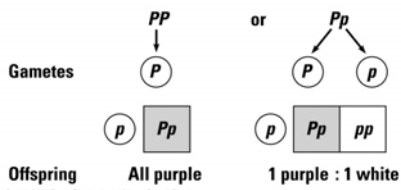


Genotypes

$P\_$

$pp$

Two possibilities for the purple flower:



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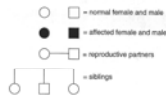
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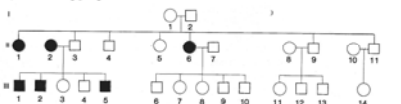
Figure 17.4 Pedigree chart symbols.



### Pedigree Chart Analyses

For each of the following pedigree charts, determine how a genetic disorder is passed. Is the inheritance pattern autosomal dominant, autosomal recessive, or X-linked recessive? Also, decide the genotype of particular individuals in the chart. Remember that the genotype indicates the dominant and recessive alleles present and the phenotype is the actual physical appearance of the trait in the individual. A pedigree chart indicates the phenotype, and you can reason out the genotype.

1. Study the following pedigree chart:



- What is the inheritance pattern for this genetic disorder?
- What is the genotype of the following individuals? Use  $A$  for the dominant allele and  $a$  for the recessive allele.
  - Generation I, individual 1 \_\_\_\_\_
  - Generation II, individual 1 \_\_\_\_\_
  - Generation III, individual 8 \_\_\_\_\_

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