Nucleic Acids

The Central Dogma of Molecular Biology

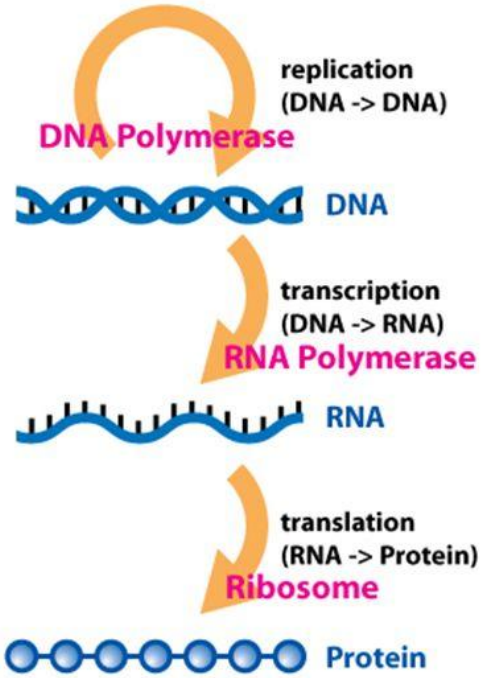
- Information is transferred from DNA to RNA to protein

  DNA -> RNA -> Protein

- Proteins create traits

- This is called **gene expression**

- This process is found in all organisms



Synthesis and degradation of nucleic acids strands

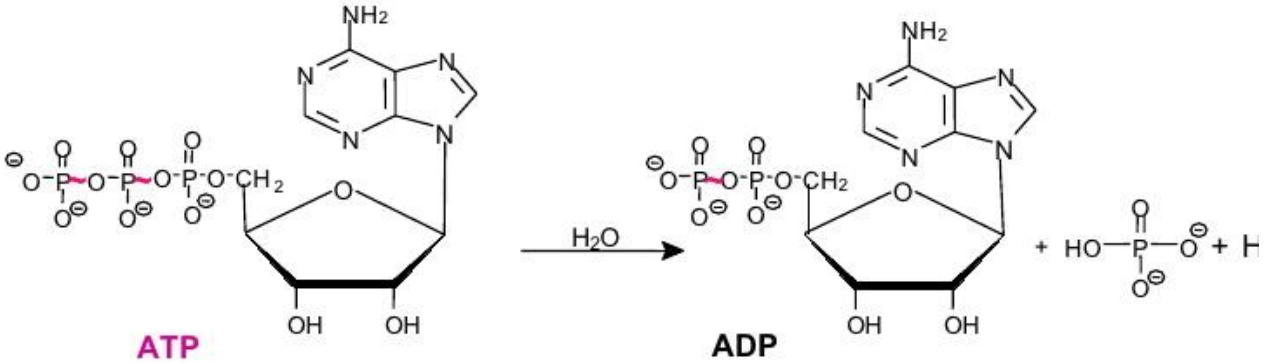
- Polymerized nucleic acid strand has higher free energy than a mixture of monomers
- Therefore nucleic acid could be degraded (hydrolyzed) with no additional energy needed.
- In order to synthesize a nucleic acid strand from monomers additional chemical energy is required. This energy comes in a form of a high-energy (macroergic) phosphate bond.

ATP

The term „high-energy compound“

(also „macroergic compound“ or „energy rich compounds“)

The most important is ATP



Two stages of ATP hydrolysis

ATP provides energy in two reactions:

$ATP + H_2O \rightarrow ADP + P_i$ $\quad \Delta G^{0'} = -30{,}5$ kJ/mol

$ATP + H_2O \rightarrow AMP + PP_i$ $\quad \Delta G^{0'} = -32{,}0$ kJ/mol

Reactions are catalyzed by enzymes

Similarly GTP, UTP a CTP can provide energy

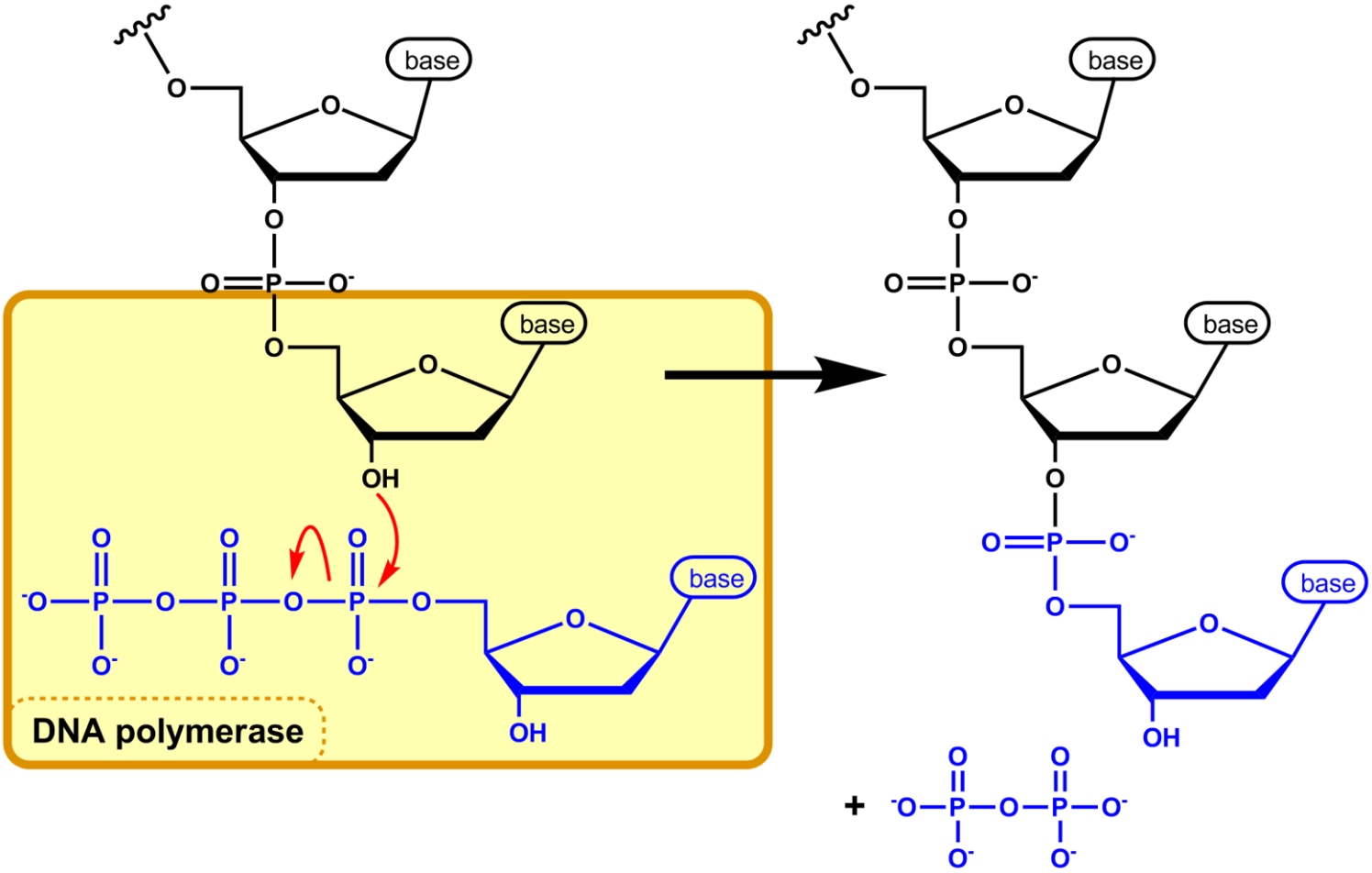
ATP in cells

- Life expectancy of an ATP molecule is about 2 min.
- It must be permanently synthesized
- Momentary content of ATP in a human body is about 100 g, but 60-70 kg is produced daily
- Adenylate kinase maintains the equilibrium between ATP, ADP a AMP

$$ATP + AMP \rightleftarrows 2\ ADP$$

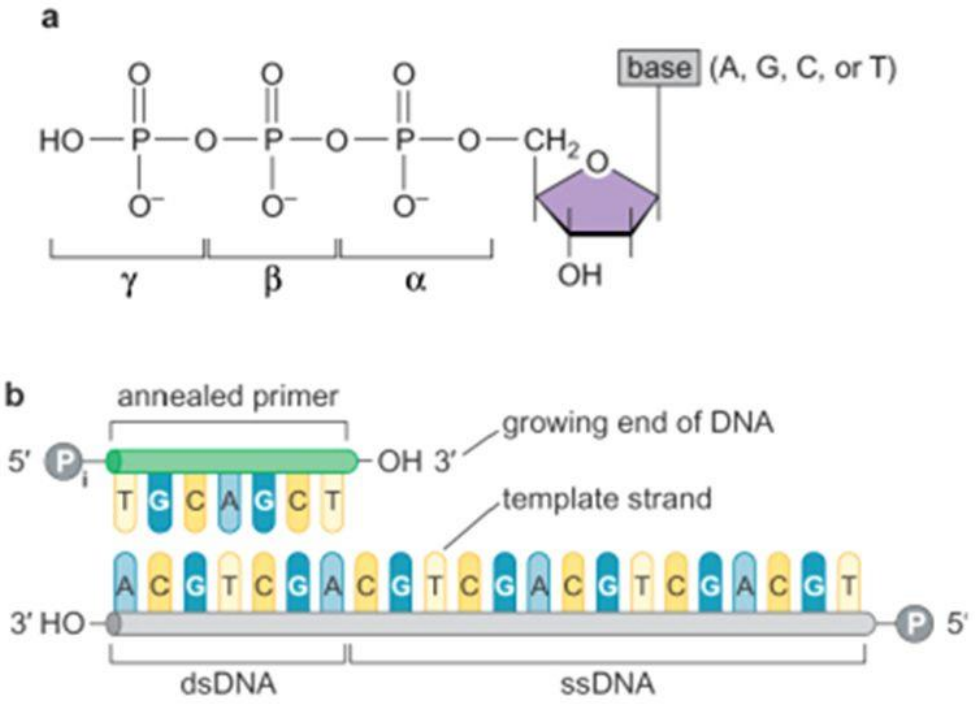
ATP is a universal "fuel" in the cell used in the majority of the reactions that require additional energy

Addition of new monomer to the growing DNA (RNA) strand



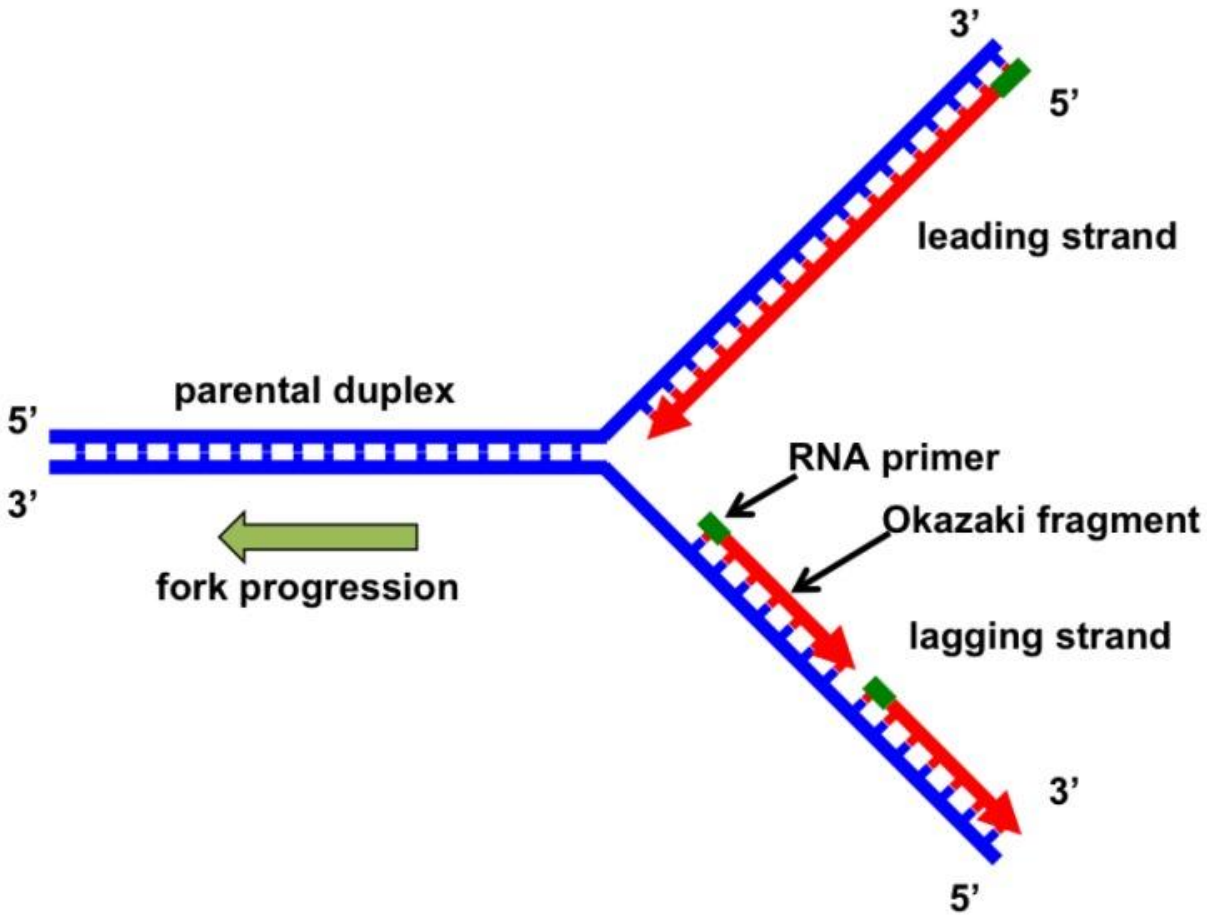
- There are many enzymes that can catalyze polymerization of DNA or RNA strand
- In the processes of DNA replication and transcription into RNA new nucleic acid strand is copied from a template NA that has complimentary sequence to the new strand.
- Some enzymes can extend NA strand without a template

Substrates required for DNA synthesis

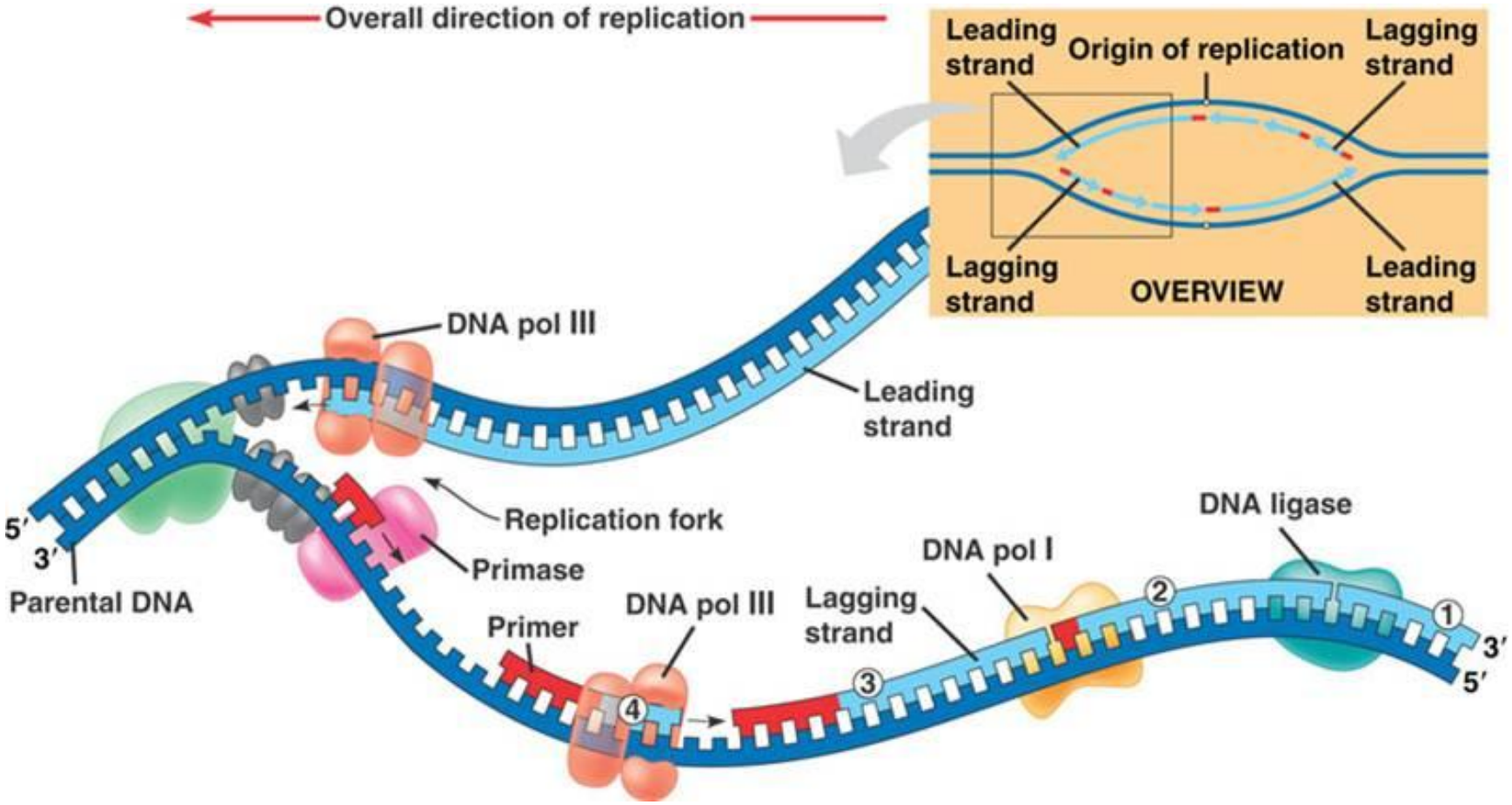


Newly synthesized NA strand grows from in the 5’ to 3’ direction

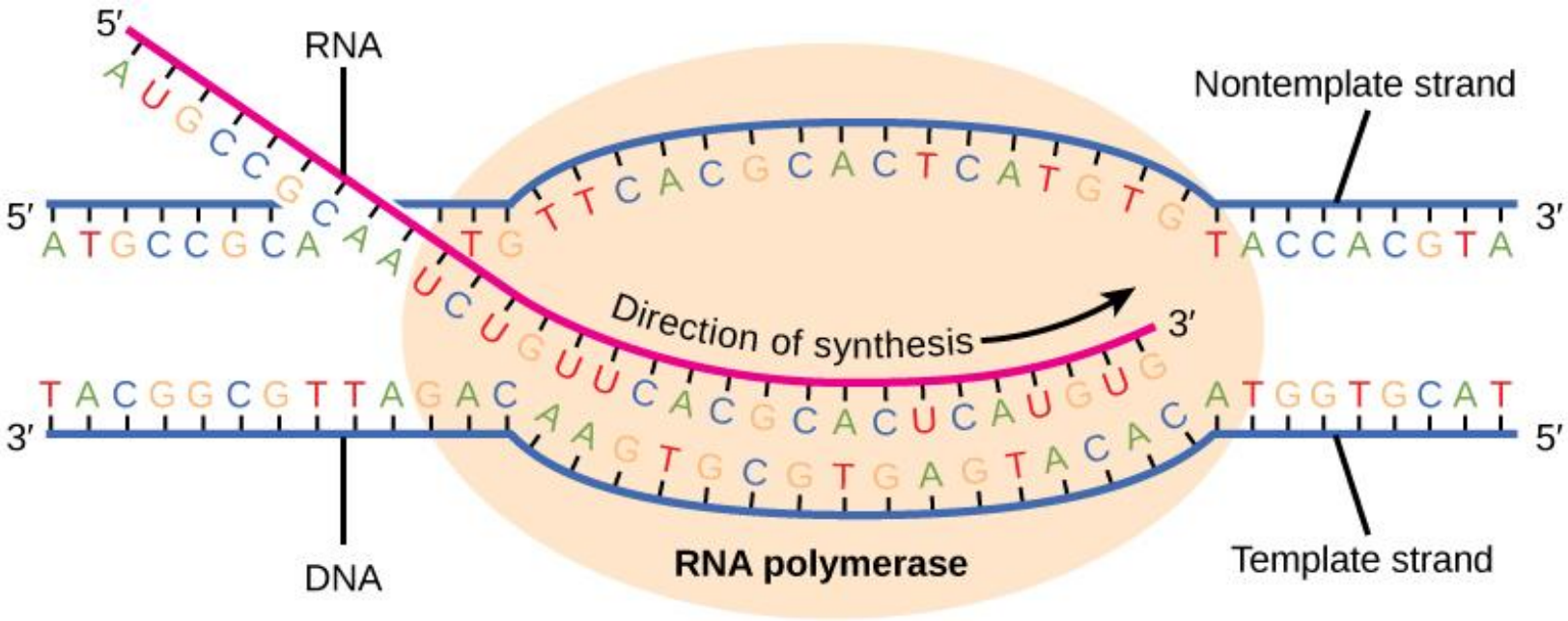
DNA replication



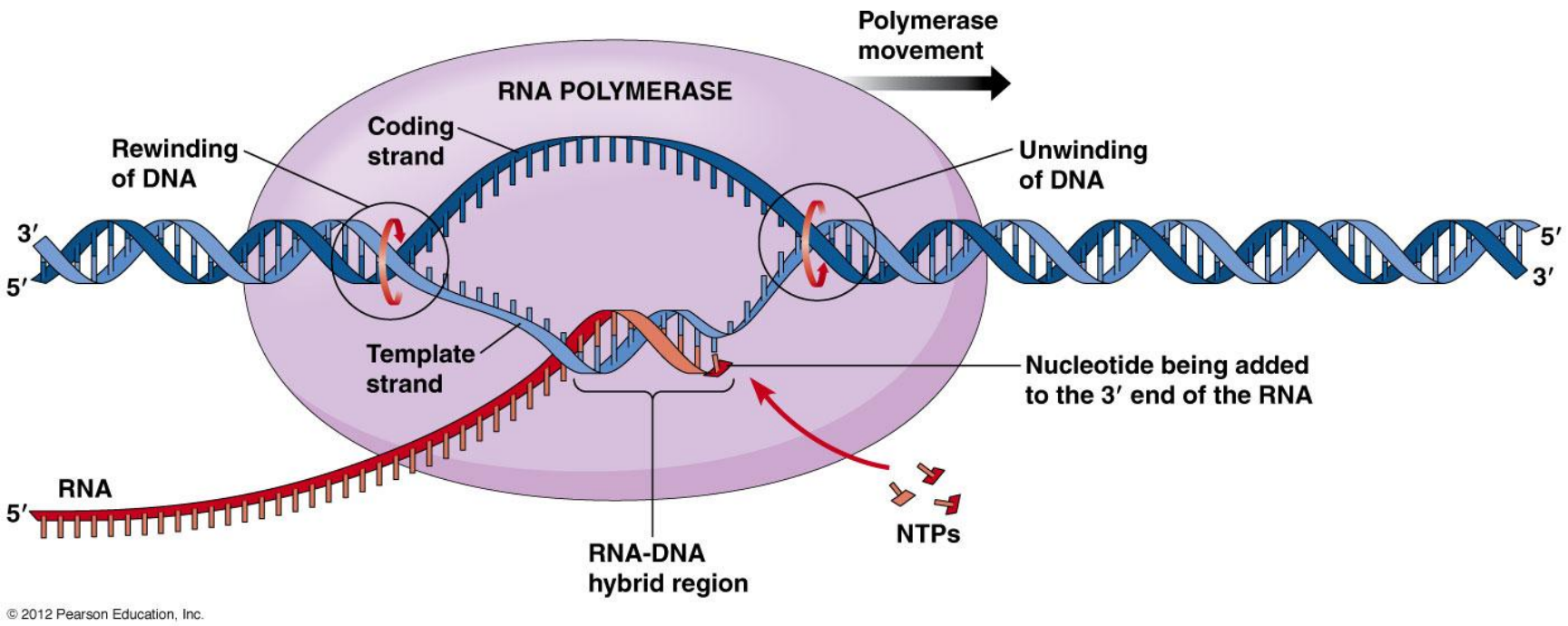
DNA replication



Transcription



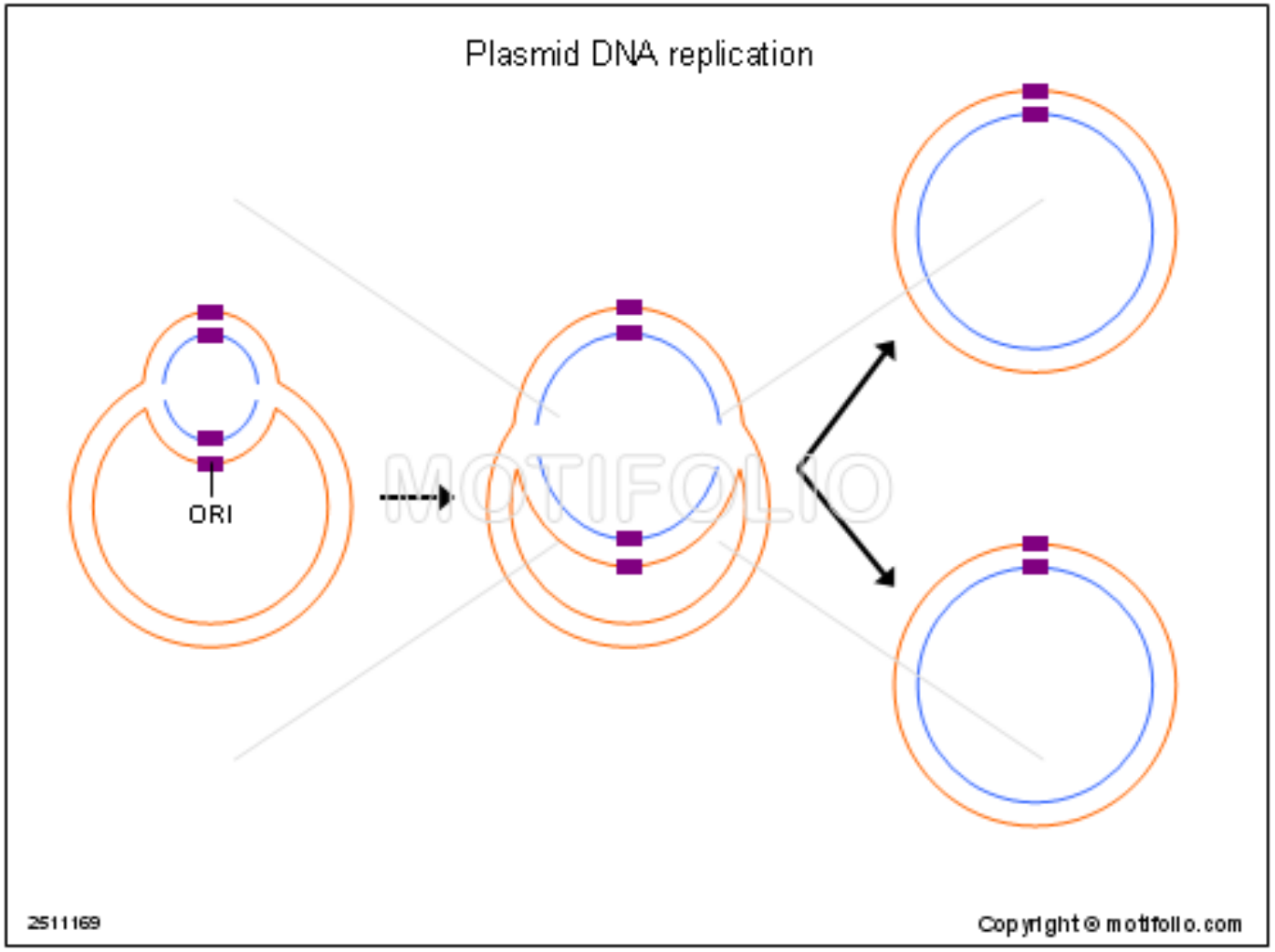
Transcription



3 stages of a new nucleic acid strand synthesis

- Initiation
- Elongation
- Termination

Plasmid DNA replication



Cell cycle

- **The cell cycle, or cell-division cycle, is the series of events that take place in a cell leading to its division and duplication of its DNA (DNA replication) to produce two daughter cells.**
- **Cell cycle is a complexly regulated process.**

Bacterial cell cycle

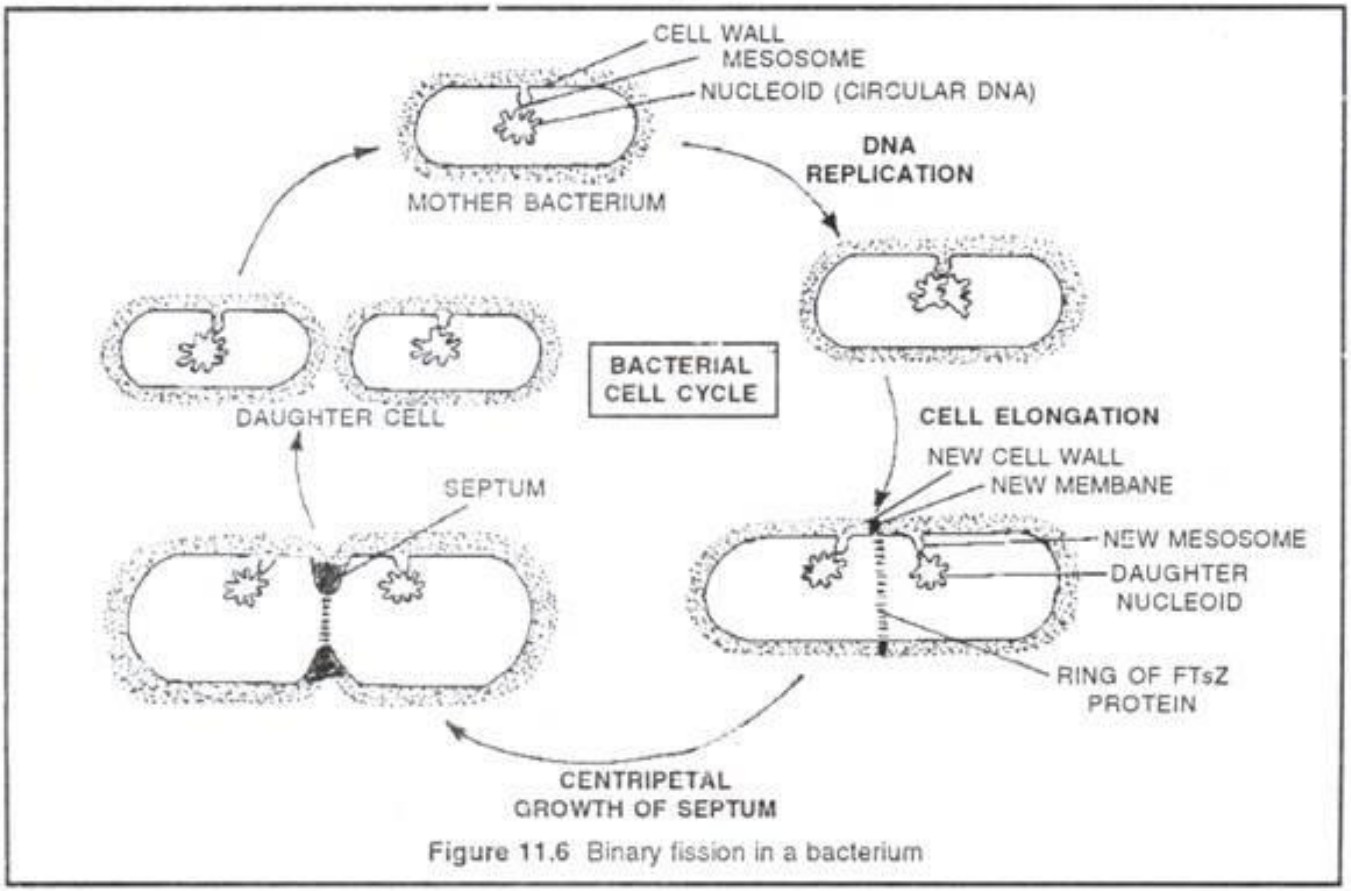
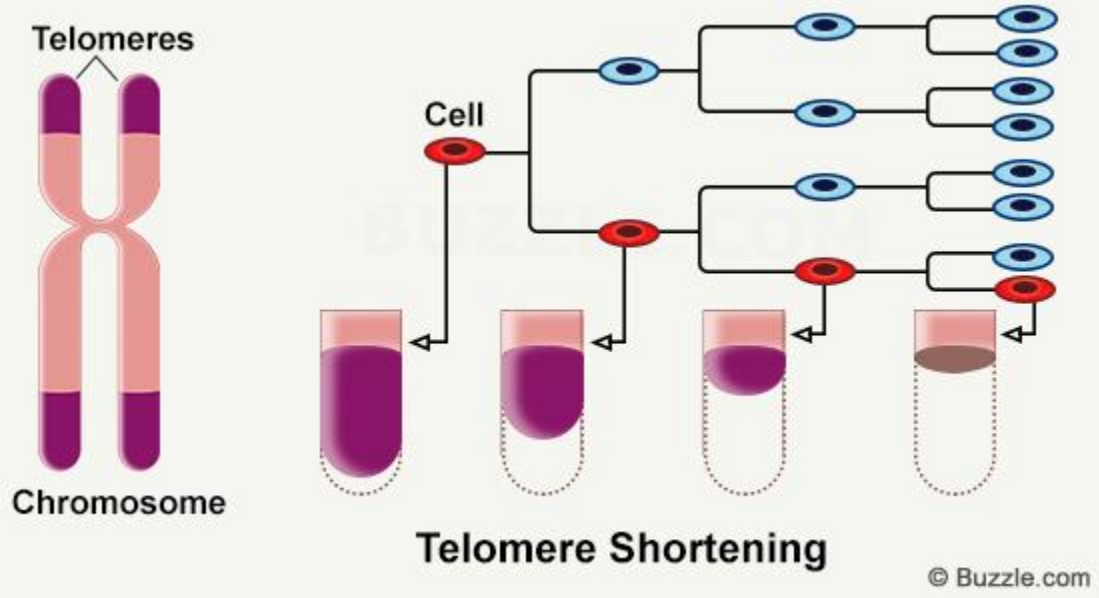


Figure 11.6 Binary fission in a bacterium

- **Bacterial chromosome is circular, thus its replication terminates in the same way as replication of plasmid DNA – trhough simple resolution of two daughter DNA molecules.**
- **Eukaryotic chromosomes are linear. Unidirectional (5’ to 3’) nature of DNA replication creates a problem of potential chromosome end truncation. The problem is solved in nature by adding special regions called *telomeres* to the ends of eukaryotic chromosomes.**

Telomeres


Telomeres
Chromosome
Cell
Telomere Shortening
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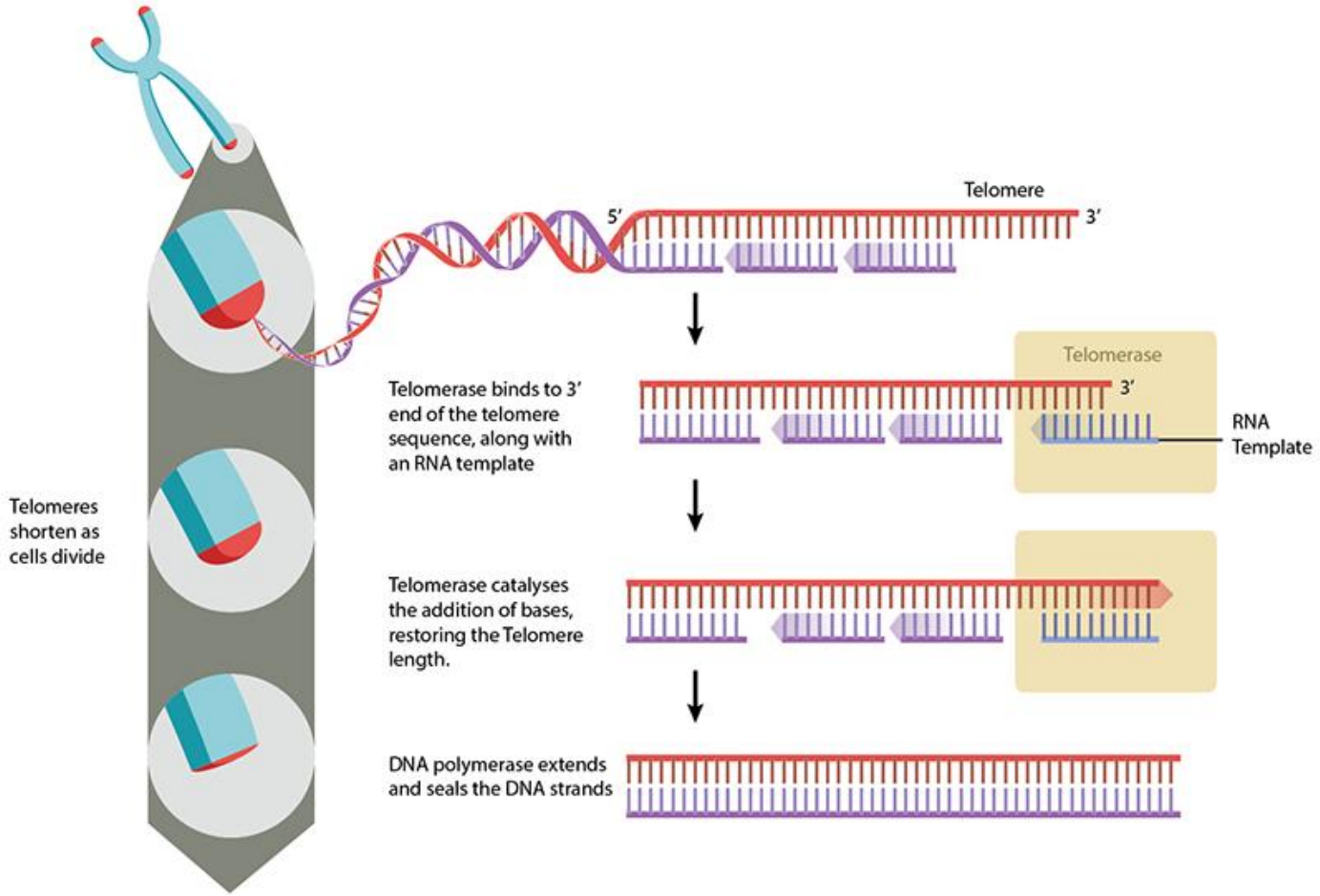
Telomerase


Telomeres shorten as cells divide
Telomere
5′
3′
Telomerase binds to 3′ end of the telomere sequence, along with an RNA template
Telomerase
3′
RNA Template
Telomerase catalyses the addition of bases, restoring the Telomere length.
DNA polymerase extends and seals the DNA strands