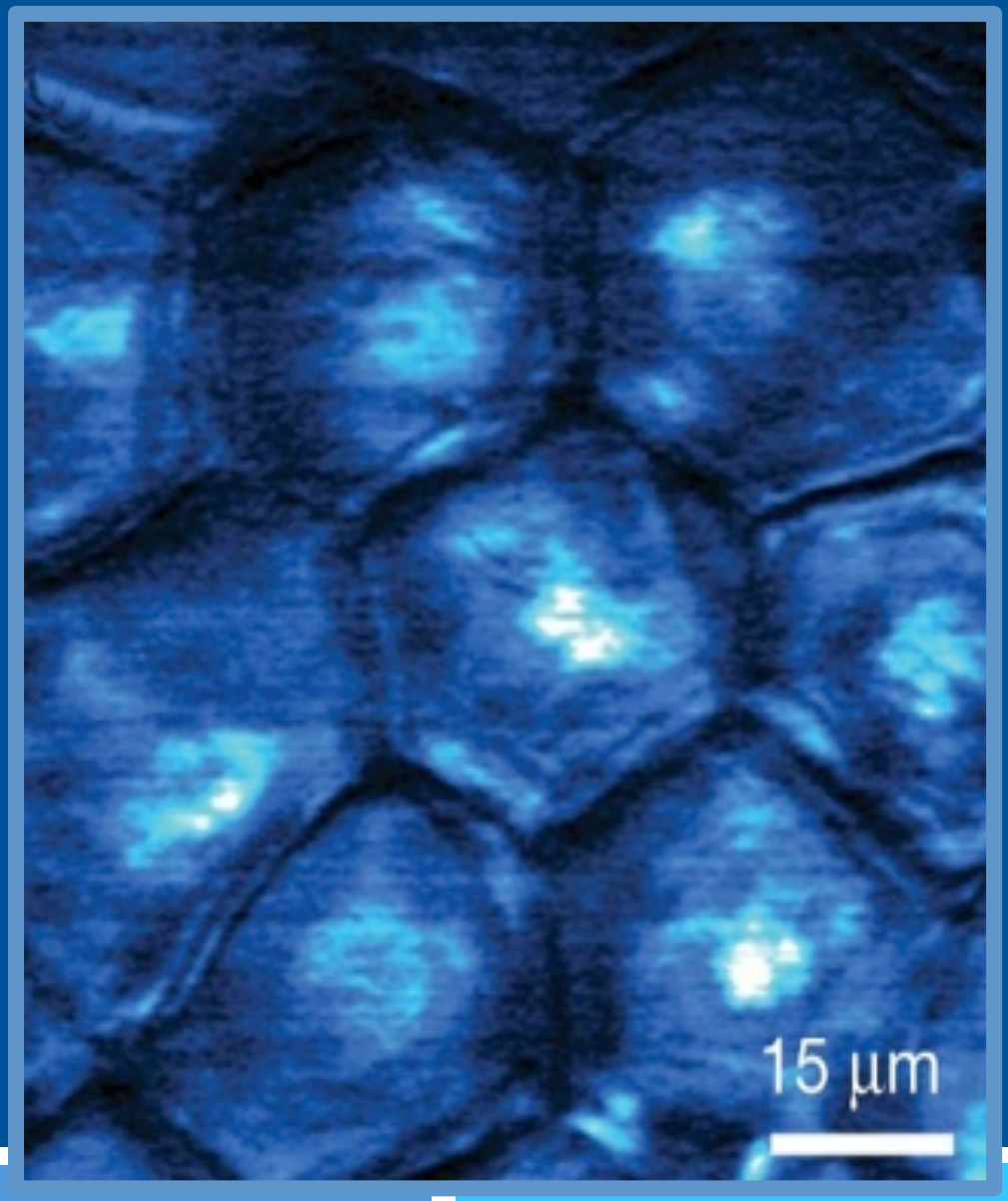

GENES AND CHROMOSOMES-I

Lecture 3

BIOL 266/2

2014-15

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Biology Department
Concordia University

GENE AND THE GENOME

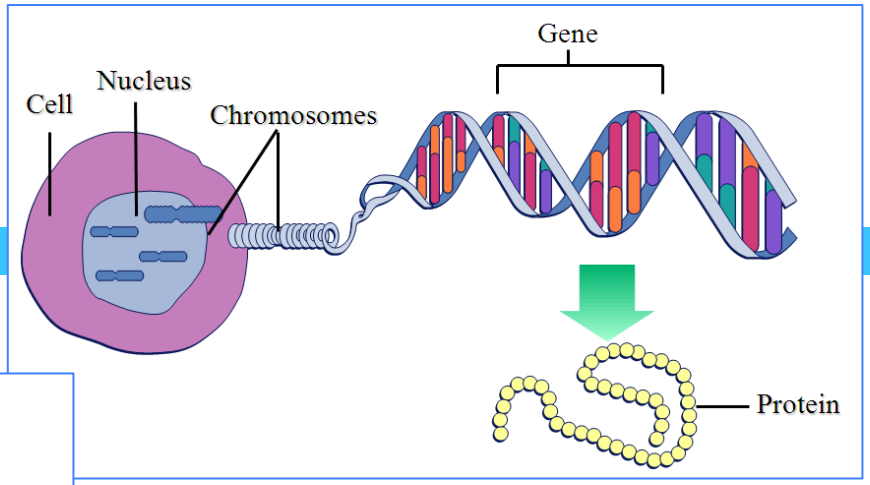
Science and Society/SuperStock

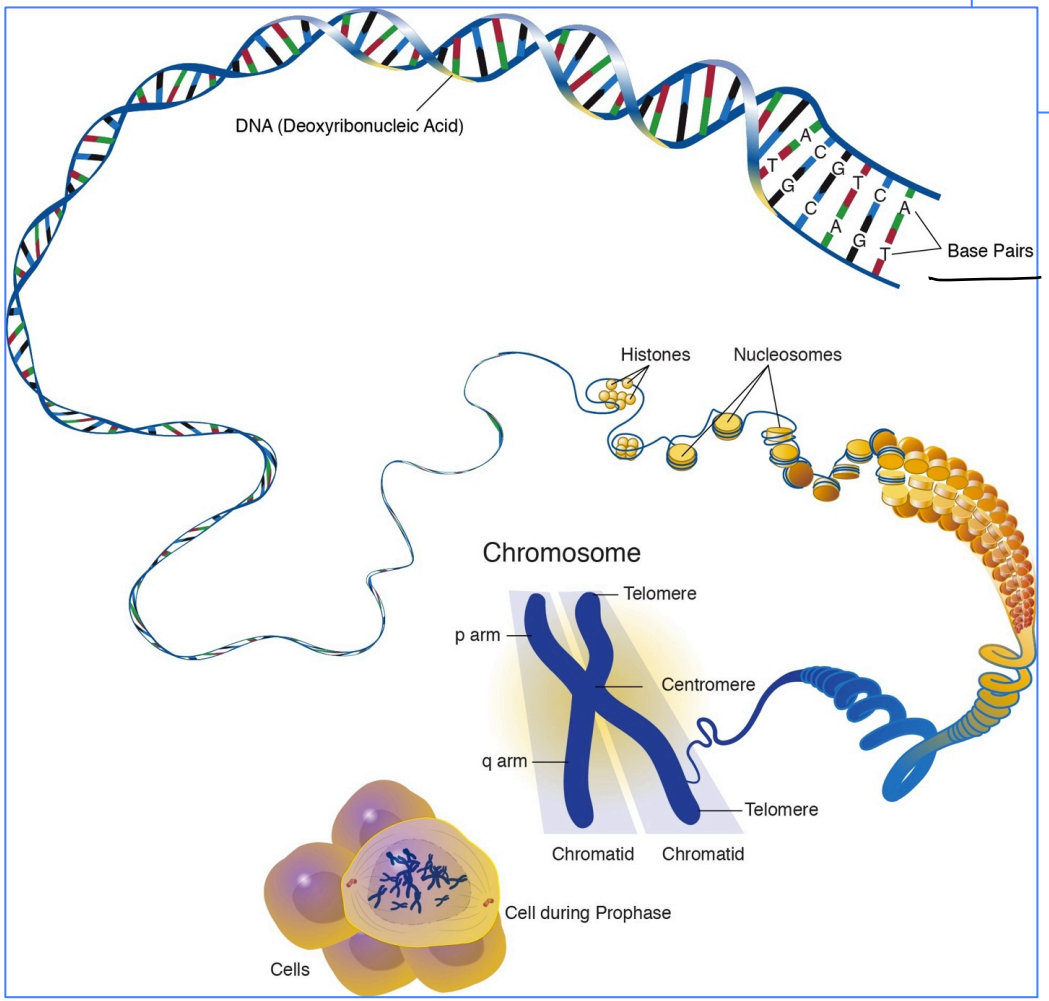
Terms to remember….

- Base pairs : via h-bonding.
- Genes → one character of the organism
- Histones
- Nucleosomes
- DNA
- Chromatids : 2 per chromosome
- Chromosomes = nucleosomes + coiling
- Nucleus

proteins

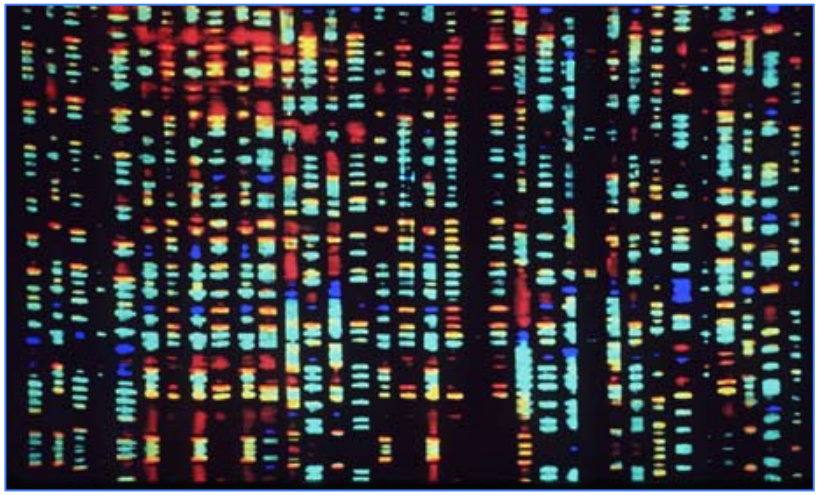
Genes and Chromosomes



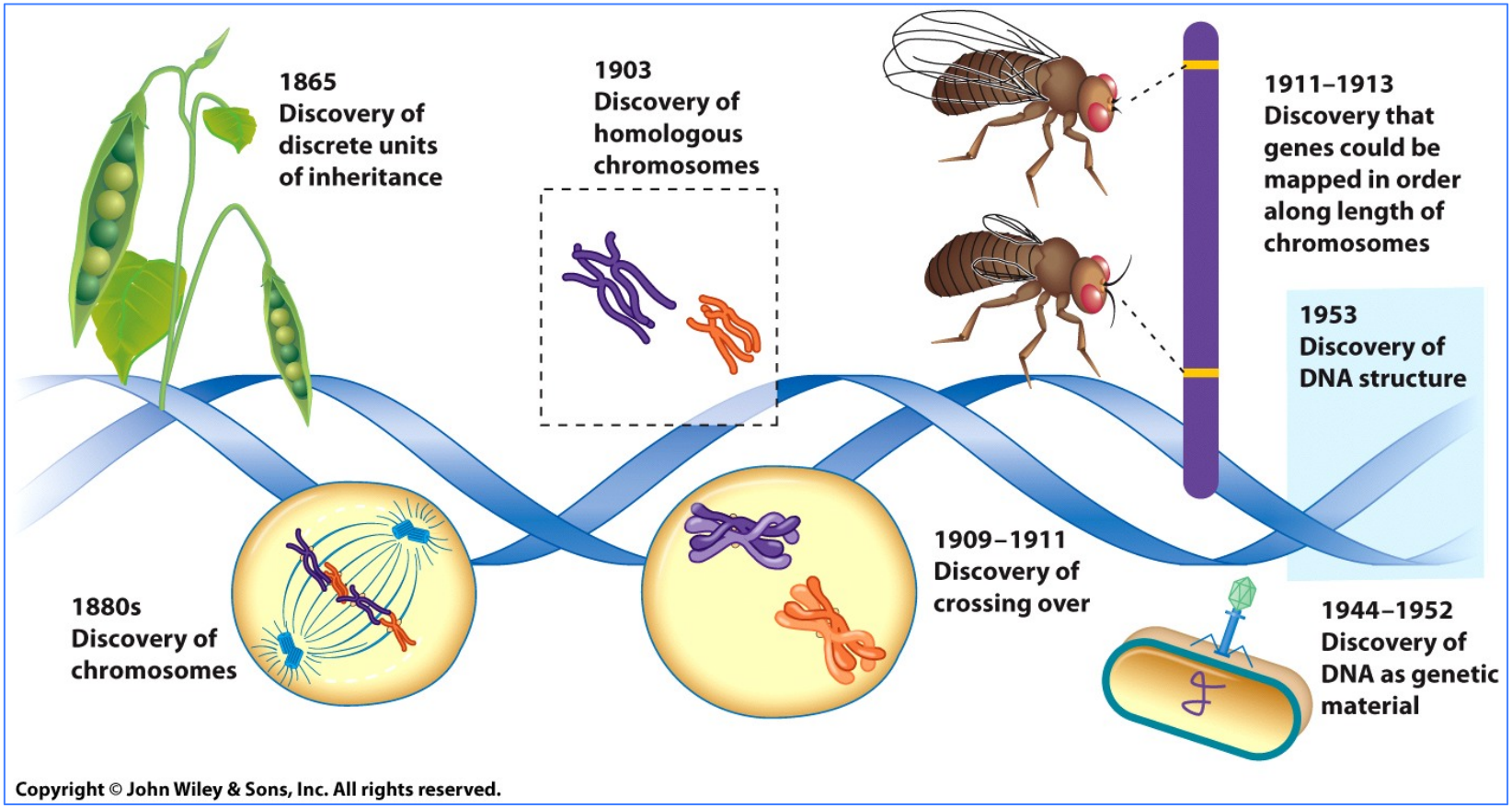


The Genome

- Hereditary factors consist of DNA and reside on chromosomes.
- The collective body of genetic information in an organism is called the **genome**.



Early discoveries on the nature of gene



Mendel's Experiment

- Science of genetics began in 1860 with the work of Gregor Mendel
- Mendel's work became the foundation for the science of genetics.
- Mendel crossbred plants through several generations and counted the number of individuals with various characteristics.
- He established the laws of inheritance based on his studies of pea plants.

Table 10.1 Seven Traits of Mendel's Pea Plants

Trait	Dominant allele	Recessive allele
Height	Tall	Dwarf
Seed color	Yellow	Green
Seed shape	Round	Angular (wrinkled)
Flower color	Purple	White
Flower position	Along stem	At stem tips
Pod color	Green	Yellow
Pod shape	Inflated	Constricted

(See www.mendelweb.org for a discussion of Mendel's work.)

Mendel chose to focus on seven clearly definable traits, including plant height and flower color, each of which occurred in two alternate and clearly identifiable forms.

Mendel's Conclusions

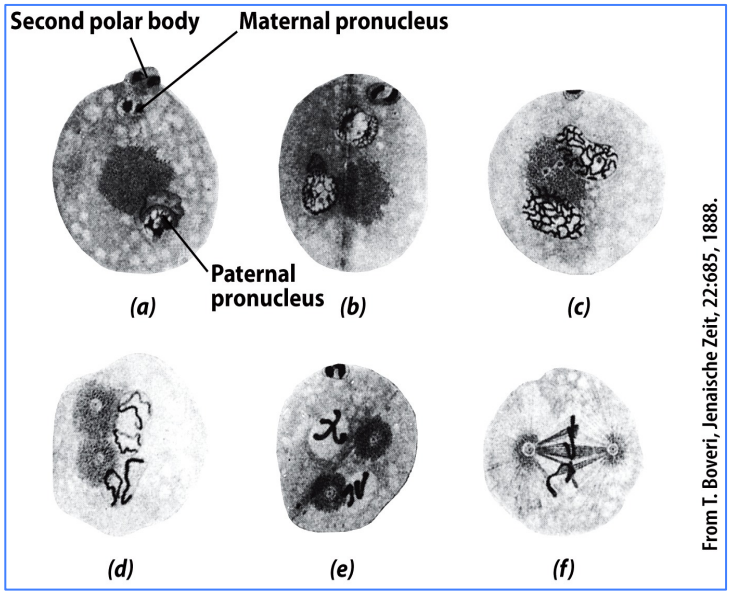
1. Characteristics of organisms are governed by units of inheritance called **genes.**
   a) Each trait is controlled by two forms of a gene called **alleles.**
   b) Alleles could be identical or non-identical.
   c) When alleles are non-identical, the dominant allele masks the recessive allele.
2. A reproductive cell (*gamete*) contains one gene for each trait.
   a) Somatic cells arise by the union of male and female gametes.
   b) Two alleles controlling each trait are inherited; one from each parent.
3. The pairs of genes are separated (*segregated*) during gamete formation.
4. Genes controlling different traits segregate independently of each (*independent assortment*)

[clicker Q]

Chromosomes: The Physical Carriers of Genes

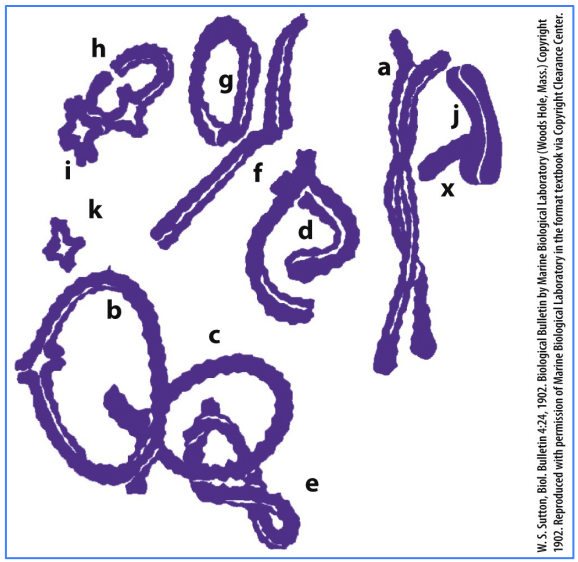
Chromosomes

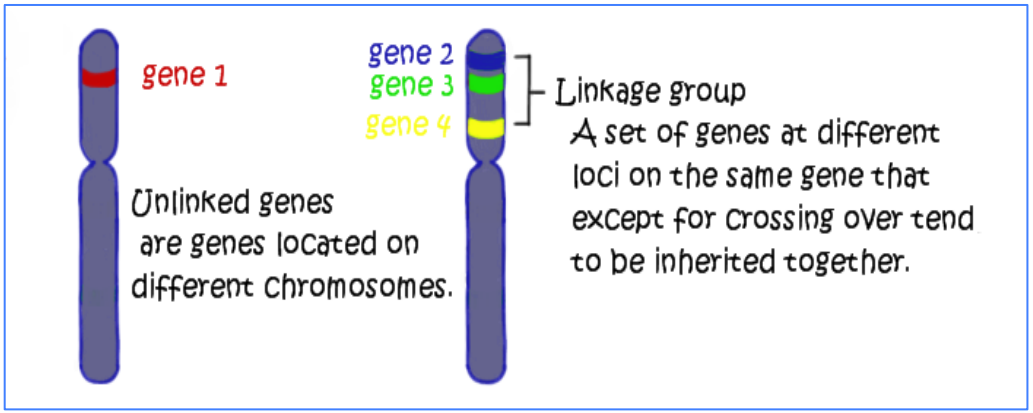
- are the carriers of genetic Information
- were first observed in dividing cells, using the light microscope.
- are present as pairs of **homologous chromosomes.**
- Chromosomal behavior correlates with Mendel's laws of inheritance.



Chromosomes: The Physical Carriers of Genes

- Genes that are on the same chromosome do not assort independently.
- Genes on the same chromosome are part of the same **linkage group.**
- The traits analyzed by Mendel occur on different chromosomes.



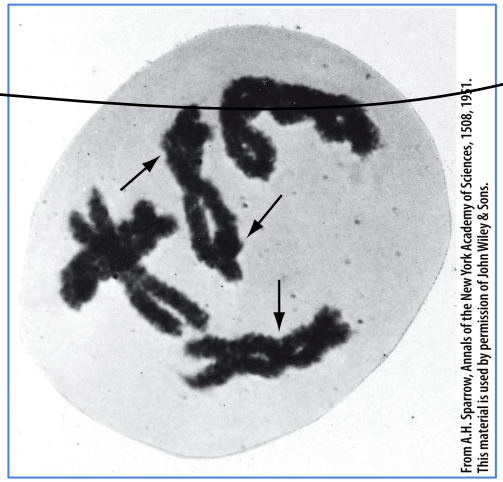


Chromosomes: The Physical Carriers of Genes

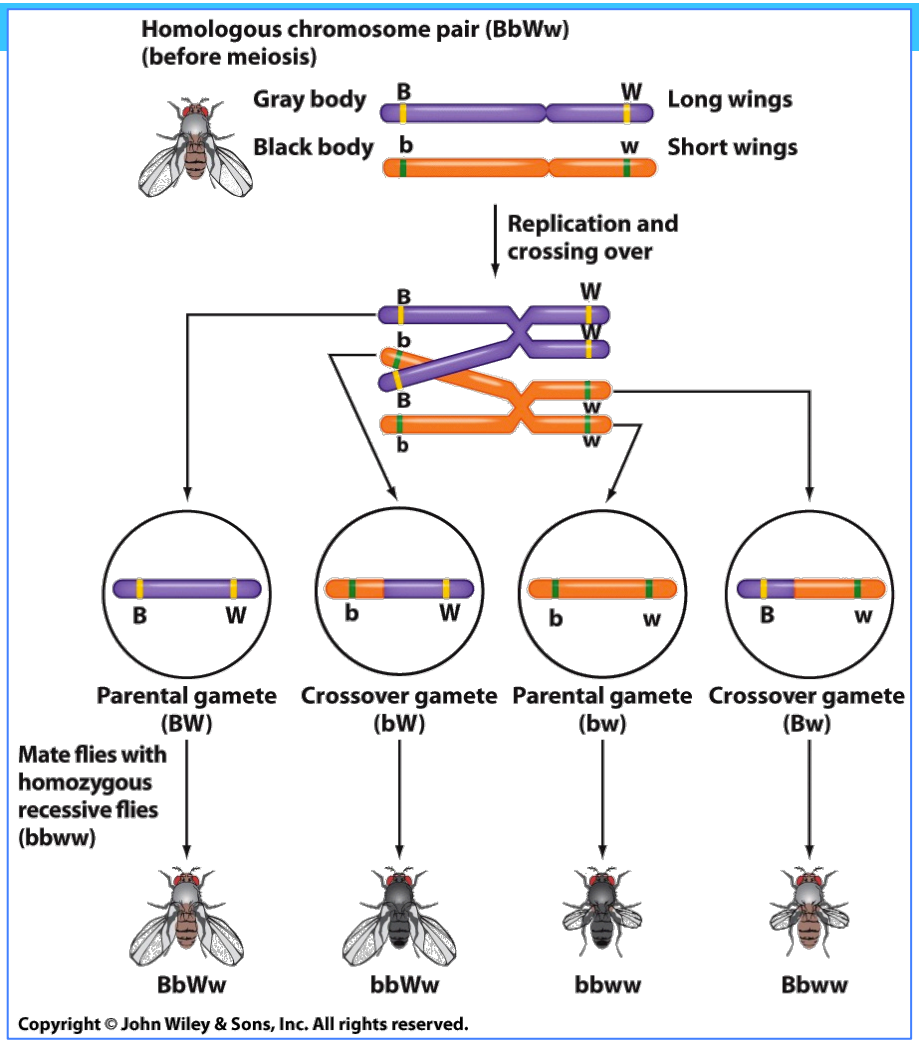
Crossing Over and Recombination

- Linkage between alleles on the same chromosome is *incomplete*.
- Maternal and paternal chromosomes can exchange pieces during **crossing over** or **genetic recombination.**
- Frequency of recombination indicates distance, and increases as distance increases

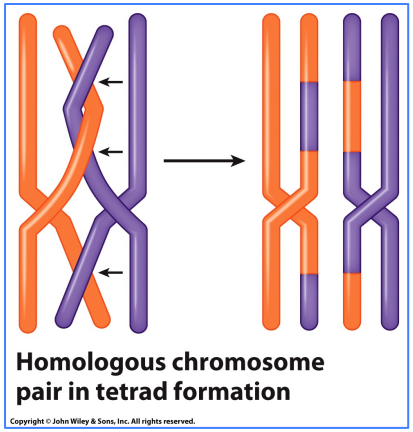
Micrograph of a lily cell: Homologous chromosomes wrap around each other during meiosis. The points at which the homologues are crossed are termed as *chiasmata* (arrows)



Crossing over in Drosophila



Simplified representation of a single crossover in a *Drosophila* heterozygote and the resulting gametes

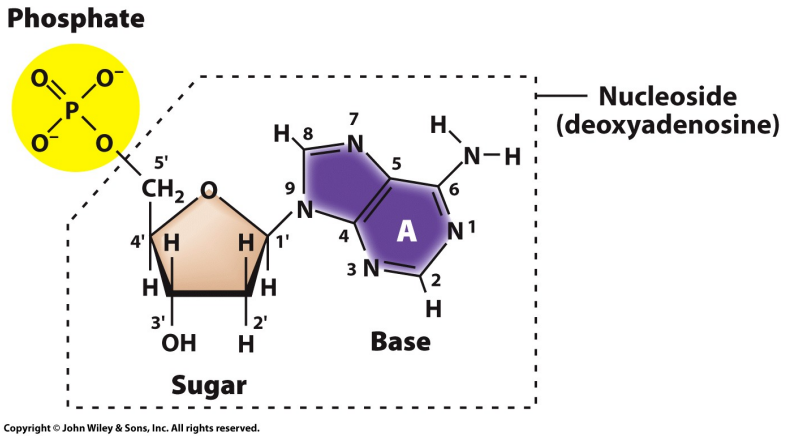


The Chemical Nature of the Gene

The Structure of DNA:

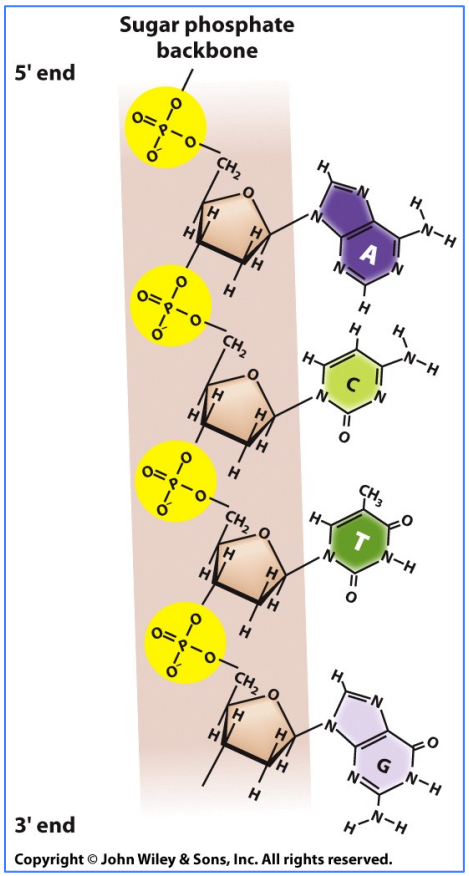
- **Nucleotide** is the building block of DNA.
- It consists of a phosphate, a sugar, and either a **pyrimidine** or **purine** nitrogenous base.
  - Two different pyrimidines: *thymine (T)* and *cytosine (C)*.
  - Two different purines: *adenine (A)* and *guanine (G)*.

Chemical structure of a DNA nucleotide containing the base adenosine



The Chemical Nature of the Gene

- Nucleotides have a polarized structure where the ends are called *5'* and *3'*
- Nucleotides are linked into nucleic acids polymers:
  - Sugar and phosphates are linked by 3',5'-phosphodiester bonds.
  - Nitrogenous bases project out like stacked shelves.
- Chargaff established rules after doing **base composition** analysis:
  - Number of adenine = number of thymine
  - Number of cytosine = number of guanine

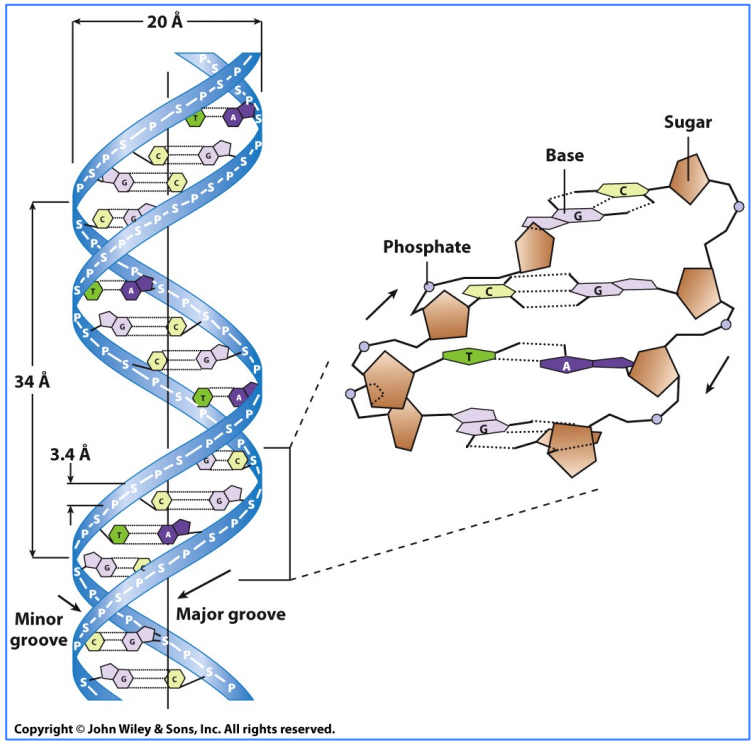


The Chemical Nature of the Gene

The double helix

The Watson-Crick Proposal

- DNA molecule is a double helix.
- DNA is composed of two chains of nucleotides.
- The two chains spiral around each other forming a pair of right-hand helices.
- The two chains are *antiparallel*, they run in opposite directions.
- The sugar-phosphate backbone is located on the outside of the molecule.
- The bases are inside the helix.

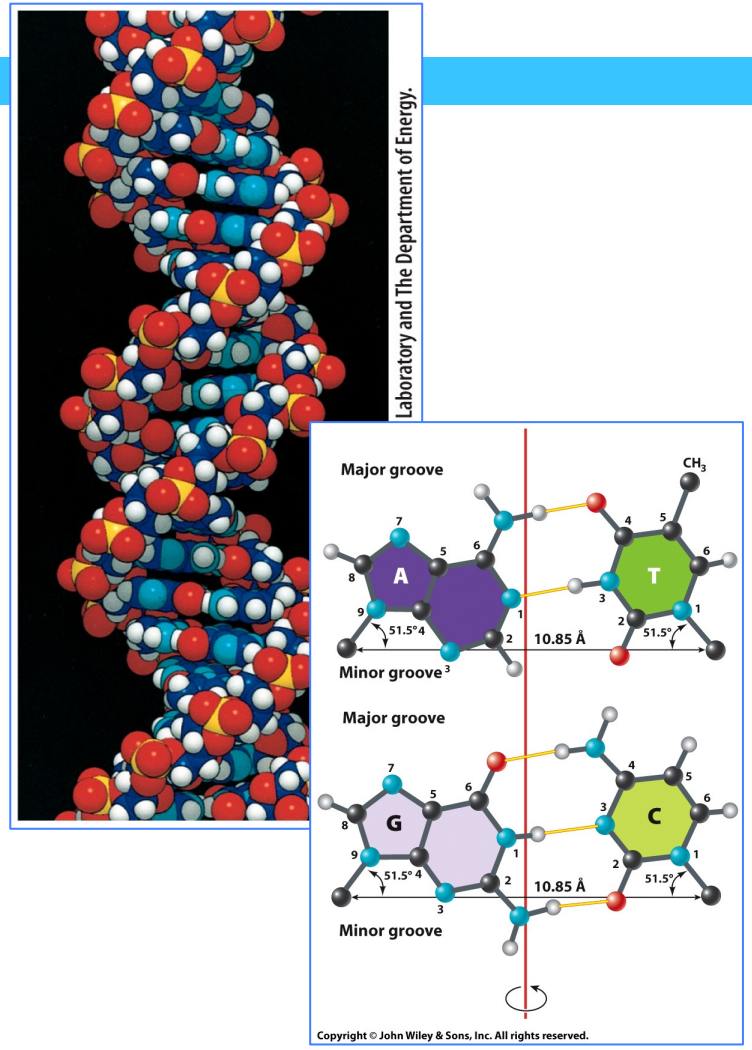


Schematic representation of the DNA double helix

The Chemical Nature of the Gene

The double helix

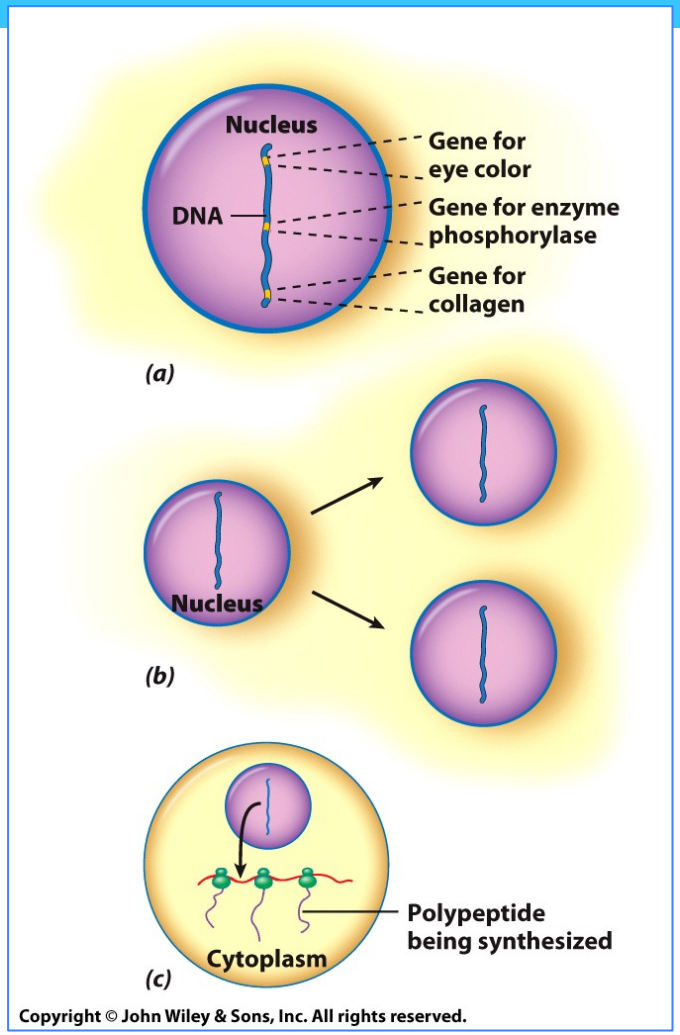
- The two DNA chains are held together by hydrogen bonds between each base.
- The double helix is 2 nm wide.
- Pyrimidines are always paired with purines.
- Only A-T and C-G pairs fit within double helix.
- Molecule has a major groove and a minor groove.
- The two chains are complementary to each other



The Chemical Nature of the Gene

Three functions of the genetic material

- The Importance of the Watson-Crick Proposal
  1. Storage of genetic information.
  2. Replication and inheritance.
  3. Expression of the genetic message.

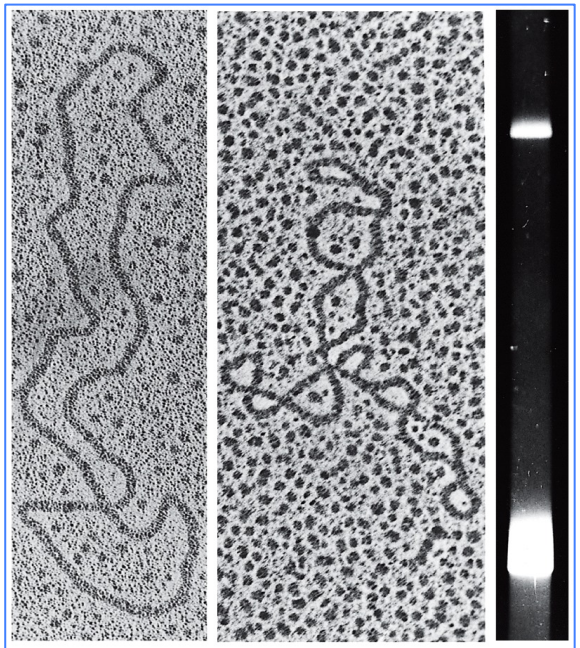


The Chemical Nature of the Gene

DNA supercoiling

- DNA that is more compact than its relaxed counterpart is called supercoiled.
- Underwound DNA is negatively supercoiled, and overwound DNA is positively supercoiled.
- ~~Negative~~ supercoiling plays a role in allowing chromosomes to fit within the cell nucleus.

should say "positive"

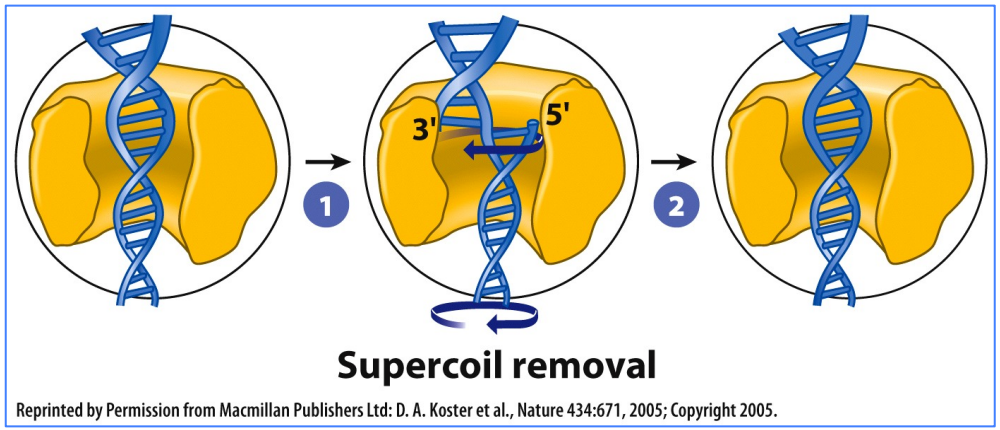


Courtesy James C. Wang; From Walter Keller, Proc. Nat'l Acad. Sci. U.S. 72:2553, 1975.

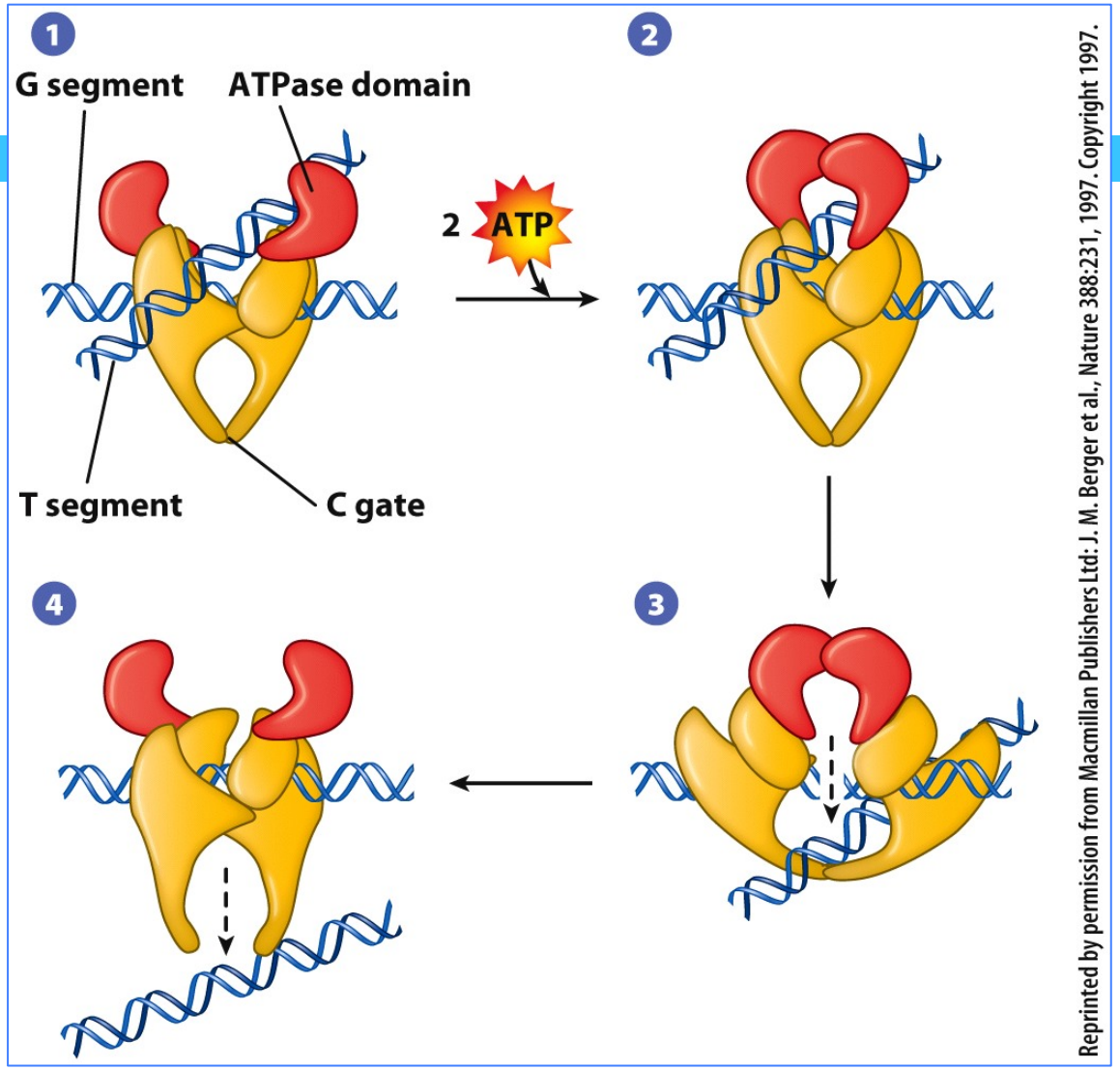
The Chemical Nature of the Gene

DNA Supercoiling

- Enzymes called topoisomerases change the level of DNA supercoiling.
- Cells contain a variety of topoisomerases.
  - *Type I* – change the supercoiled state by creating a transient break in one strand of the duplex.
  - *Type II* – make a transient break in both strands of the DNA duplex.



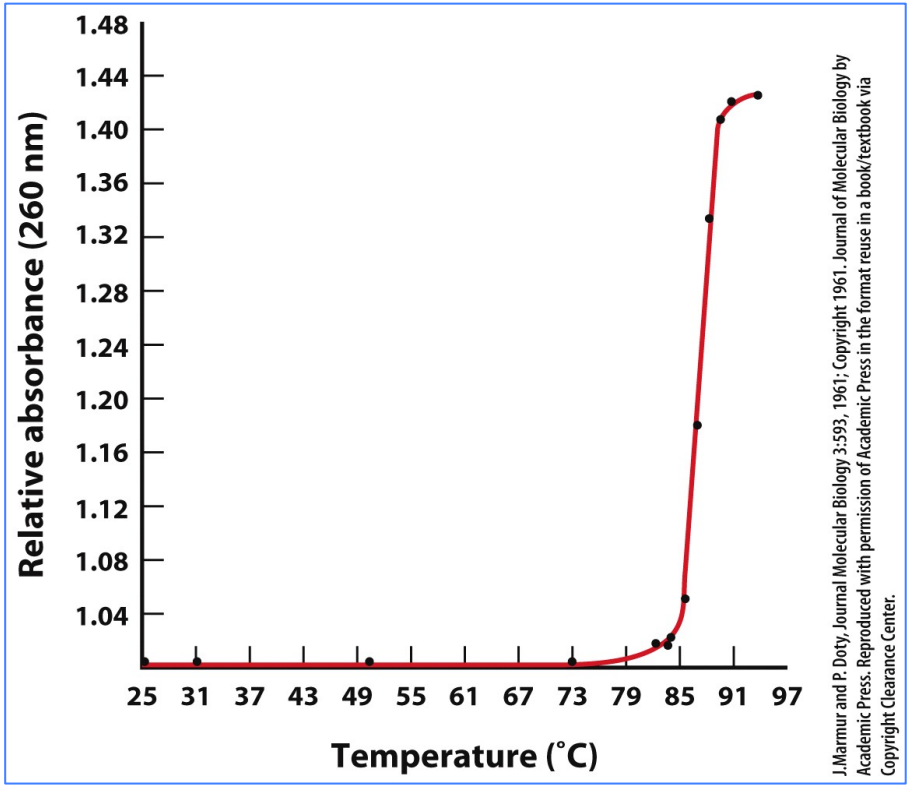
Modeling the action of human topoisomerase I



Modeling the action of human topoisomerase II

Denaturation of DNA

- The genome of a cell is its unique content of genetic information.
- One important property of DNA is its ability to separate into two strands (denaturation).



Renaturation of DNA

- Renaturation or reanneling is when single-stranded DNA molecules are capable of associating.
- Reanneling has led to the development of nucleic acid hybridization in which complementary strands of nucleic acids form different sources can form hybrid molecules.