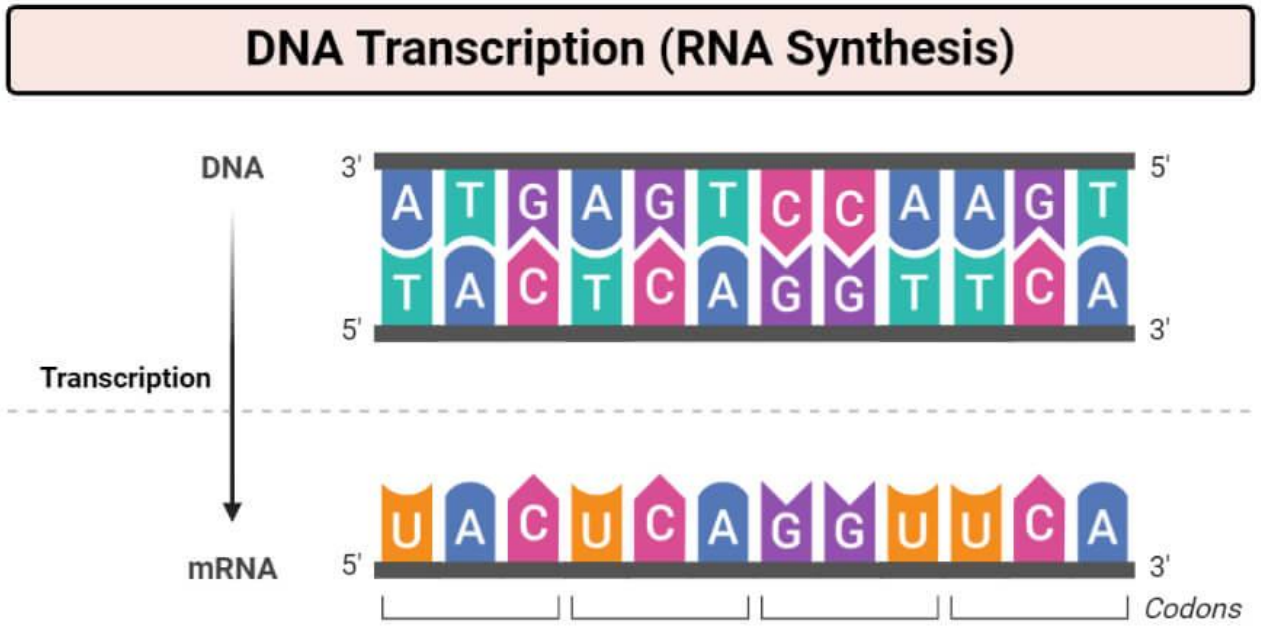
Lesson 11
DNA transcription



DNA transcription

- DNA contains all the instructions for life (i.e., protein production), but it is too large and valuable to leave the nucleus
- Cells need a way to send genetic instructions to the protein-making machinery without risking damage to the original DNA
- RNA is a temporary copy of DNA used for protein production
- Unlike DNA, RNA is single-stranded, contains ribose sugar, and replaces Thymine (T) with Uracil (U)
- 🛠 Engineering Analogy: DNA = The original blueprints stored safely

  RNA = A disposable photocopy of the blueprint used on the factory floor

DNA transcription

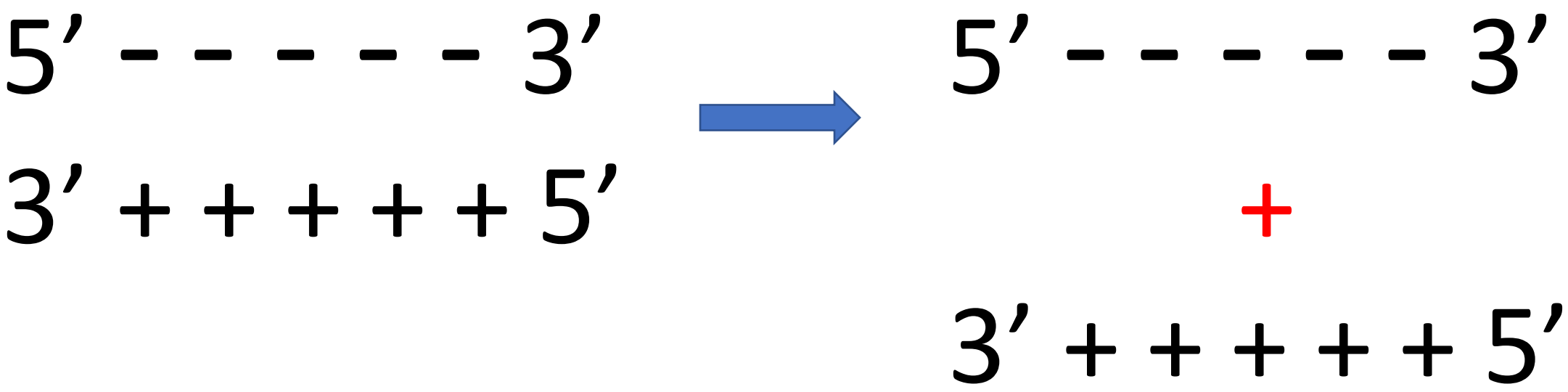
- **DNA (gene) transcription** is a process that produces an **mRNA** from a DNA template
- The process takes place in the cell nucleus
- Two major difference with DNA replication
  - RNA uses U instead of T
  - **Only 1 DNA template strand is used: the BOTTOM strand**

5’ - - - - - 3’→ non-template strand

3’ + + + + + 5’→ **template strand**

DNA transcription

1. DNA strands separate



DNA transcription

2. mRNA is transcribed (copied) from the DNA template strand

5’ – – – – – 3’

+

3’ + + + + + 5’

mRNA TRANSCRIBED STRAND

5’ x x x x x 3’

3’ + + + + + 5’

DNA TEMPLATE STRAND

DNA transcription

3. mRNA transcribed strand leaves the DNA template strand
4. DNA template and non-template strands base-pair again

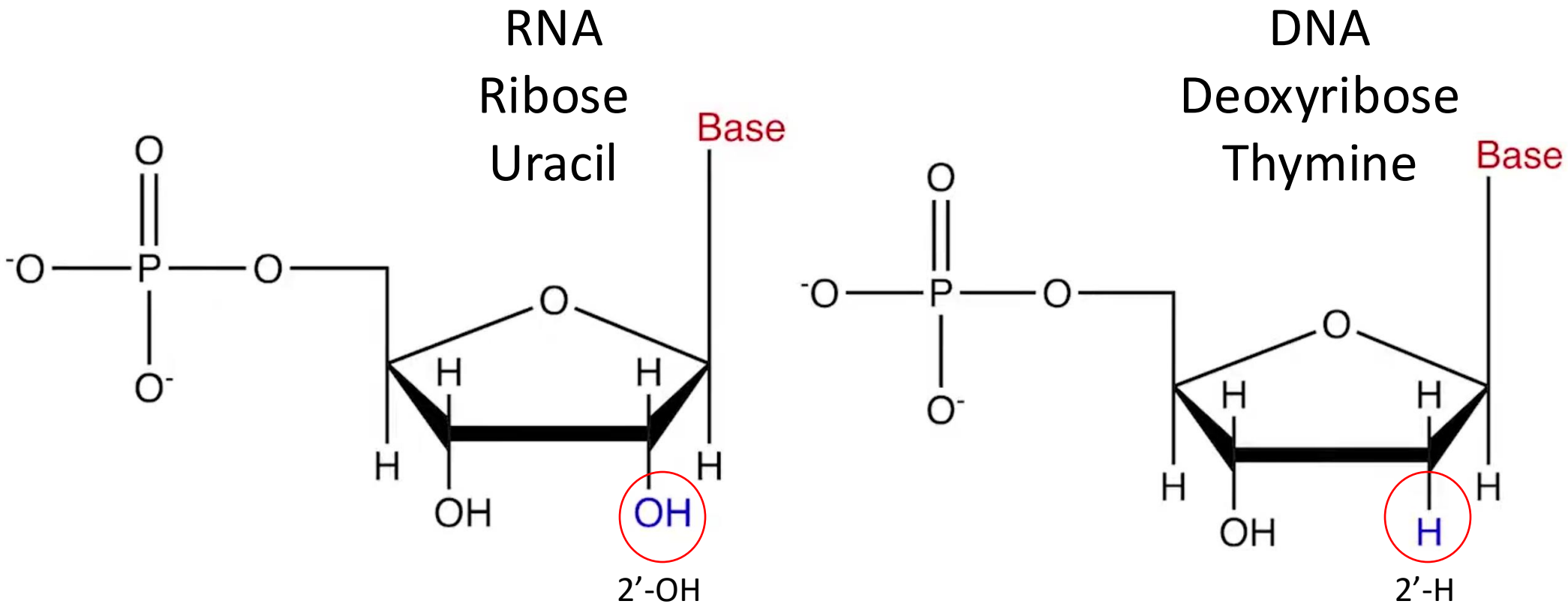
5’ x x x x x 3’ 5’ – – – – – 3’

+

3’ + + + + + 5’

DNA transcription

- The transcribed 5'xxxxx3' mRNA strand = same as DNA non-template strand (with U in place of T)



DNA transcription

- The transcribed 5’xxxxx3’ mRNA strand = same as DNA non-template strand (with U in place of T)
- The 2’-OH on ribose is a reactive group
  - Makes RNA substantially more reactive (hydrolysis) = less stable than DNA
- This is why DNA (a double stranded nucleic acid) is a better genetic storage material than RNA (usually a single stranded nucleic acid)

Locating the file to be transcribed

- Only 2% of DNA contains the codes for proteins
  - We are still figuring our what are the functions of the other 98%
    - Much of it seems to be involved in regulating how the informaion in DNA is used
- Cells do not transcribe the entire DNA - only the genes they need
- When a cell needs to build a protein, it must recognize the gene for that protein among all other genes
- Cells recognize a specific gene by its **PROMOTER**
  - A unique sequence on DNA that is located at the beginning of the gene to be expressed

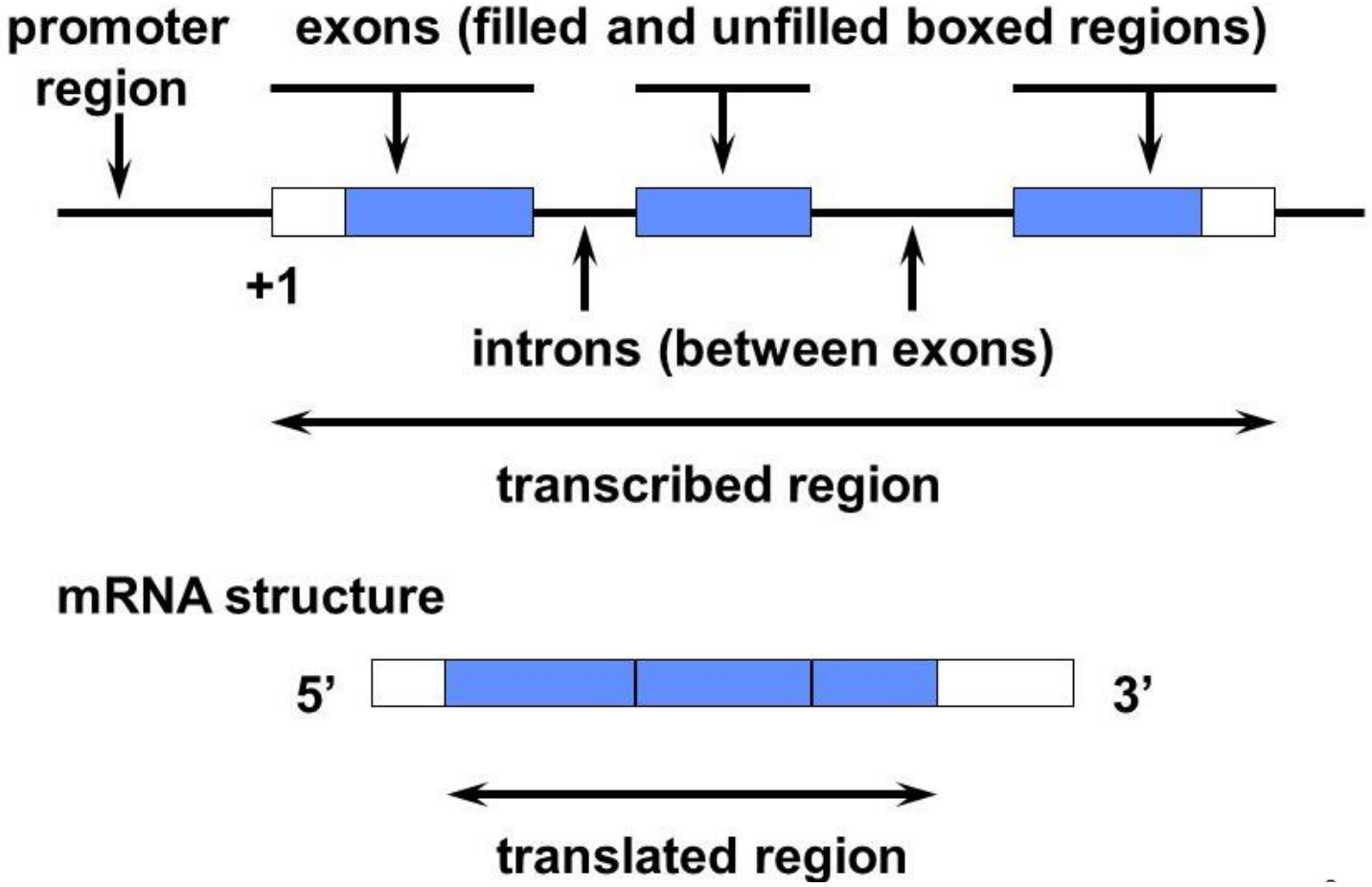
Promoters

- In eukaryotes, promoters have variable sequences
- Yet, 20% eukaryotic promoters contain a common sequence:

  TATAAA

- This is called a

  TATA box

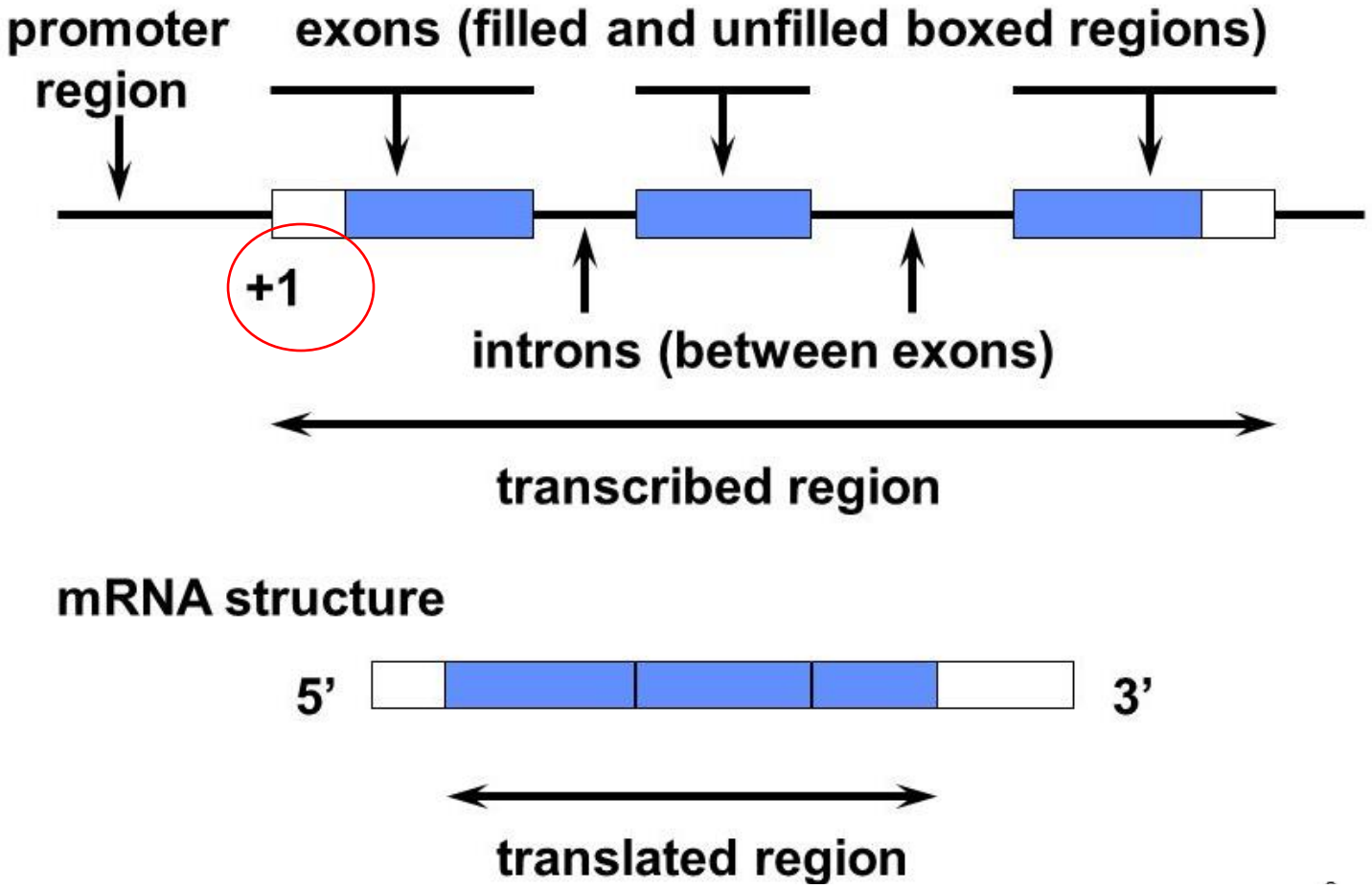


Promoters

- In eukaryotes, promoters have variable sequences
- Yet, 20% eukaryotic promoters contain a common sequence:

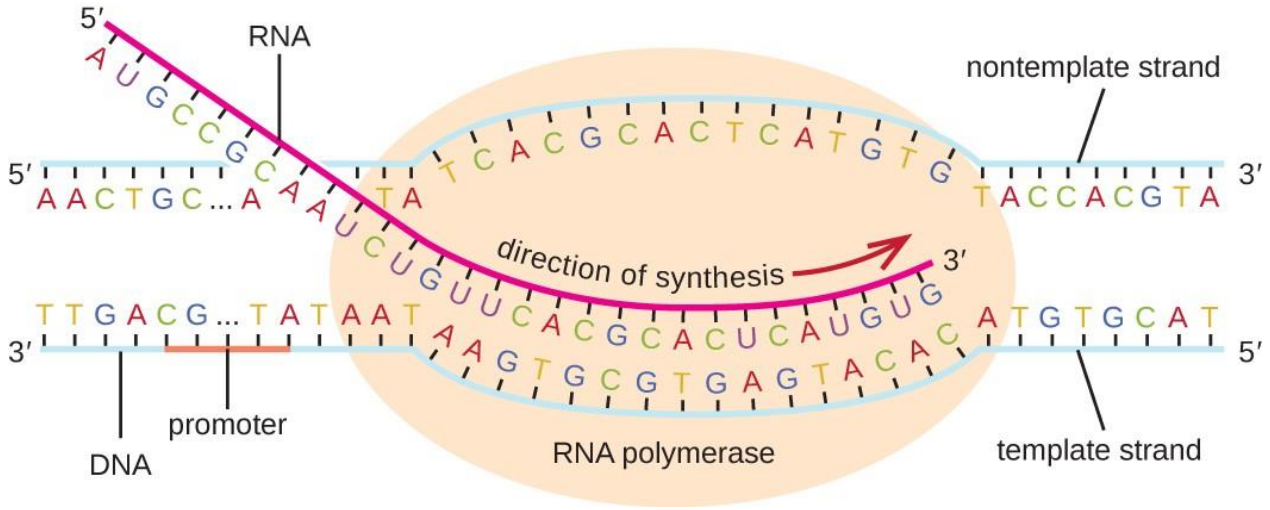
  TATAAA
- This is called a **TATA box**

- The TATA box is located near the site where transcription begins
  - called +1 site



RNA polymerase – the transcription master

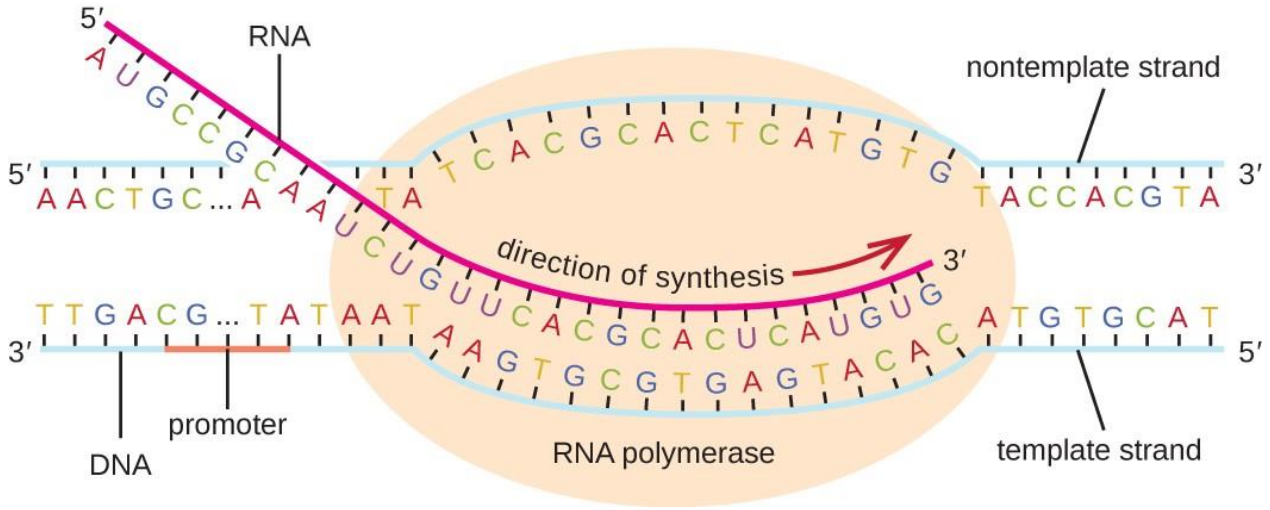
- **RNA Polymerase** is the enzyme that reads DNA and makes an RNA copy
- It moves along the DNA strand, adding complementary RNA bases (A, U, G, C)



RNA polymerase – the transcription master

- **RNA Polymerase** is the enzyme that reads DNA and makes an RNA copy
- It moves along the DNA strand, adding complementary RNA bases (A, U, G, C)

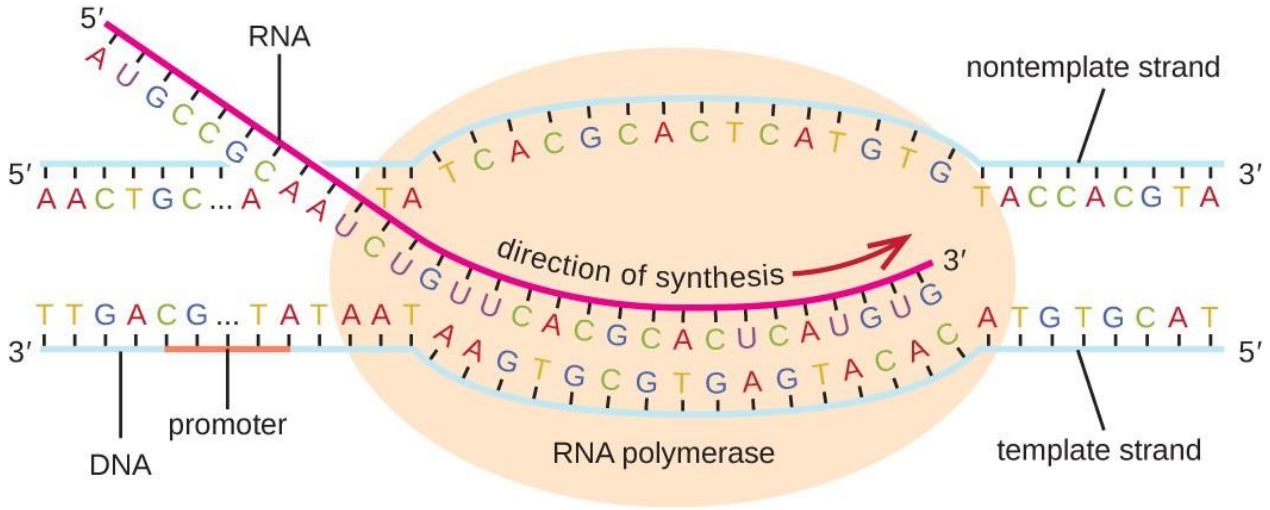
- The RNA POL
  - Binds at the promoter
  - Unwinds the DNA DH
  - Uses the template strand (3'-5') to build the RNA molecules based on the complementarity principle



RNA polymerase – the transcription master

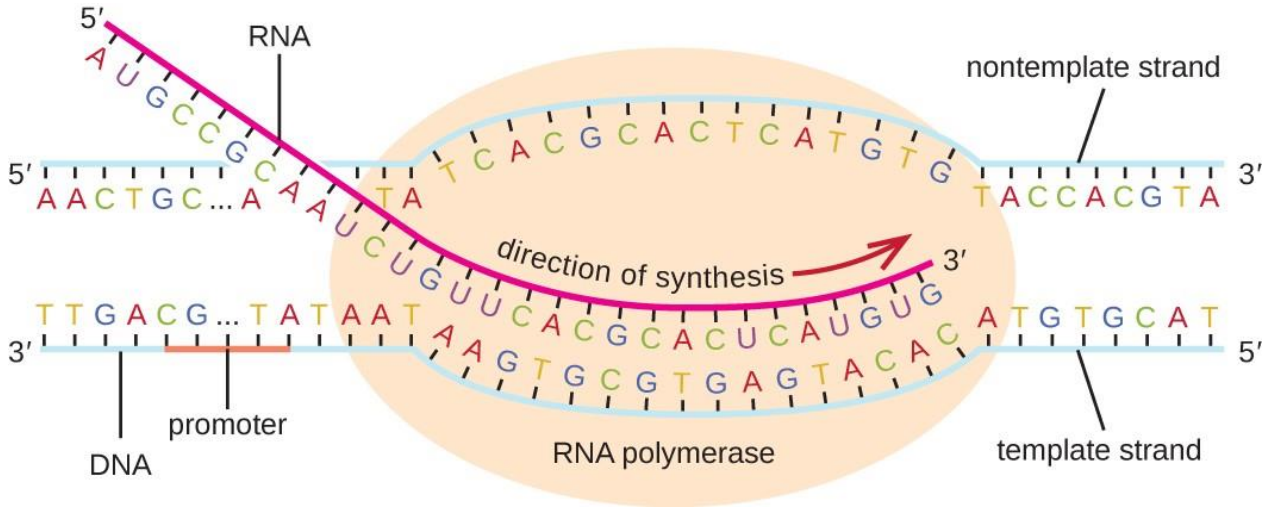
- The enzymes that reads and copies the info onto RNA is called **RNA polymerase**
- The RNA POL
  - Binds at the promoter
  - Unwinds the DNA DH
  - Uses the template strand (3'-5') to build the RNA molecules based on the complementarity principle

- The DNA strand that is not read is called non-template strand
  - it is often called coding strand
- This might seem confusing
  - **The reason is that, ultimately, the sequence of the non-template strand is the same of the newly synthesized RNA (only with U in place of T)**



RNA polymerase – the transcription master

- RNA POL reads the template strand of DNA in the 3’ to 5’ direction in order to build the new RNA molecule in the 5’ to 3’ direction
- *i.e.*, the 5’ end of the incoming nucleotide is added to the 3’ end of the growing RNA chain



The RNA POL helpers – transcription factors

- RNA POL needs helpers to recognize promoters
  - Regulatory proteins that control the transcription process
- In eukaryotes, these proteins are called **transcription factors**
  - They help RNA POL in locating and binding to promoters

Transcription terminators

- Cells must **stop transcription at the right time** to prevent making unnecessary RNA
- **A termination sequence** tells RNA Polymerase to stop and release the RNA strand

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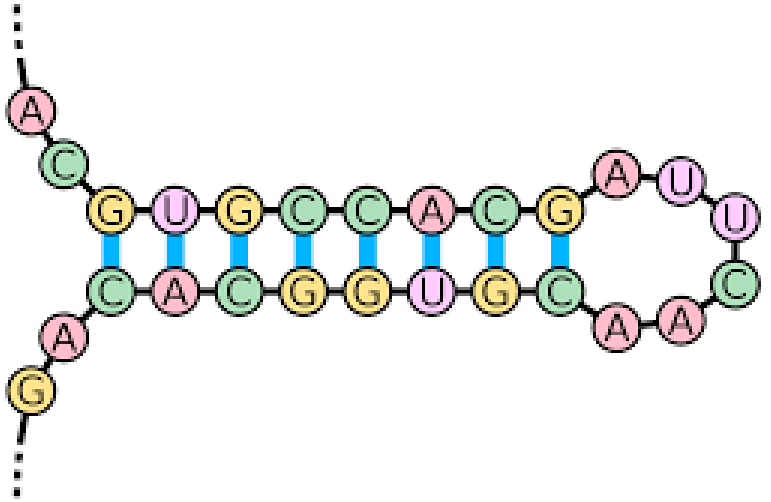
- Just like promoter sequences mark the beginning of genes, transcription **terminators** mark the end of genes
- Once the RNA POL reads in a terminator sequence, it
    - unbinds from the DNA template strand and
    - releases the newly synthesized RNA

Transcription terminators

- A transcription terminator often contains a code that induces the corresponding synthesized RNA to fold back onto itself to form a hairpin loop (or stem-loop)
  - This structure knocks off the RNA POL from DNA, ending transcription

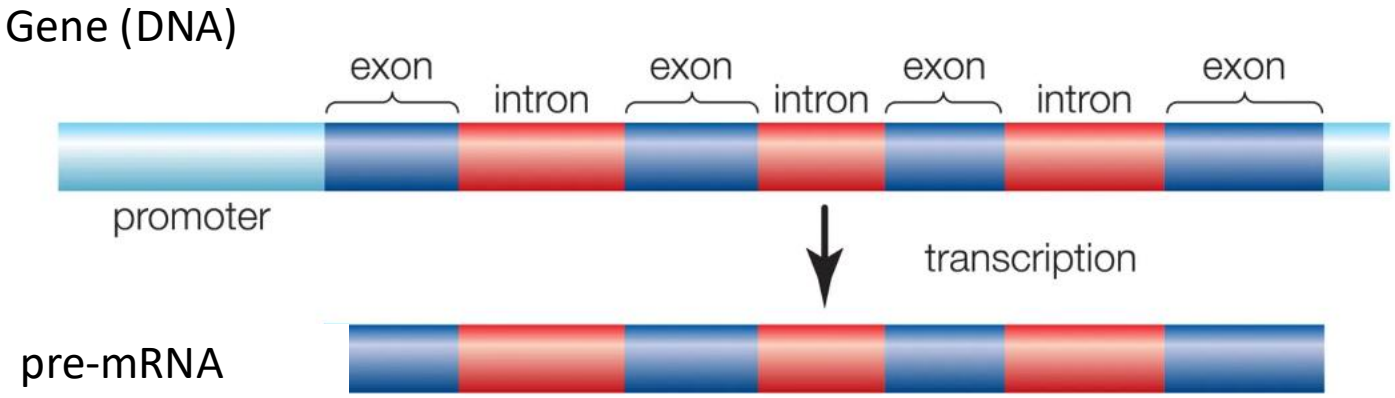


RNA processing in eukaryotes – a finishing touch

- RNA Is Born Messy: *The Rough Draft* Analogy
- When RNA is first copied from DNA, it contains extra, unnecessary sequences and needs further processing
  - Just like a rough draft of a report, it needs editing before it can be useful
- This version is called **pre-mRNA** or **primary RNA transcript**
- Cells must "clean up" this pre-mRNA and write the final mRNA before sending it to the ribosome

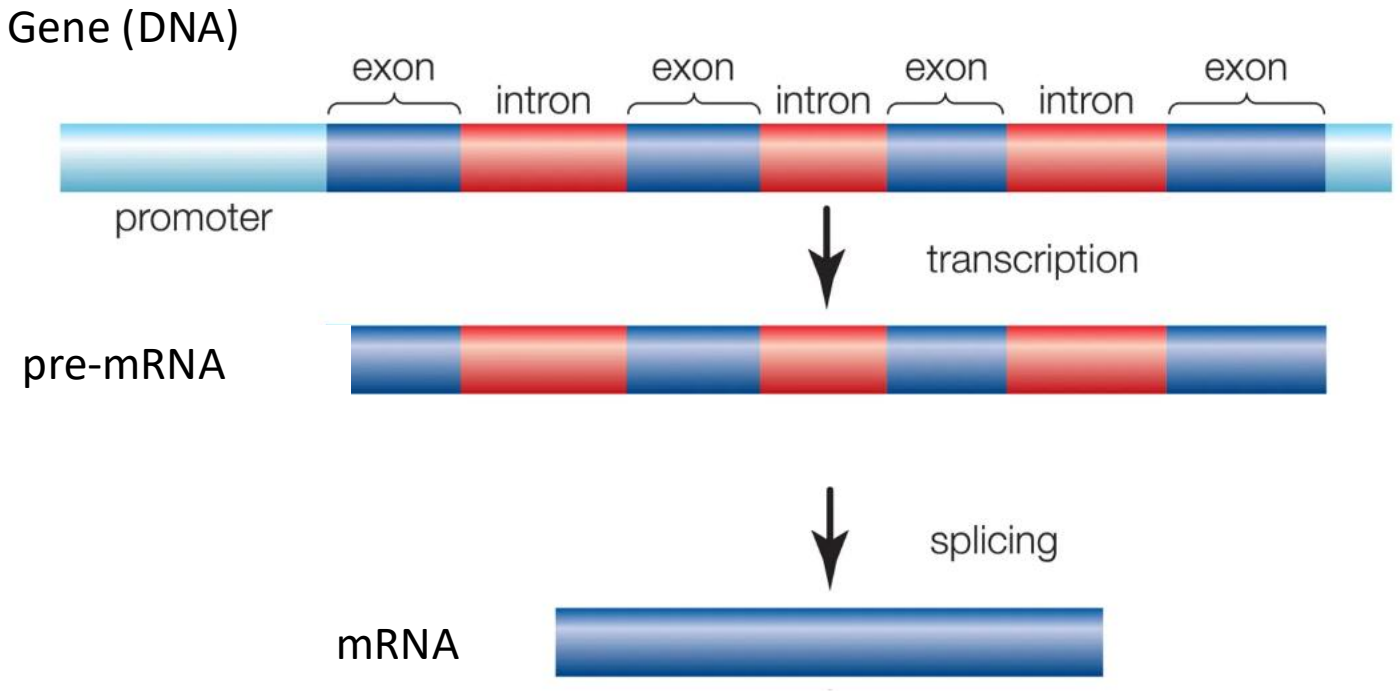
RNA processing in eukaryotes – a finishing touch

- Pre-mRNA in fact contains **two types of sequences**:
  ✅ **Exons** (important information, like final text in a report)
  ❌ **Introns** (extra, non-essential information, like comments or outdated notes)



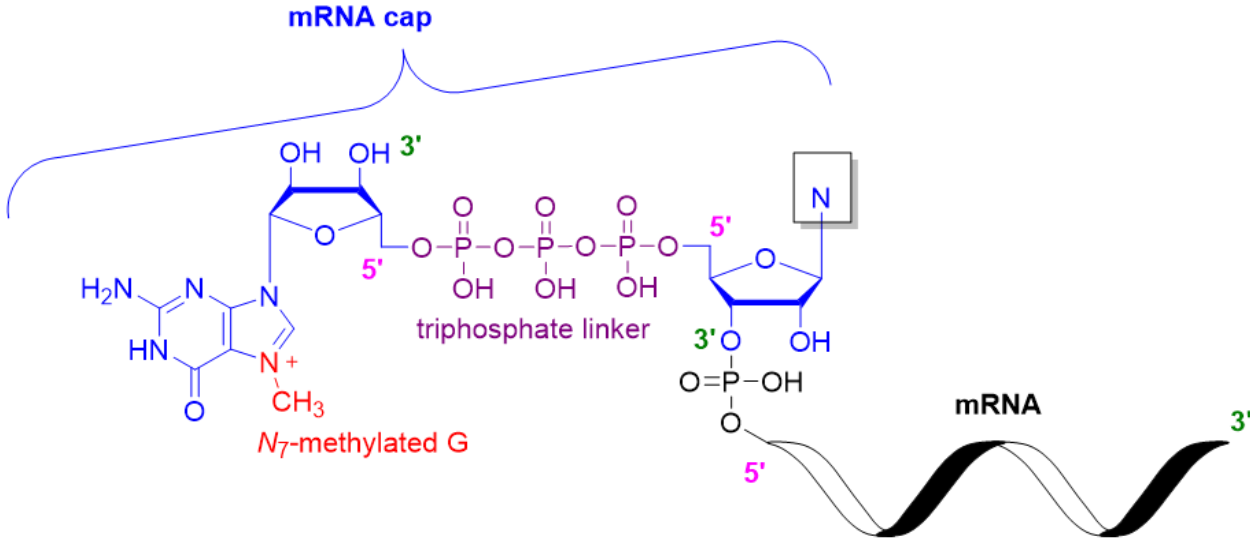
RNA processing in eukaryotes – a finishing touch

- Cells must first cut out introns and stitch exons together to make a clean message through a process termed **splicing**



RNA processing in eukaryotes – a finishing touch

- Next they must add a **cap** to the beginning of the RNA strand to **protect it from damage (RNA capping)**
- This helps the RNA survive long enough to reach the ribosome
- 🛠 Analogy: Capping = Adding a cover to a book to protect it from getting torn or damaged

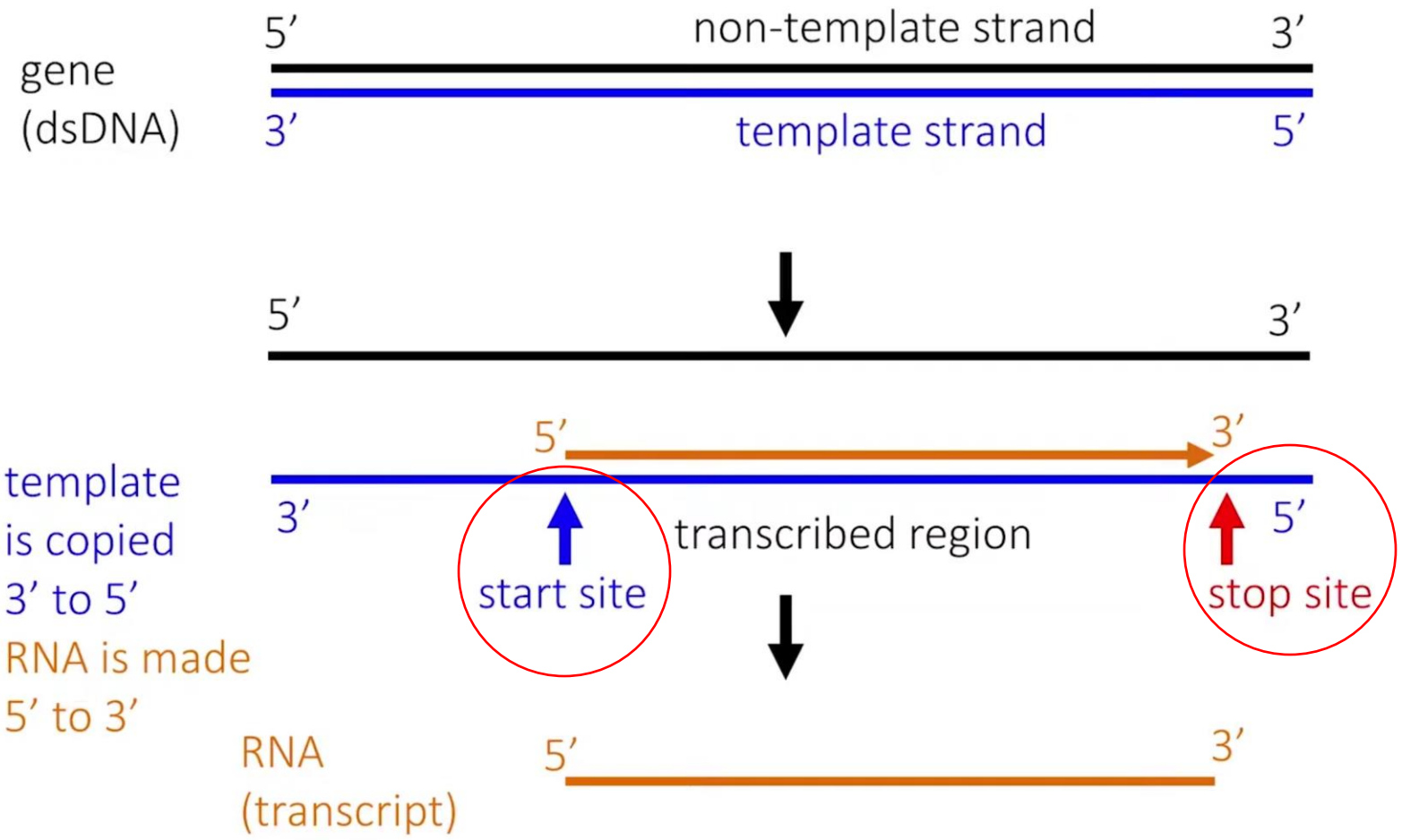


RNA processing in eukaryotes – a finishing touch

- Finally, a **Poly-A Tail** (a long chain of adenines) is added at the **end** of the RNA strand
- The longer the tail, the longer the RNA lasts before being broken down
- 🛠 Analogy: Poly-A Tail = An expiration date on food packaging
  - RNA with a long Poly-A Tail lasts longer in the cell, just like food with a later expiration date stays fresh longer

DNA transcription

Transcription from specific strand/position



DNA transcription – ONLY THE BOTTOM STRAND

- Complementary DNA strands are transcribed into different mRNAs