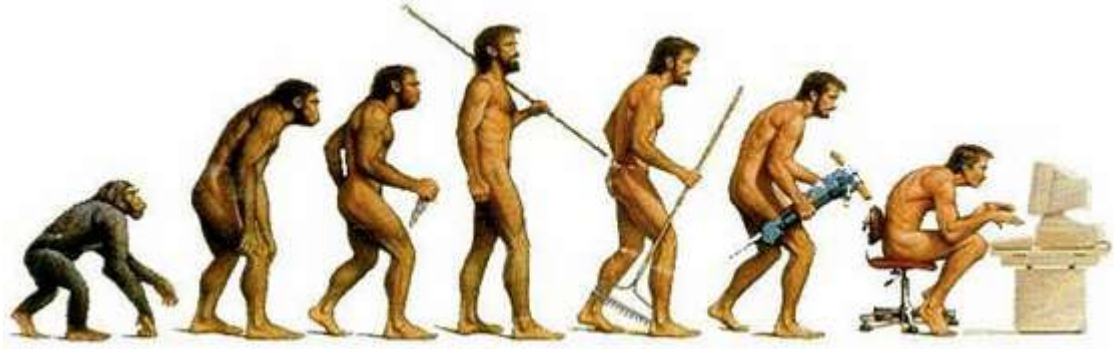
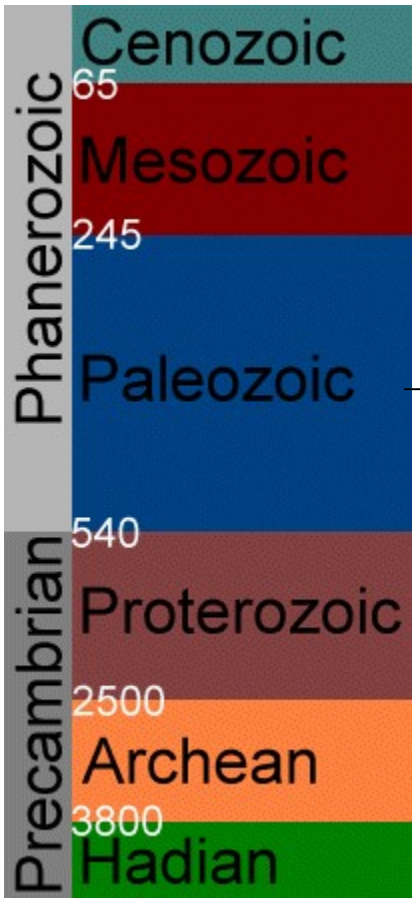
Molecular Evolution of Life

Biochemical Evolution



- What is Evolution?
- How did first cells become life as we know it today?
- how was the first cell created?
- What is a CELL?

6 Eras on the geological timescale



many mammals- whales, the great hunter cats & Humans, birds, insects, and many new plants .

cretaceous, the Jurassic, Triassic - dinosaurs

nearly all of the invertebrates & Plants-Rainforests

Bacterial life and Archaean life

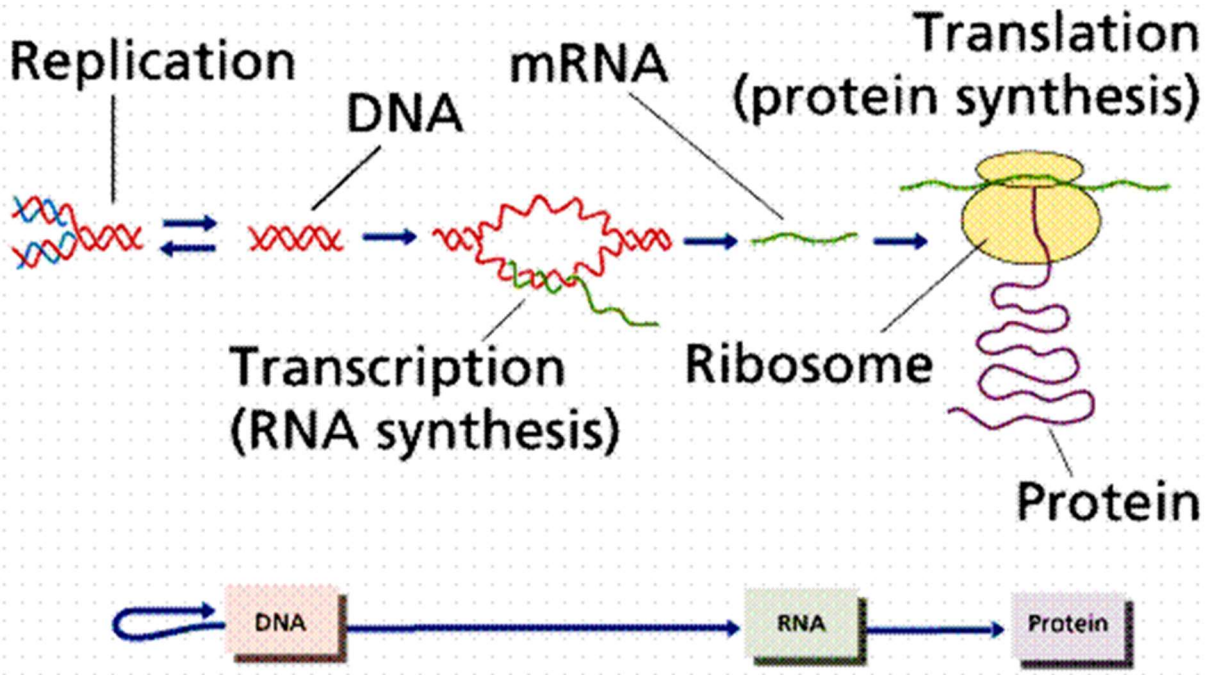
Formation of the first cells

The Hadean era did not contain life

Molecular Evolution

"**Molecular Evolution**" is a term that describes the stages that preceded the origin of life on Earth.

It is concerned with the processes of evolution at the scale of DNA, RNA, and proteins.



Milestones in the study of molecular evolution

- Around 1900, George Nuttal mixed

Sera and antisera from different species

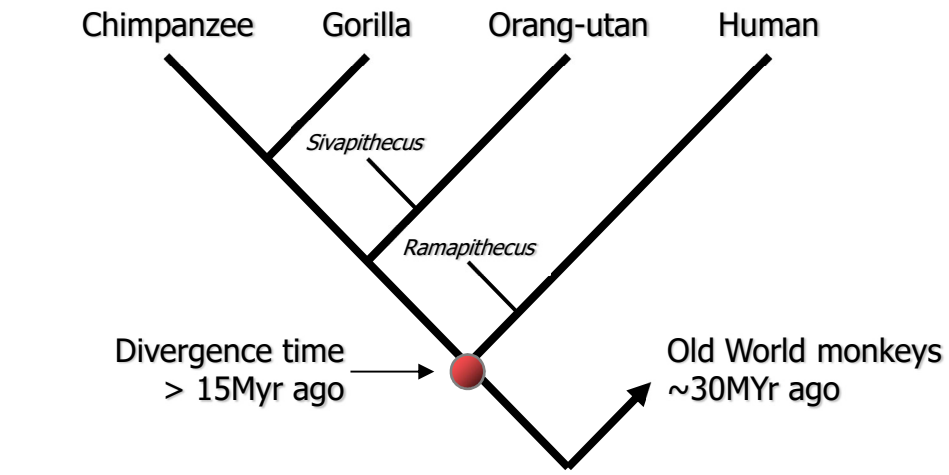
to determine “blood relationships”:

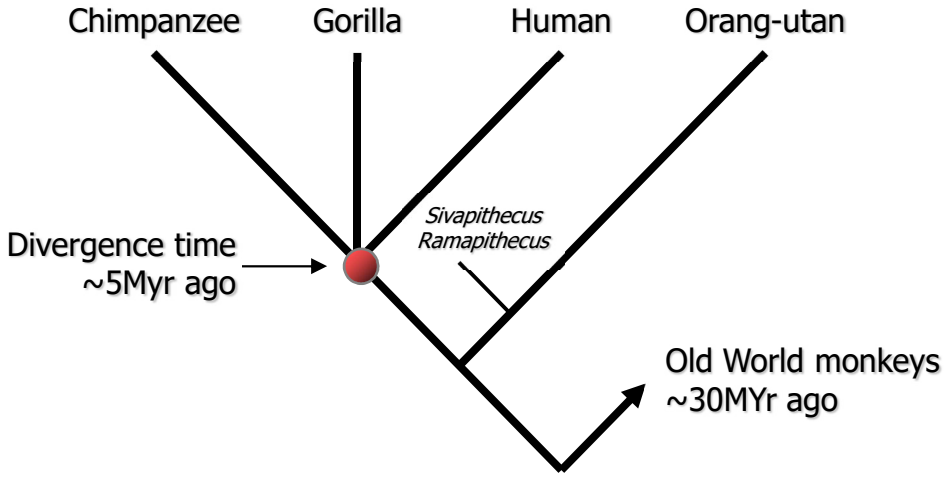
  - more closely related species would exhibit strongest cross-reactions between sera and antisera
  - Displayed that degree of similarity between genes reflects strength of evolutionary relationship between them

- Despite advances in theoretical evolutionary biology (“neo-Darwinian synthesis”), the study of molecular evolution made little progress in the next fifty years due to a lack of data

- **Commonly held view on human origins was that humans were genetically distinct from great apes**

- Sarich & Wilson (1967) changed this view:
  - Cross-reacted serum albumin between primates
  - Demonstrated that human, gorilla and chimpazee were genetically equidistant and distinct from orang-utan
  - Calibrated molecular clock

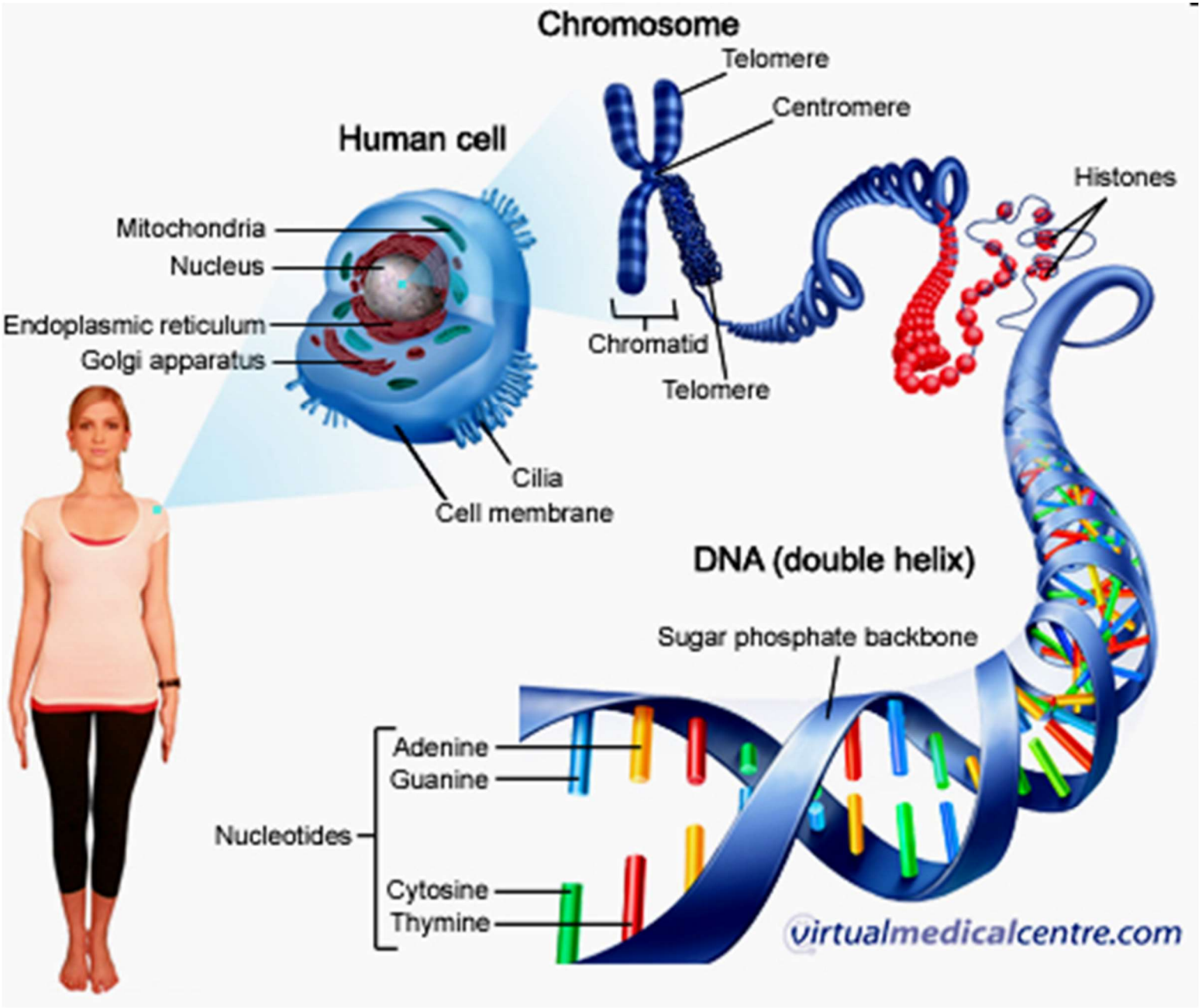




- In 1953, James Watson and Francis Crick proposed the double-helical model of the structure of DNA
- This revealed the mechanism by which DNA carried hereditary information between generations

In 1955, Fred Sanger and colleagues sequenced the first protein, insulin:

Sequences were obtained for cattle, pigs and sheep
Three amino acid differences showed genetic variation alongside morphological variation


Chromosome
Telomere
Centromere
Human cell
Histones
Mitochondria
Nucleus
Endoplasmic reticulum
Golgi apparatus
Chromatid
Telomere
Cilia
Cell membrane
DNA (double helix)
Sugar phosphate backbone
Adenine
Guanine
Nucleotides
Cytosine
Thymine
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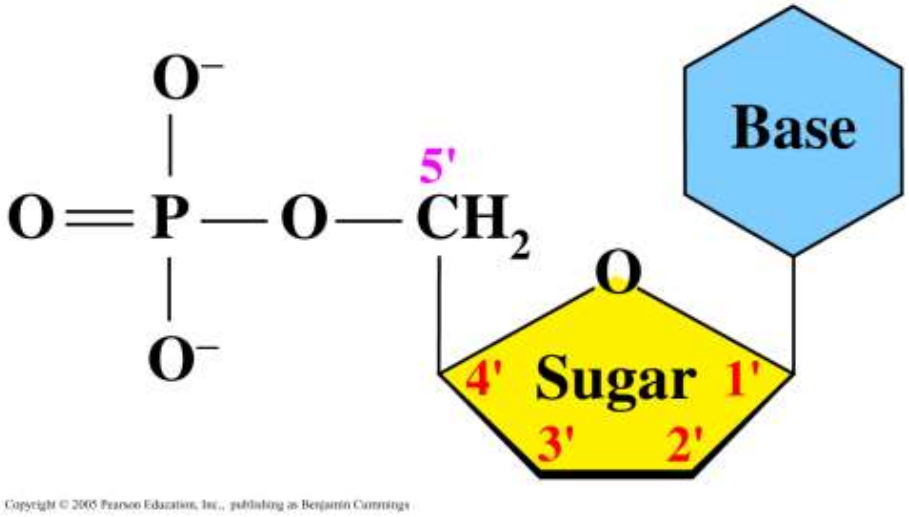
Nucleic Acids

Components of Nucleic Acids

Primary Structure of Nucleic Acids



Nucleic Acids

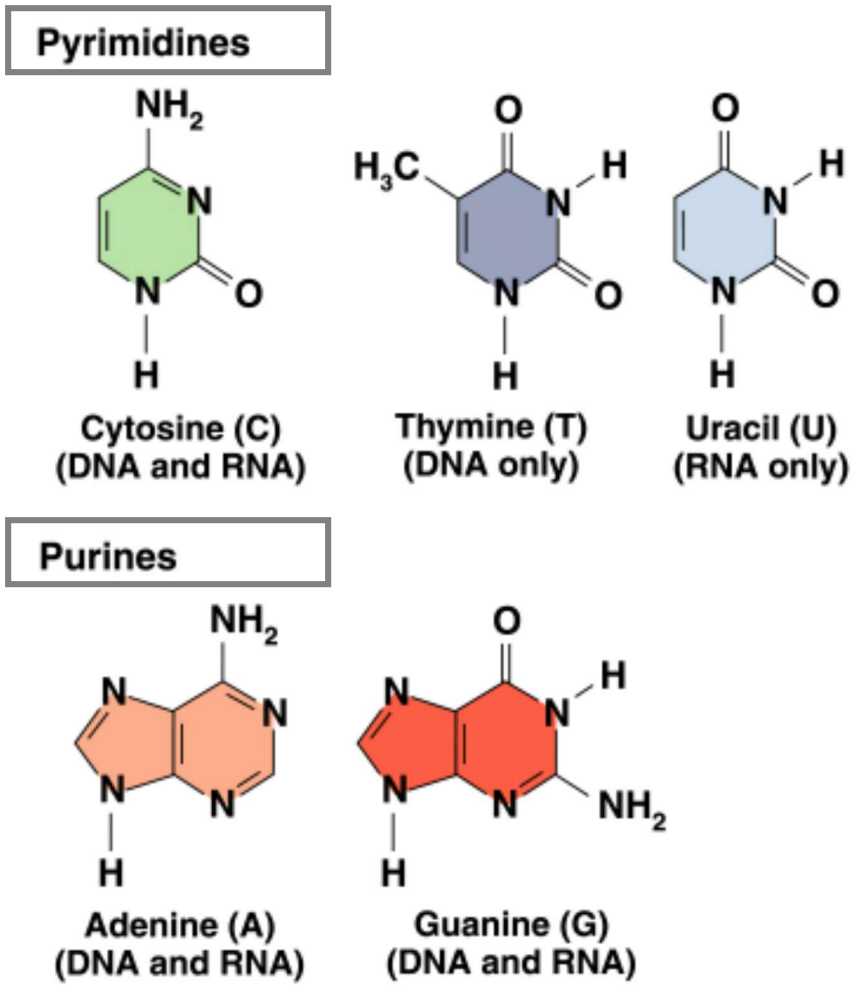
Nucleic acids are:

- molecules that store information for cellular growth and reproduction.
- deoxyribonucleic acid (DNA) and ribonucleic acid (RNA).
- large molecules consisting of long chains of monomers called nucleotides.

Nitrogen Bases

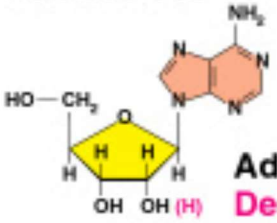
The **nitrogen bases** in DNA and RNA are

- pyrimidines C, T, and U.
- purines A and G.

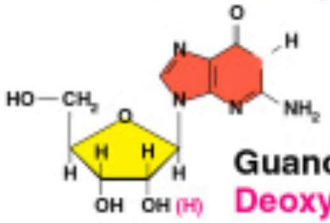


Nucleosides and Nucleotides with Purines

Nucleosides

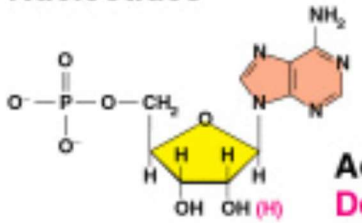


Adenosine
Deoxyadenosine



Guanosine
Deoxyguanosine

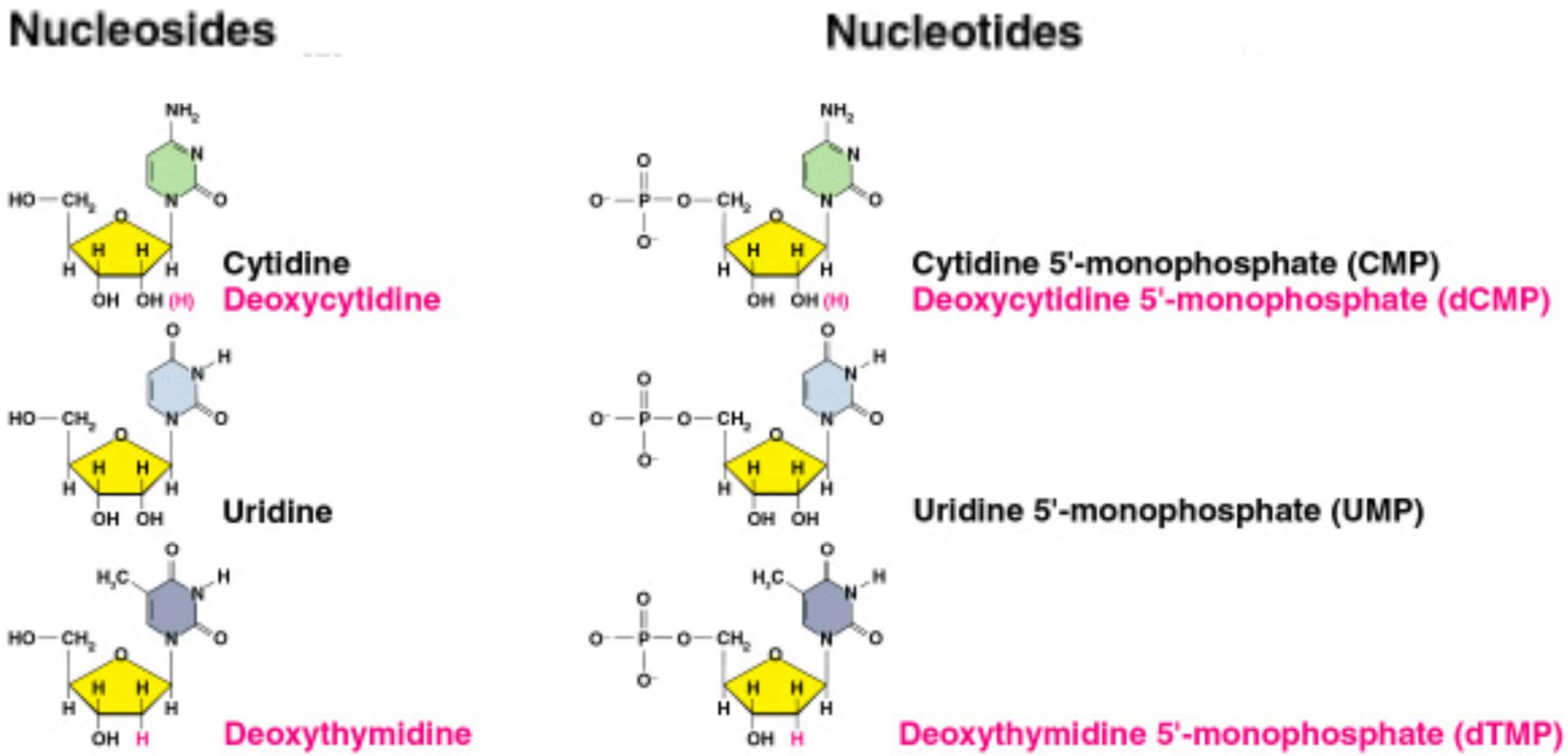
Nucleotides



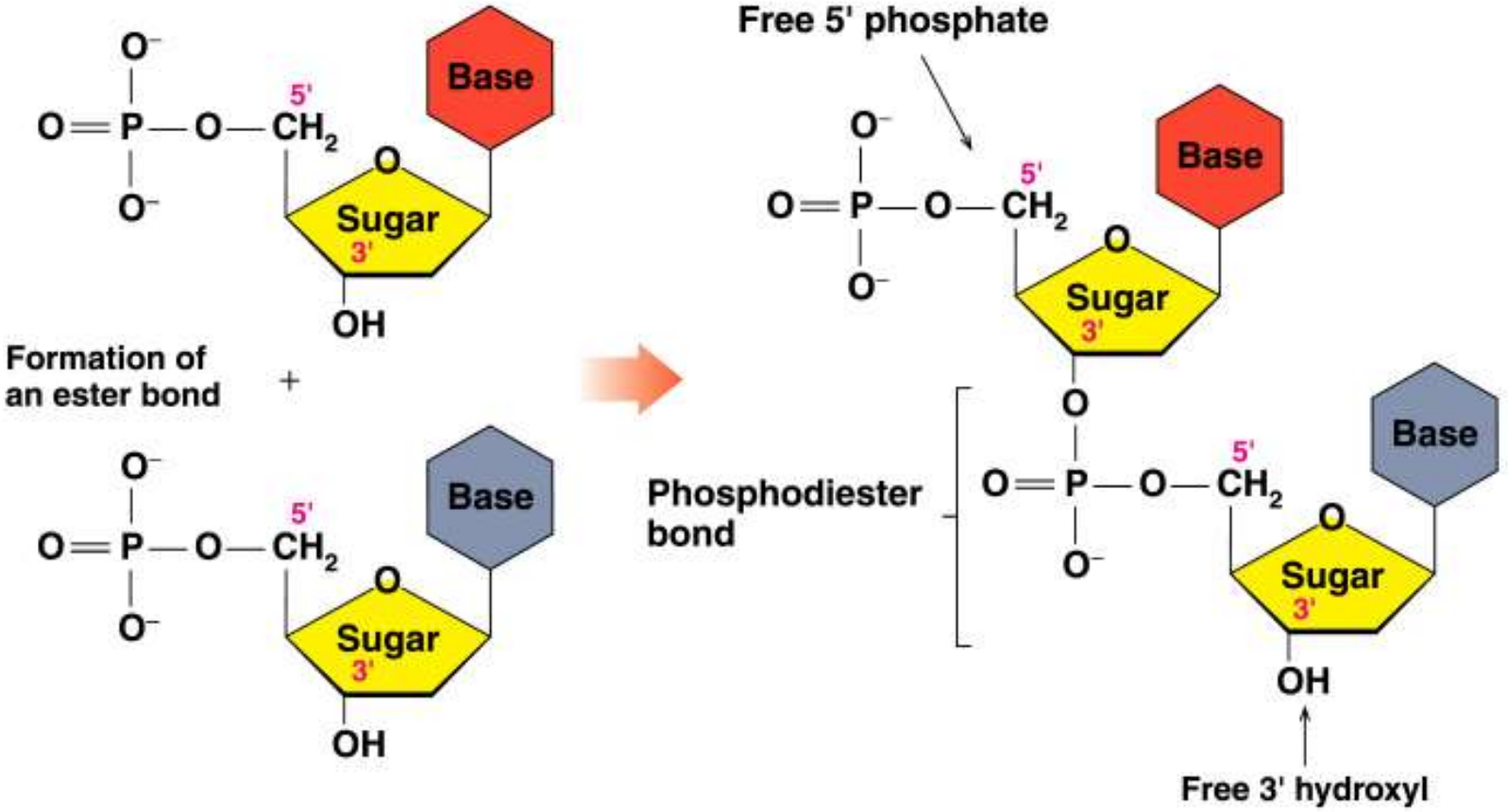
Adenosine 5'-monophosphate (AMP)
Deoxyadenosine 5'-monophosphate (dAMP)

Guanosine 5'-monophosphate (GMP)
Deoxyguanosine 5'-monophosphate (dGMP)

Nucleosides and Nucleotides with Pyrimidines



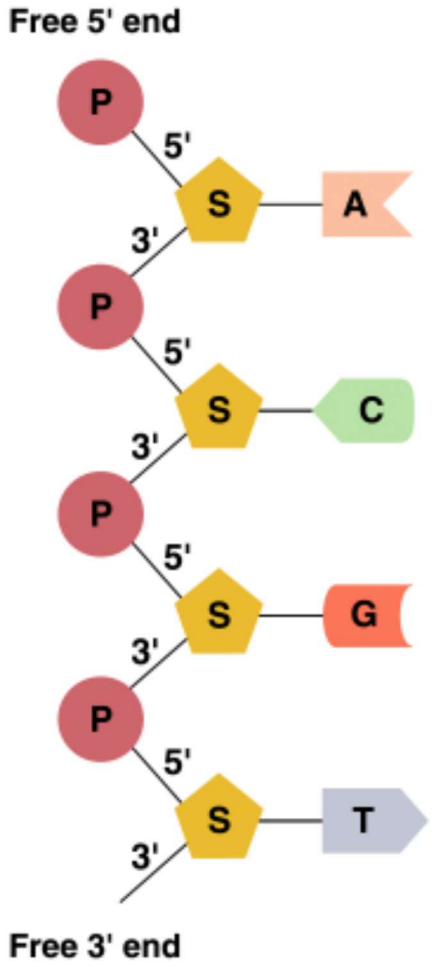
Primary Structure of Nucleic Acids



Structure of Nucleic Acids

A **nucleic acid**

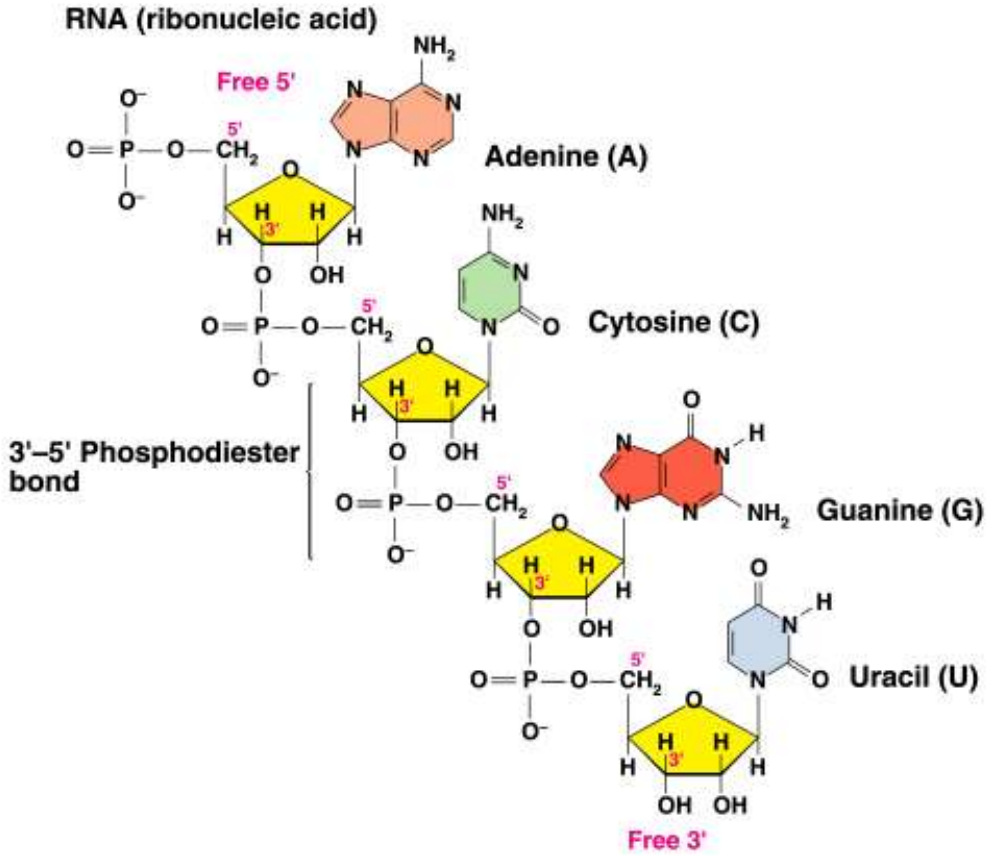
- has a free 5’-phosphate group at one end and a free 3’-OH group at the other end.
- is read from the free 5’-end using the letters of the bases.
- This example reads
  —A—C—G—T—.



Example of RNA Structure

The primary structure of RNA,

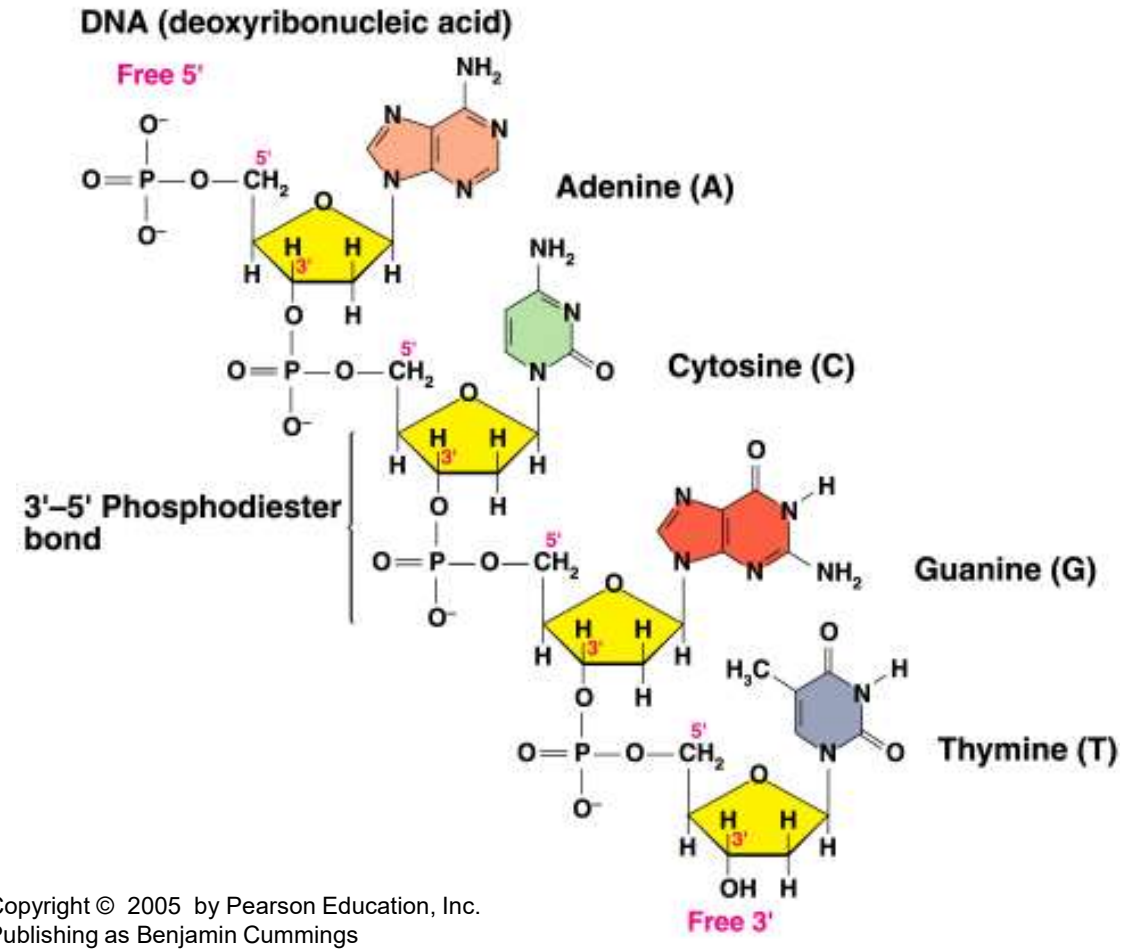
- is a single strand of nucleotides with bases A, C, G, and U.
- is linked by phosophodiester bonds between ribose and phosphate.



Example of DNA

In DNA,

- nucleotides containing bases A, C, G, and T are linked by ester bonds between deoxyribose sugars and phosphate groups.

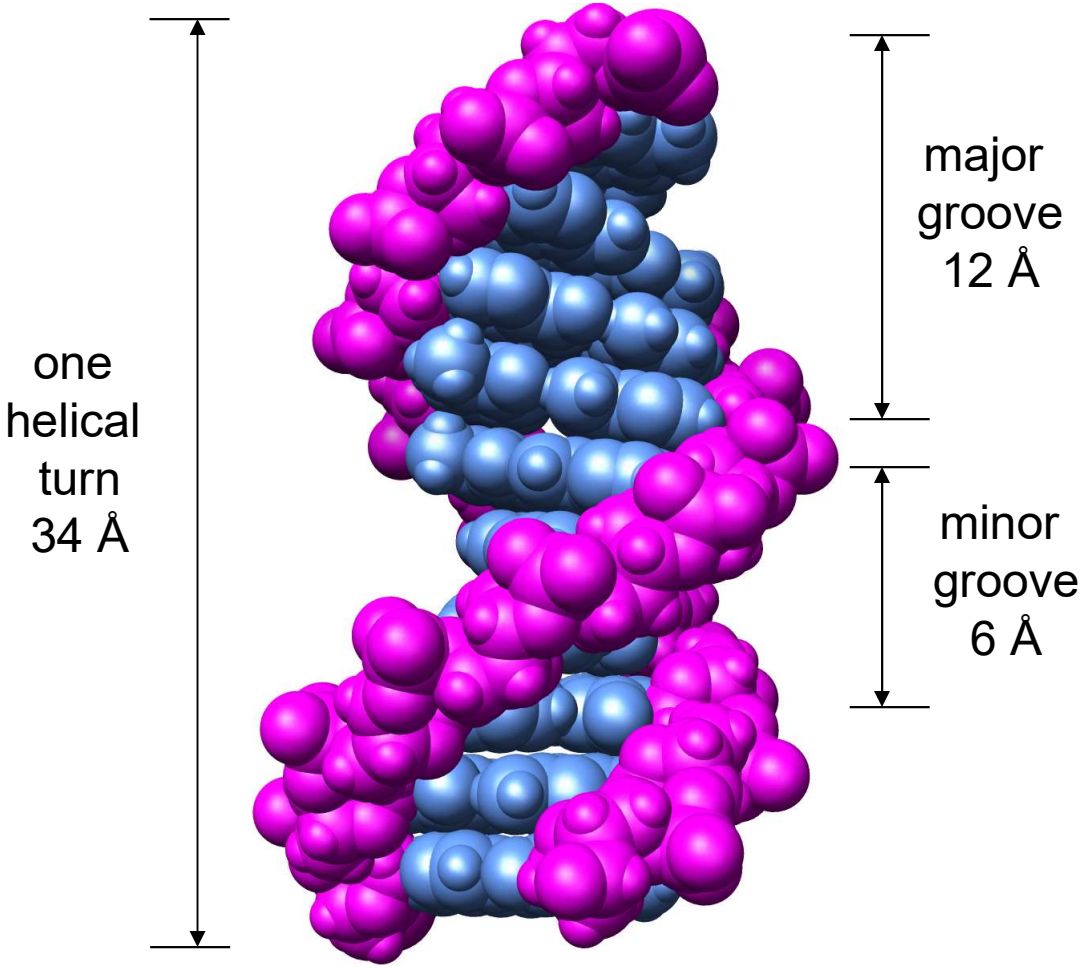


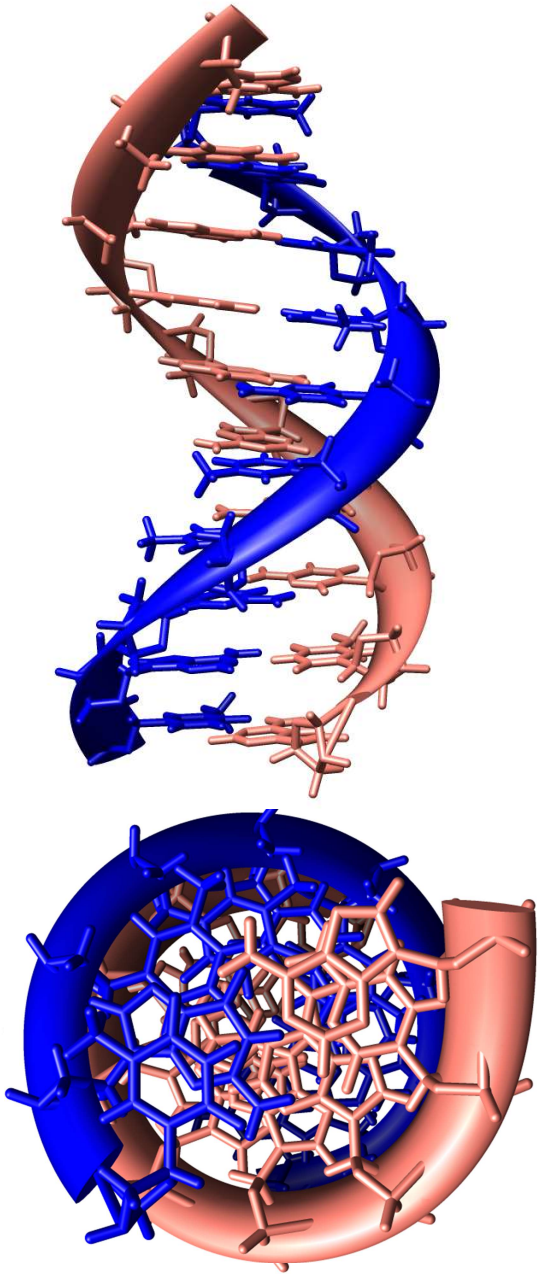
DNA Double Helix

A double helix

- is the structure of DNA.
- has two strands of nucleotides that wind together.
- is held in place by of two hydrogen bonds that form between the base pairs A-T.
- is held in place by three hydrogen bonds that form between the base pairs G-C.

DNA double helix



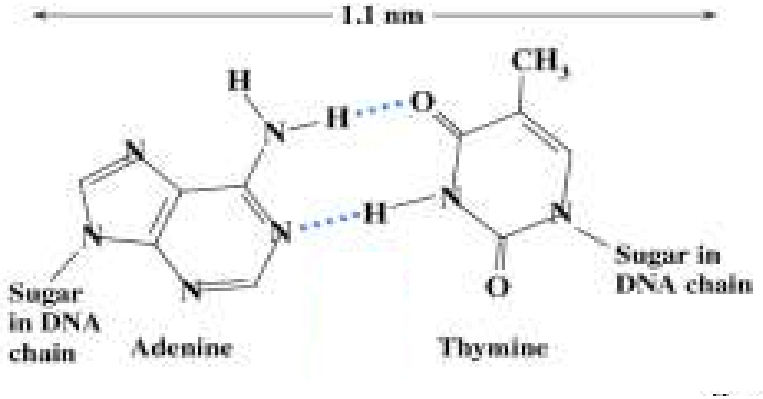


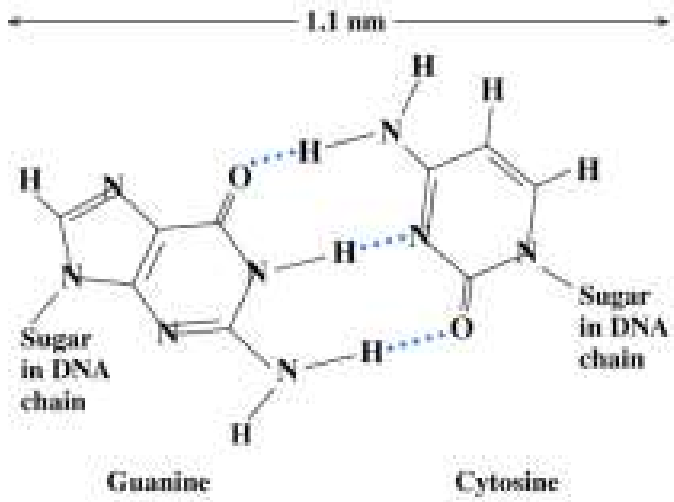
backbone: deoxyribose and phosphodiester linkage
bases

Complementary Base Pairs

DNA contains **complementary base pairs** in which

- Adenine is always linked by two hydrogen bonds with thymine (A−T).
- Guanine is always linked by three hydrogen with Cytosine (G−C).

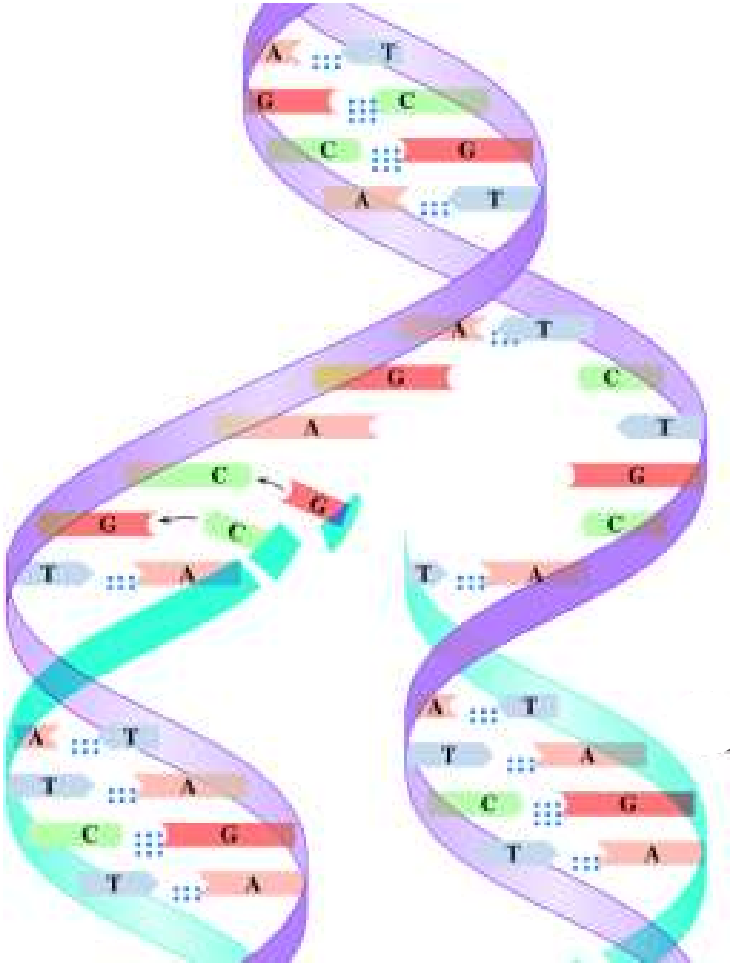




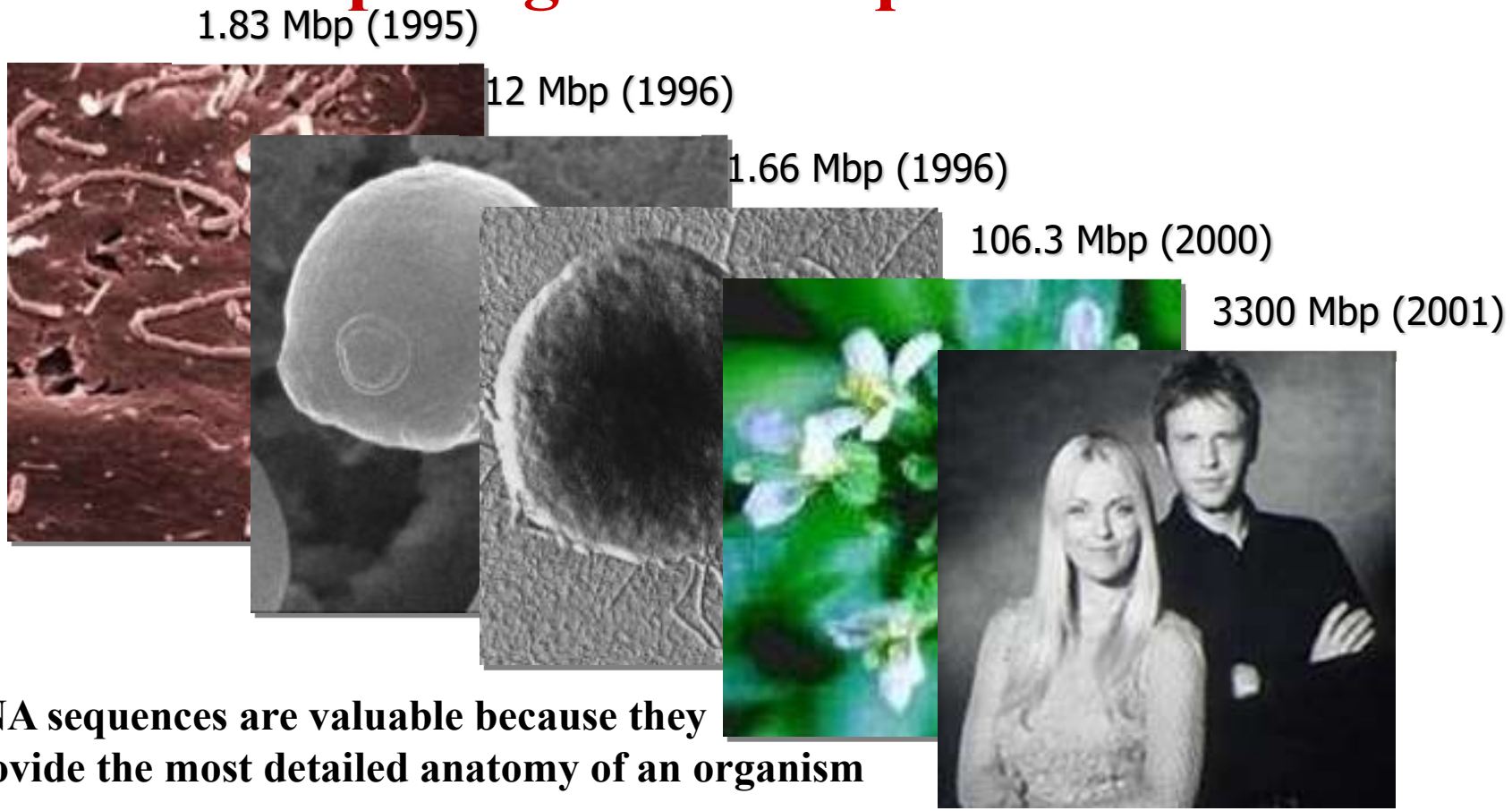
DNA Replication

In **DNA replication**

- genetic information is maintained each time a cell divides.
- the DNA strands unwind.
- each parent strand bonds with new complementary bases.
- two new DNA strands form that are exact copies of the original DNA.



Complete genome sequences

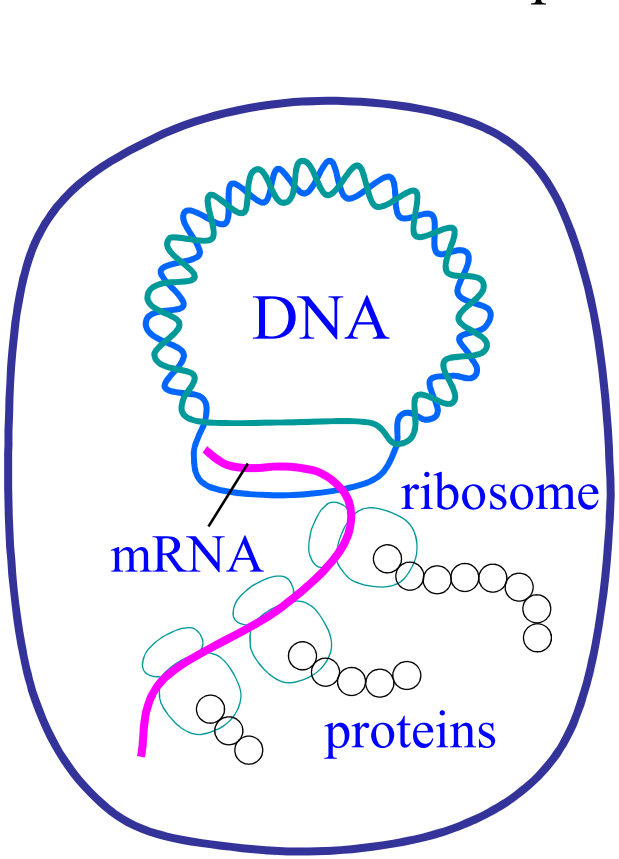


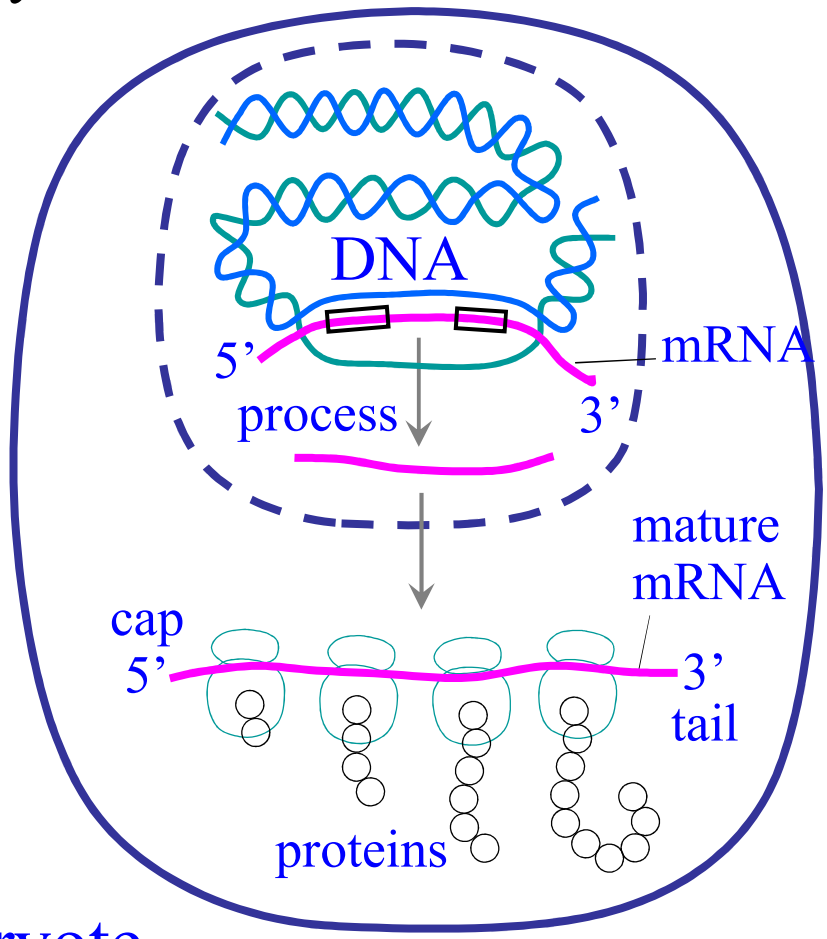
- **DNA sequences are valuable because they provide the most detailed anatomy of an organism**
- **Much of modern biology relies on unravelling information stored in gene sequences**
- **Importance of molecular evolution as a science:**
  - **Gene sequences represent an invaluable document of the history of life on earth**

Final Version of Cellular Genetic Mechanism

DNA replaced RNA becoming the major genetic material

RNA shifted its role to protein biosynthesis





Prokaryote

Student dormitory

Eukaryote

Furnished apartment

Molecular Cloning

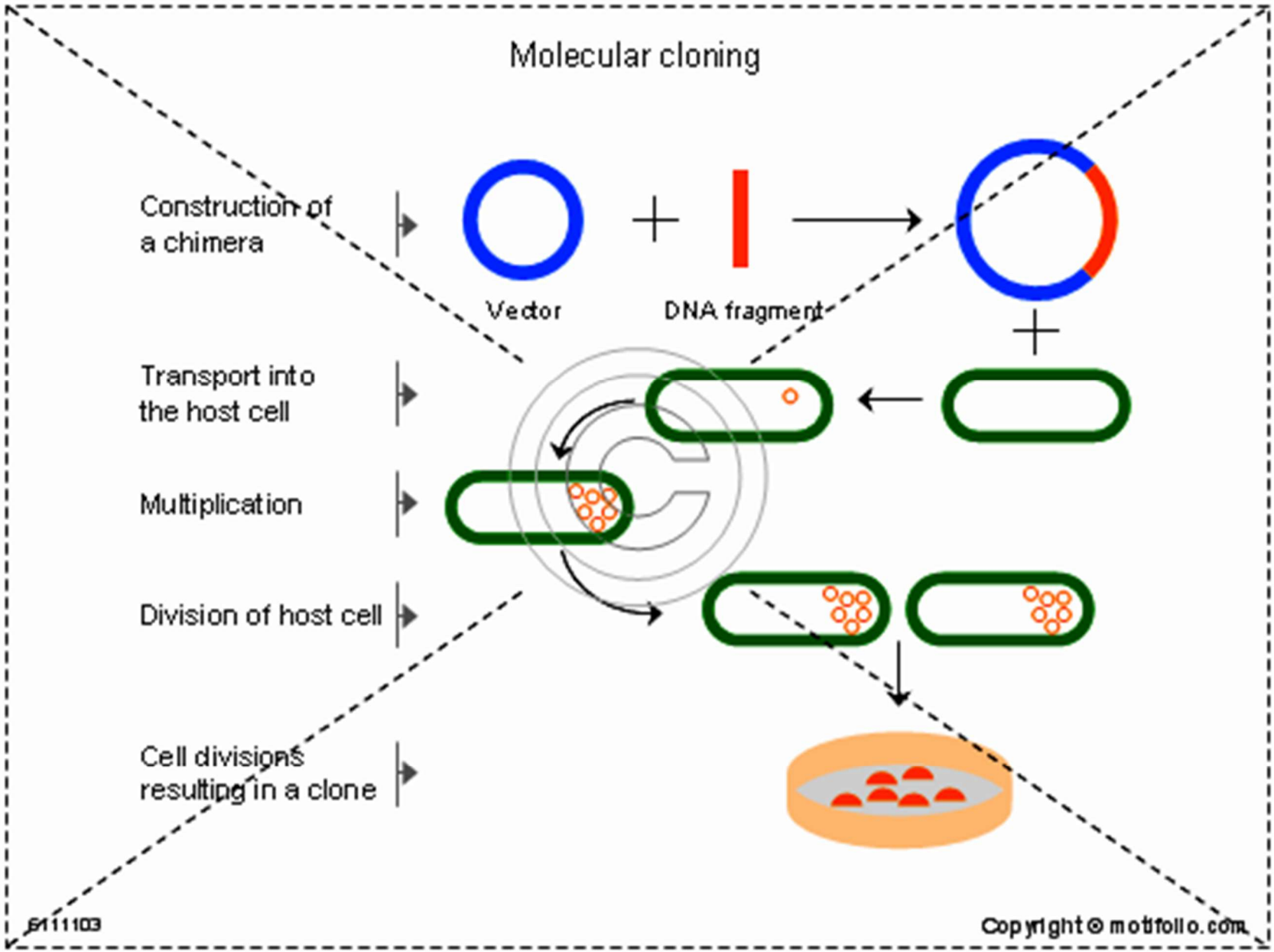
Inserting a piece of DNA molecule (of interest) into a DNA carrier (vector) to generate multiple copies in a host cell such as bacteria

Purposes

Separate a gene from others
Amplification of modified forms of genetic materials
Manipulation of DNA for further experiments

Vector (DNA carrier)

Plasmids
Cosmids
Bacteriophage
Virus


Molecular cloning
Construction of a chimera
Vector
DNA fragment
Transport into the host cell
Multiplication
Division of host cell
Cell divisions resulting in a clone
S111103
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Restriction Endonucleases
--The Molecular Scissors

Host enzymes that prevent the invasion of foreign DNAs such as viral DNA, by cutting them up.

→ **Restriction**

These enzymes cut within the foreign DNAs, rather than chewing them away from the ends.

→ **Endonucleases**

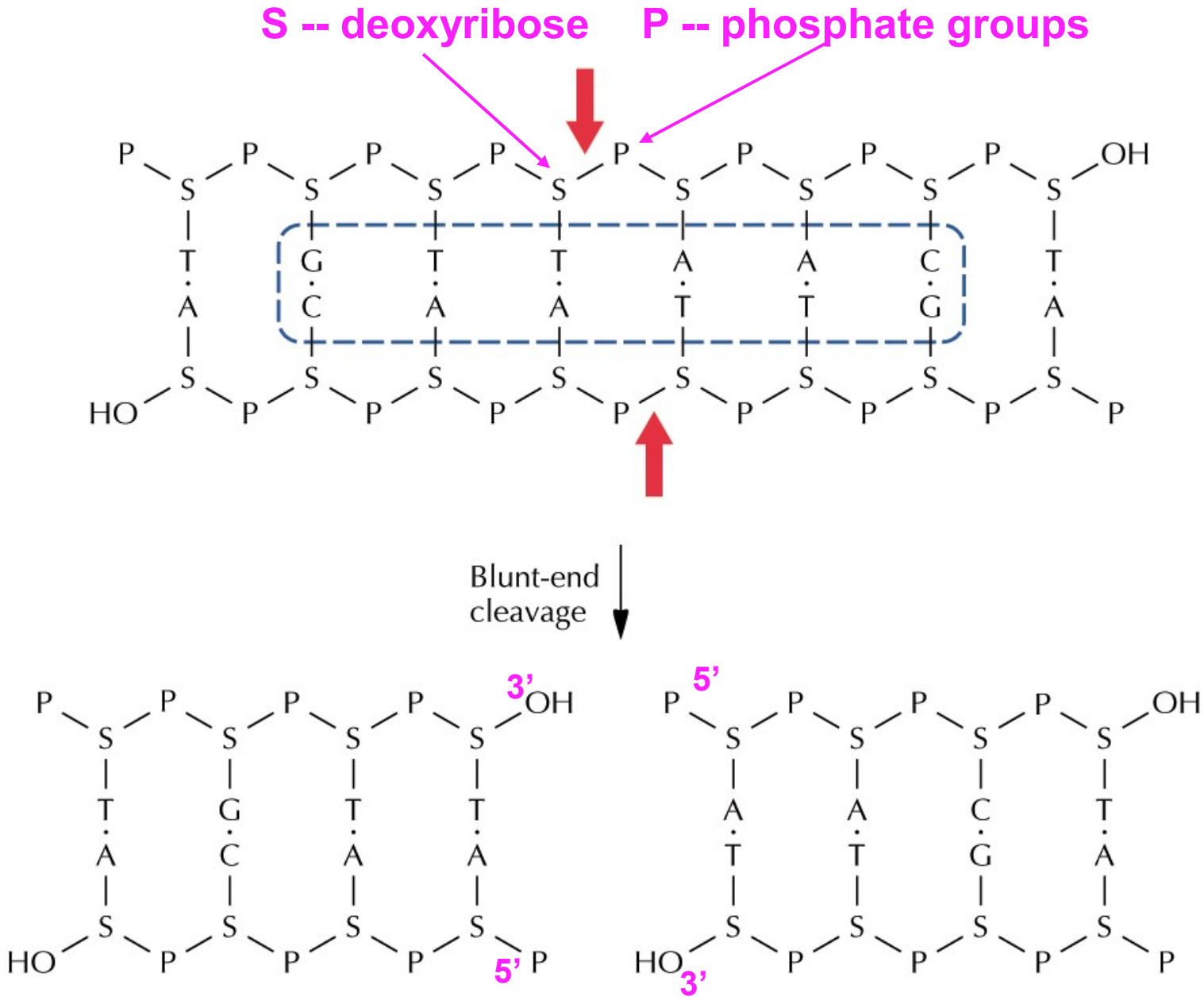
These enzymes recognize a specific DNA sequence (4-12bp) which is twofold symmetry and cut both DNA strands

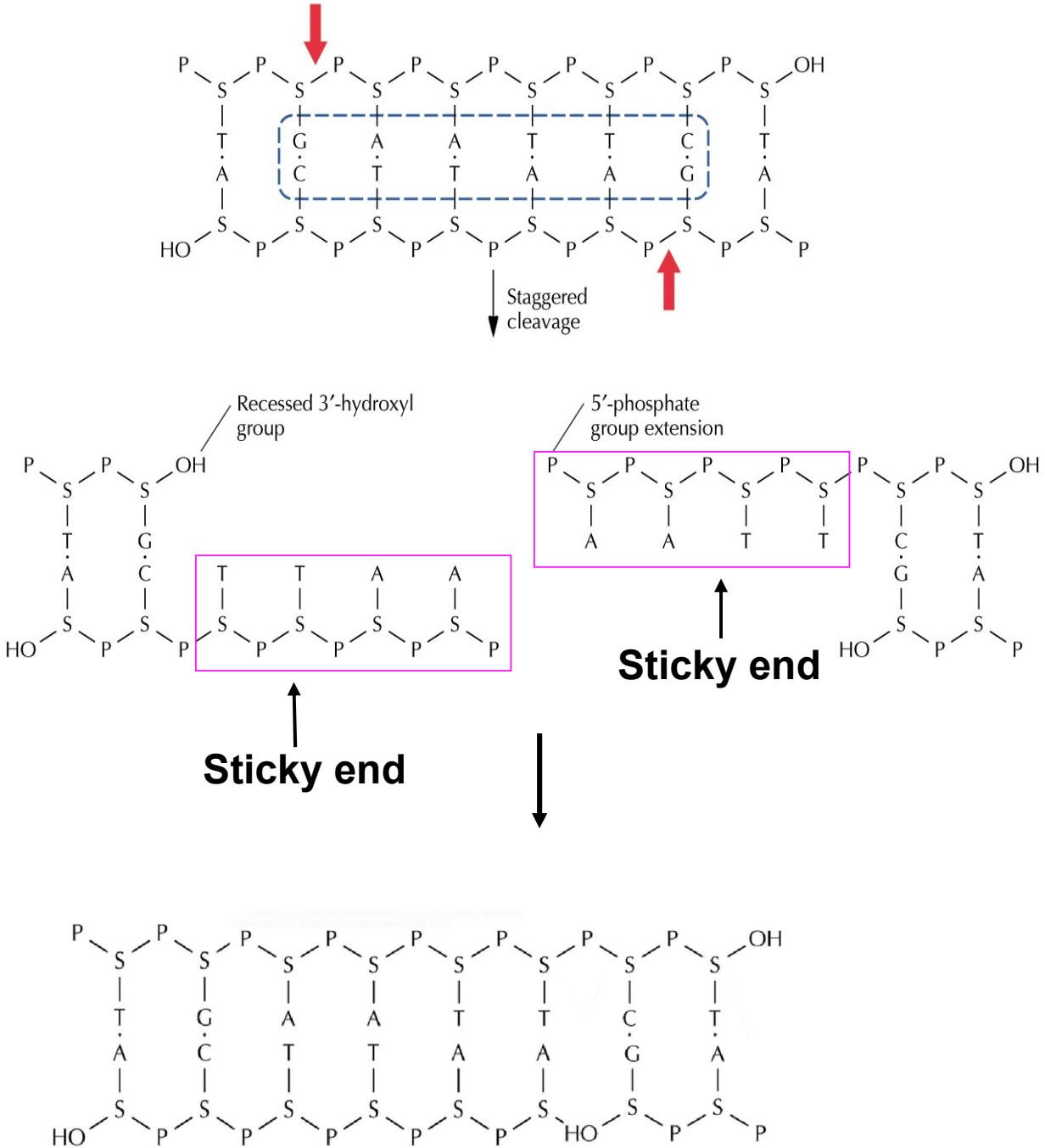
Some enzymes make staggered cuts

Cohesive
Or sticky

Some make even cuts

blunt


S -- deoxyribose
P -- phosphate groups
HO
OH
Blunt-end cleavage
3’
OH
5’ P
5’
HO
3’

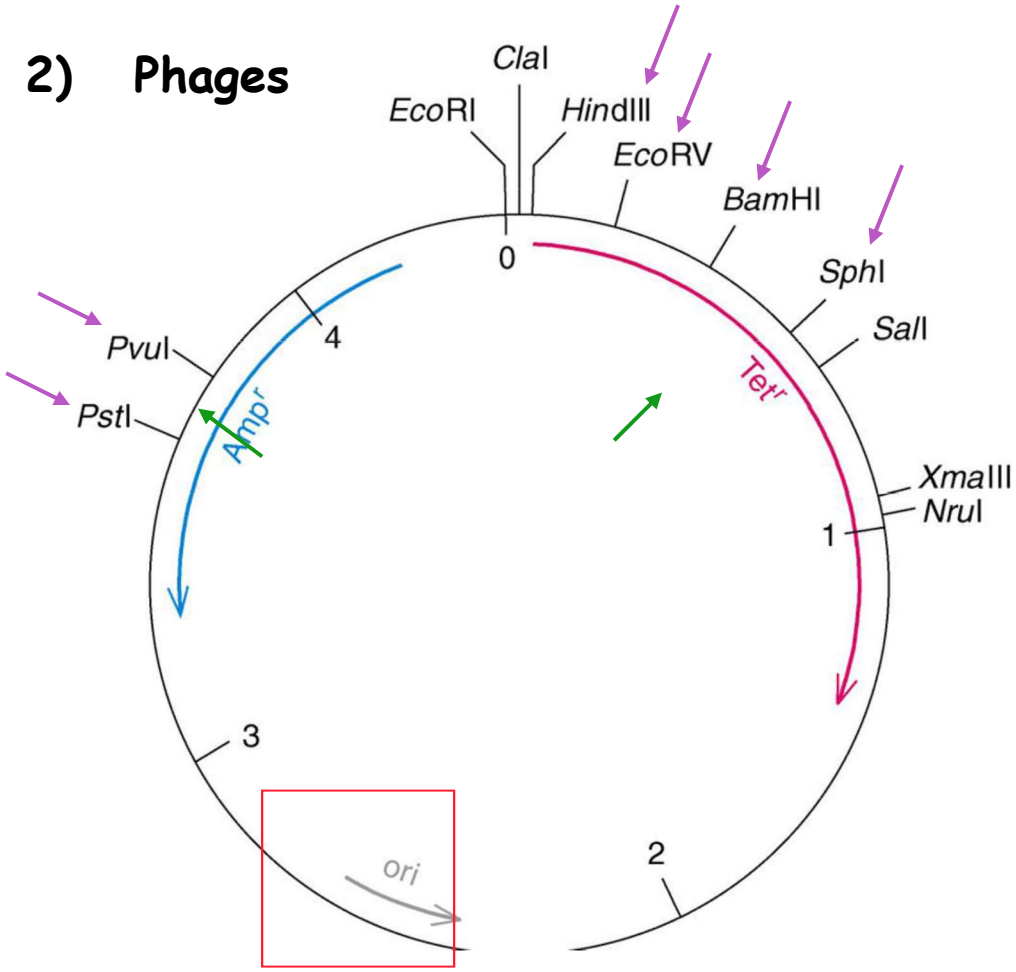

Staggered cleavage
Recessed 3′-hydroxyl group
5′-phosphate group extension
Sticky end
Sticky end

Vectors -- the DNA carriers

Capable of replicating in bacteria -- an origin of replication
Allow the vector as well as the foreign DNA to amplify in the host cell

1) Plasmids

2) Phages



1. Origin of replication

2. Antibiotic-resistant genes

   Allow the host to grow on selective media
   Can selectively amplify this specific vector in the host cell

3. Multiple cloning sites

Allow insertion of foreign DNA

Animal Cloning:
To Clone, or not to Clone

Advantages

- Cure human disease using animal organs
- Create animals that are disease resistant
- More consistent food products
- Save endangered species

Disadvantages

- Public perception
- Use technology to clone humans
- Expensive
- Not efficient
- Cloned products cannot be marketed

Cloning

Definition: The process of making identical genomic copies of an original animal.

Encyclopedia Britannica: An individual organism that was grown from a single body cell of its parent and that is genetically identical to it.

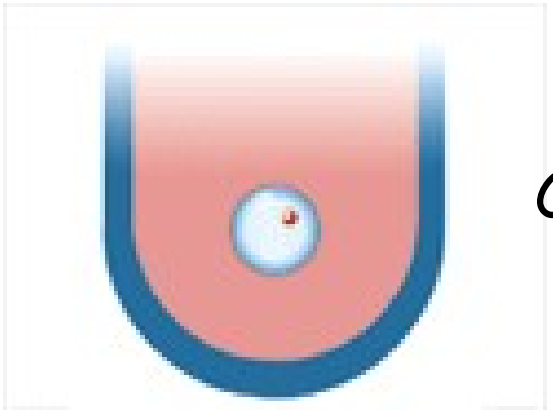
History of cloning

- 1953: Watson and Crick find the structure of DNA.
- 1962: John Gurdon clones frogs from differentiated cells.
- 1963: J.B.S. Haldane coins the term 'clone'.
- 1978: Splitting embryos
- 1986: Embryo Cloning
- 1994: Embryonic cell line cloning
- 1996: Adult or Somatic cell cloning

Creating Dolly

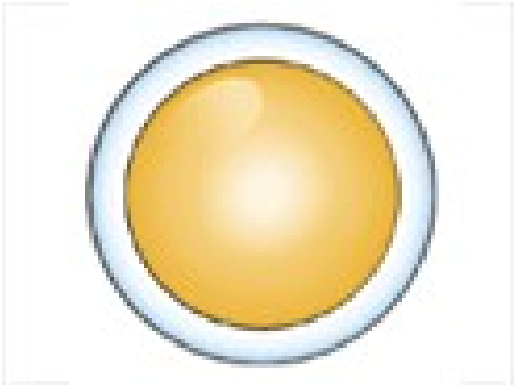
Dolly

Stage 1



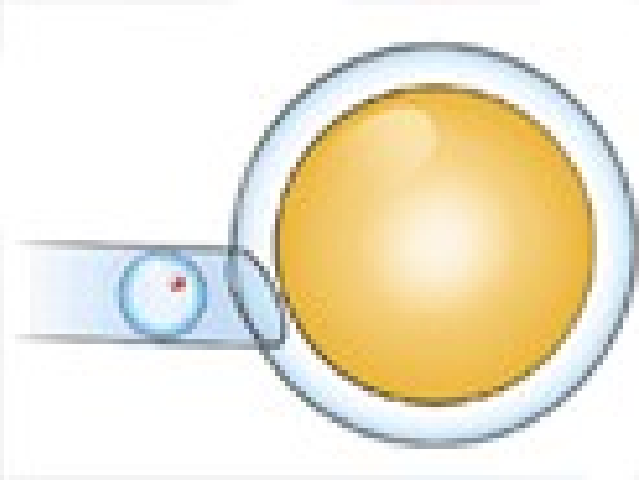
Cell collected from a sheep's udder.

Stage 2



Nucleus is removed from unfertilized egg of second sheep.

Stage 3



Udder cell is inserted into egg with no nucleus.

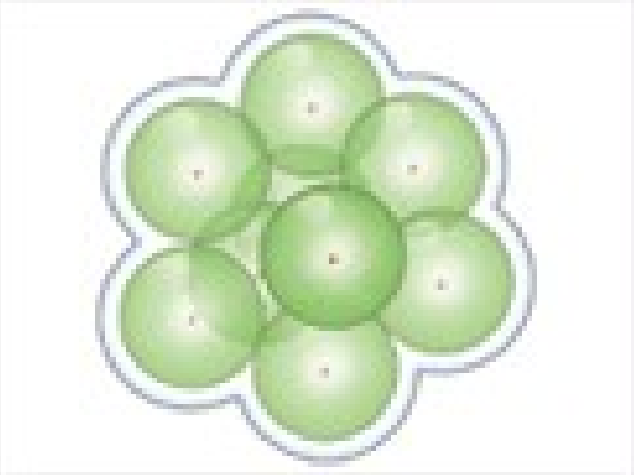
Stage 4

Insertion is successful.

Stage 5

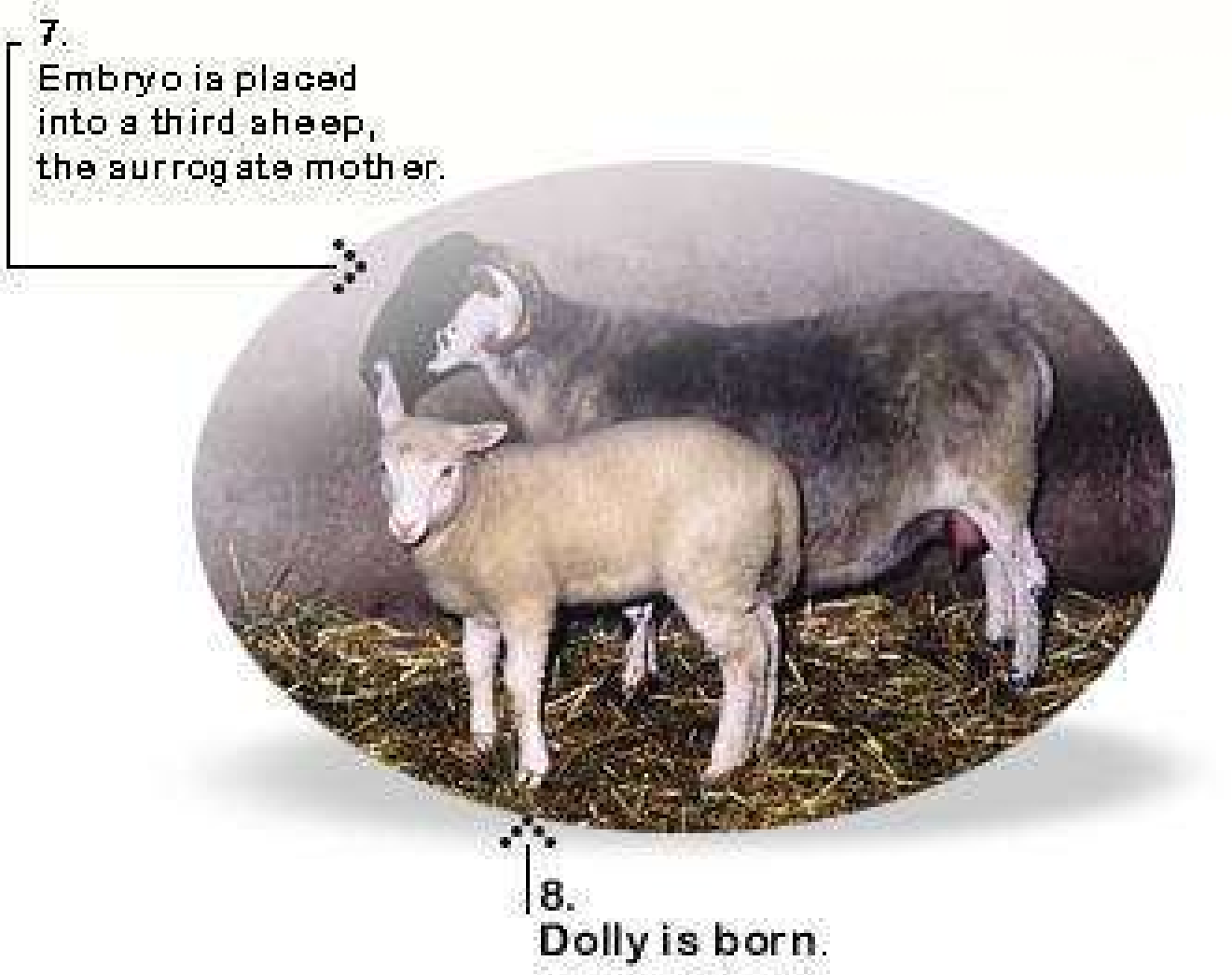
Electrical charge is supplied.

Stage 6



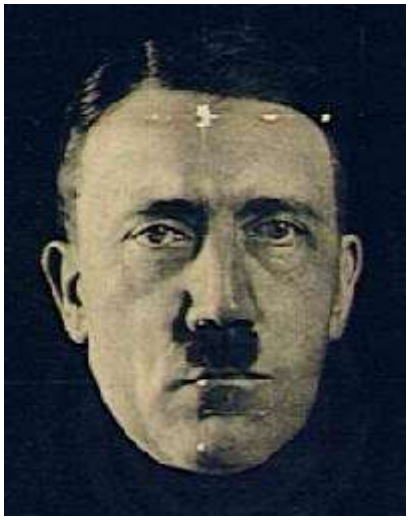
Cells begin to divide.

Stages 7 & 8


7.
Embryo is placed into a third sheep, the surrogate mother.
8.
Dolly is born.

Cloning Fallacies

- Genetic make-up is altered
- Mutants are created
- Clones are unhealthy
- Will eventually lead to cloning humans
- Possible to recreate people such as Hitler



House Bill 2505

Human Cloning Prohibition Act

- Prohibition on human cloning
- Criminal Penalty: Up to 10 years imprisonment
- Civil penalty: Minimum 1 million dollar fine