DNA

Dr. Bertolotti

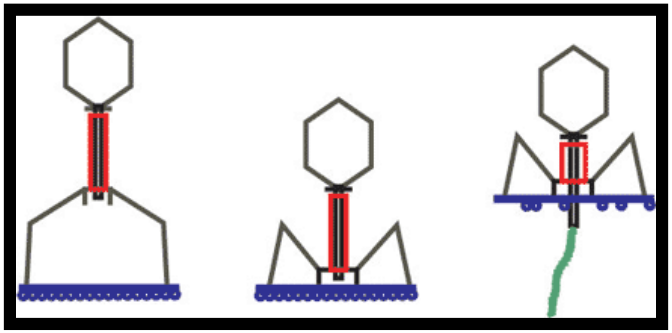
Essential Question

What is the structure of DNA, and how does it function in genetic inheritance?

What is the role of DNA in hereditary?

Transformation

- **Transformation** is the process in which one strain of bacteria is changed by a gene or genes from another strain of bacteria.
- A **bacteriophage** is a virus that infects bacteria
  - Composed of a DNA or RNA core and a protein coat.
  - When it enters a bacterium, the virus attaches to the surface of the cell and injects its genetic information into it. Then the viral genes act to produce many new bacteriophages and they gradually destroy the bacterium. When the cell splits open, hundreds of new viruses are released.



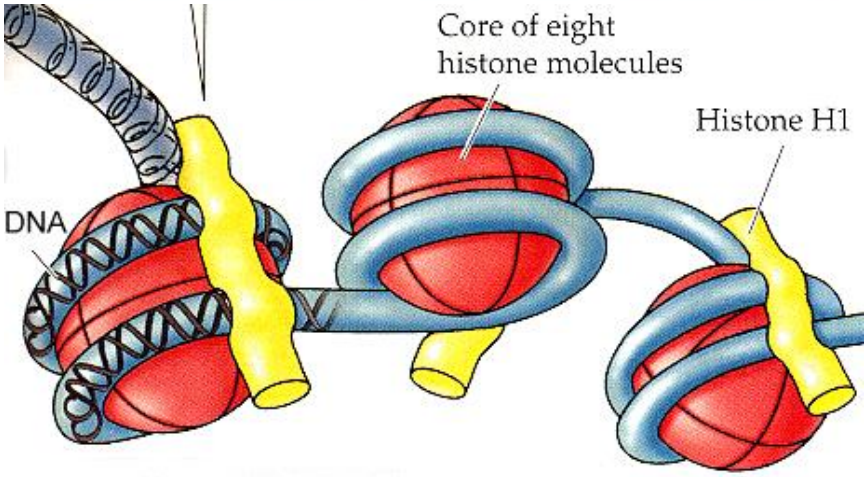
The Role of DNA

- The DNA that makes up genes must be capable of storing, copying, and transmitting the genetic information in a cell.
- The **3** functions of DNA are:
  - 1. *Storing Information*
  - 2. *Copying information*
    - Before a cell divides, it must make a complex copy of every one of its genes
  - 3. *Transmitting information*
    - DNA must be carefully sorted and passed along during cell division so that it is transmitted from one generation to the next.

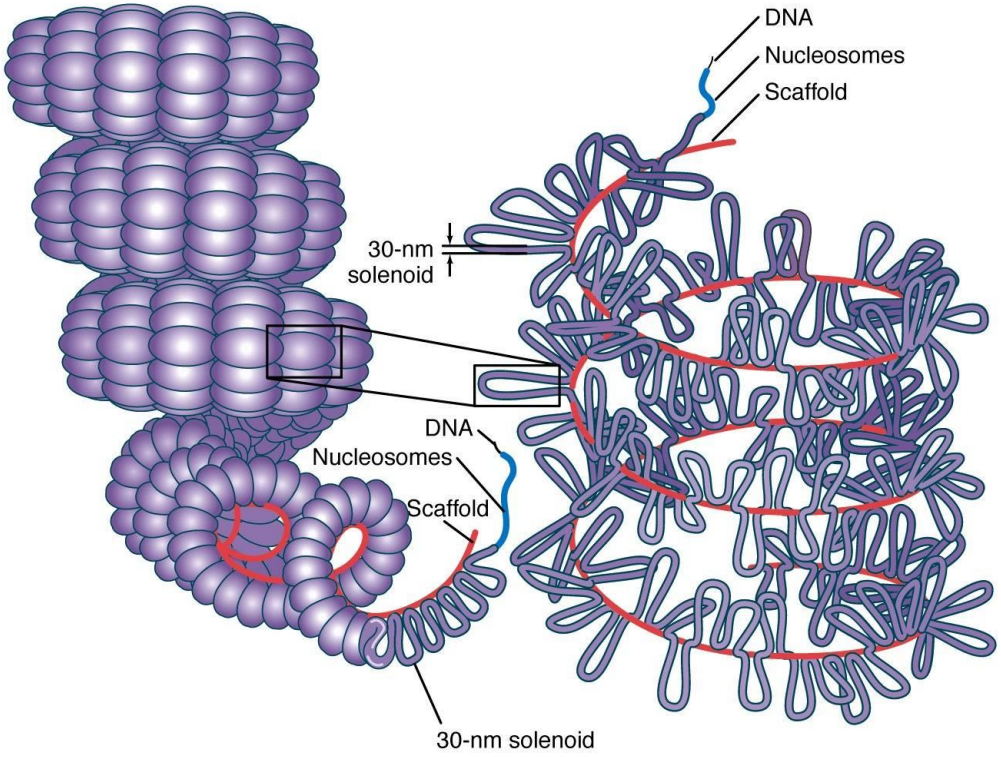
Chromosomes

- **Chromatin** is granular material visible within the nucleus that consists of DNA tightly coiled around proteins.
- **Histones** are protein molecules around which DNA is tightly coiled in chromatin.
- Each strand of DNA has all the information needed to reconstruct the other half by the mechanism of base pairing.

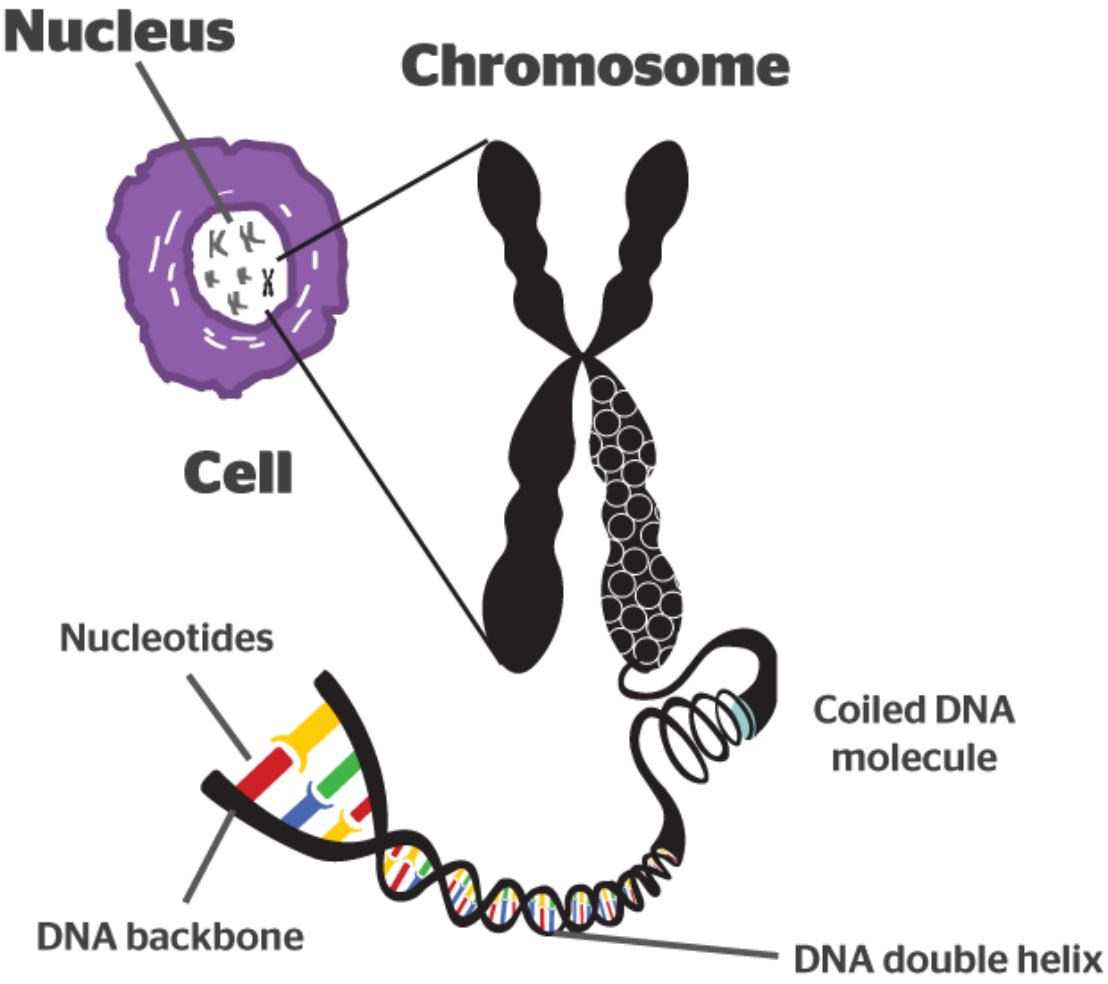
How DNA fits in the nucleus



DNA is wrapped around histones (proteins) very tightly



Chromosomes



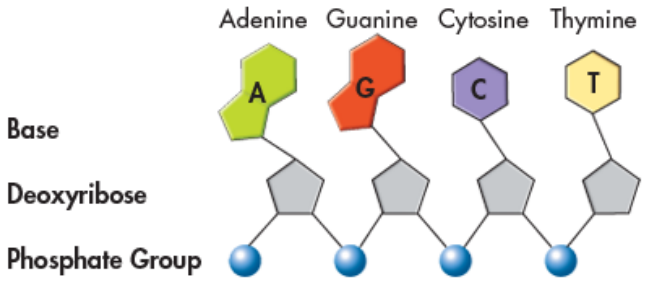
Question and Answer

What is the role of DNA in hereditary?

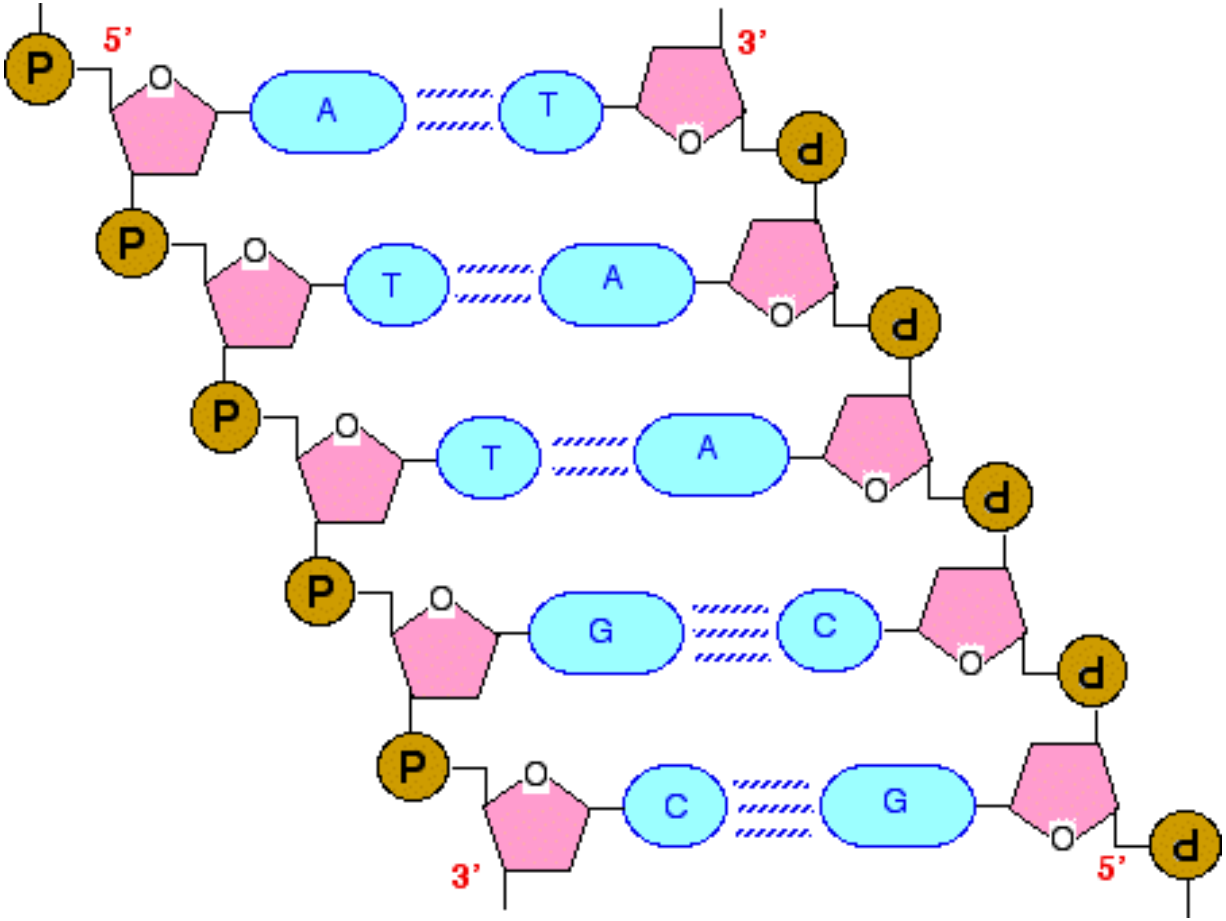
What are the chemical components of DNA?

The components and structure of DNA

- DNA is a long molecule made up of **nucleotides**: a monomer of nucleic acids made up of a phosphate group, a 5 carbon sugar, and a nitrogenous base.
- The strands of DNA are **antiparallel**- A term applied to two molecules that are side by side but run in opposite directions. The head of one strand is always laid against the tail of the other strand of DNA.
- All DNA strands are read from the 5' to the 3' end where the 5' end terminates in a phosphate group and the 3' end terminates in a sugar molecule



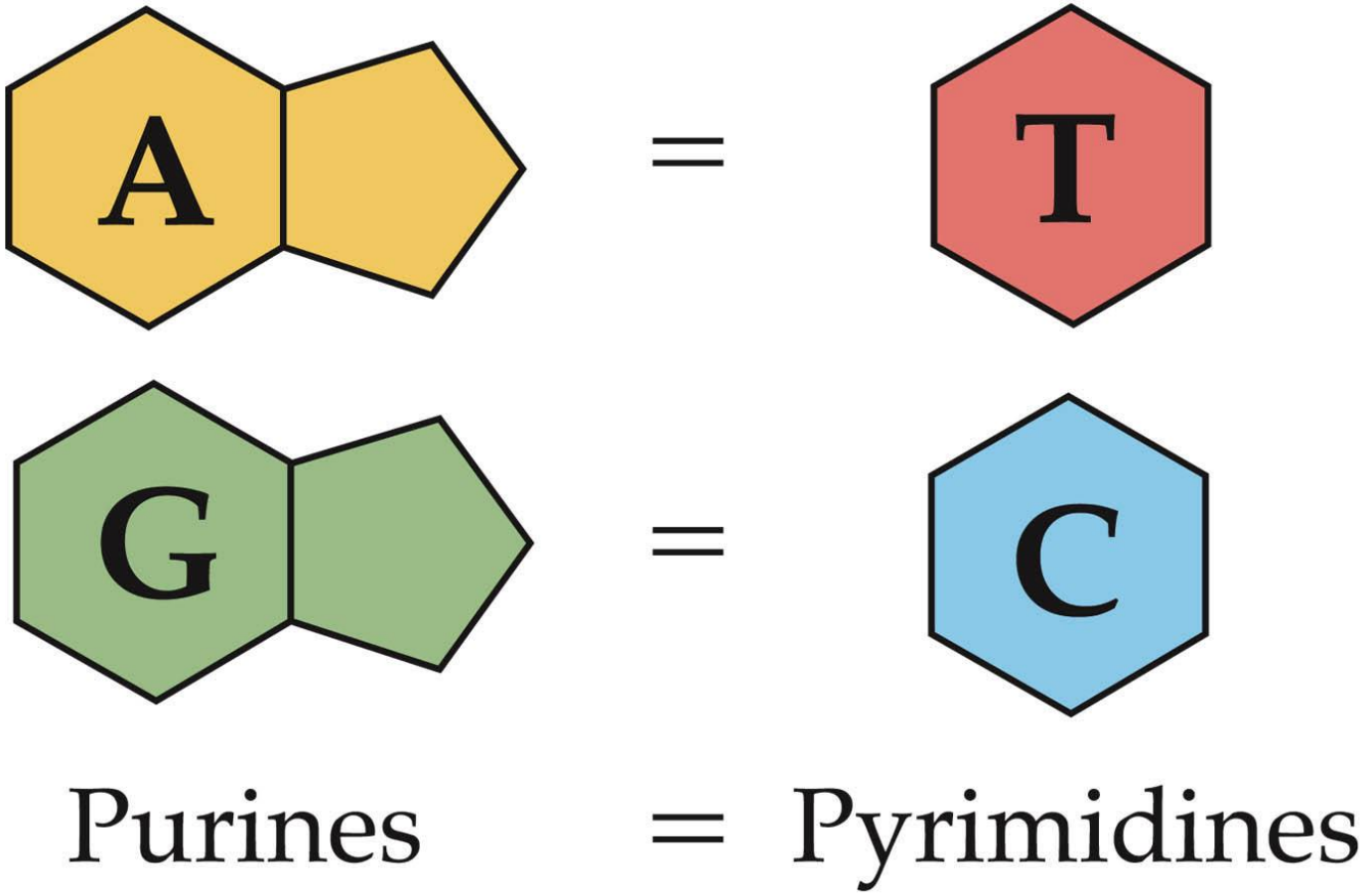
The DNA molecule



Nitrogenous Bases

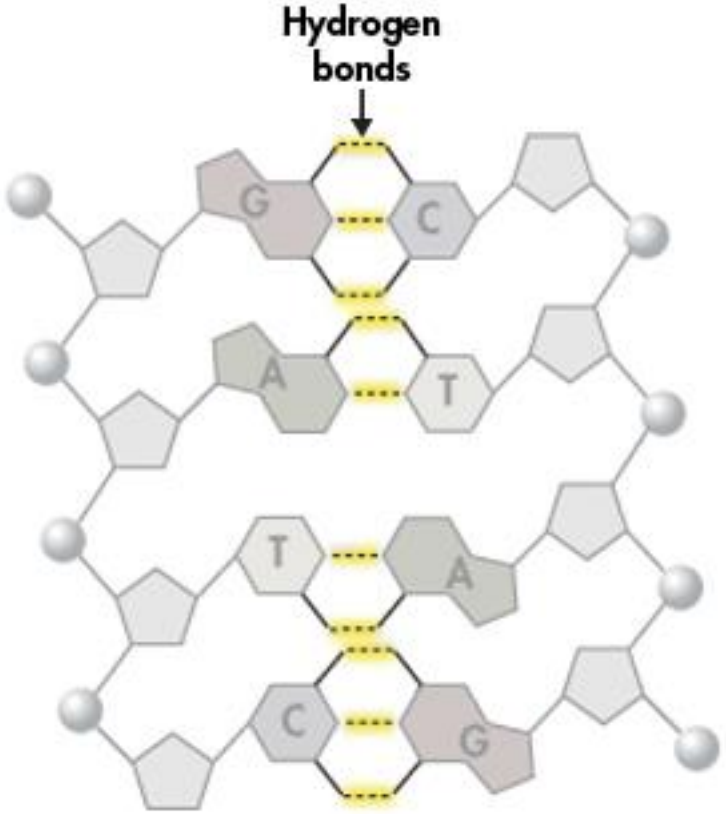
- There are **four** kinds of nitrogenous bases.
- They are divided into two classes: purines and pyrmidines.
  - Purines have 2 rings in their structures while pyrimidines have 1 ring.
    - Purines – Adenine and Guanine
    - Pyrmidines – Cytosine and Thymine
    - Adenine **always** bonds with Thymine and that Cytosine **always** bonds with Guanine.

Nitrogenous Bases



LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 11.5 Chargaff's Rule

- **Base pairing** is the principle that bonds in DNA can form only between adenine and thymine and between guanine and cytosine.
- Hydrogen bonds formed between certain nitrogenous bases holds the strands together- namely the pairs adenine and thymine, and guanine and cytosine.



Question and Answer

What are the chemical components of DNA?

How is DNA replicated in eukaryotic cells?

DNA Replication

- **DNA Replication** is the copying process by which a cell duplicates its DNA
  - Occurs during S phase of the cell cycle in the nucleus
  - Is **semiconservative** as one new strand is made and one old strand is conserved.
  - During DNA replication,
    - **DNA helicase** unwinds and separates a portion of the DNA molecule at numerous places called origins of replication by breaking the hydrogen bonds.
    - The process of unzipping DNA proceeds in two directions at the same time.

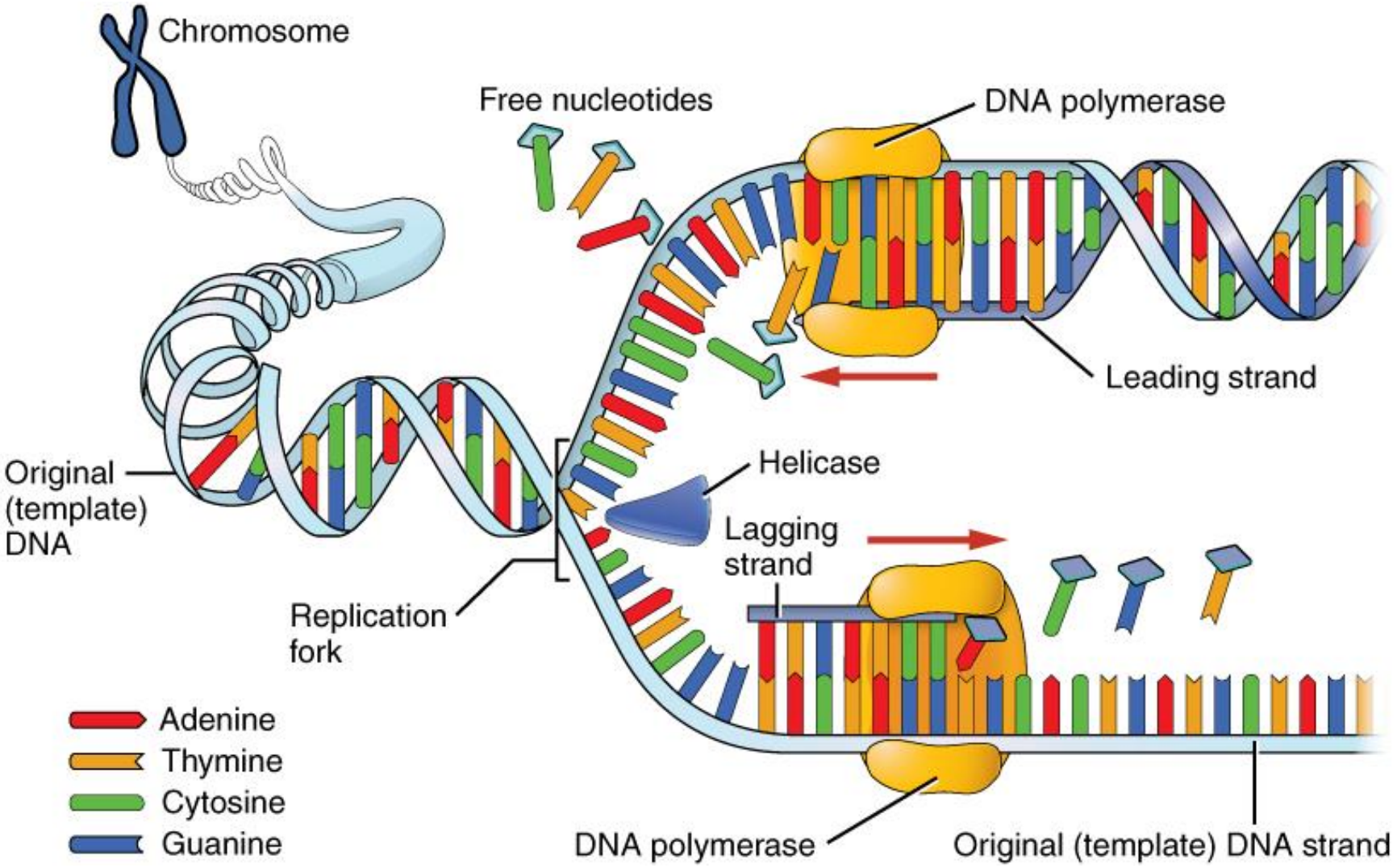
DNA Replication

- **DNA polymerase** engages the separated portion of the molecule and initiates the process of replication. DNA polymerase can only add new DNA nucleotides to a pre-existing chain of nucleotides.
- Two new complementary strands are created from following the rules of base pairing, for example a strand of DNA with the bases 5’ ATTCGAG 3’ would have a complimentary strand of 3’ TAAGCTC 5’.
- DNA replication occurs in a smooth, continuous way in one direction. This continuous strand is called the leading strand. The leading strand synthesis progresses in a **5’ → 3’** direction. On the other template, replication occurs in a discontinuous, piece-by-piece way in the opposite direction. Replication of this strand is known as the lagging strand.

DNA Replication

- Because the two complementary strands of the DNA molecule are oriented in opposite directions and the DNA polymerase can only accommodate replication in one direction, two different mechanisms for copying the strands of DNA are employed.
- One strand (leading: 5’ → 3’) is replicated continuously towards the unwinding, separating portion of the original DNA molecule; while the other strand is replicated discontinuously in the opposite direction with the formation of a series of short DNA segments called Okazaki fragments.
- The Okazaki fragments are then bonded together by **DNA ligase** into a continuous complementary strand.
- DNA replication proceeds in both directions until each chromosome is completely copied.

DNA Replication



Mutations

- DNA replication is a truly amazing biological phenomenon. Consider the countless number of times that your cells divide to make you who you are—not just during development, but even now, as a fully mature adult.
- Then consider that every time a human cell divides and its DNA replicates, it has to copy and transmit the exact same sequence of 3 billion nucleotides to its daughter cells.
- While most DNA replicates with fairly high fidelity, mistakes do happen, with polymerase enzymes sometimes inserting the wrong nucleotide or too many or too few nucleotides into a sequence. This is called a **mutation.**
  - A **mutation** is a change in DNA sequence that arises during DNA replication.

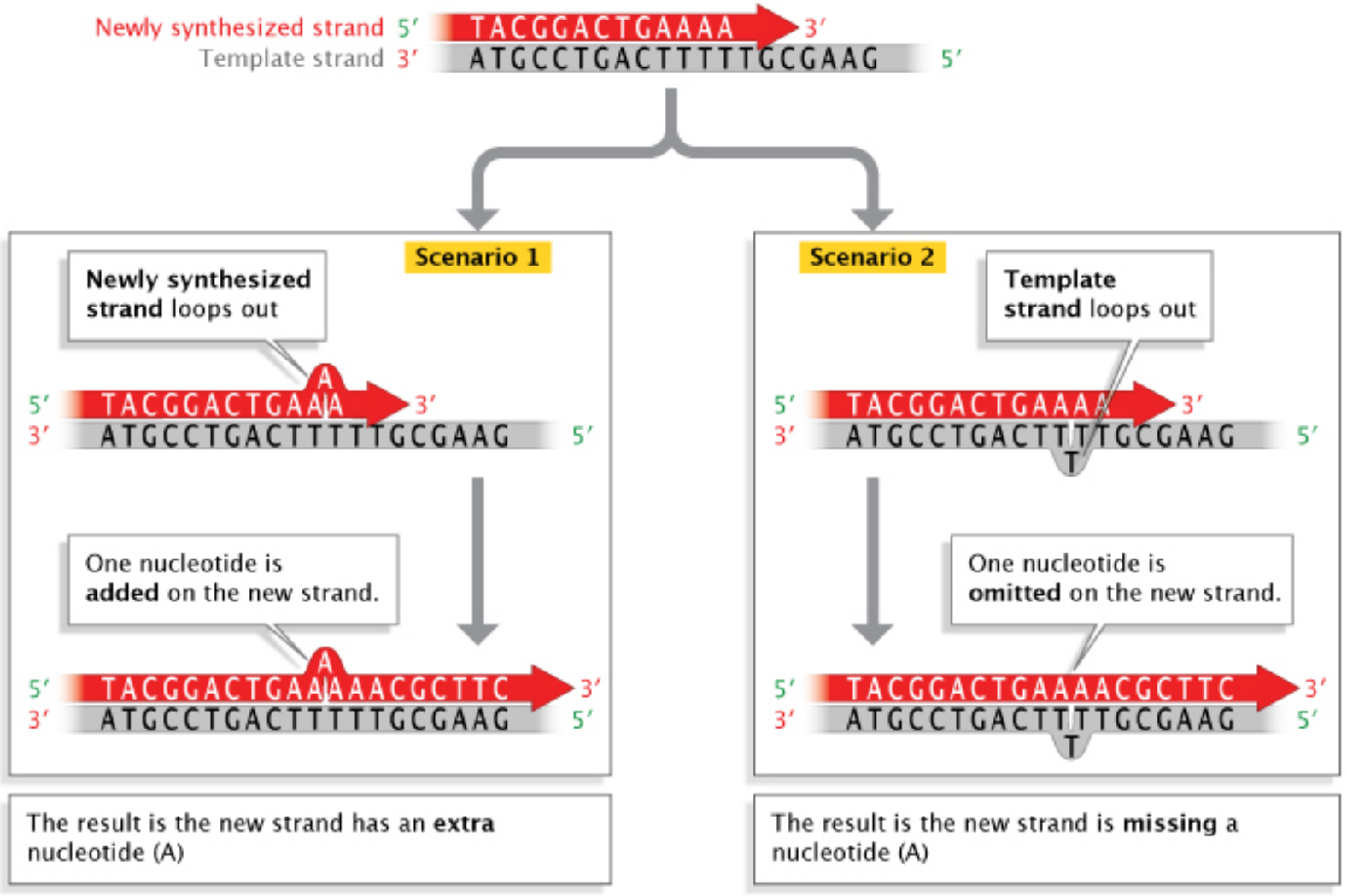
Mutations

- Fortunately, most of these mistakes are fixed through various DNA repair processes.
  - Repair enzymes recognize structural imperfections between improperly paired nucleotides, cutting out the wrong ones and putting the right ones in their place.
  - But some replication errors make it past these mechanisms, thus becoming permanent mutations.
    - » These altered nucleotide sequences can then be passed down from one cellular generation to the next, and if they occur in cells that give rise to gametes, they can even be transmitted to subsequent organismal generations.
    - » Moreover, when the genes for the DNA repair enzymes themselves become mutated, mistakes begin accumulating at a much higher rate. In eukaryotes, such mutations can lead to cancer.

Mutations

- Although most mutations are believed to be caused by replication errors, they can also be caused by various environmentally induced and spontaneous changes to DNA that occur prior to replication but are perpetuated in the same way as unfixed replication errors.
  - As with replication errors, most environmentally induced DNA damage is repaired, resulting in fewer than 1 out of every 1,000 chemically induced lesions actually becoming permanent mutations.
  - The same is true of so-called spontaneous mutations. "Spontaneous" refers to the fact that the changes occur in the absence of chemical, radiation, or other environmental damage. Rather, they are usually caused by normal chemical reactions that go on in cells, such as hydrolysis.
    - » Again, most of these spontaneous errors are corrected by DNA repair processes. But if this does not occur, a nucleotide that is added to the newly synthesized strand can become a permanent mutation

Mutations

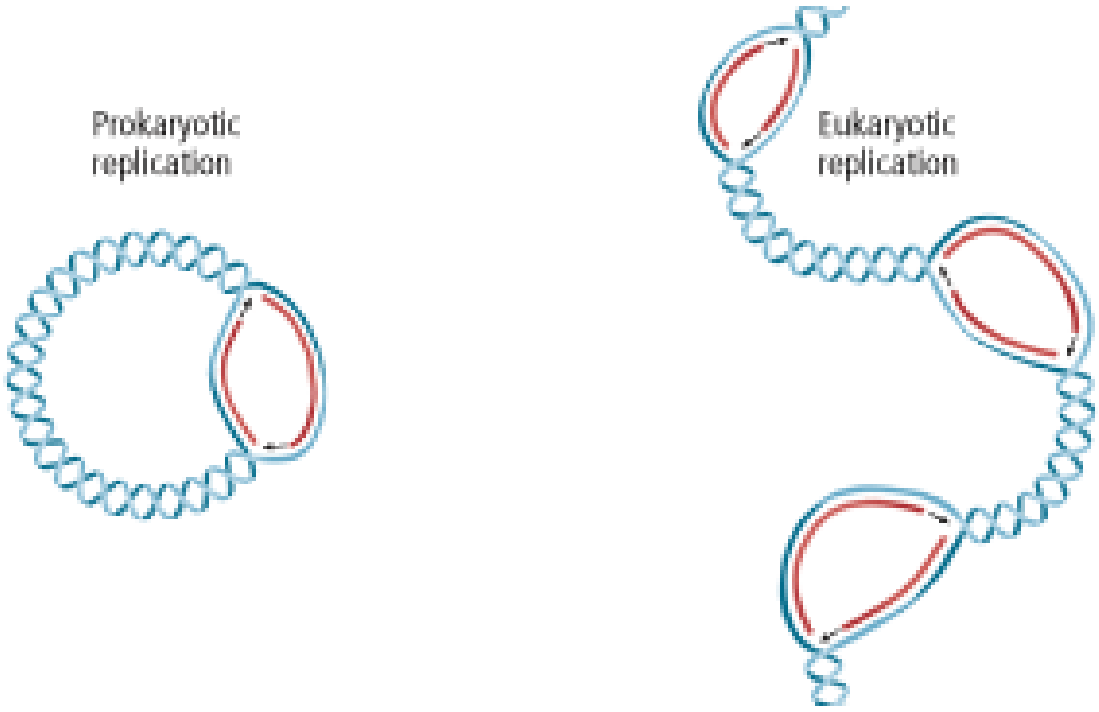

Newly synthesized strand 5′ TACGGACTGAAAA 3′
Template strand 3′ ATGCCTGACTTTTTGCGAAG 5′
Scenario 1
Newly synthesized strand loops out
5′ TACGGACTGAAAA 3′
3′ ATGCCTGACTTTTTGCGAAG 5′
One nucleotide is added on the new strand.
5′ TACGGACTGAAAAACGCTTC 3′
3′ ATGCCTGACTTTTTGCGAAG 5′
The result is the new strand has an extra nucleotide (A)
Scenario 2
Template strand loops out
5′ TACGGACTGAAAA 3′
3′ ATGCCTGACTTTTGCGAAG 5′
T
One nucleotide is omitted on the new strand.
5′ TACGGACTGAAAACGCTTC 3′
3′ ATGCCTGACTTTTGCGAAG 5′
T
The result is the new strand is missing a nucleotide (A)

Prokaryotic DNA Replication

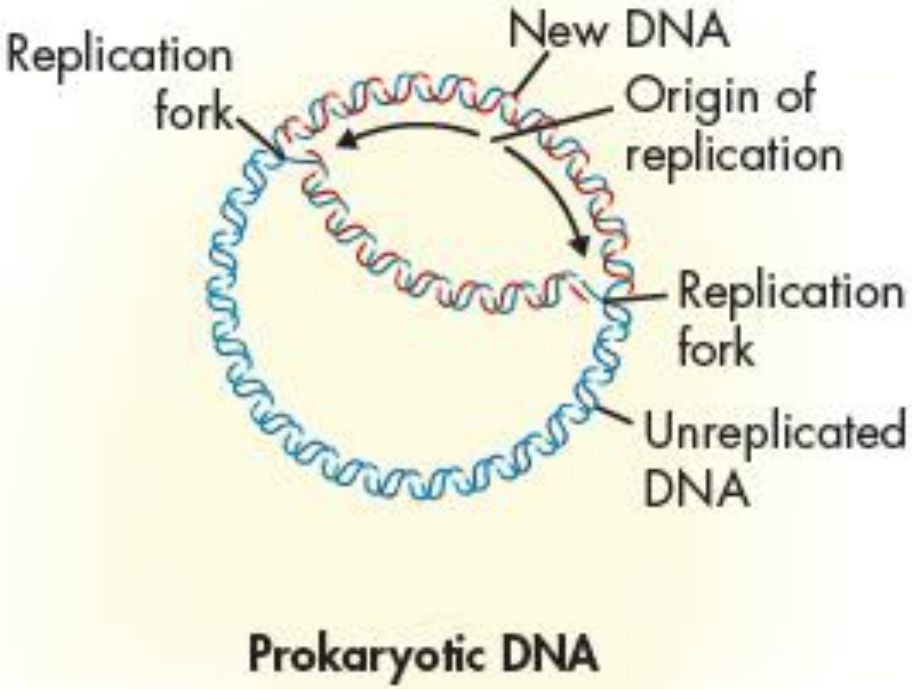
- In most prokaryotes, DNA replication does not start until regulatory proteins bind to a single starting point on the chromosome. This triggers the beginning of DNA replication.
- Replication in most prokaryotic cells starts from a single point and proceeds in two directions until the entire chromosome is copied.
- Often, the 2 chromosomes produced by replication are attached to different points inside the cell membrane and are separated when the cell splits to form two new cells.

Prokaryotic DNA Replication

NOTE FROM ARTICULATE:
The last comment asked us to make this resemble C12-21A so it wouldn't look "faded". We can only assume editorial meant to make the DNA blue, like in C12-21A. So that's what we did.



Prokaryotic DNA Replication



Prokaryotic DNA

Question and Answer

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