

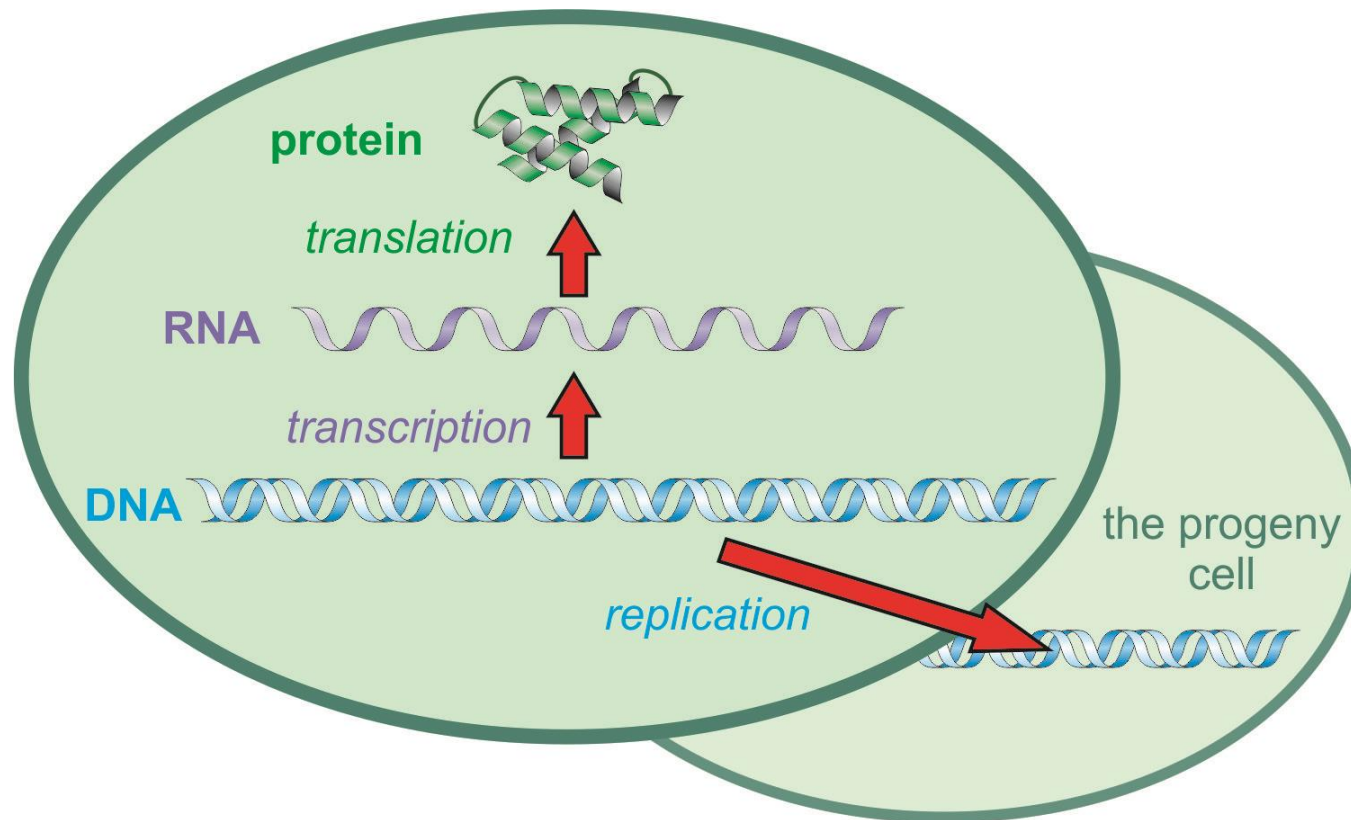
DNA and replication

dr hab. Krzysztof Leśniewicz

Course title: From molecules to cells

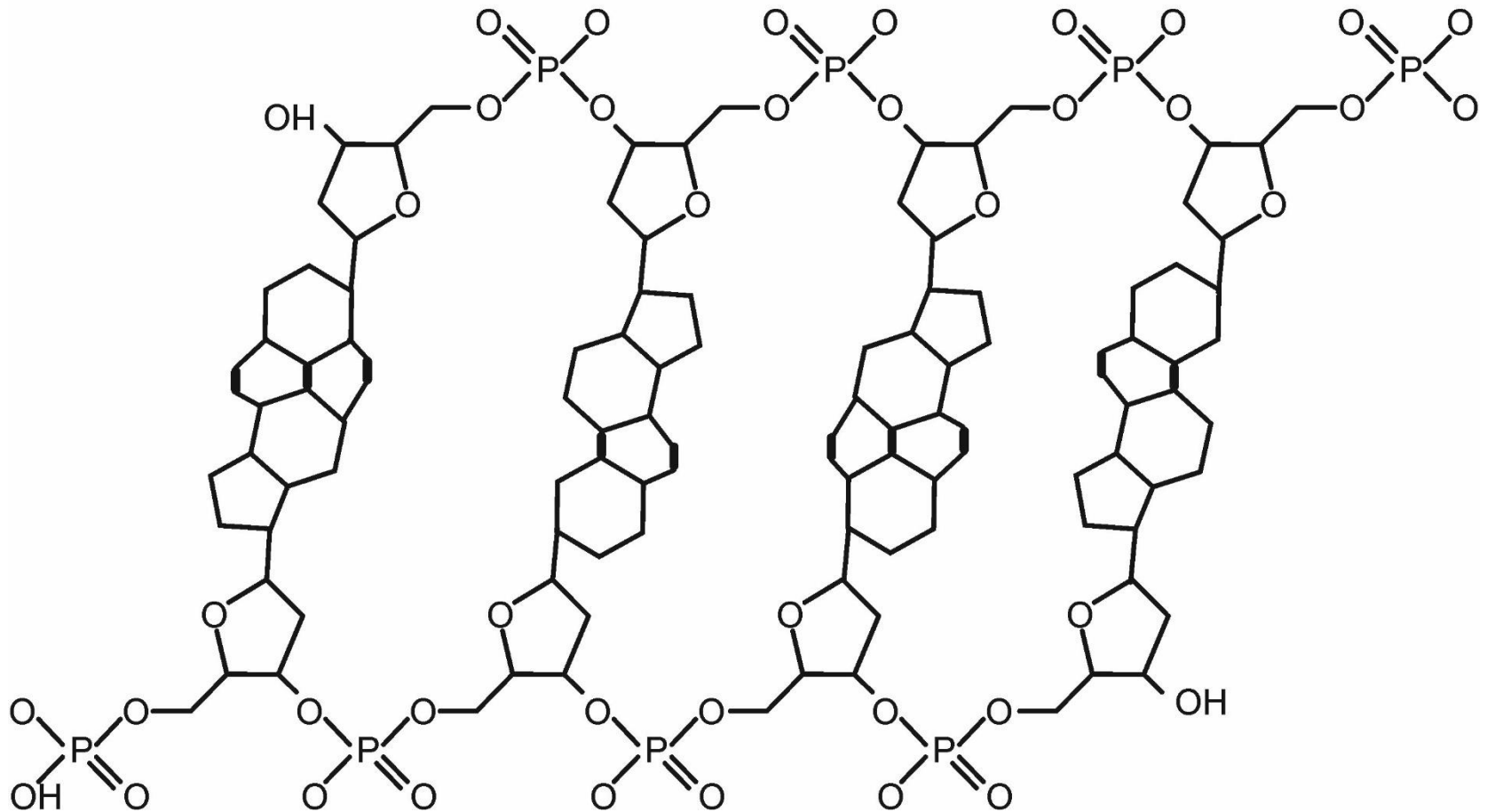
Central dogma of molecular biology

The transfer of genetic information within a biological system

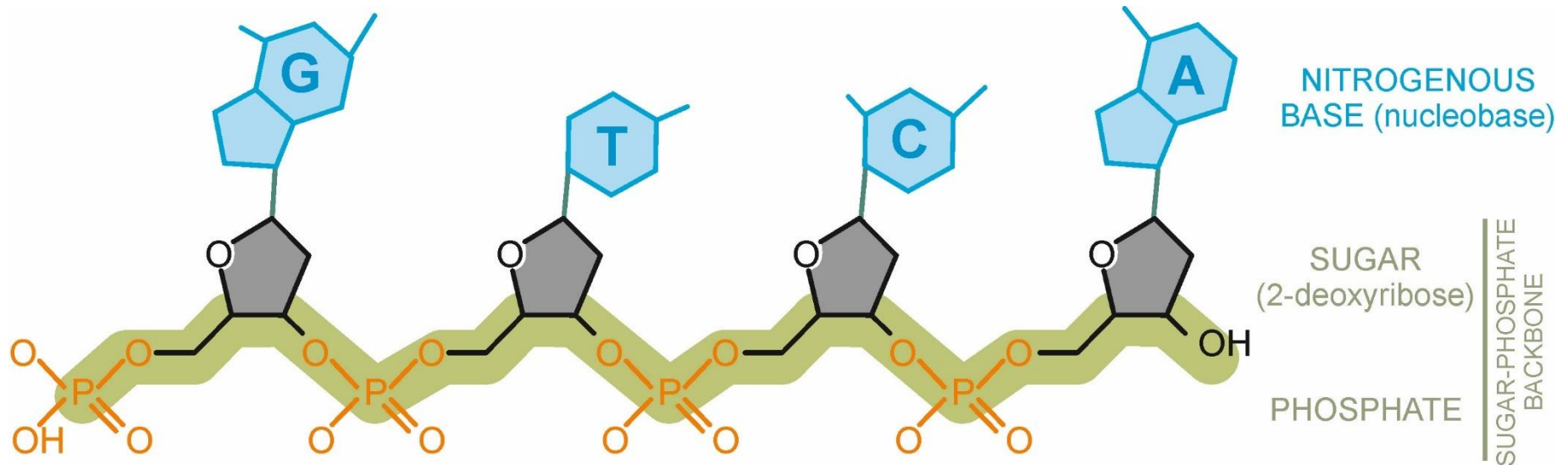


What we need to know to understand how DNA works

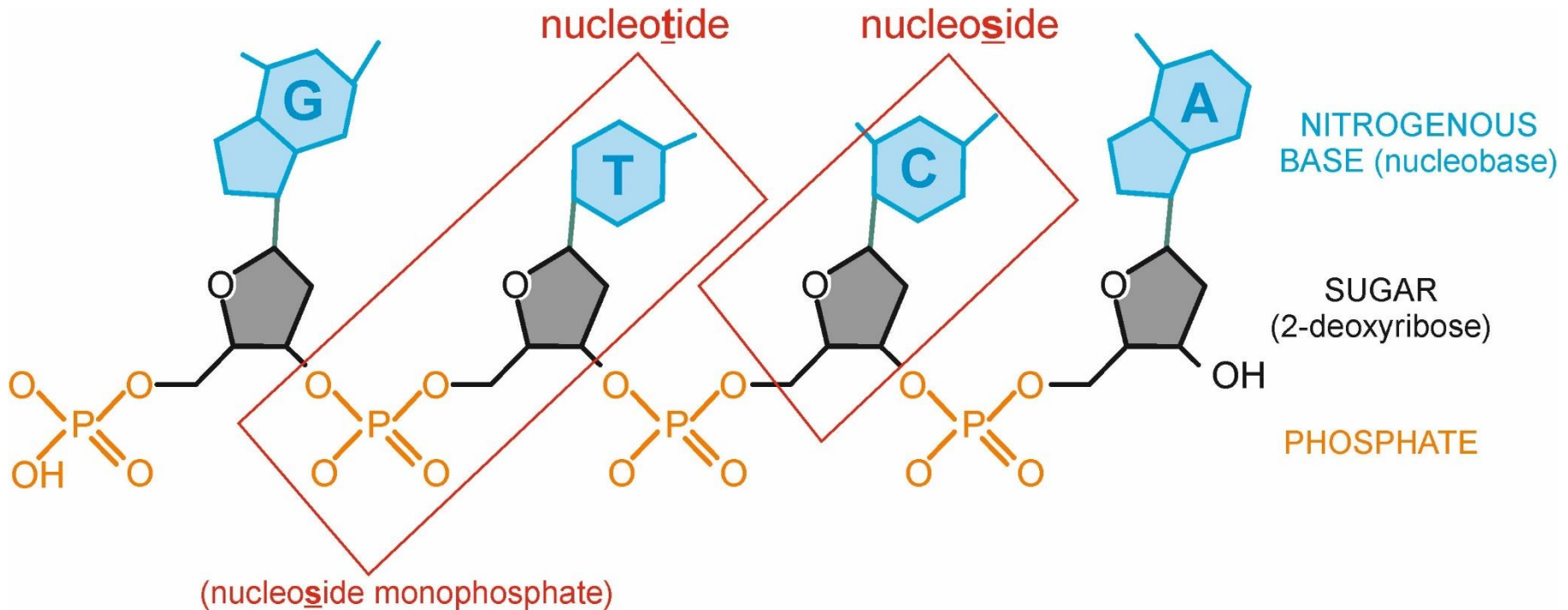
GTCA



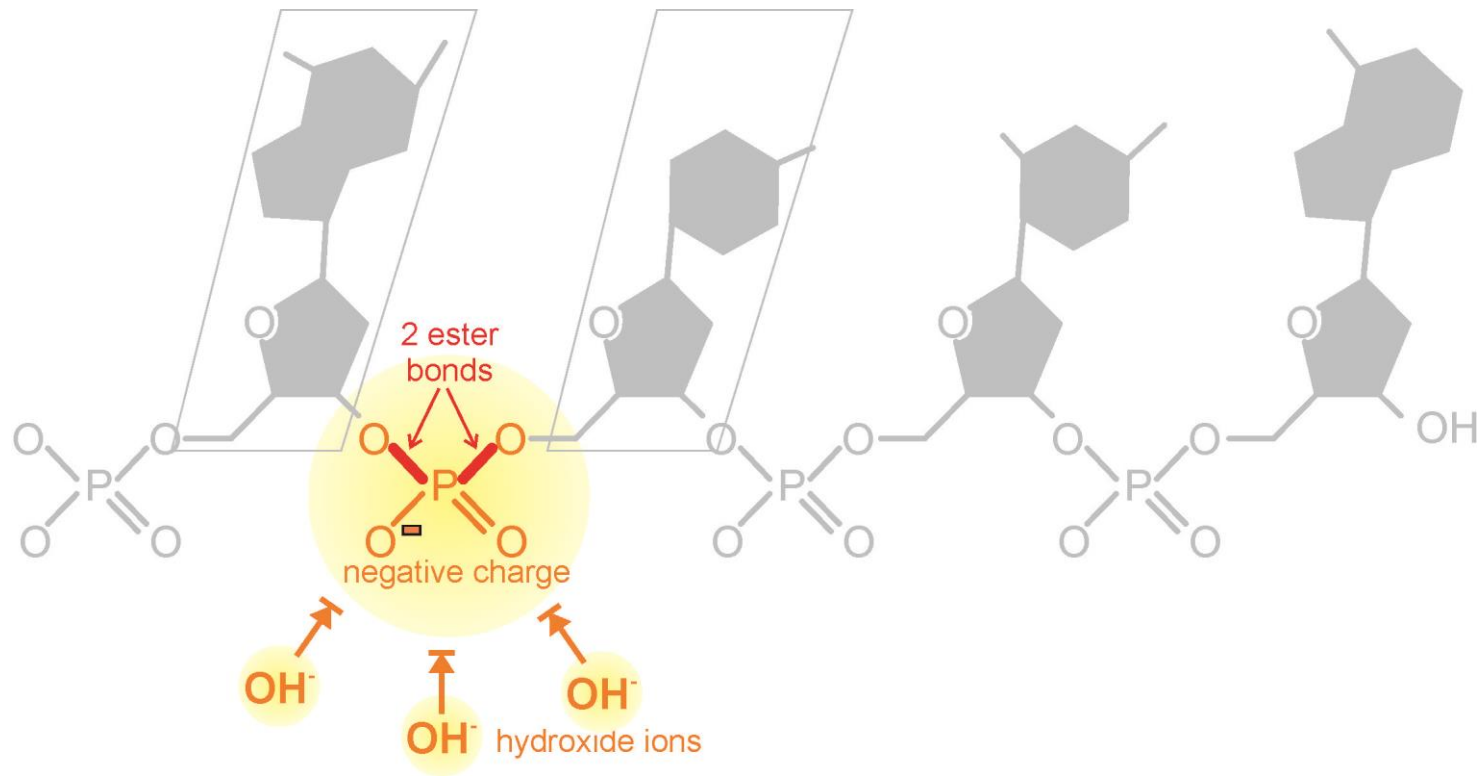
DNA is a polymer composed of nucleotides



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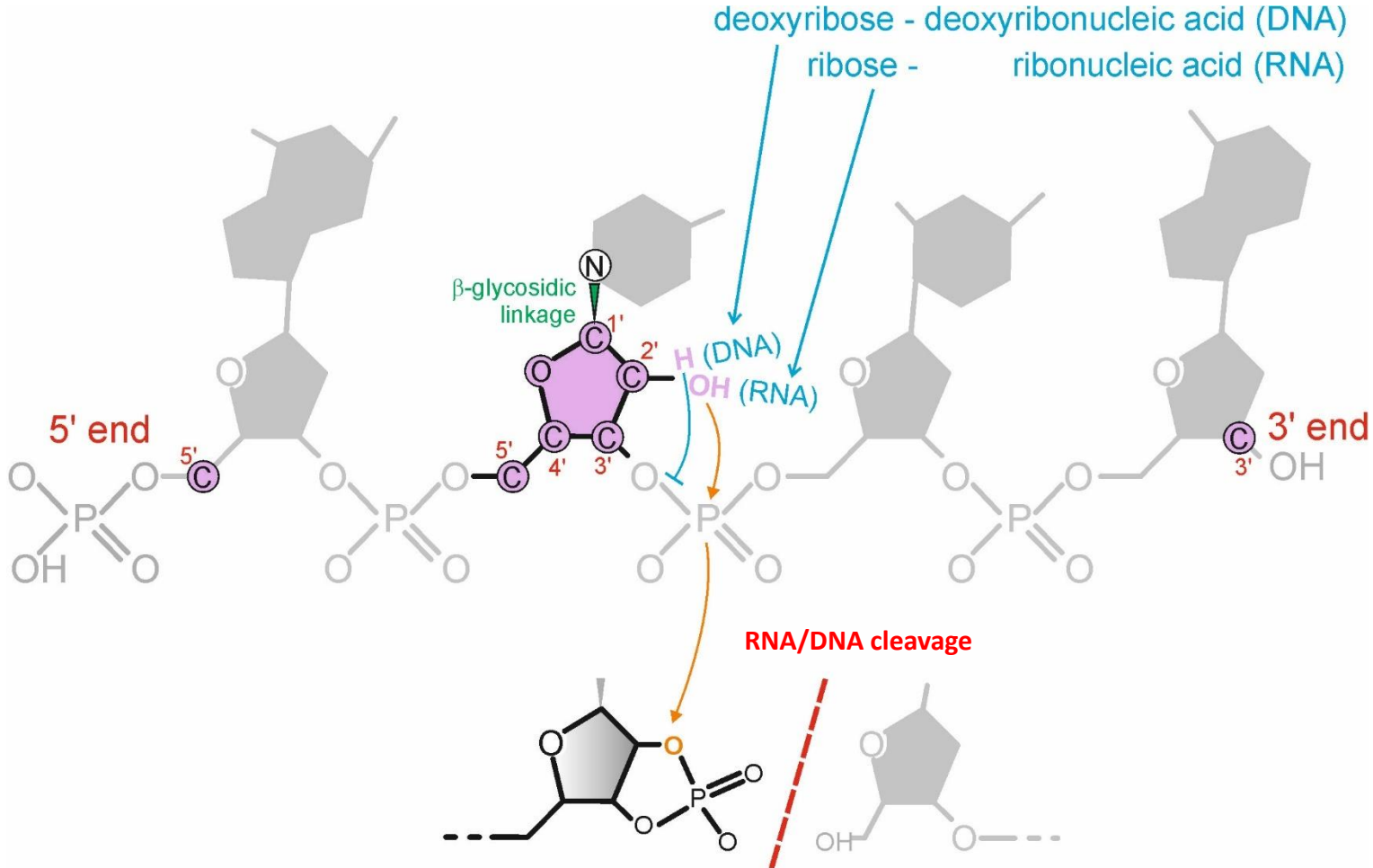


Phosphodiester bridge is negatively charged and give DNA molecules a negative charge

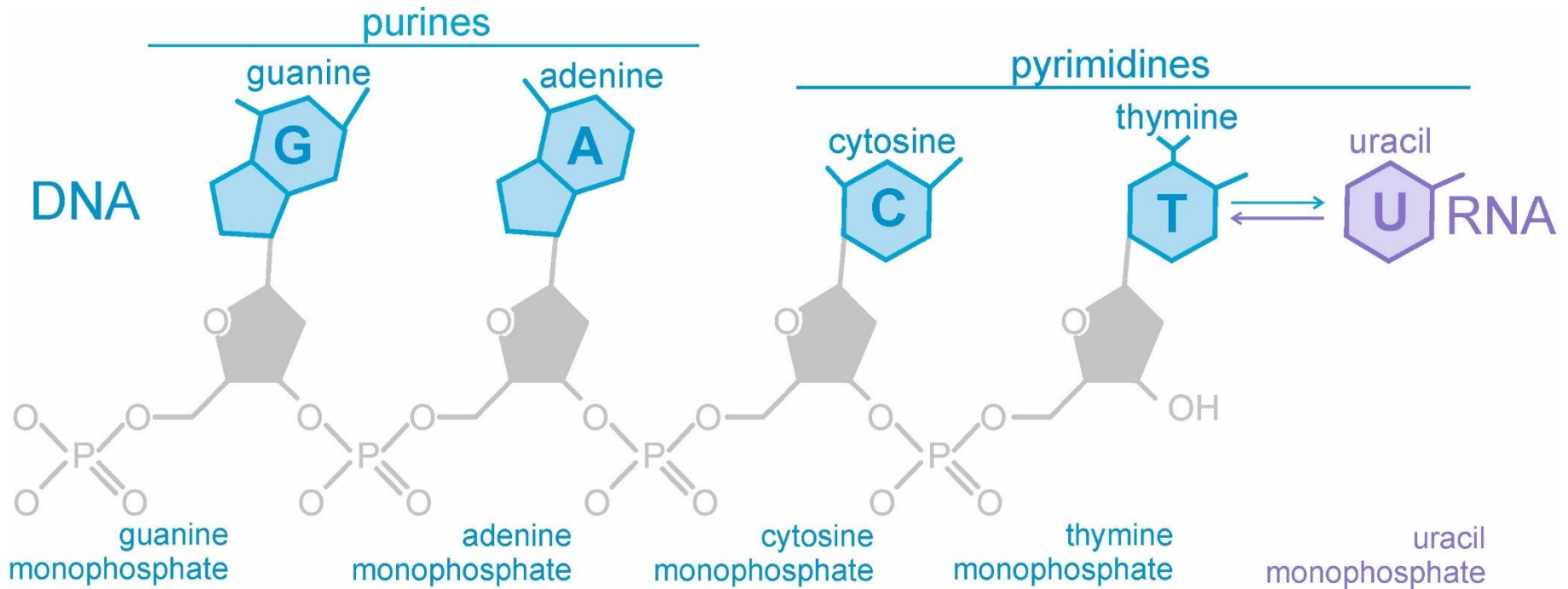


charge repulsion

Ribose and deoxyribose are components of RNA and DNA, respectively.

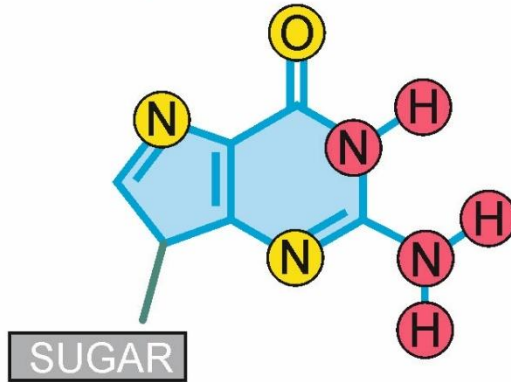


Genetic information is coded in the sequence of nitrogenous bases

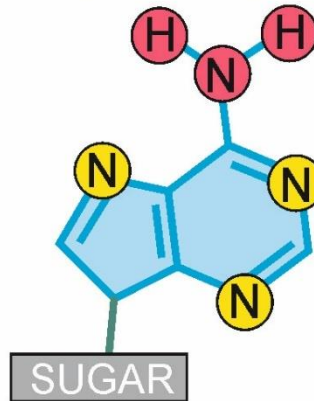


Nitrogenous bases can form hydrogen bonds

guanine



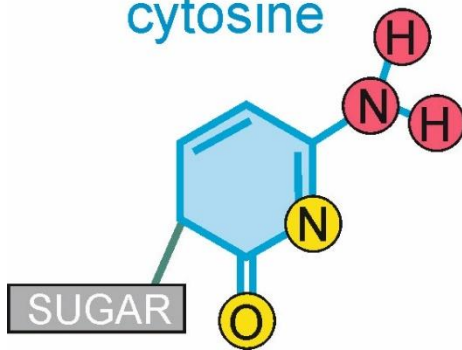
adenine



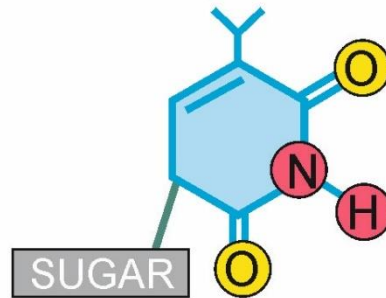
hydrogen bond donors
primary, secondary amine group

hydrogen bond acceptors
tertiary amine, carbonyl group

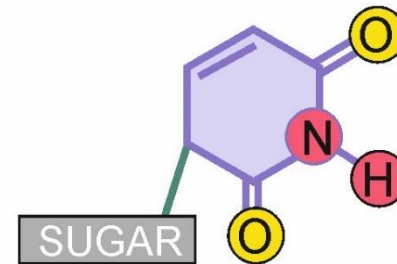
cytosine



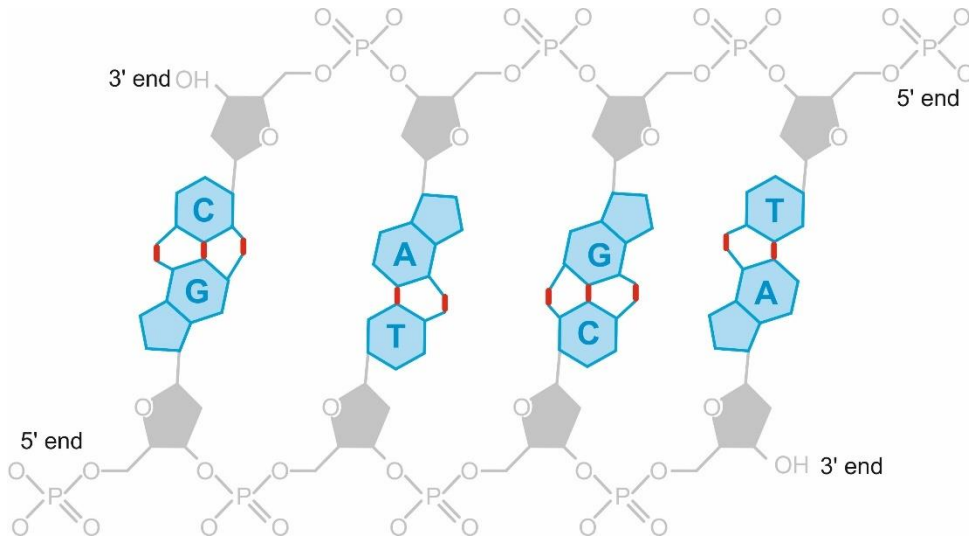
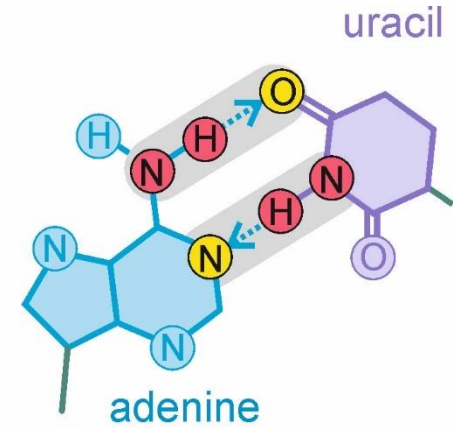
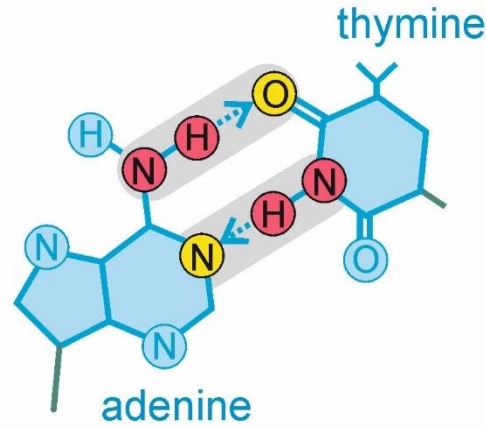
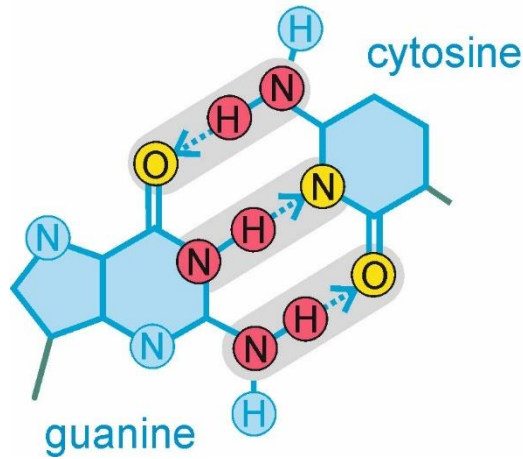
thymine



uracil



Nitrogenous bases pair with each other using hydrogen bonds



DNA $\xrightarrow{\text{replication}}$ DNA (dsDNA)

DNA $\xrightarrow{\text{transcription}}$ mRNA

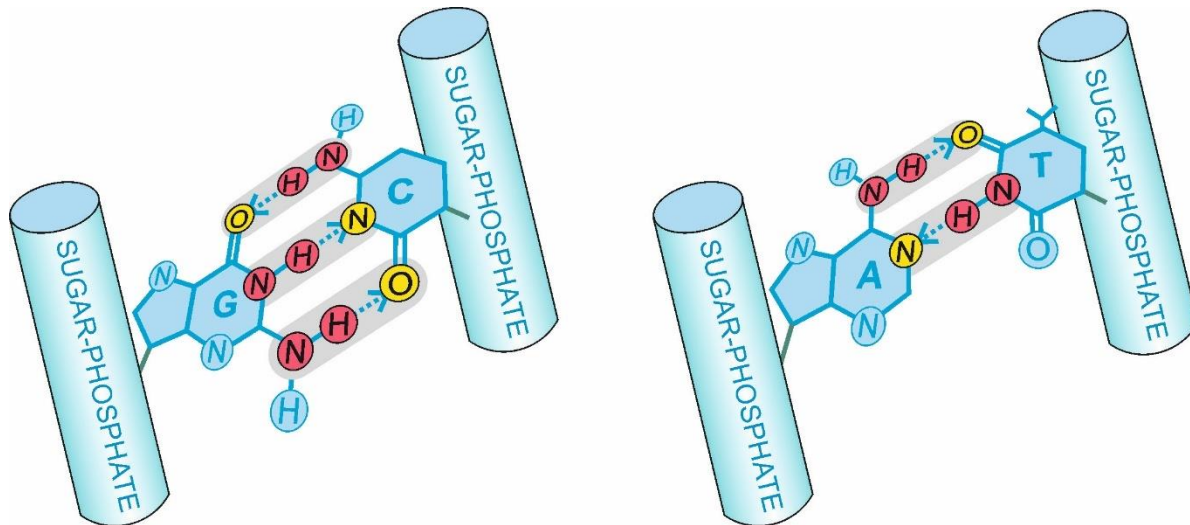
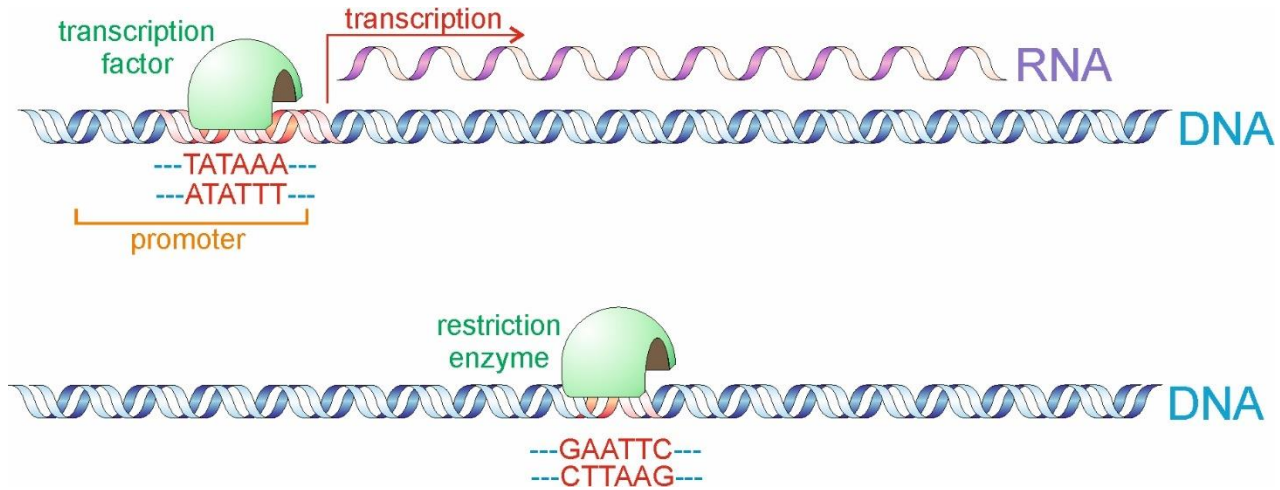
mRNA $\xrightarrow{\text{translation}}$ tRNA \rightarrow protein

siRNA $\xrightarrow{\text{RNAi regulation}}$ mRNA

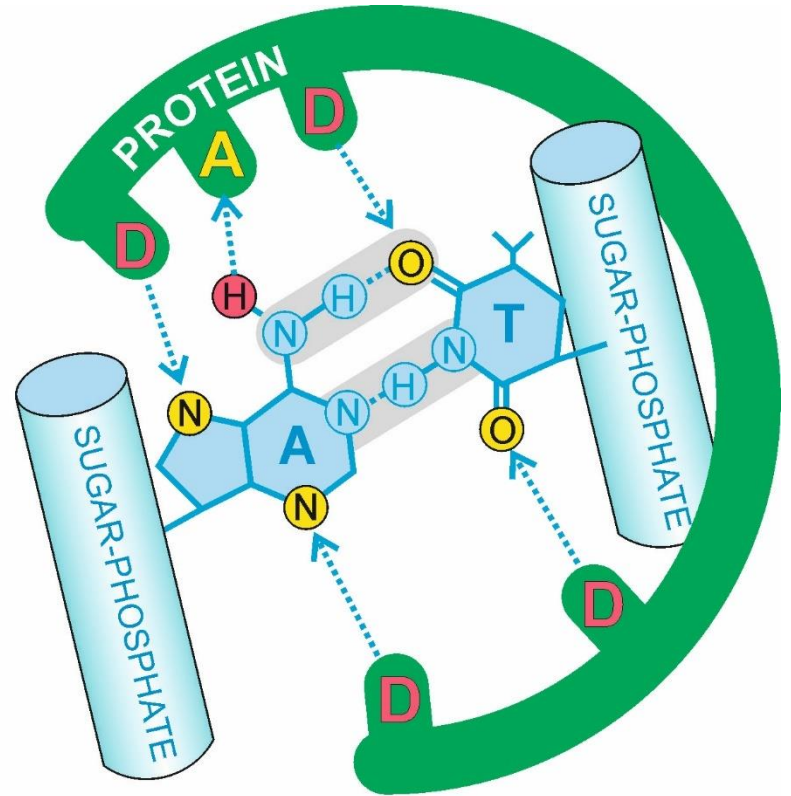
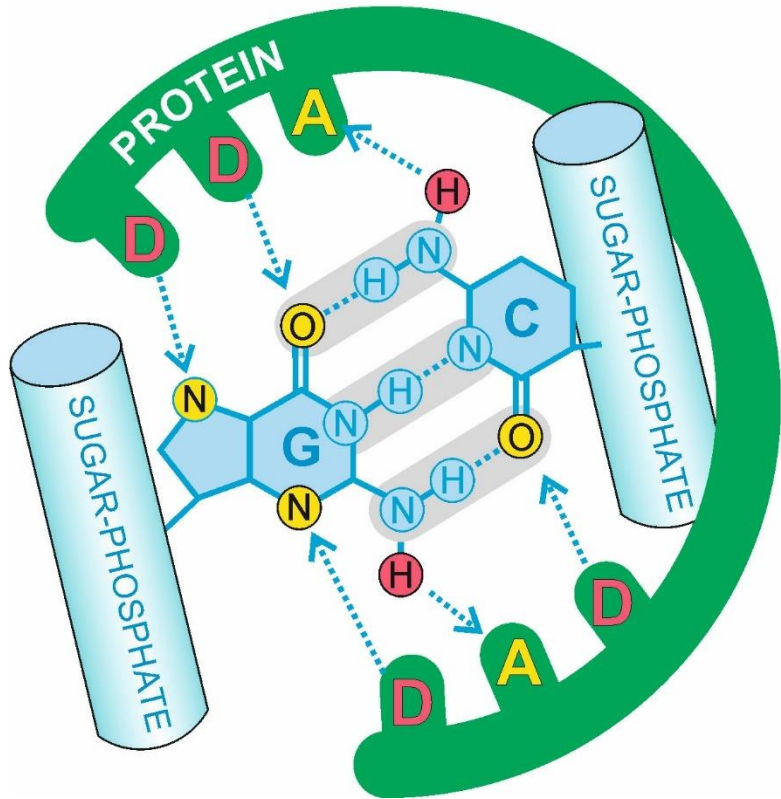
RNA $\xrightarrow{\text{reverse transcrip}}$ DNA

ssRNA $\xrightarrow{\text{RNA virus replication}}$ dsRNA

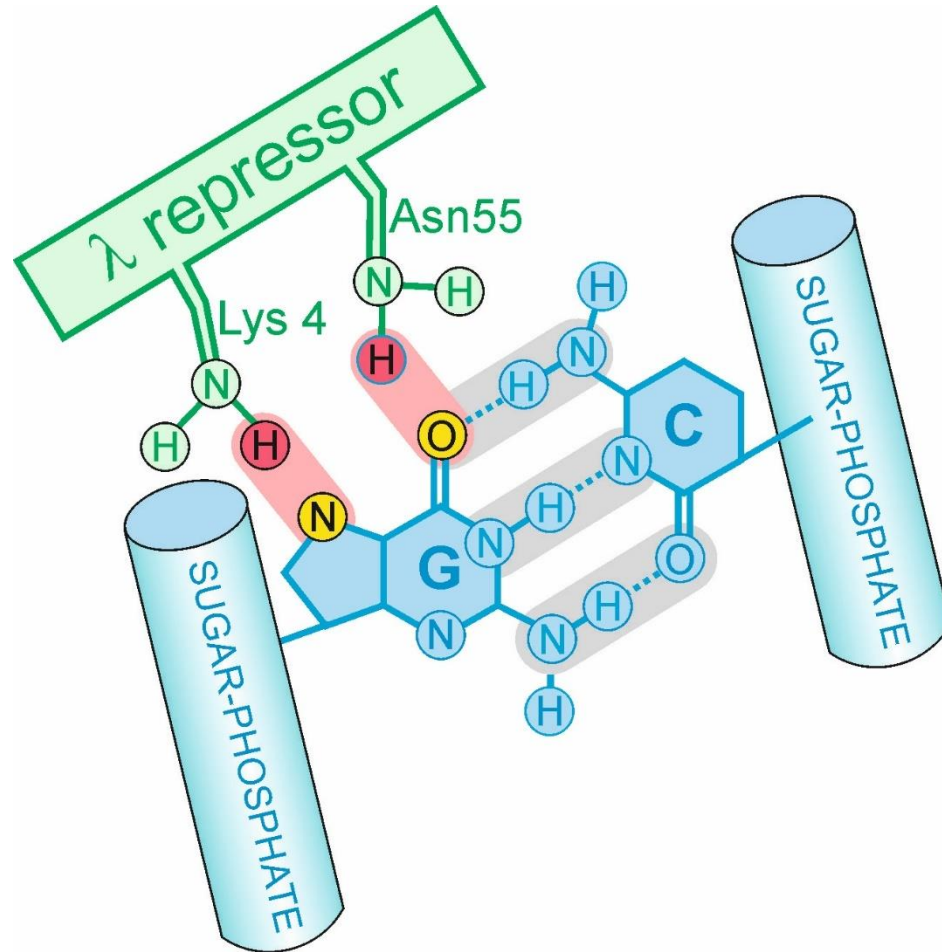
How proteins recognize and bind specific double-stranded nucleic acid sequences



Proteins recognize specific DNA sequences by selective hydrogen bonds to the DNA bases



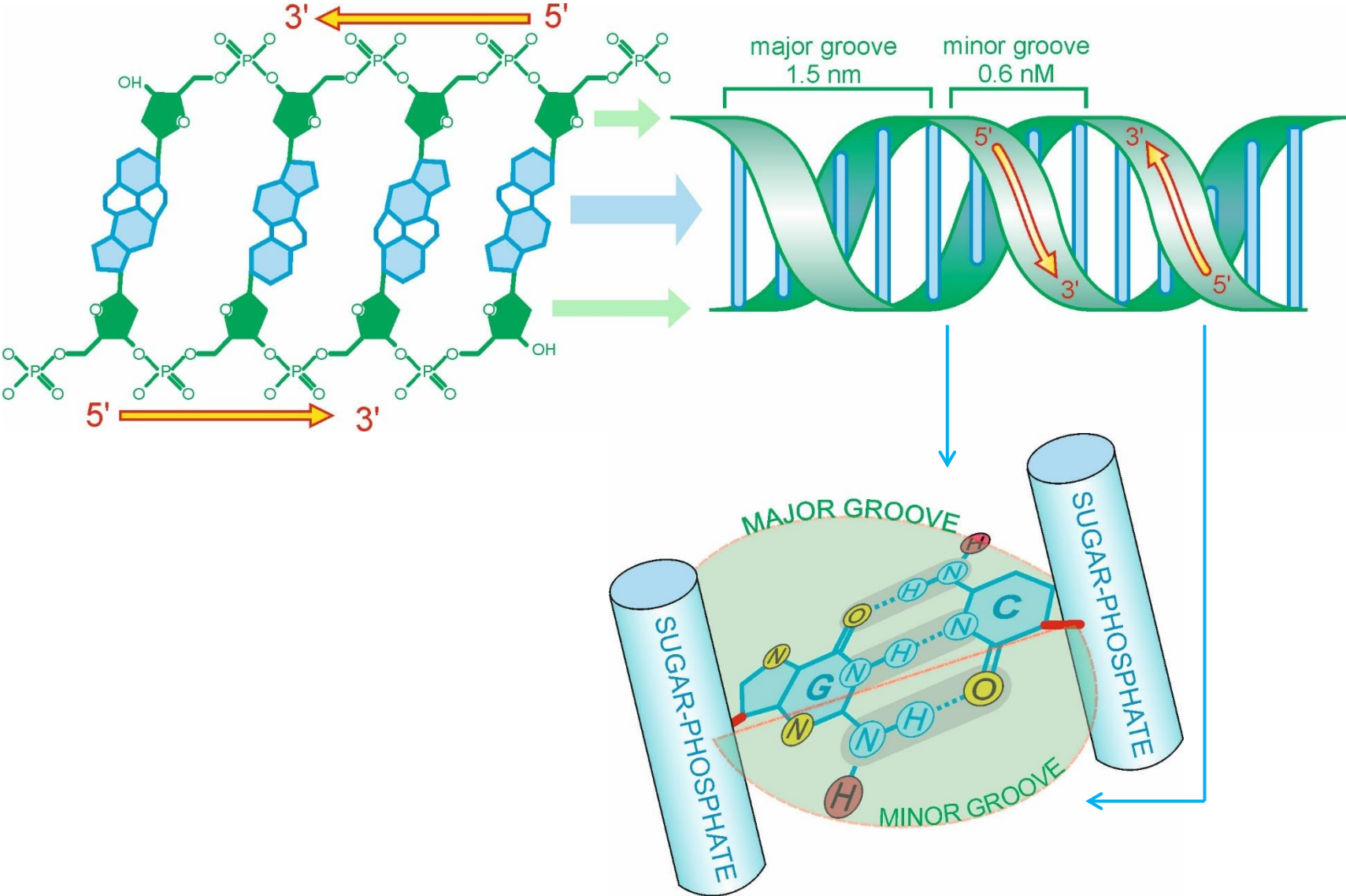
Lambda-repressor-like proteins recognize DNA by hydrogen bonds



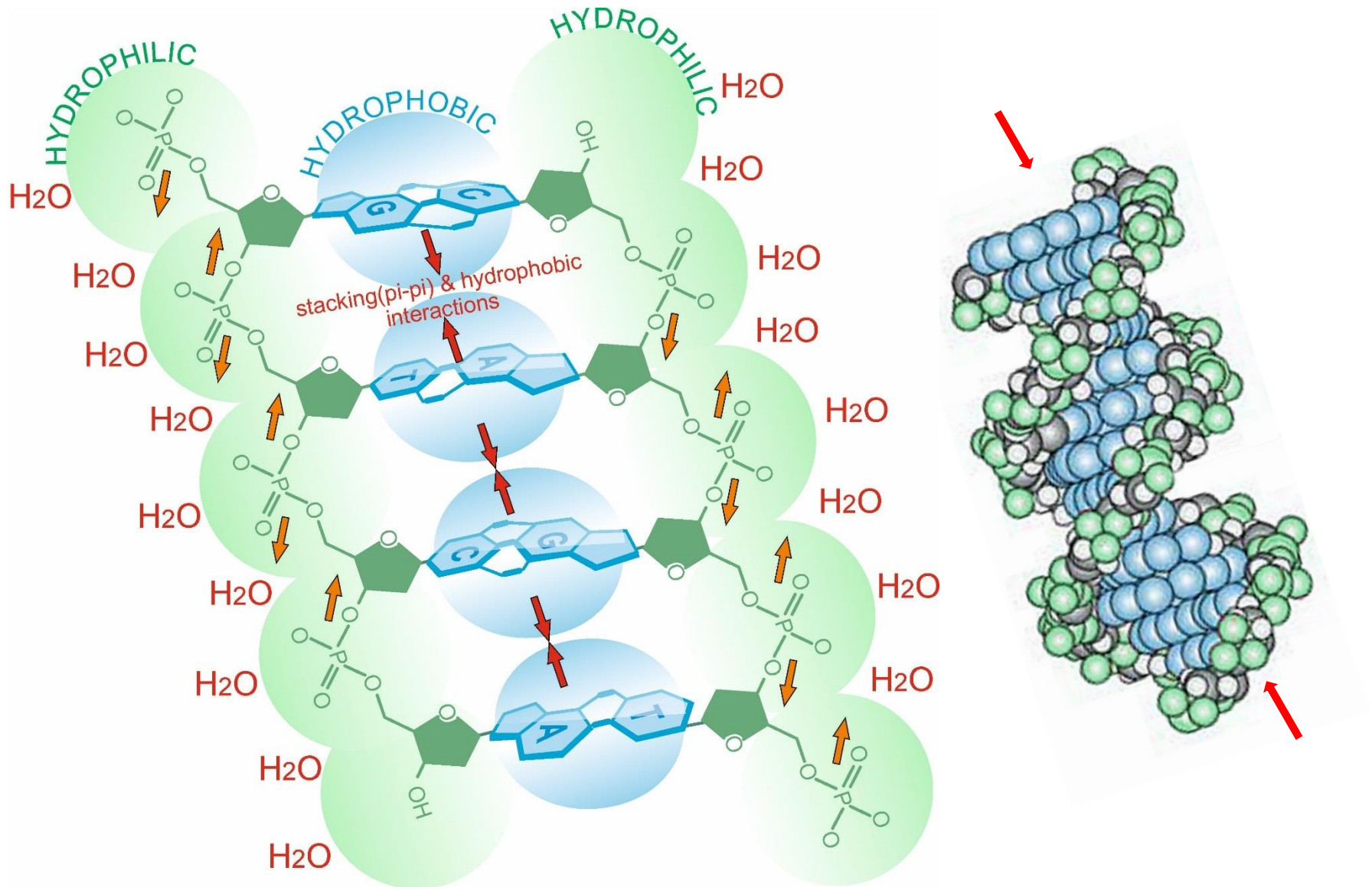
DNA has a double-helix structure

primary structure

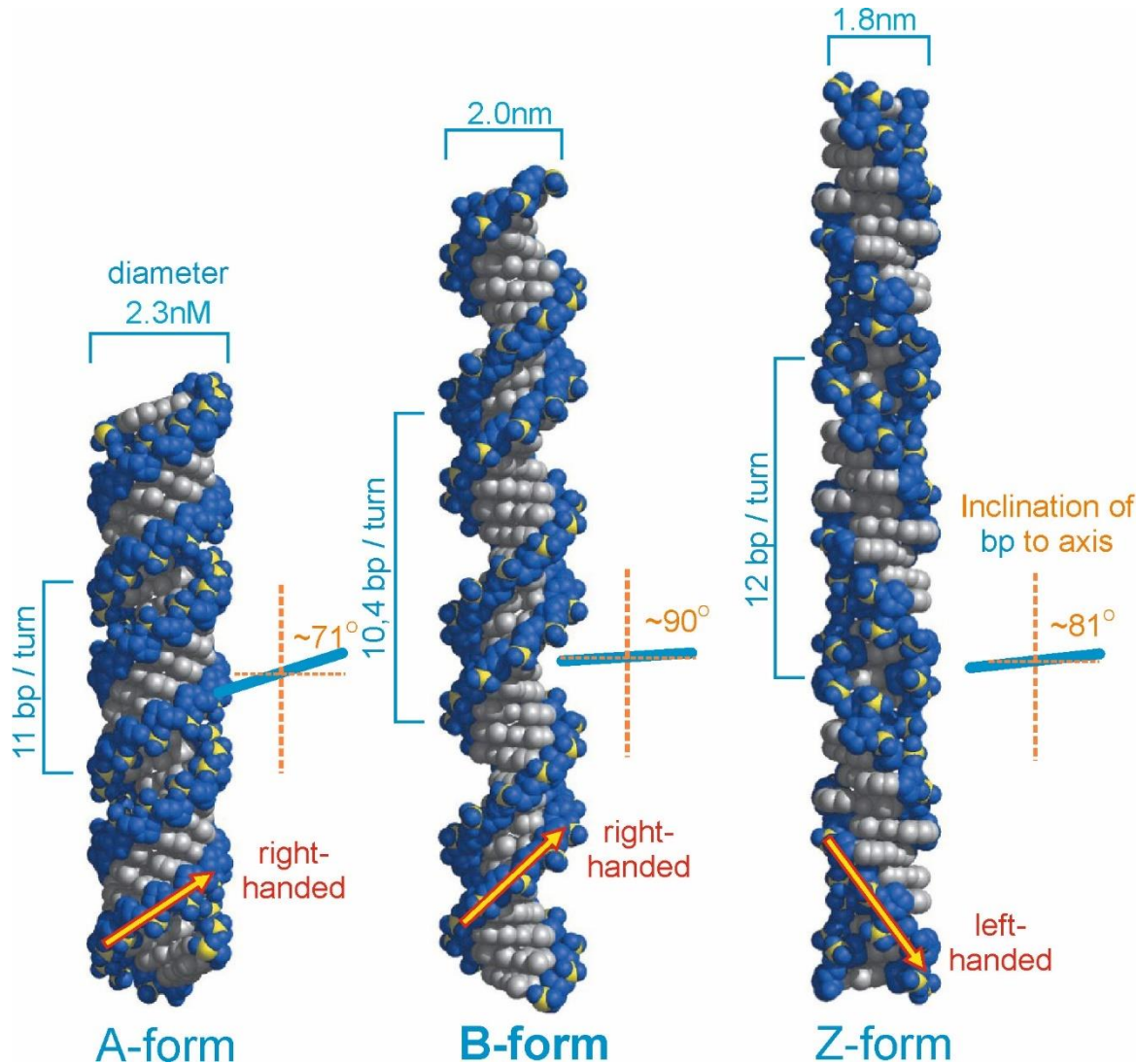
secondary structure



Water environment determines DNA double helix conformation



DNA can adopt three different forms



A-form

DNA/RNA, RNA/RNA duplexes
dsDNA under dehydrating cond.

B-form

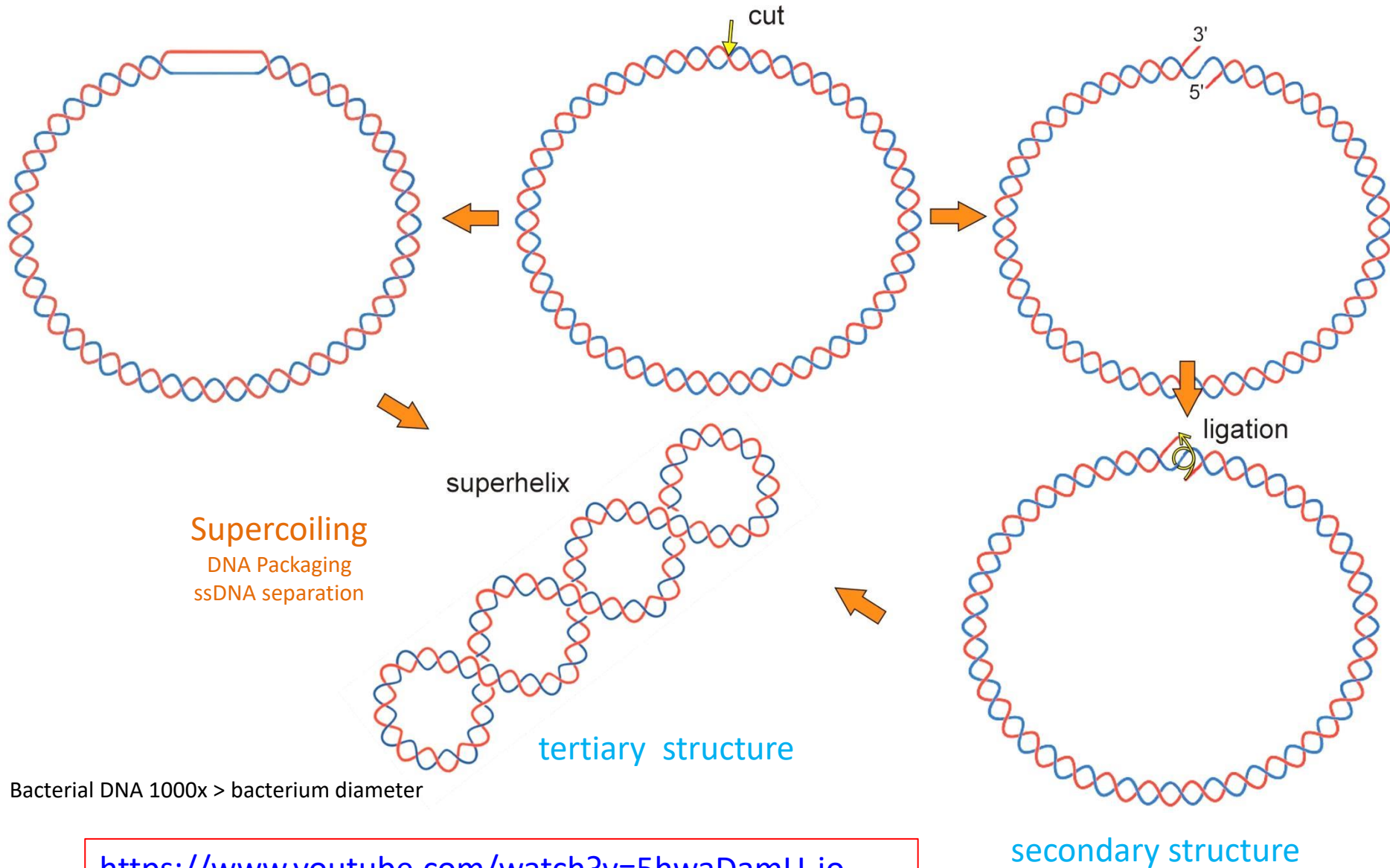
dsDNA in physiological cond.

Z-form

pur/pir sequences (GCGCGC)
negatively supercoiled DNA

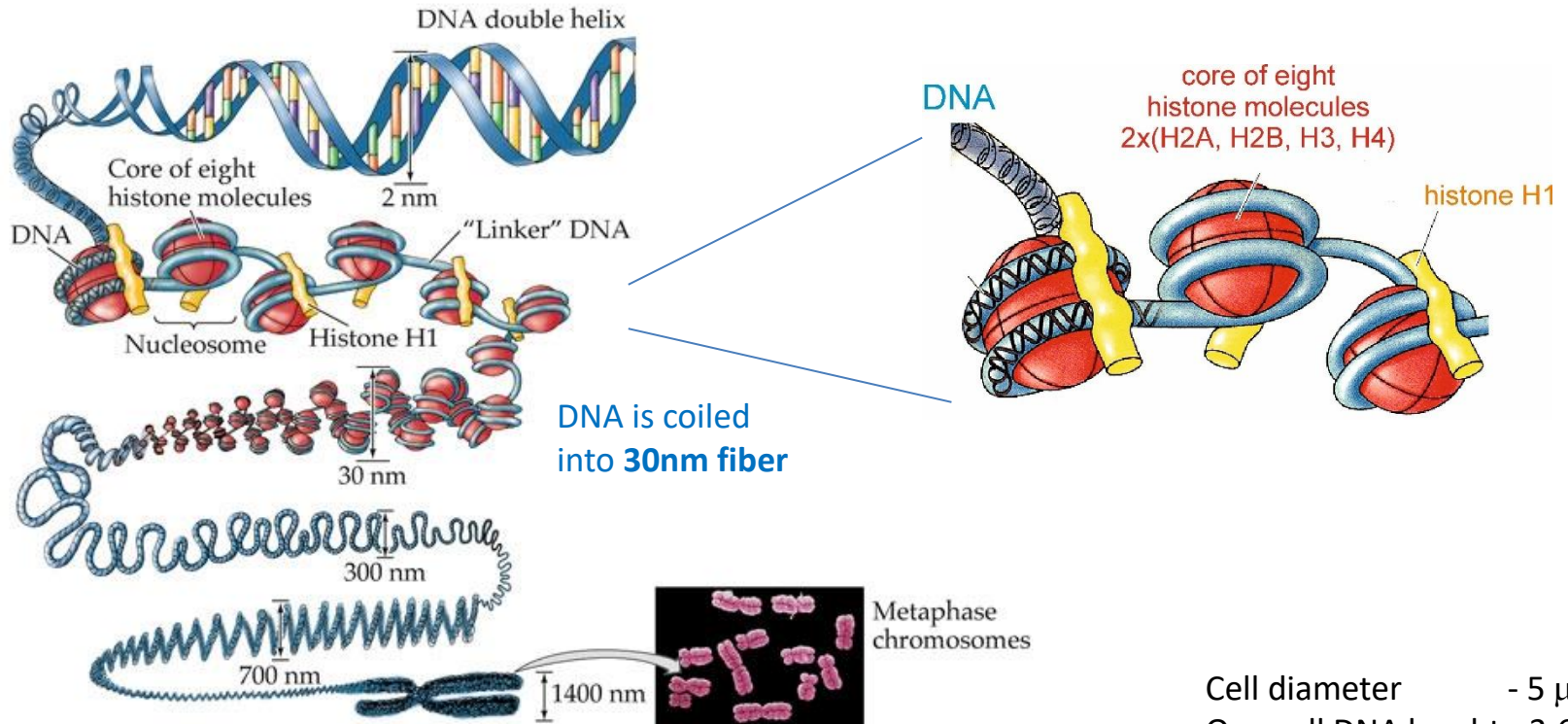
https://www.youtube.com/watch?v=o_-6JXLYS-k 4.30s

What happens when we change the numbers of turns



<https://www.youtube.com/watch?v=5hwaDamU-jo>

Eucaryotic DNA is wrapped around histones to form nucleosomes



LIFE: THE SCIENCE OF BIOLOGY, Seventh Edition, Figure 9.6 DNA Packs into a Mitotic Chromosome
© 2004 Sinauer Associates, Inc. and W. H. Freeman & Co.

Cell diameter - 5 μm
One cell DNA length - 3.6 m



interphase chromatin

<https://www.youtube.com/watch?v=OjPcT1uUZiE>

Replication

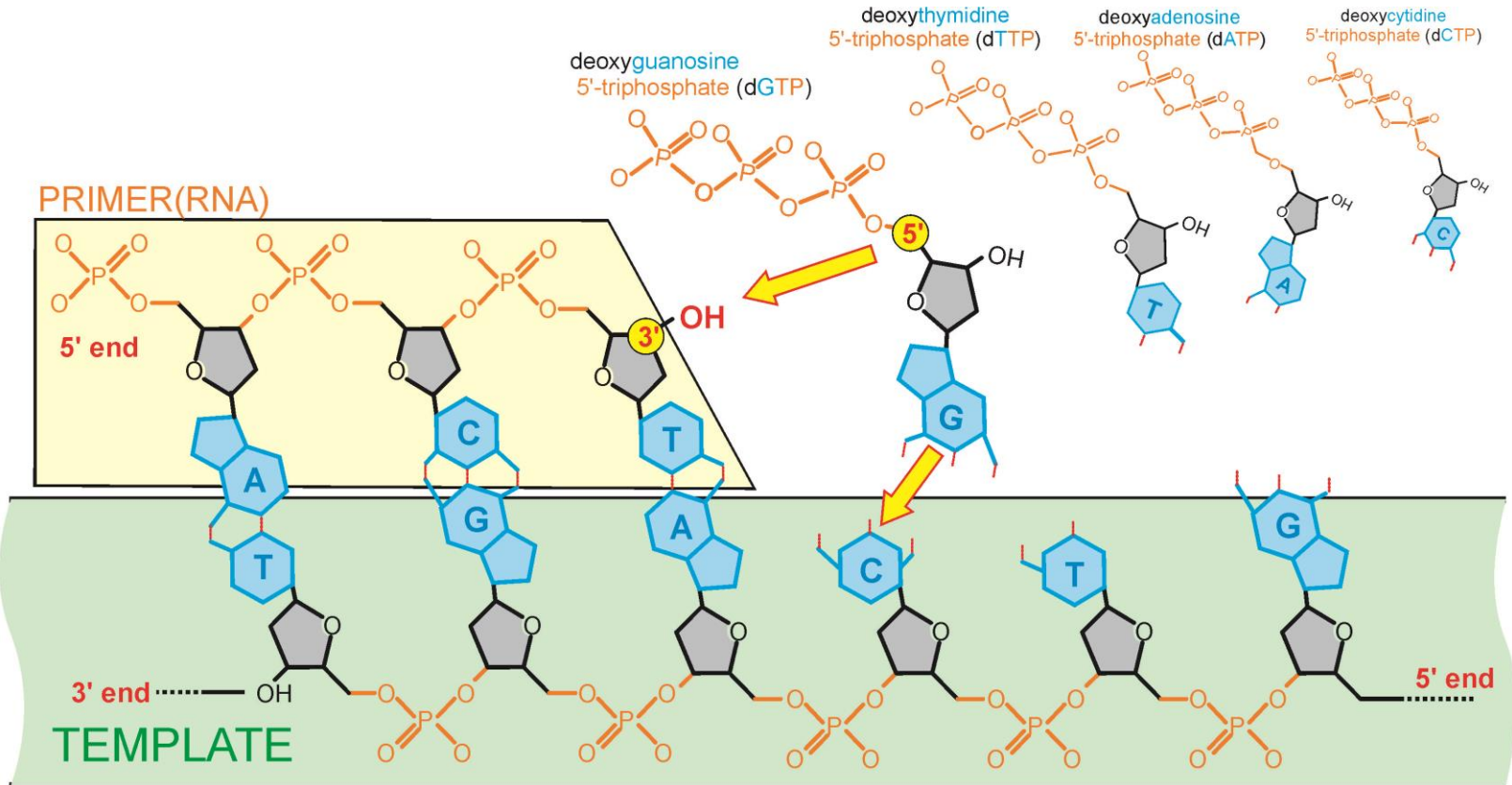
Life is distinguished by the capacity to:

- ❖ grow
- ❖ metabolize
- ❖ respond to stimuli
- ❖ adapt
- ❖ and **reproduce**

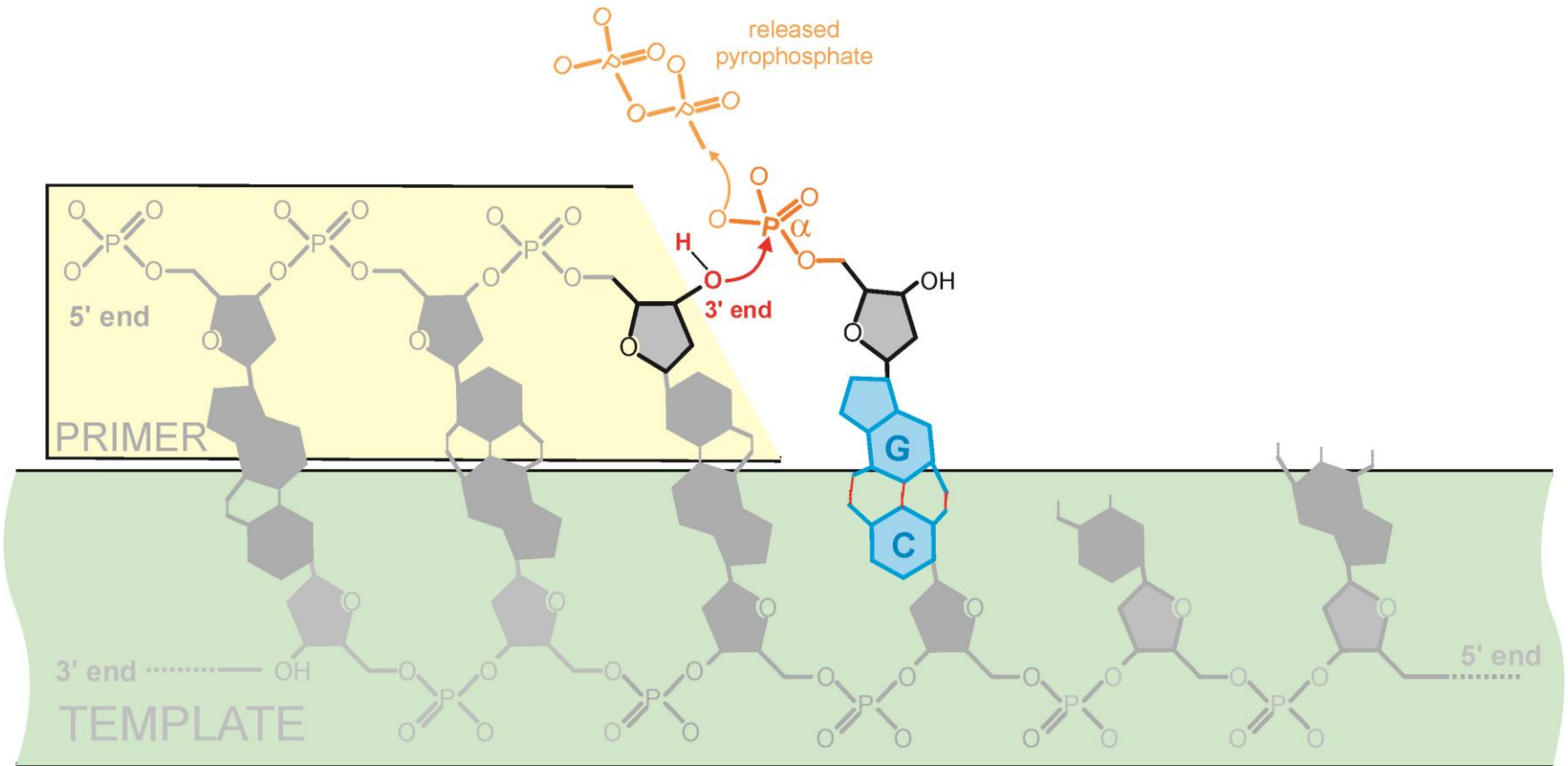
Bacteria have several DNA polymerases

Name	Function	Composition
DNA pol I	REPLICATION and DNA repair	single polypeptide
DNA pol II	DNA repair	
DNA pol III	REPLICATION	composed of 10 subunits (Polymerase holoenzyme) α subunit – DNA synthesis
DNA pol IV	DNA repair	
DNA pol V	DNA repair	

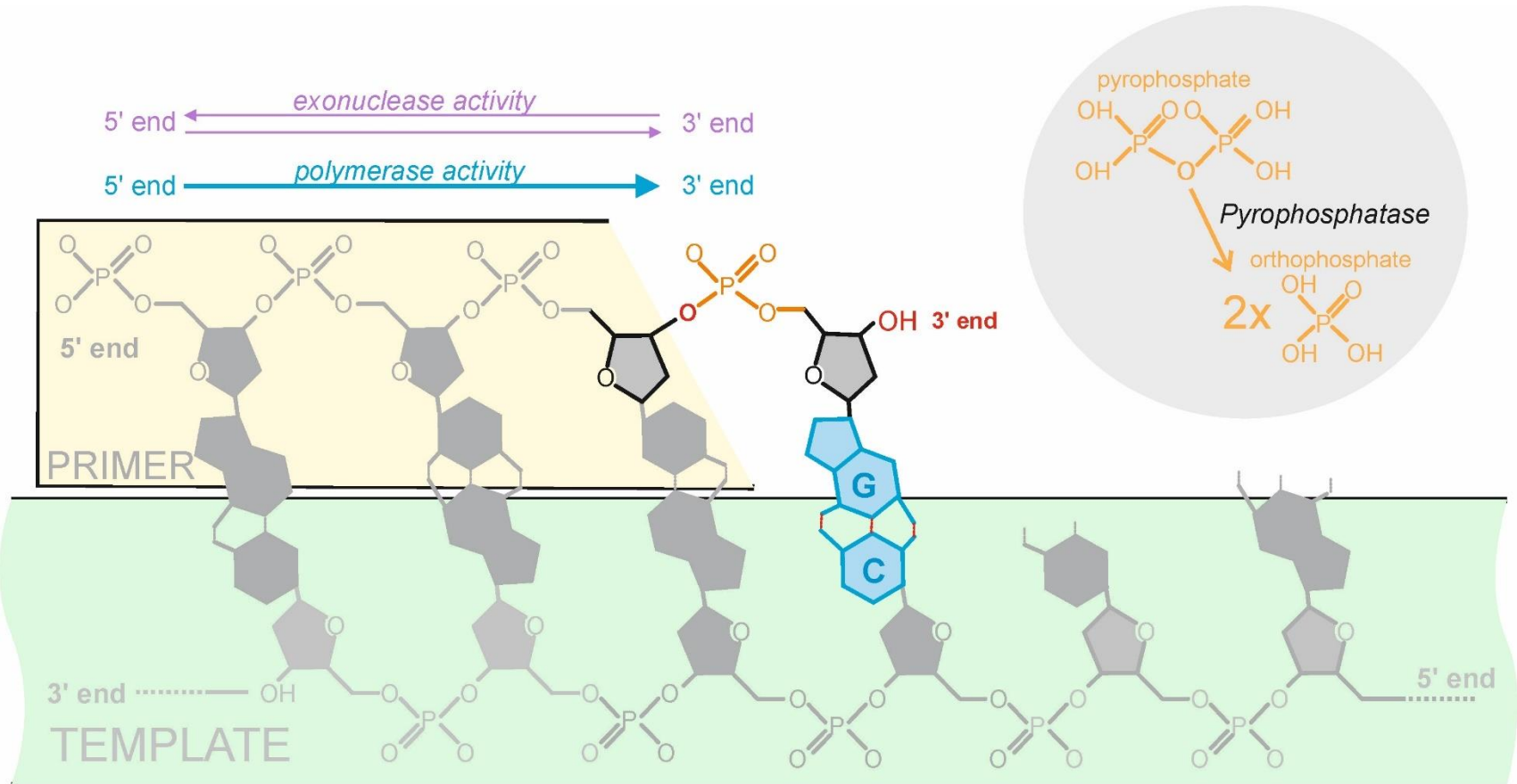
DNA polymerase requirement



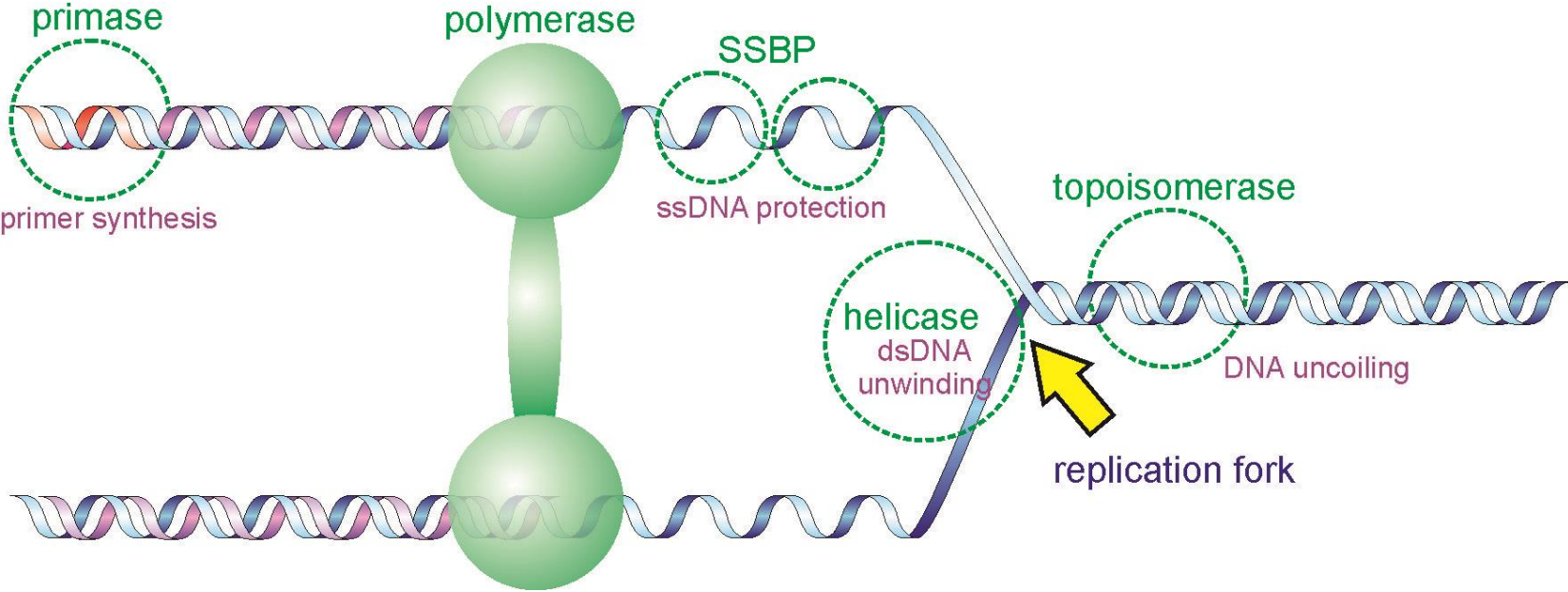
DNA polymerase catalysis



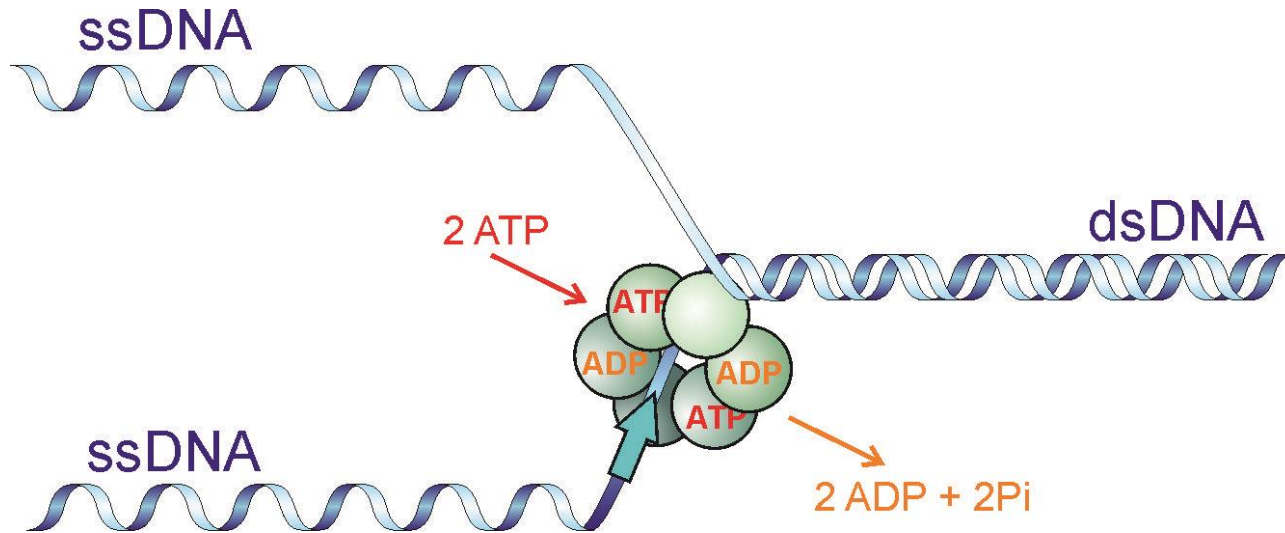
DNA polymerase catalysis



Other enzymes cooperating with DNA polymerase

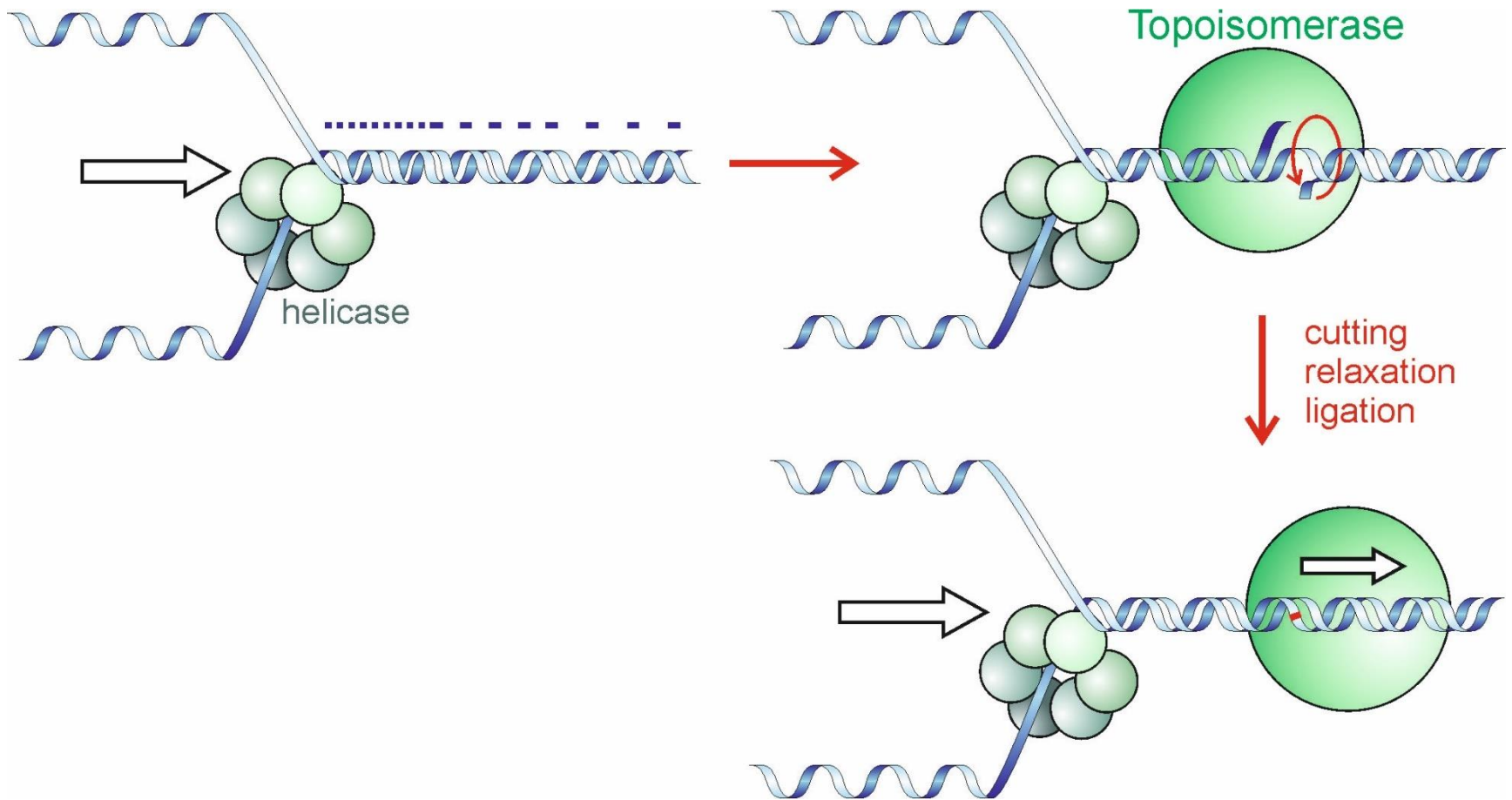


Helicase catalyzes the unwinding and separation of double-stranded DNA



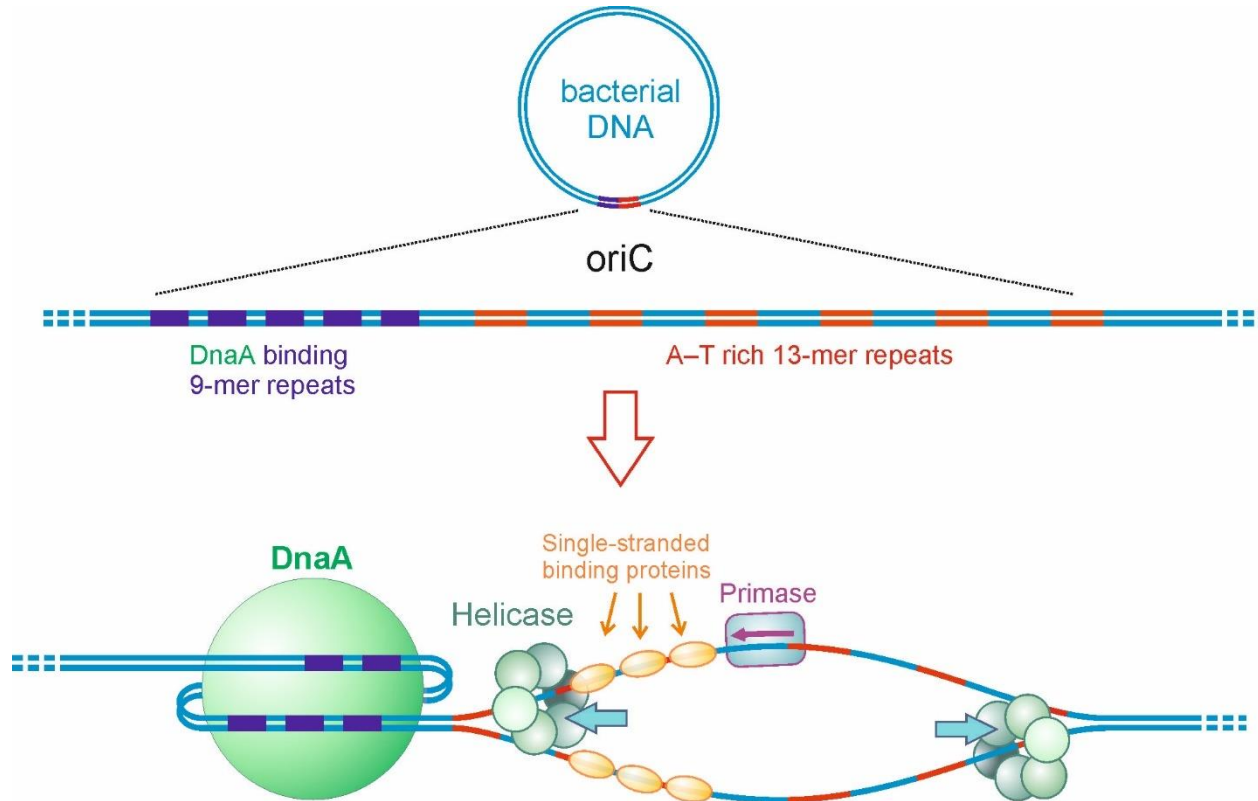
- <https://www.youtube.com/watch?v=Z9ER-04WEBk>

DNA topoisomerase I catalyzes the relaxation of supercoiled DNA ahead of a replication fork



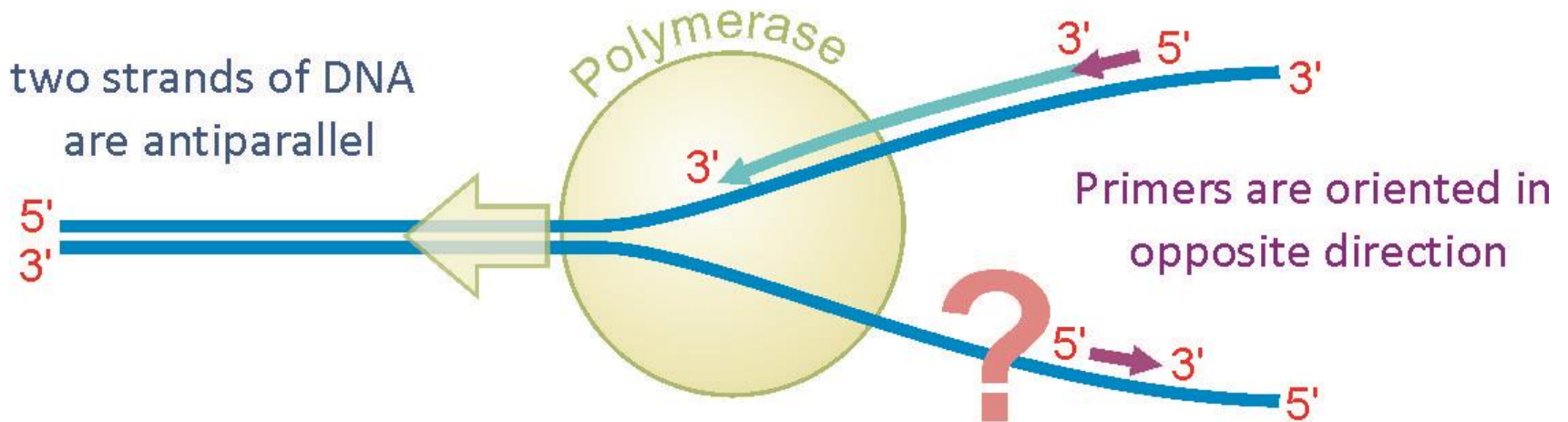
<https://www.youtube.com/watch?v=MTZVYL9eBxQ>

DNA replication in bacteria begins at unique site

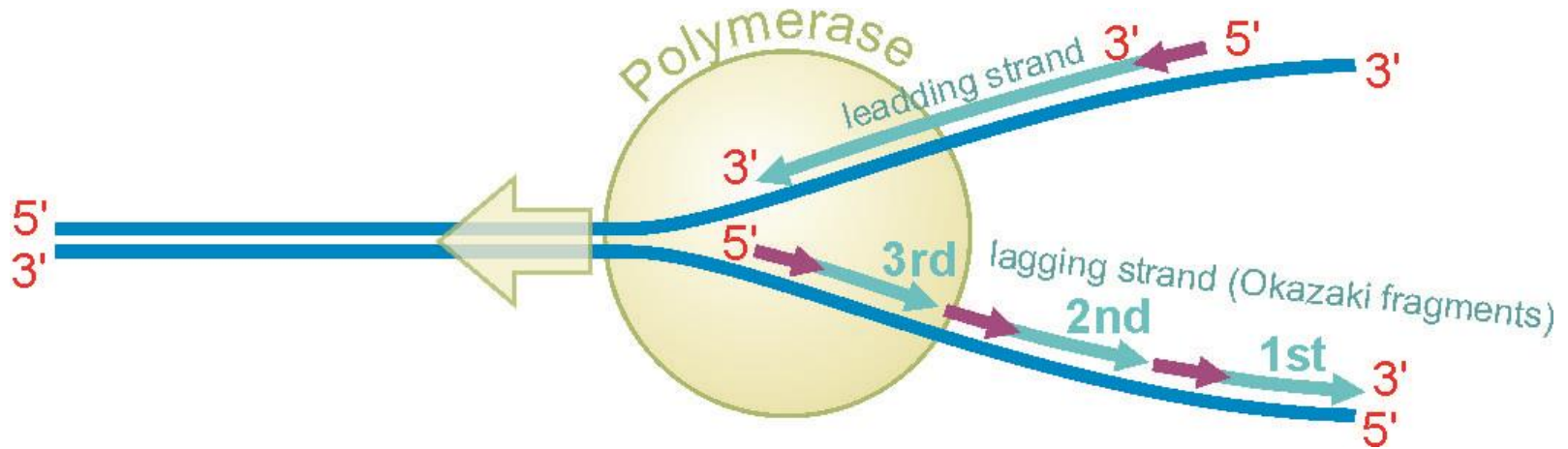


<https://www.youtube.com/watch?v=TNKWgcFPHqw>
<https://www.youtube.com/watch?v=0Ha9nppnwOc>

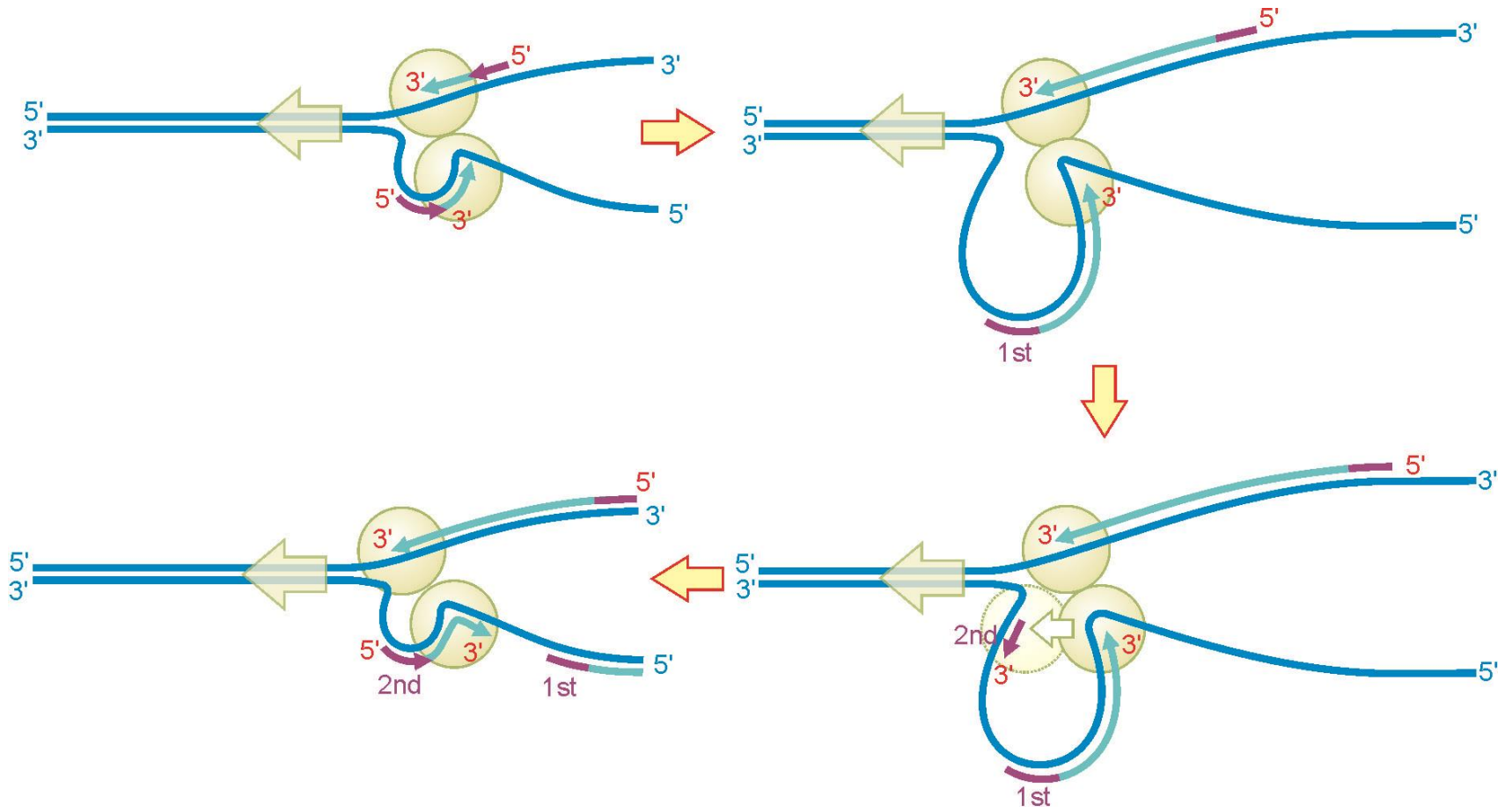
One strand is made continuously and other strand is synthesized in fragments



One strand is made continuously and other strand is synthesized in fragments

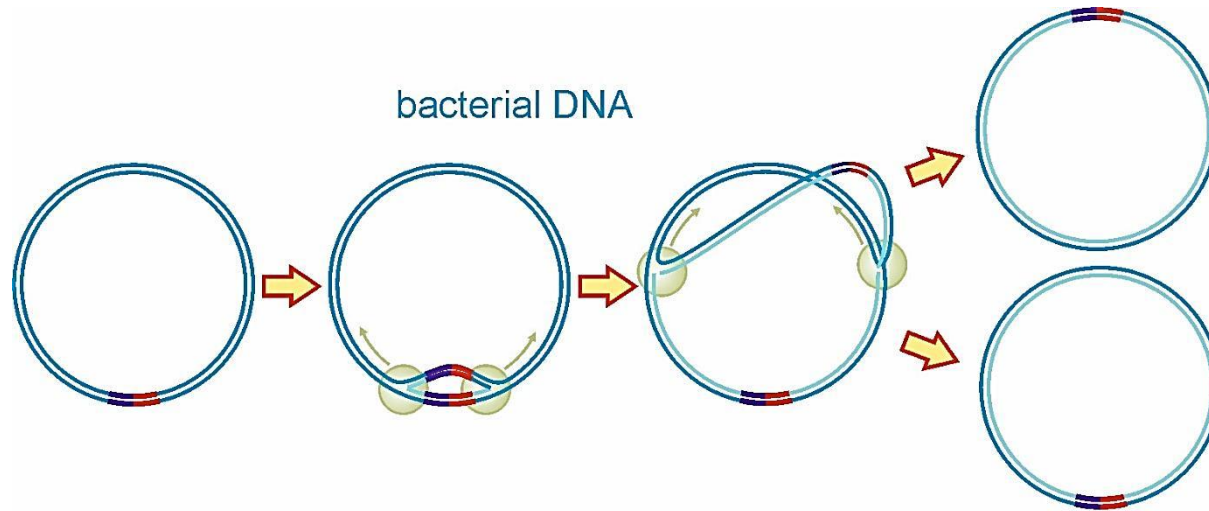


The synthesis of lagging-strand

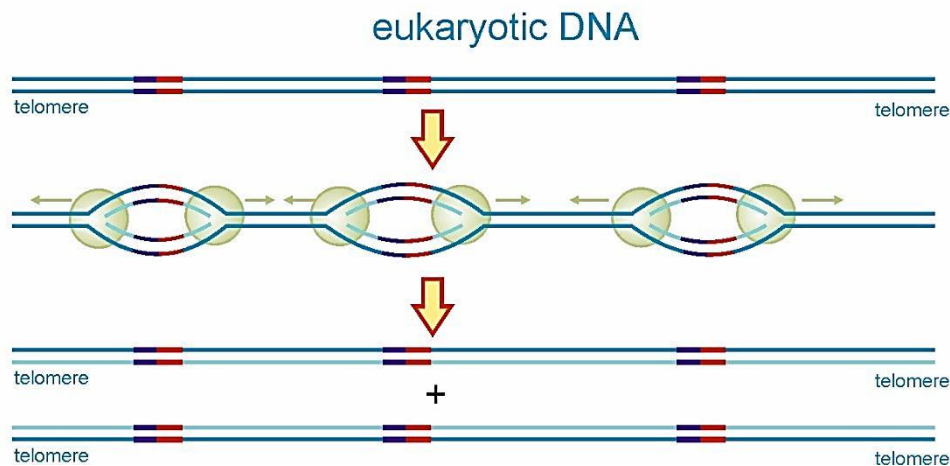


<https://www.youtube.com/watch?v=TNKWgcFPHqw>
<https://www.youtube.com/watch?v=QMX7lpME7X8>
<https://www.youtube.com/watch?v=5Vefal0LrgE>

Differences between prokaryotic and eukaryotic replication



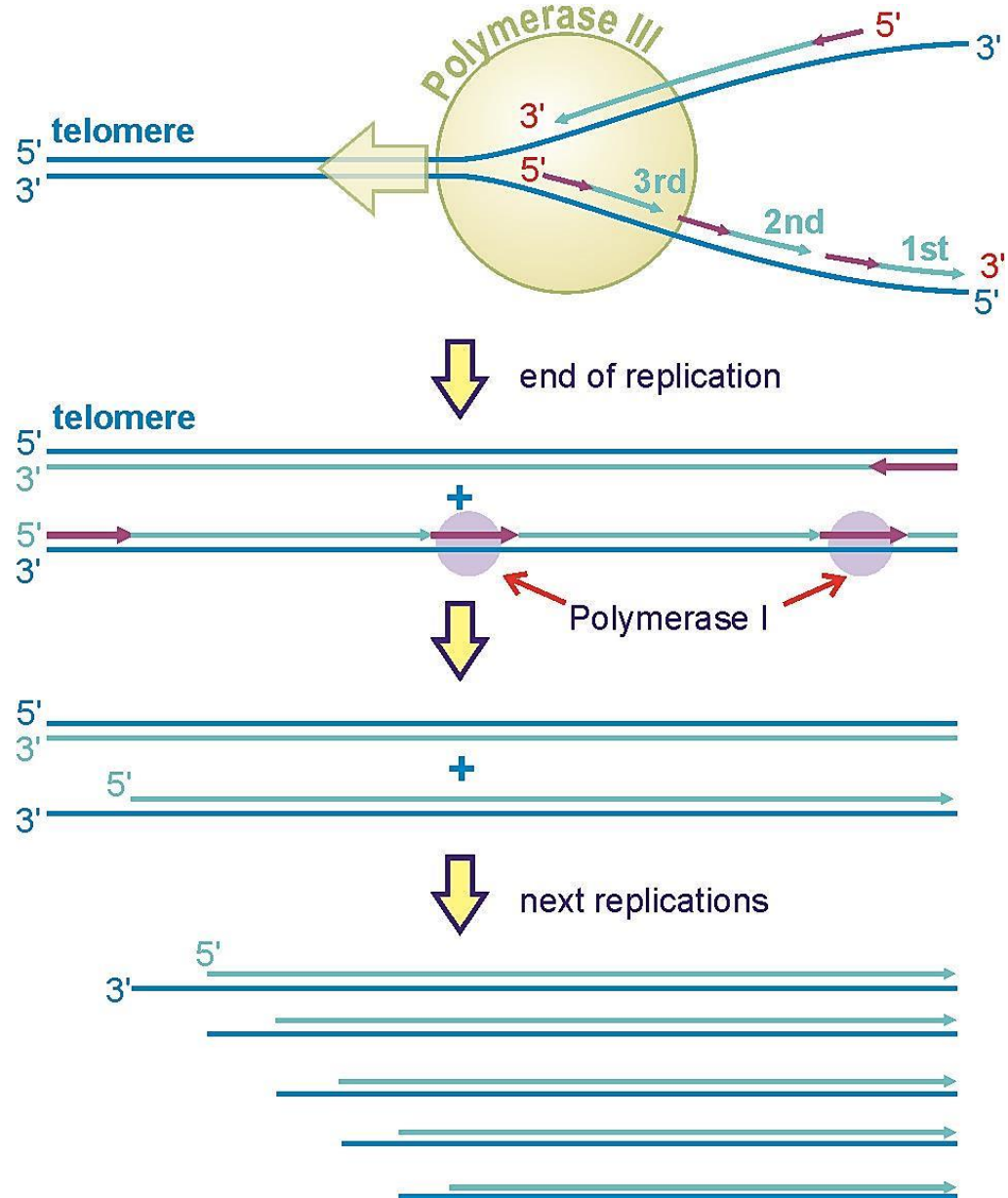
- Size of genome - about 4.6 million bp
- Single origin of replication (replication bubble)
- Circular chromosome (genophore)



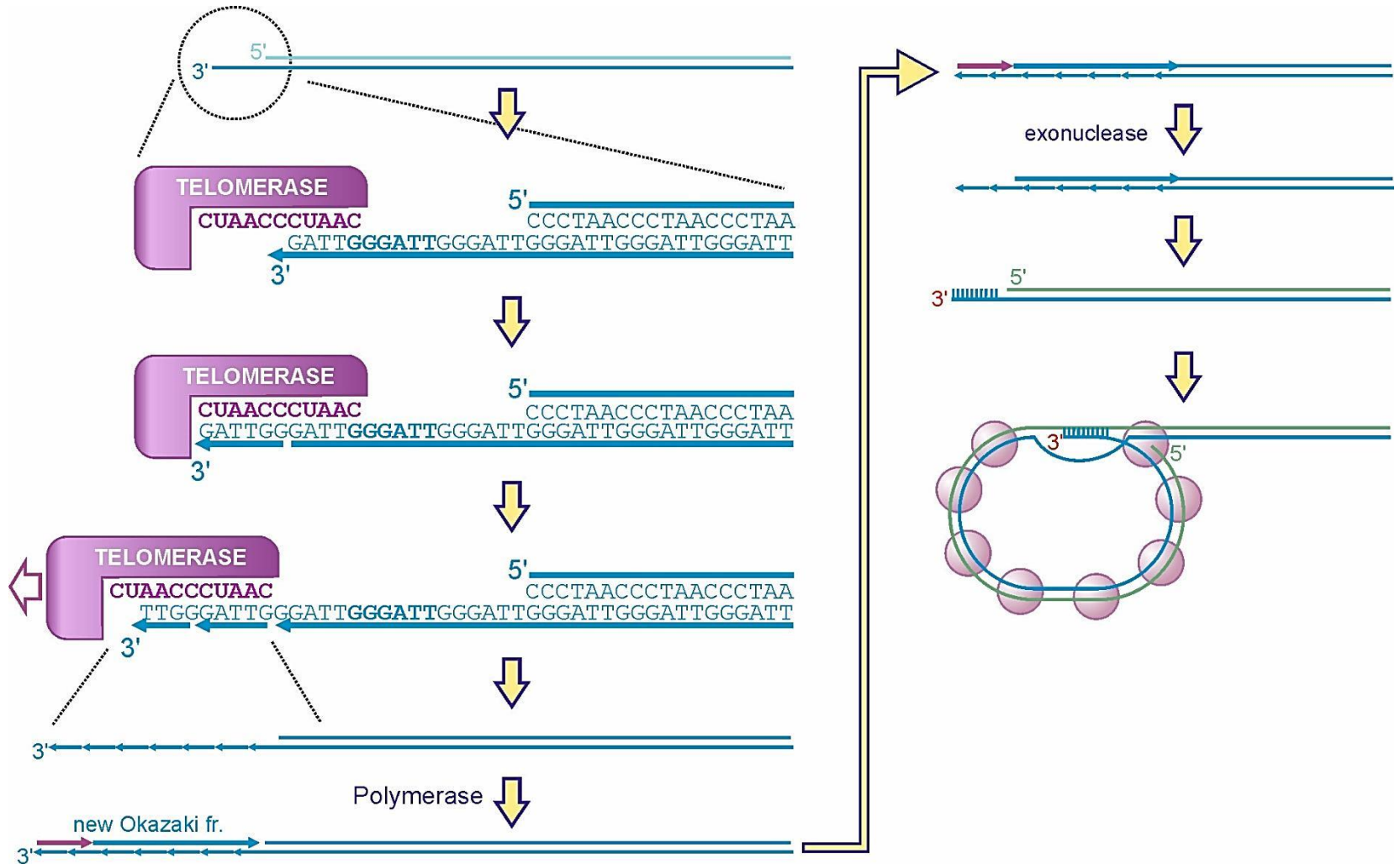
- Size of genome - about 6 billion bp
- multiple origin of replication (several hundred/chromosome)
- Linear chromosome with ends

Semiconservative replication produce two copies that each contained one of the original strands and one new strand

During replication telomeres are shortened



Telomerase reconstructs the telomeres



Telomerase

<https://www.youtube.com/watch?v=i6nE6gUp2cw>

Replication

- <https://www.youtube.com/watch?v=4jtmOZalvS0>
- <https://www.youtube.com/watch?v=FBYeBb4C5Rc>