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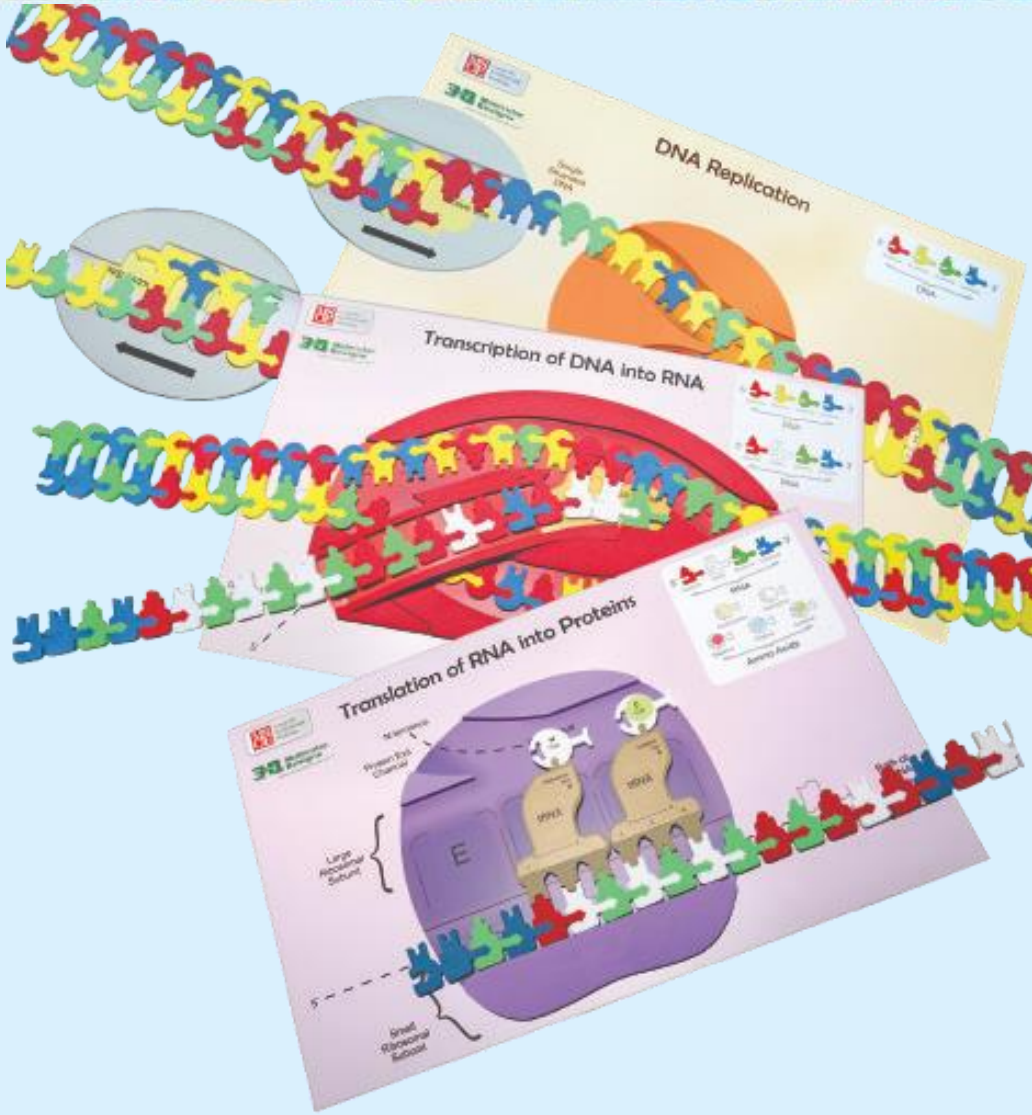
Transforming Science Learning



Modeling mRNA – Life After Transcription

Alice Scheele
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Biology Teacher
Patrick Henry High School
Ashland, VA

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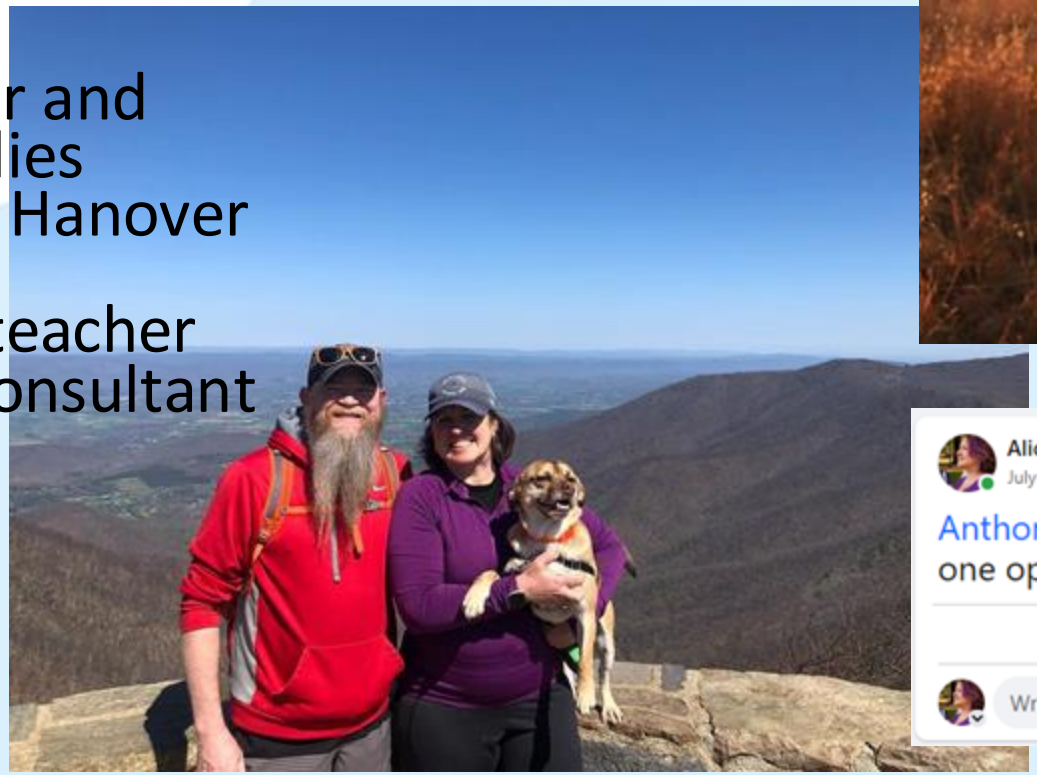
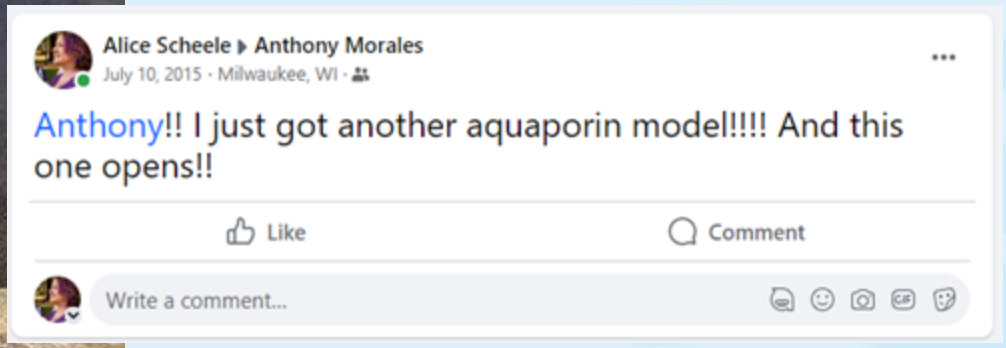
Who am I?

- Biology teacher and Advanced Studies Coordinator in Hanover County, VA
- 3DMD Model teacher
- AP Reader & consultant





Learning Intentions/ Session Goals

- I am learning about the mechanisms by which genetic information flows from DNA to RNA to protein.
- I am learning about the series of enzyme-regulated modifications of the mRNA transcript in eukaryotic cells

Success Criteria

- ❑I can model the addition of a poly-A tail and describe its purpose.
- ❑I can model the addition of a GTP cap and describe its purpose.
- ❑I can model the excision of introns and splicing and retention of exons.

Do you teach with models?

2018 VA Biology SOLs:

SOL strand	Essential knowledge & practices	Enduring Understanding
BIO.2 The student will investigate and understand that chemical and biochemical processes are essential for life. Key ideas include d) protein synthesis is the process of forming proteins which influences inheritance and evolution;	explain the process of protein synthesis, including transcription and translation (BIO.2 d)	explain the process of protein synthesis, including transcription and translation (BIO.2 d)
BIO.5 The student will investigate and understand that there are common mechanisms for inheritance. Key ideas include a) DNA has structure and is the foundation for protein synthesis	compare a variety of DNA models and evaluate them for their effectiveness in explaining its structure and function (BIO.5 a)	The information encoded in DNA molecules provides instructions for assembling amino acids, which ultimately form protein molecules. The code for specific amino acids is virtually the same for all life forms (BIO.5 a). All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins (BIO.5 a).
BIO.5 The student will investigate and understand that there are common mechanisms for inheritance. Key ideas include c) the variety of traits in an organism are the result of the expression of various combinations of alleles;		Each chromosome consists of a single, very long DNA molecule, and each gene on the chromosome is a particular segment of that DNA. The instructions for forming species' characteristics are carried in DNA. All cells in an organism have the same genetic content, but the genes used (expressed) by the cell may be regulated in different ways. Not all DNA codes for a protein; some segments of DNA are involved in regulatory or structural functions, and some have no as-yet-known function (BIO.5 c).

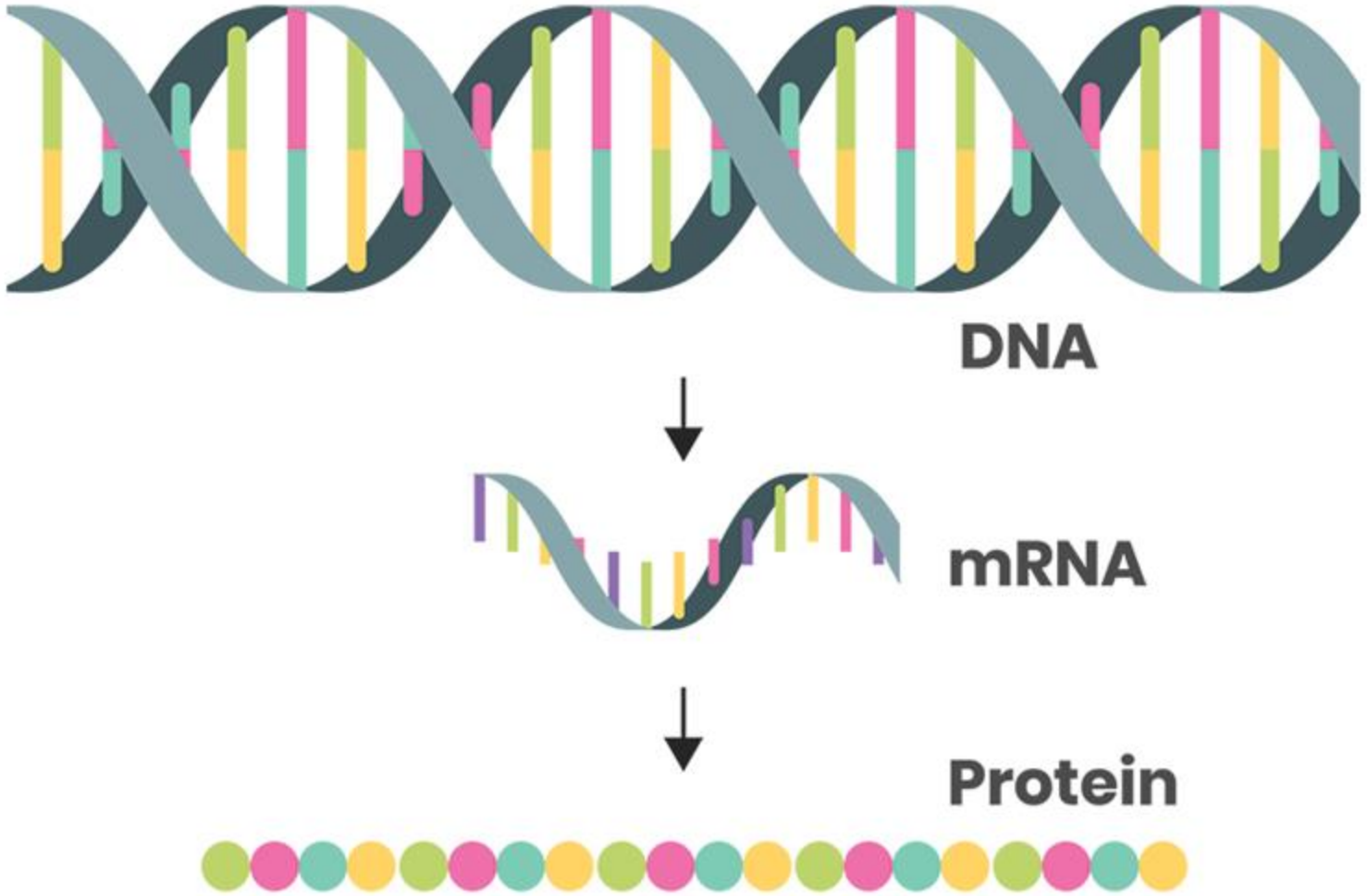
AP Course & Exam Description

Topic	ENDURING UNDERSTANDING	LEARNING OBJECTIVE	Essential Knowledge
6.3 Transcription and RNA Processing	**IST-1** Heritable information provides for continuity of life.	**IST-1.N** Describe the mechanisms by which genetic information flows from DNA to RNA to protein.	**IST-1.N.6** In eukaryotic cells the mRNA transcript undergoes a series of enzyme-regulated modifications— a. Addition of a poly-A tail. b. Addition of a GTP cap. c. Excision of introns and splicing and retention of exons. d. Excision of introns and splicing and retention of exons can generate different versions of the resulting mRNA molecule; this is known as alternative splicing.

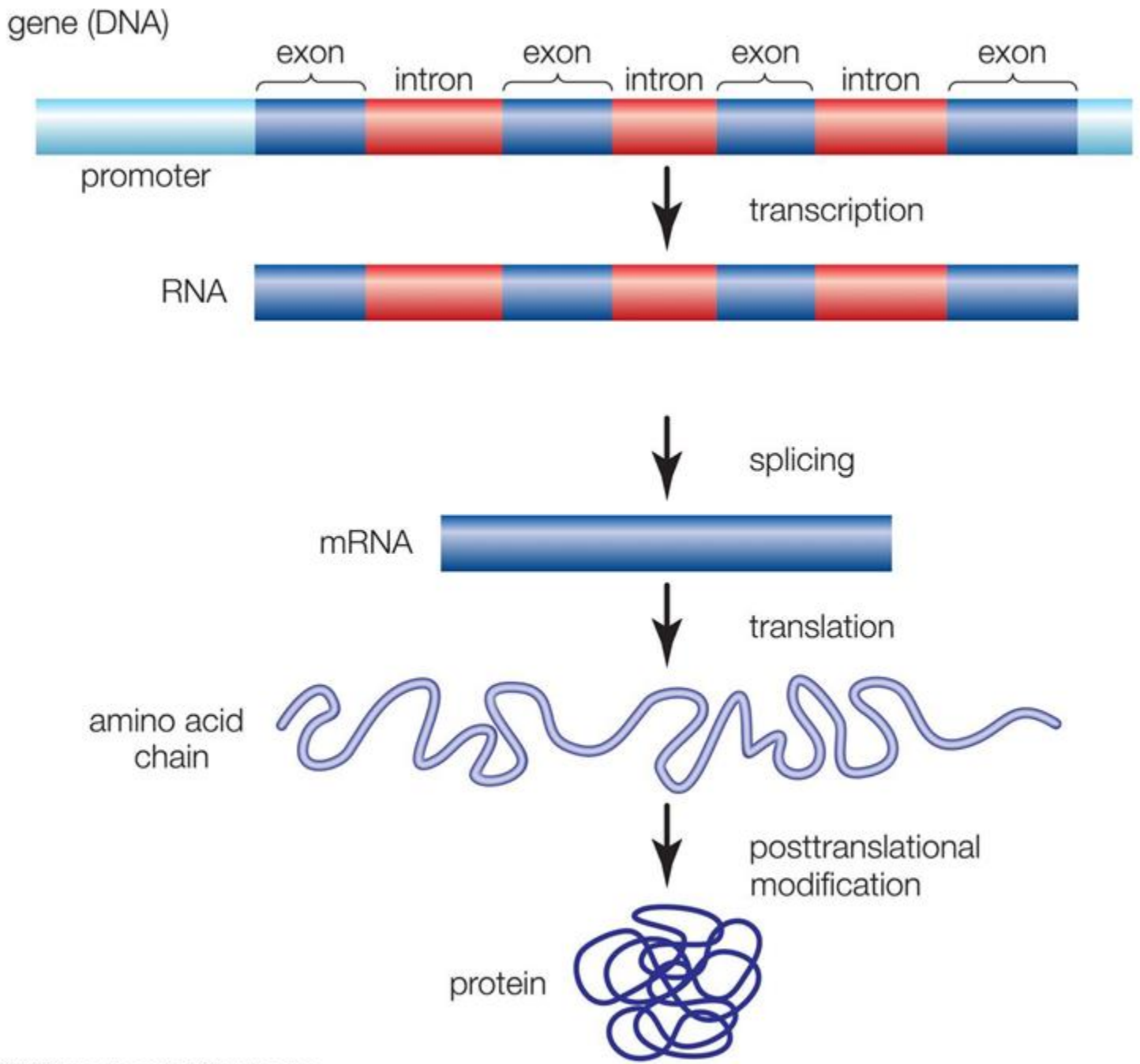
2025 IB Biology – Higher Level topic

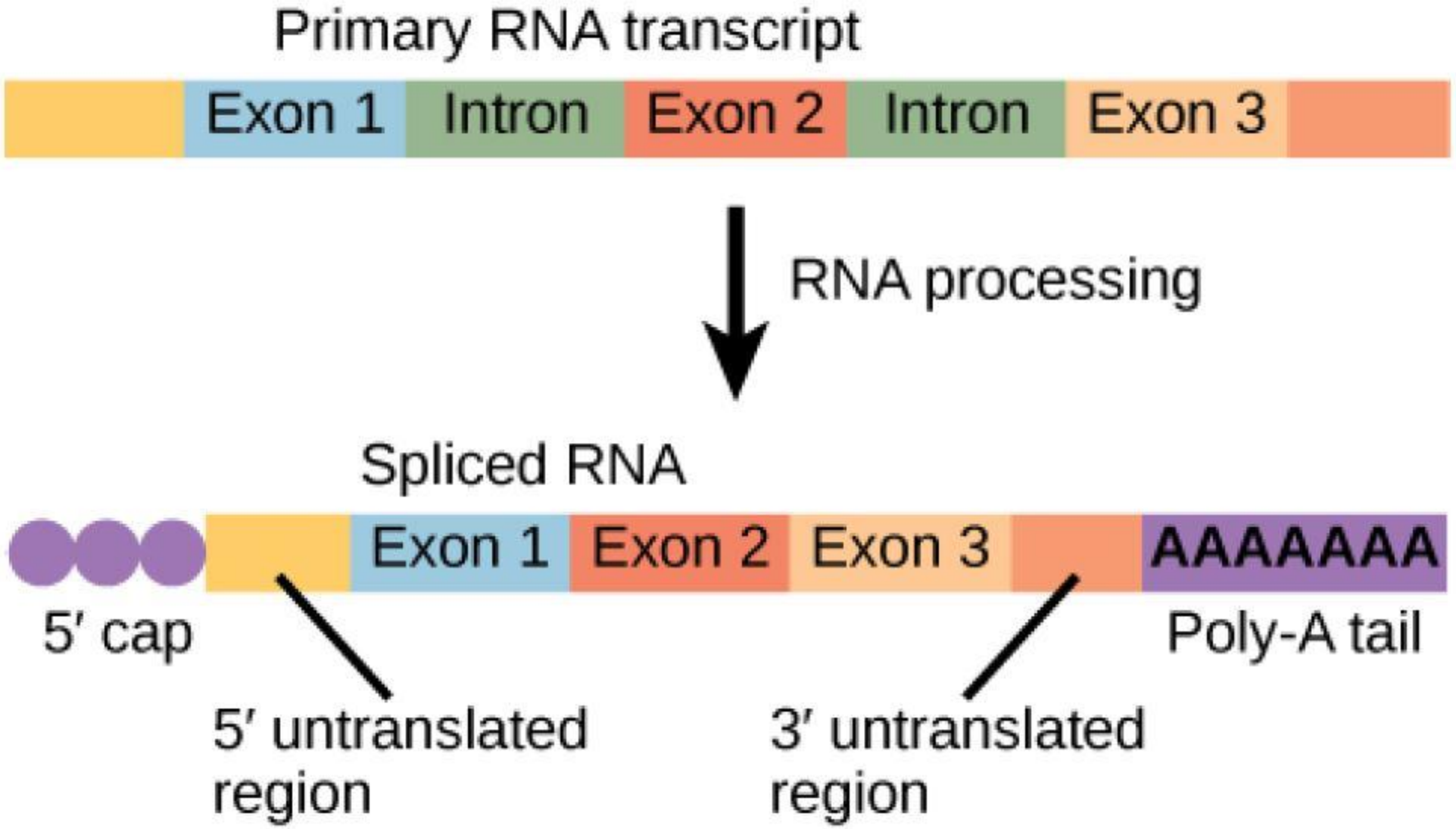
Theme	Molecules	Understanding, application, skill
D Continuity and change Living things have mechanisms for maintaining equilibrium and for bringing about transformation. Environmental change is a driver of evolution by natural selection.	D1.2 Protein synthesis	**D1.2.15- Post-transcriptional modification in eukaryotic cells.** Outline the location and timing of post-transcriptional modification of RNA. Describe the function of the 5’ cap and poly-A tail. Compare intron and exon sequences of genes. Outline the process of RNA splicing.

Basics



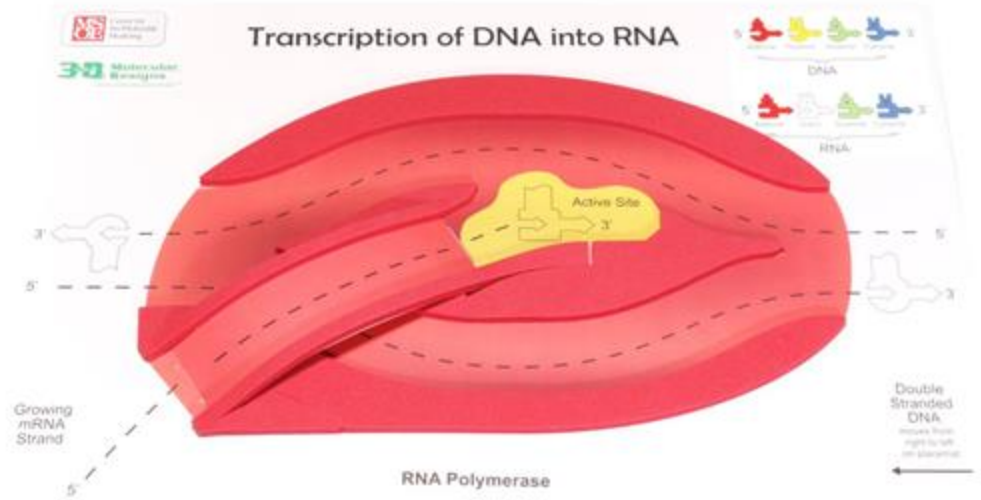

Transcription of DNA into RNA




Primary RNA transcript
Exon 1
Intron
Exon 2
Intron
Exon 3
RNA processing
Spliced RNA
Exon 1
Exon 2
Exon 3
AAAAAAA
5′ cap
Poly-A tail
5′ untranslated region
3′ untranslated region

Lets model it!

1. Get your red placemat out.

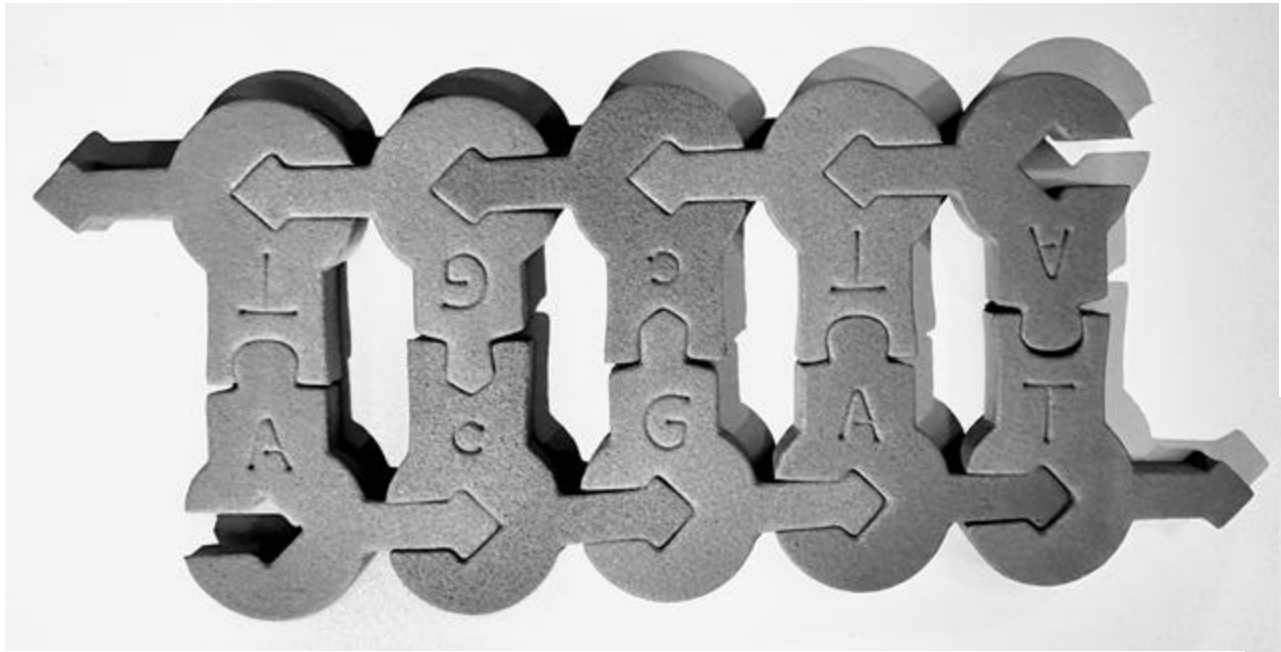


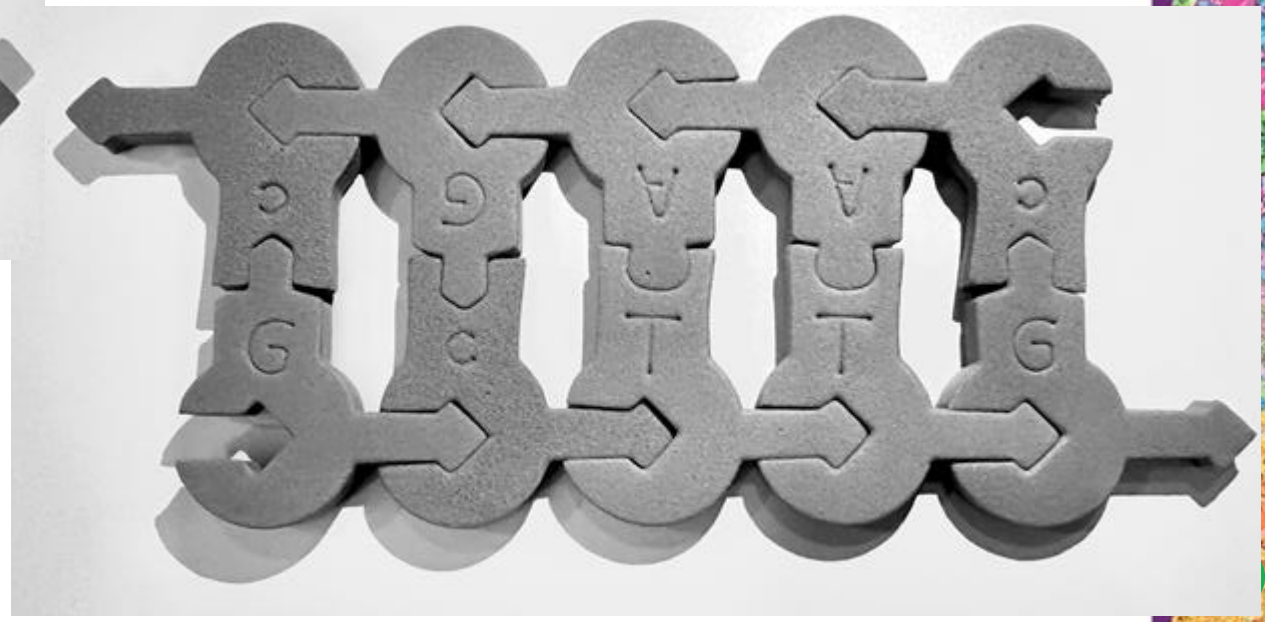
2. You DNA sequence using the colored pieces & the template strip.

3. Get your colored mRNA pieces out

Lets model it!

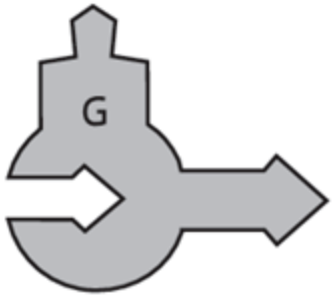
4. Get out your grey pieces.
   build two sections of DNA with grey



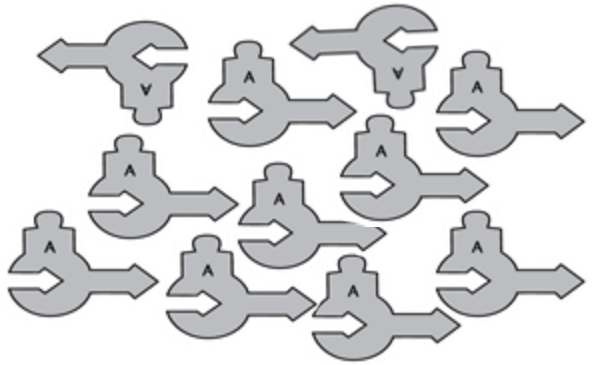


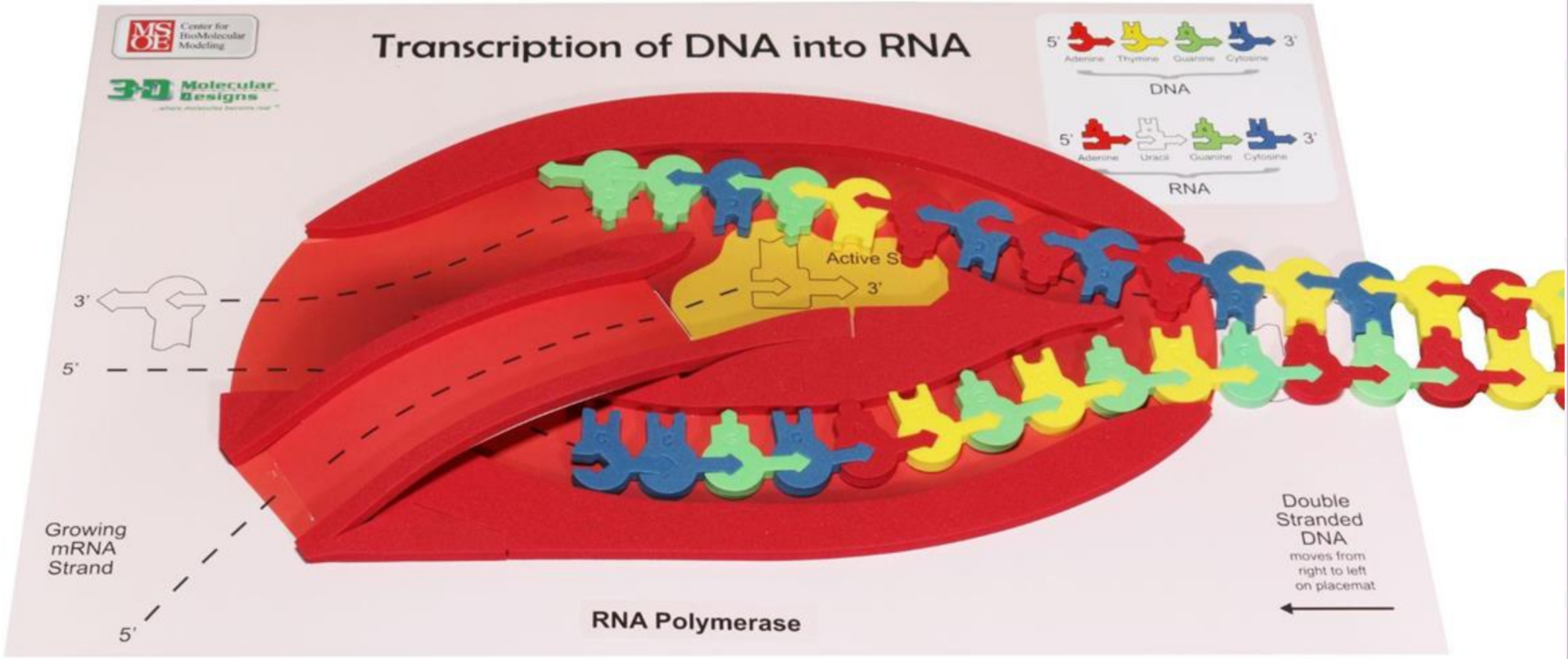
Lets model it!

one single grey G



pile up ~11 grey adenine

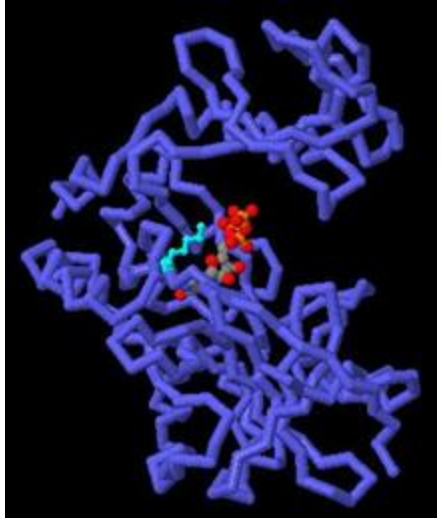


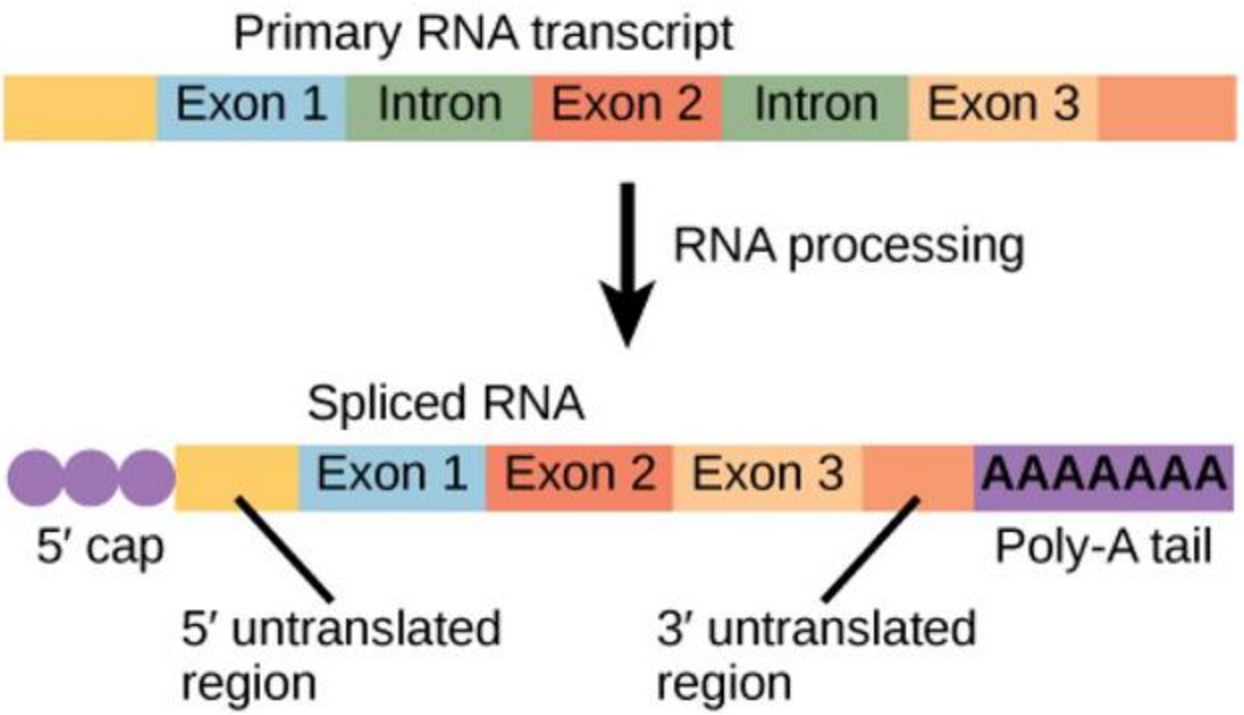


1. load your DNA on the right side of your placemat.
2. feed the DNA into the RNA polymerase and build mRNA as the DNA reaches the yellow active site and start building your mRNA.

3. Pause when the mRNA reaches the end of the bridge

5’ GTP cap





Why?

- required for translation (translation initiation complex assembly)
- protection from exonucleases
- promotes splicing & nuclear export
- helps immune system recognize self & foreign RNA for destruction

When?

- capping enzyme complex (CEC)/ cap binding complex (CBC) binds to the RNA polymerase prior to transcription starting
- as the mRNA emerges from the RNA polymerase the CEC/CBC adds the cap

4. Add the grey Guanine piece to the 5’ end of the growing mRNA strand.

5. Then, continue to transcribe your DNA until the pre-mRNA is complete and released from the RNA polymerase.

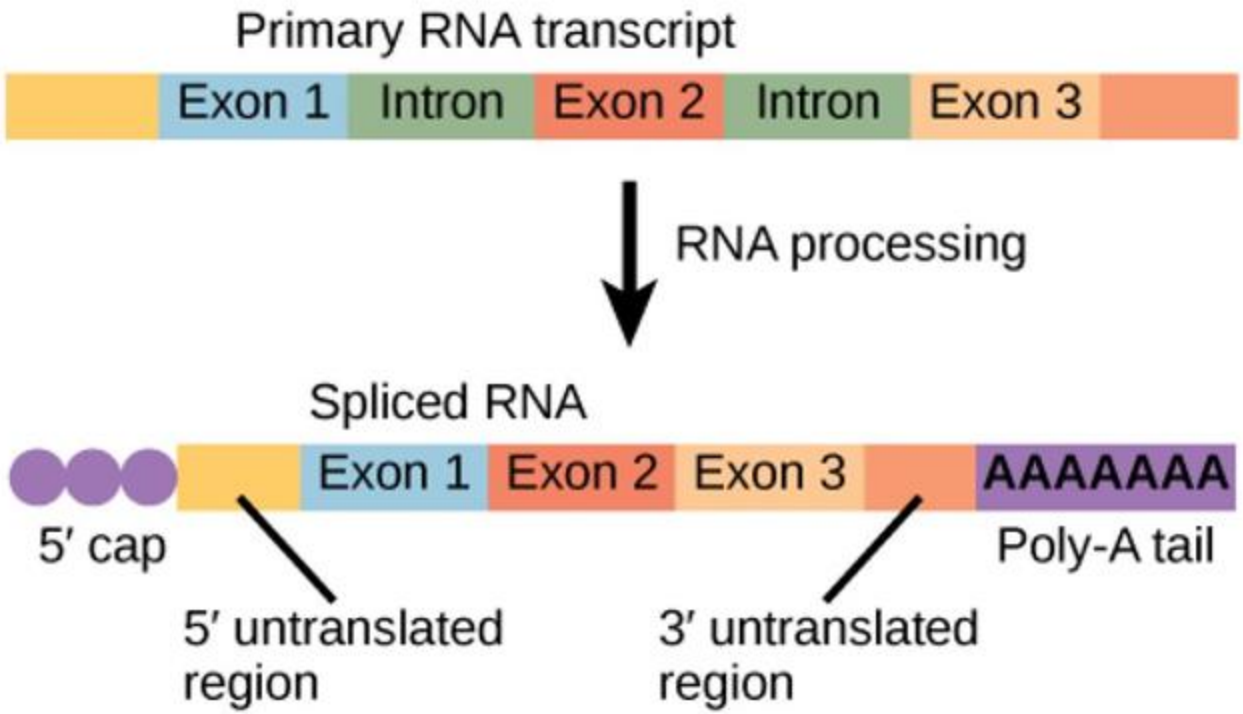
UTR

What?

- untranslated regions at the 5’ and 3’ ends

Why?

- required ribosome binding



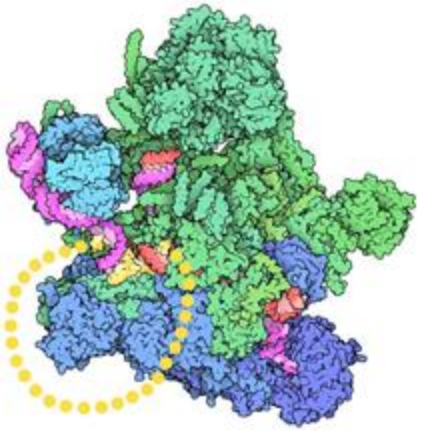
When?

- part of the original transcribed pre-m RNA

RNA Splicing

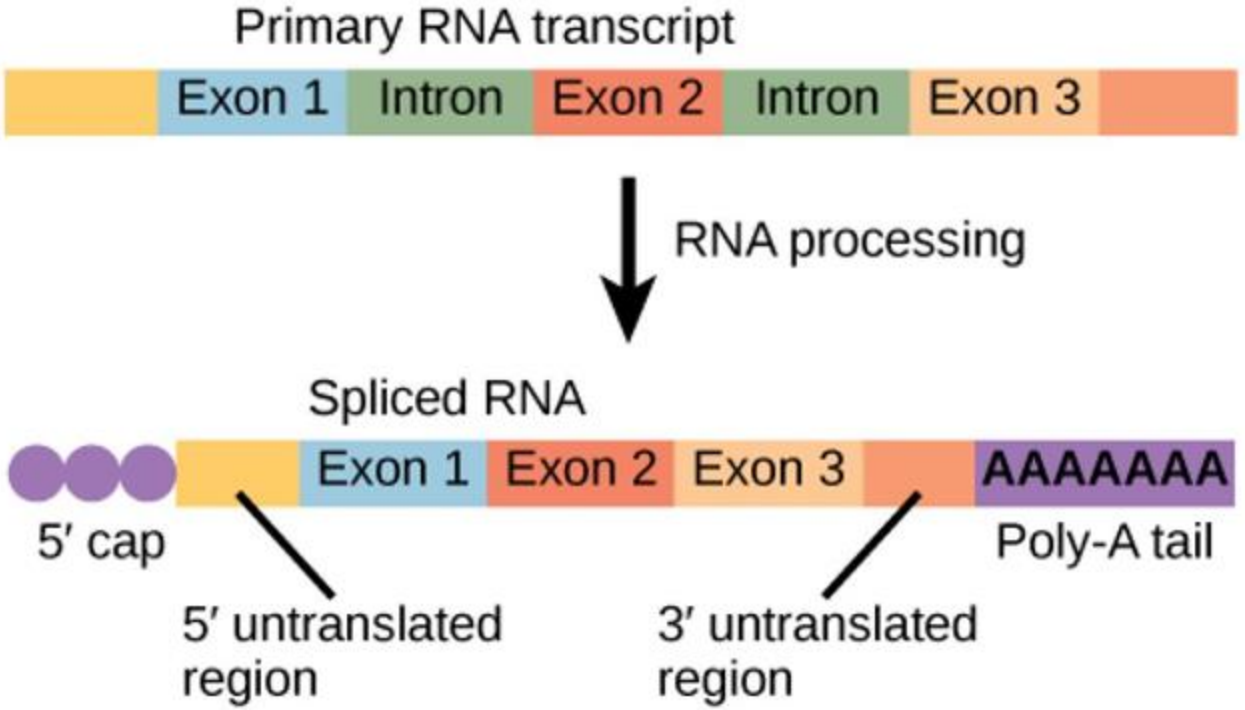
What?

- large sections of the RNA are removed and remaining portions are reconnected
  - introns
  - exons



Why?

- allows for a single gene to encode more than one polypeptide



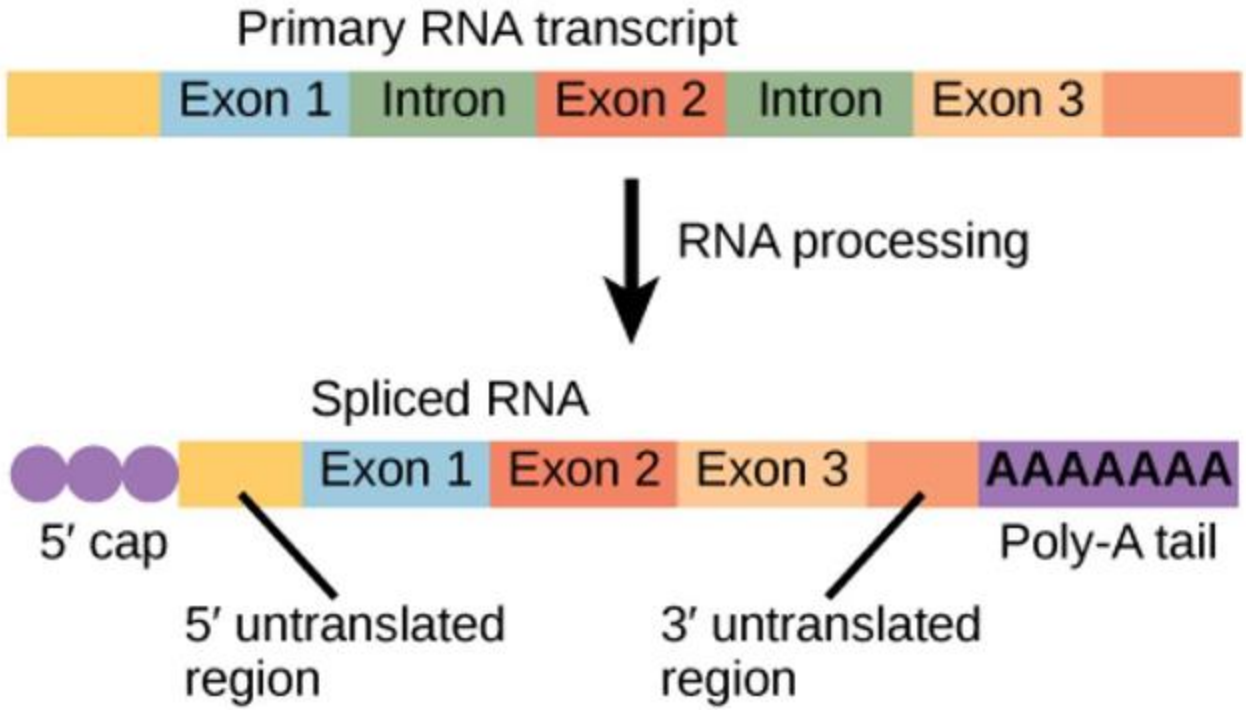
How?

- spliceosomes bind to pre-m RNA
- recognition of specific sites along the intron
- cut and release the intron
- splice together exons

Poly-A tail

Why?

- required for translation - the tail binds proteins to initiate translation
- protection from enzymatic degradation in the cytoplasm
- nuclear export

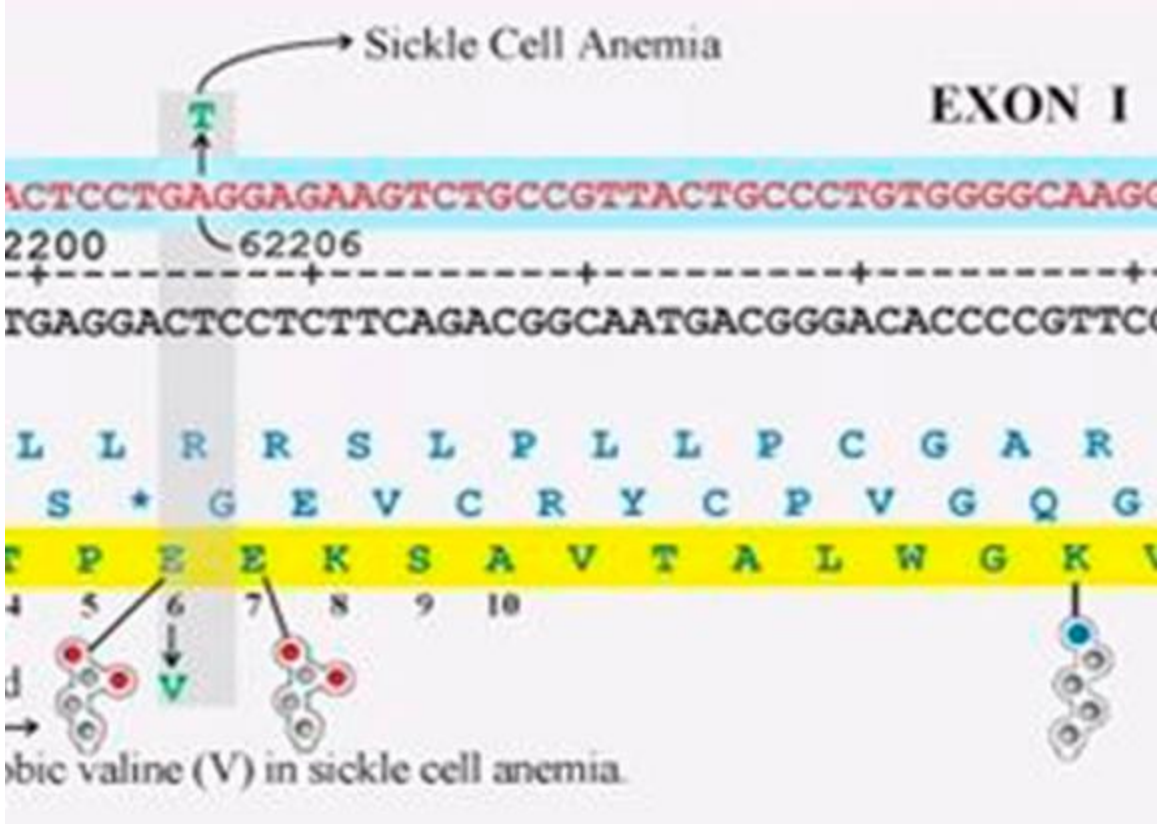


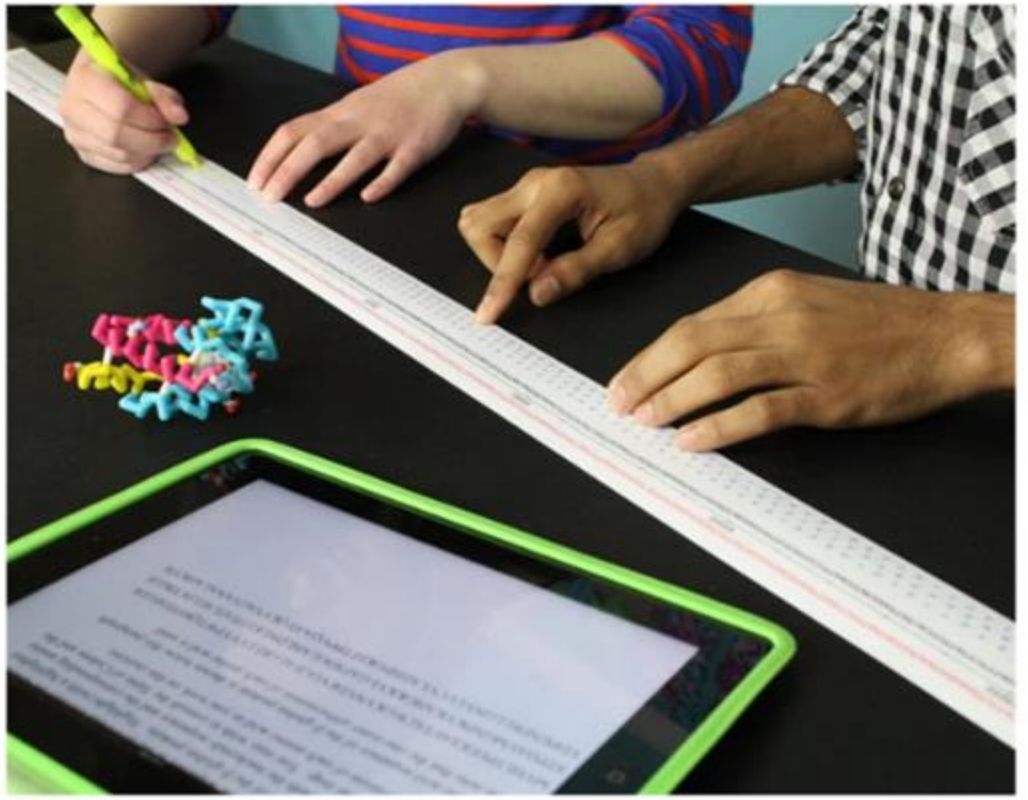
When?

- polyadenylation signal AAUAAA is transcribed
- pre-m RNA is cut
- 50-250 adenine nucleotides are added

Next steps to modeling mRNA modifications

Map of the Human ß-Globin Gene©





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OR

Session 2: August 5 - August 9

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- Learn tips and techniques from experienced teachers who have fostered student modeling, discovery, and inquiry in their classrooms
- Become part of a community of outstanding educators utilizing 3D Molecular Design's kits and models in a variety of courses
- Learn how to incorporate modeling with NGSS standards
- Leave with an introductory set of innovative materials, including a Water Kit©, Amino Acid Starter Kit©, Dynamic DNA Kit©, a cellular landscape by David Goodsell, and more

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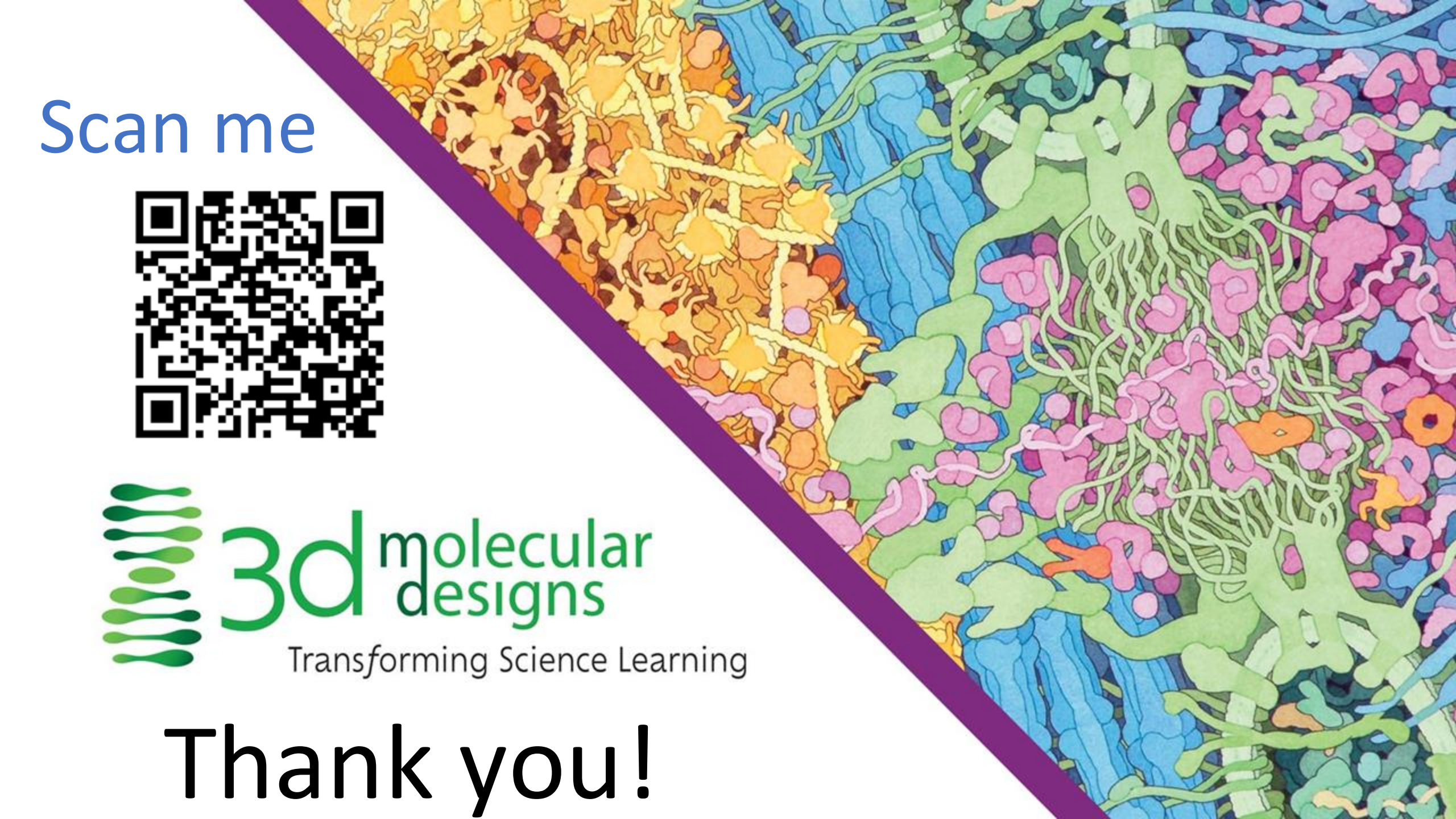

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Thank you!