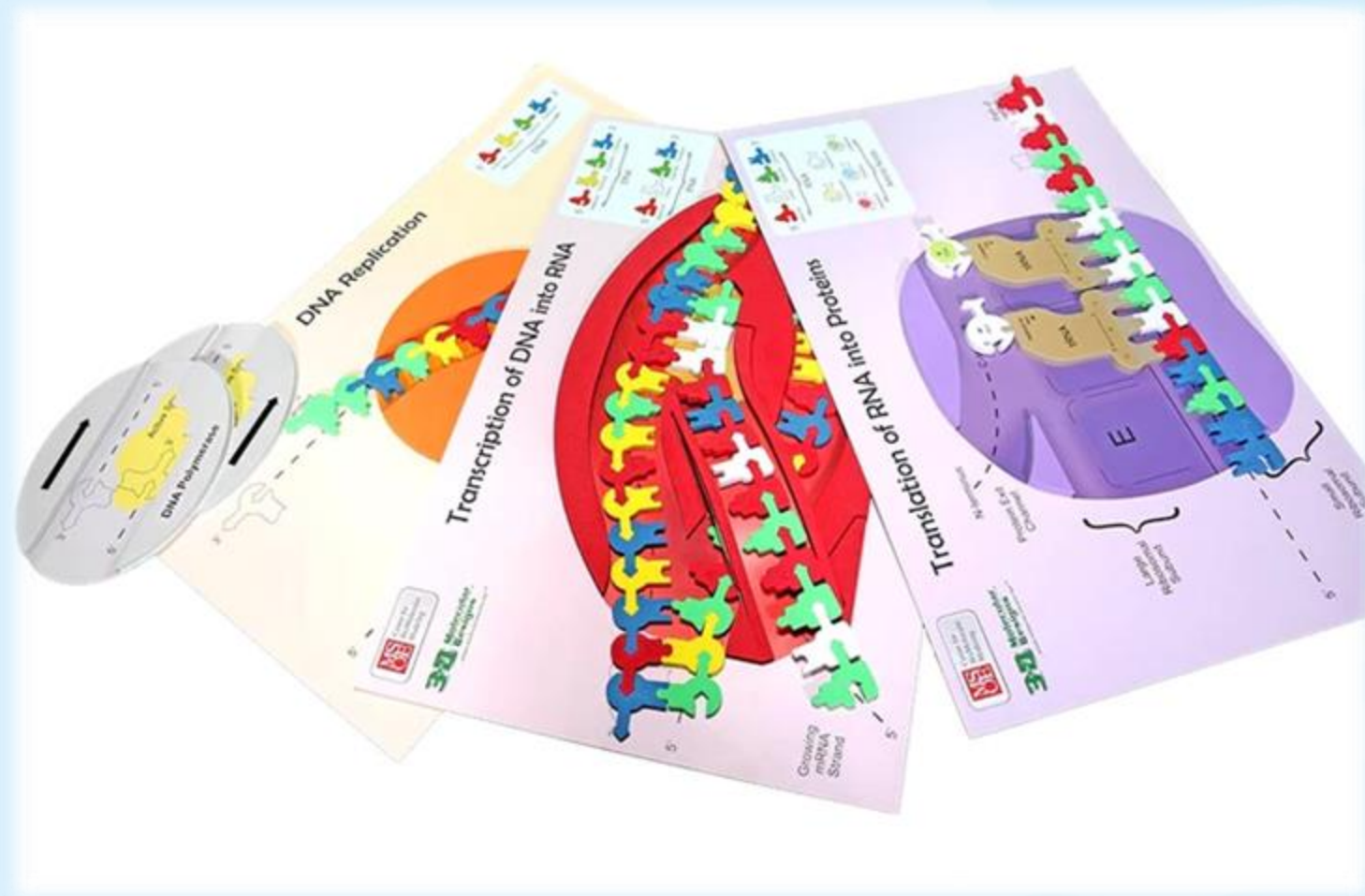
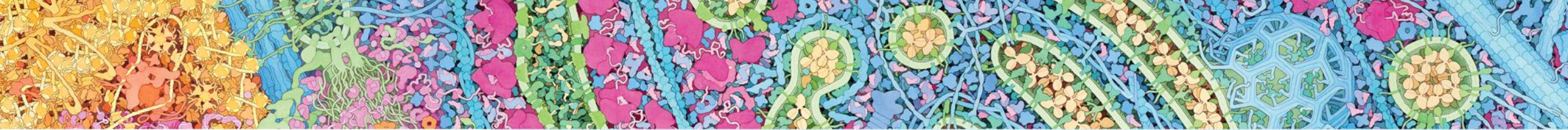


From Code to Creation: The Central Dogma Essentials

Ruth Hutson, MSSE

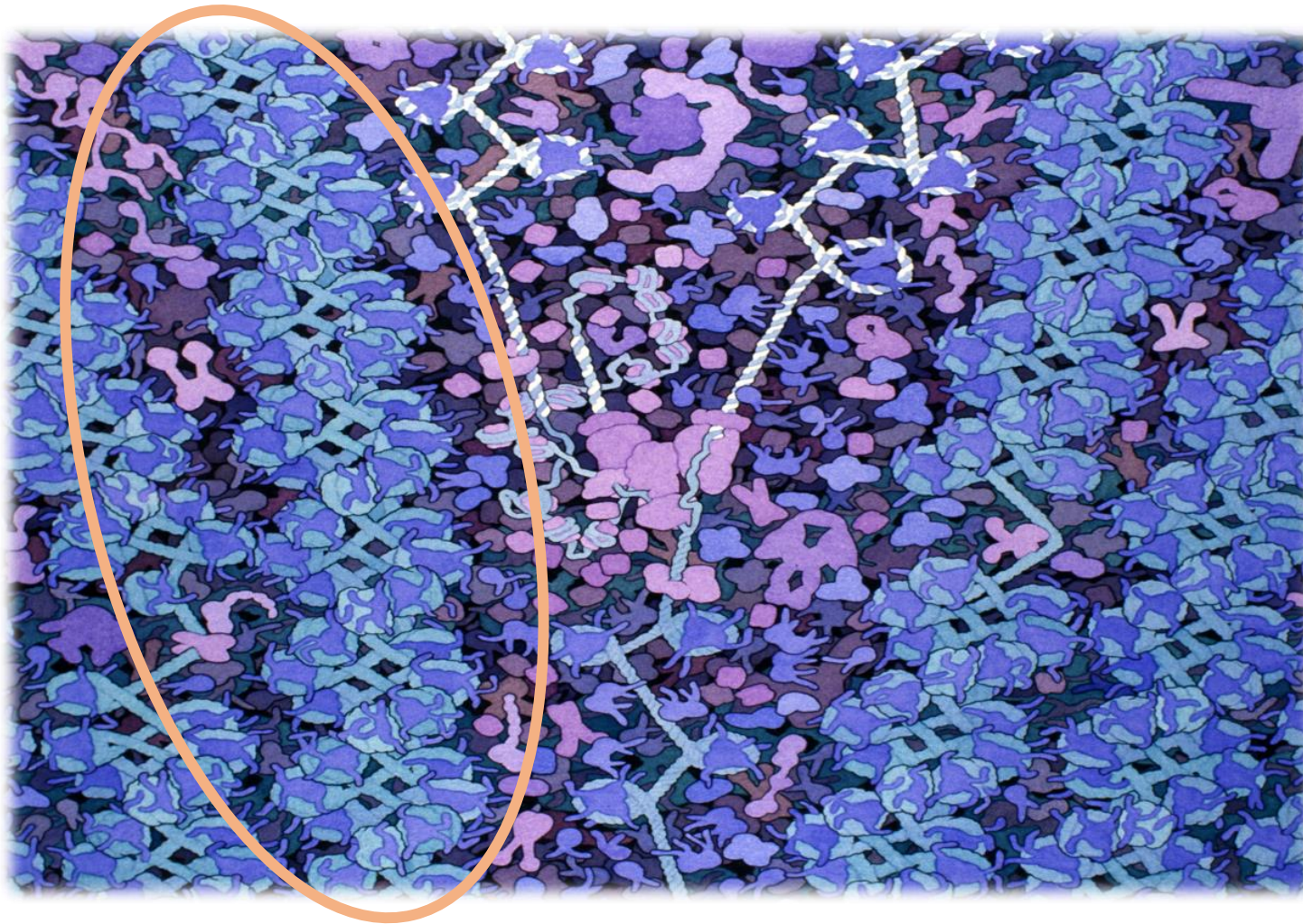




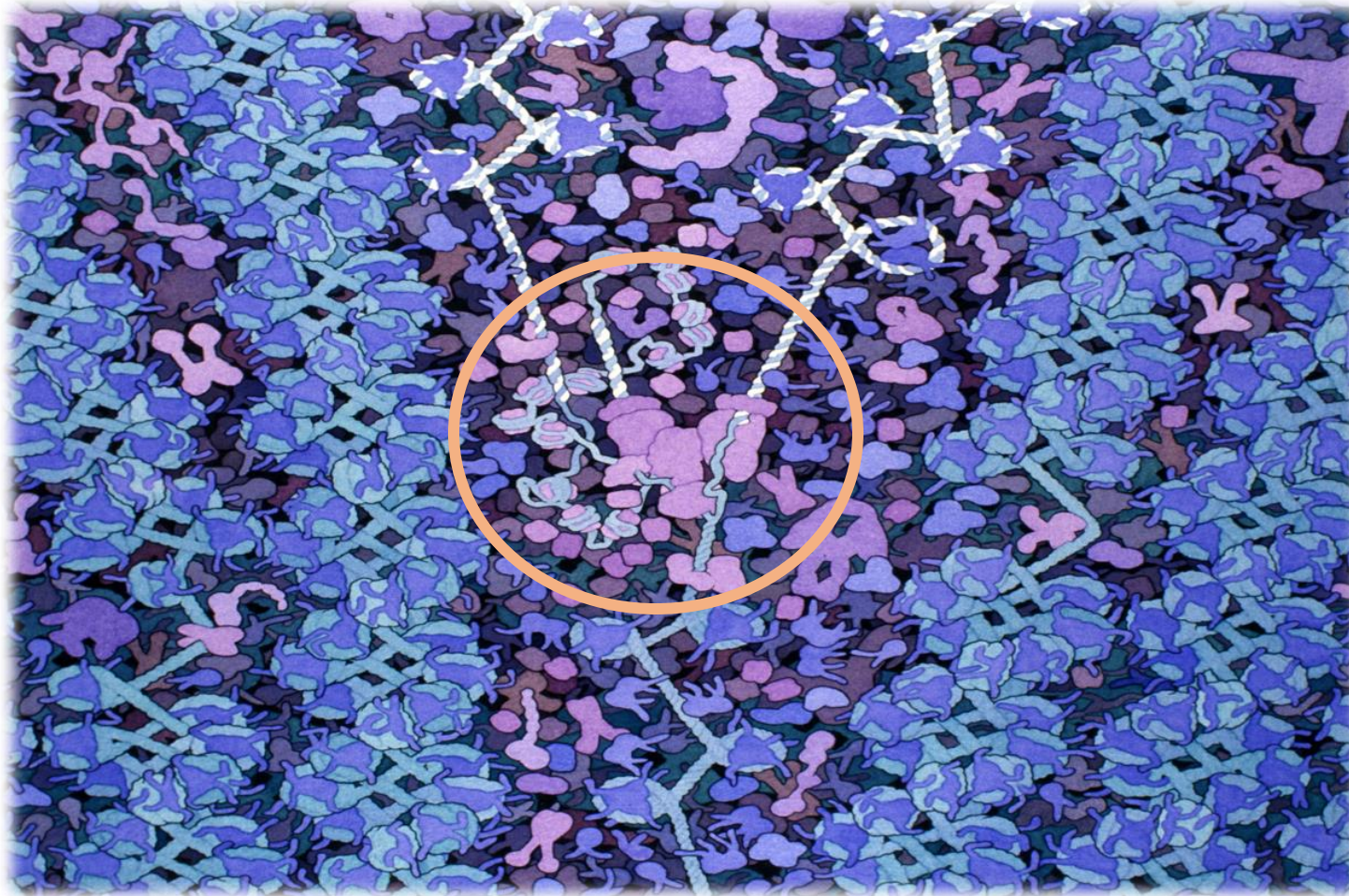
Workshop Outcomes

- Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential function of life through systems of specialized cells by explaining the purpose and purpose of replication, transcription, and translation using models of DNA and RNA.
- Examine patterns within and between side chains of amino acids.
- Model protein secondary and tertiary structure based on the primary structure of amino acid sequence.

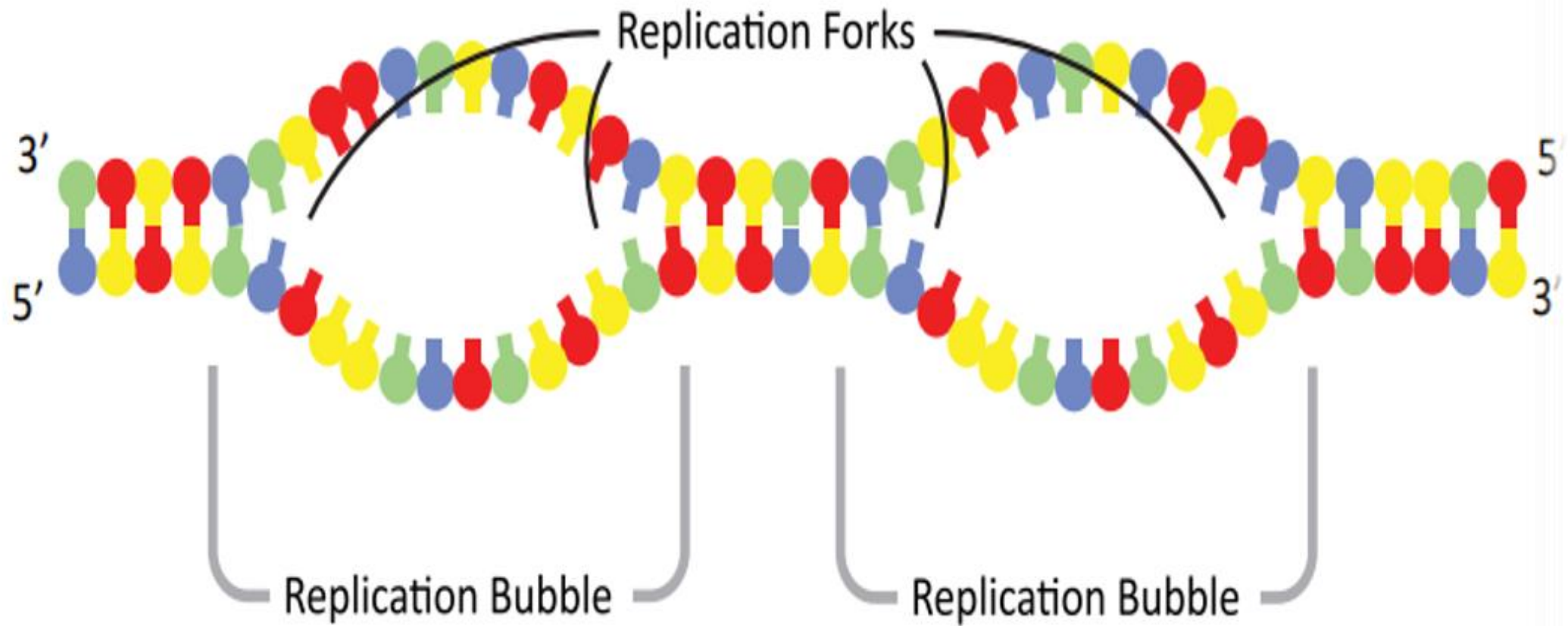
Replication in the Eukaryotic Nucleus



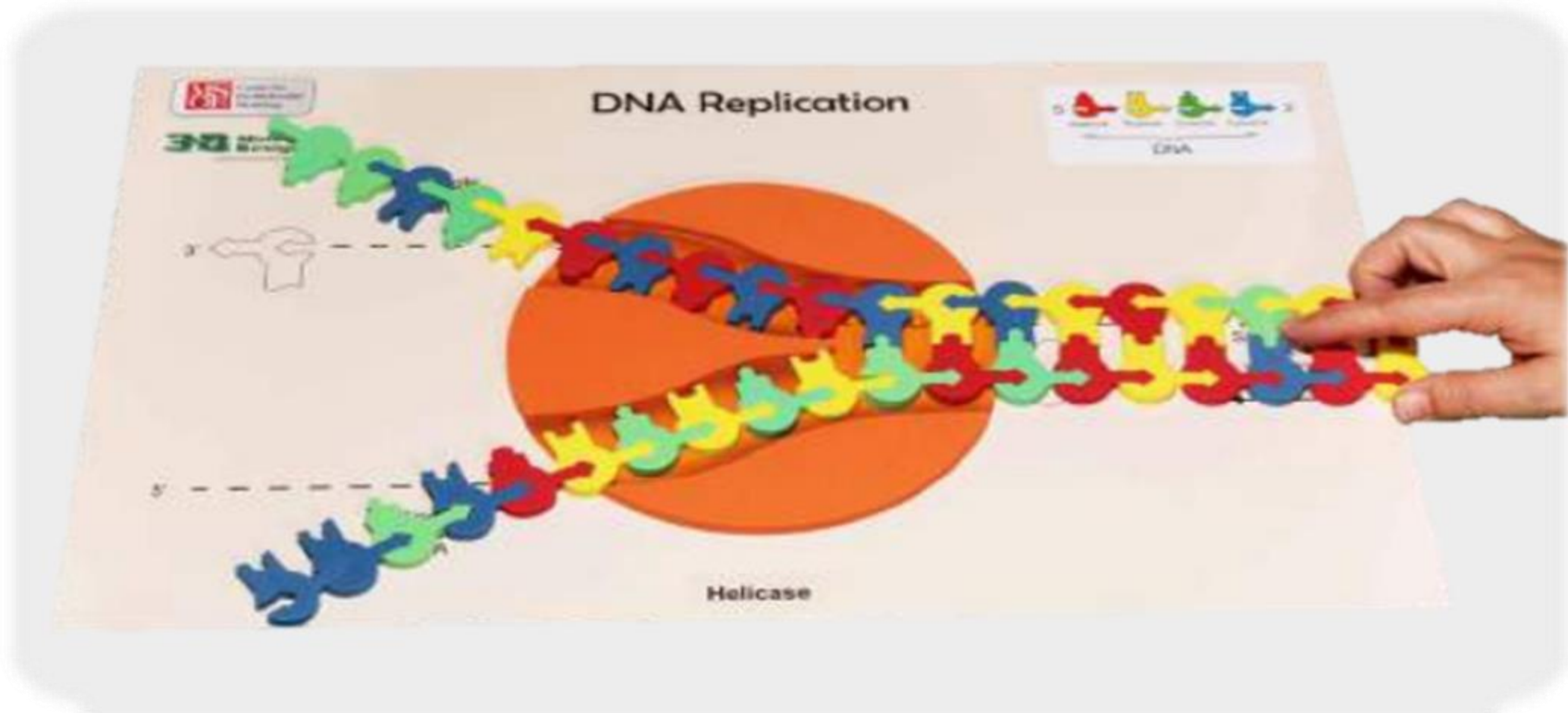
Replication in the Eukaryotic Nucleus



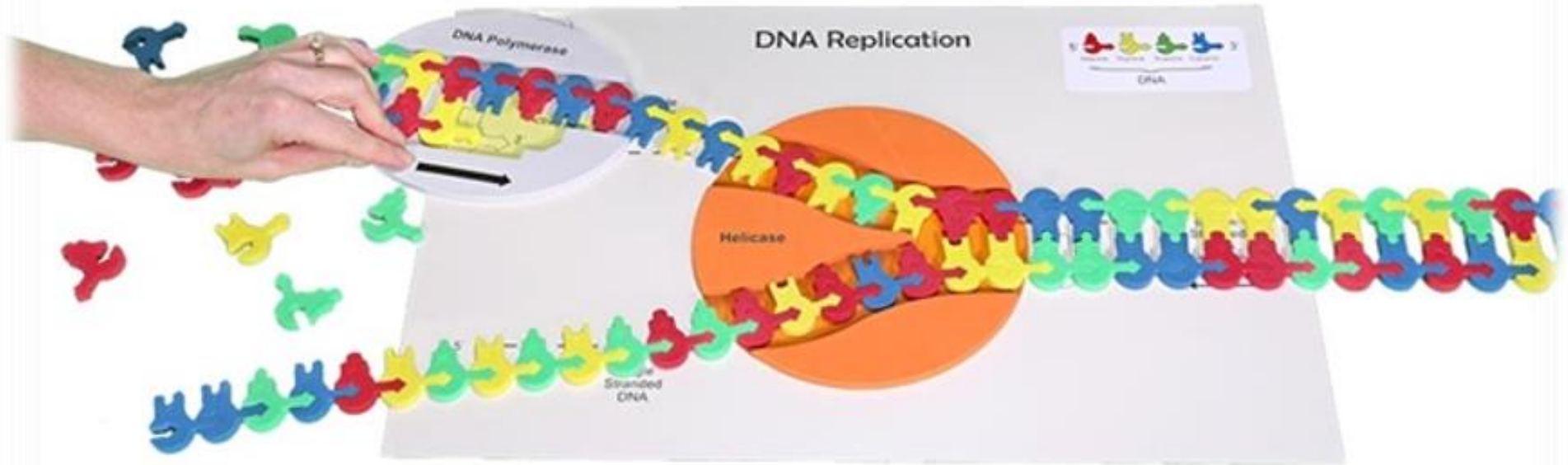
Replication Forks



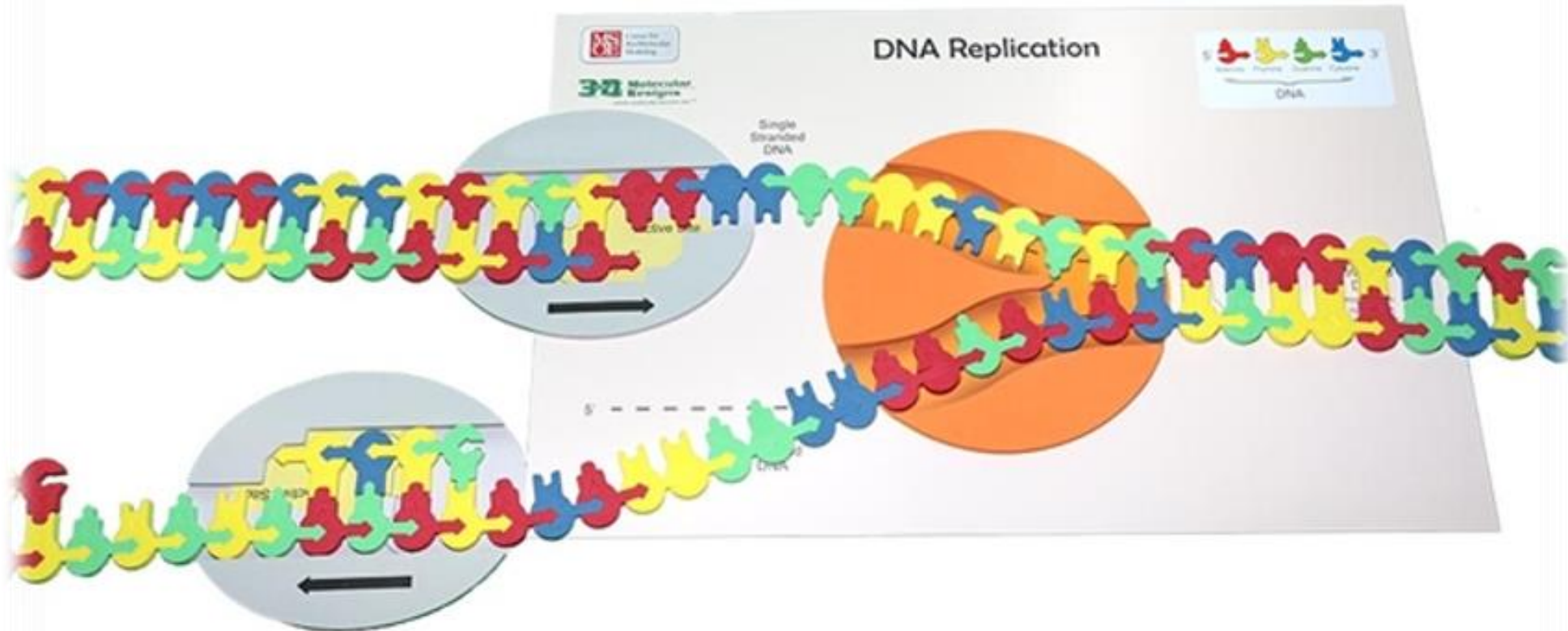
Replication



Continuous Replication



Discontinuous Replication



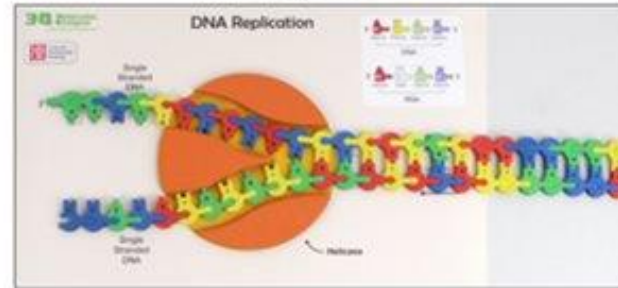
Comparing Leading and Lagging Strands



Template
Non-template



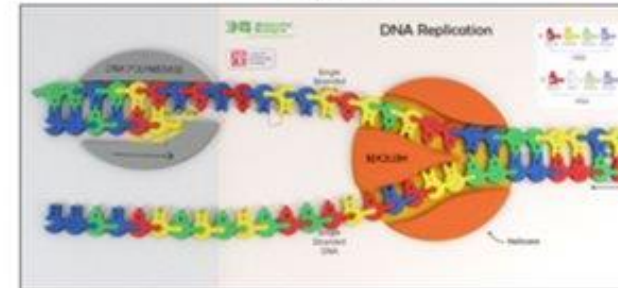
Diagram 1



Helicase unwinds the DNA at the replication fork

Helicases are enzymes that untwist the double helix and separate the two strands.

Diagram 2



DNA polymerase catalyzes the synthesis of new DNA

Leading Strand: New DNA can elongate only in the $5' \rightarrow 3'$ direction. The DNA strand that is made **continuously** is referred to as the leading strand. DNA polymerase moves toward the replication fork.

Diagram 3

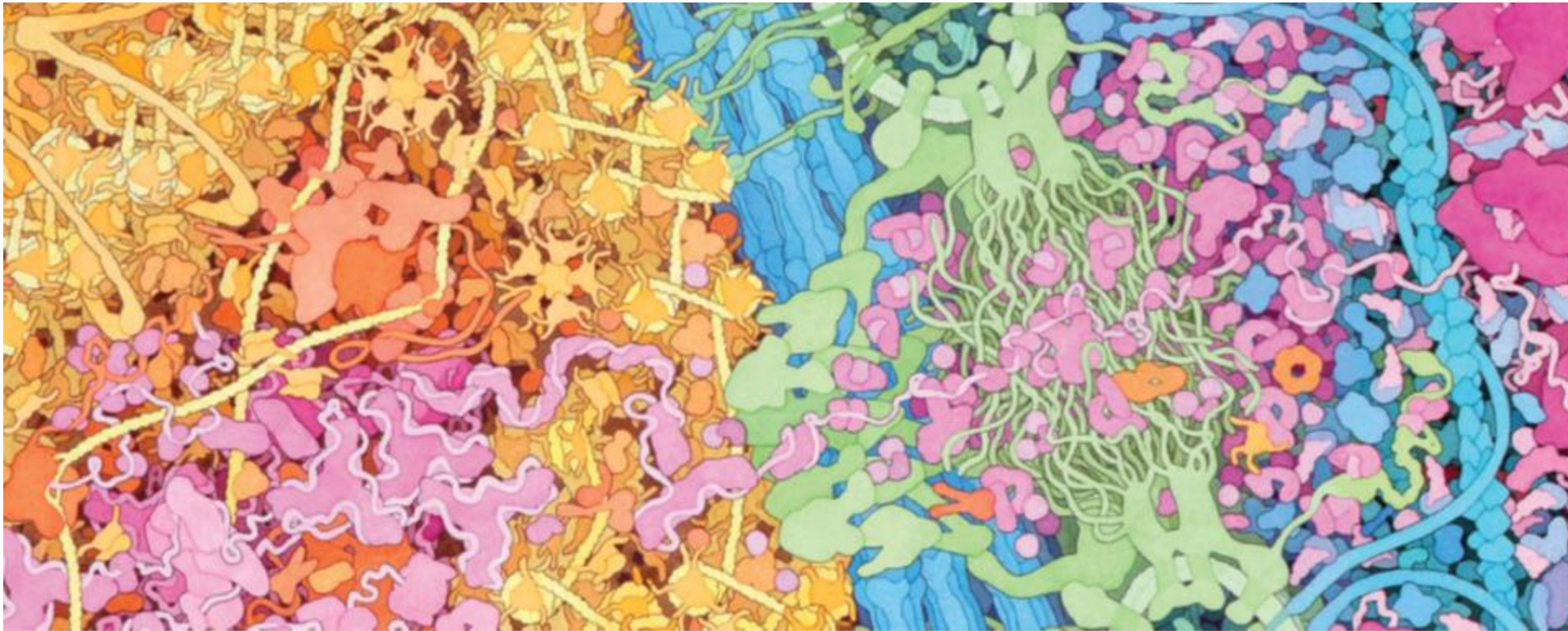


Diagram 4



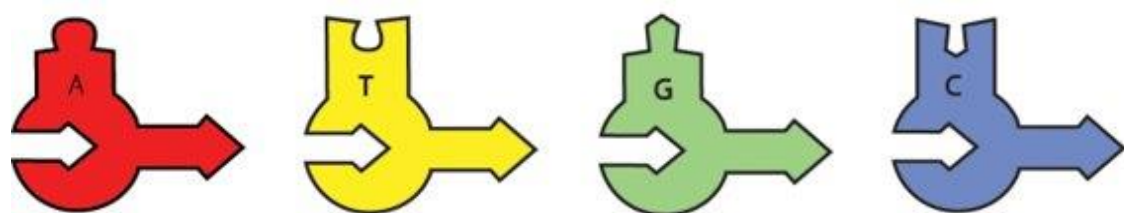
Lagging Strand: DNA polymerase must move away from the fork instead of toward the fork as it did in the leading strand in order to maintain $5' \rightarrow 3'$ DNA synthesis (diagram 3). The lagging strand is synthesized in a series of **discontinuous** fragments referred to as Okazaki fragments (diagram 4).

A Brief Tour Through the Cell

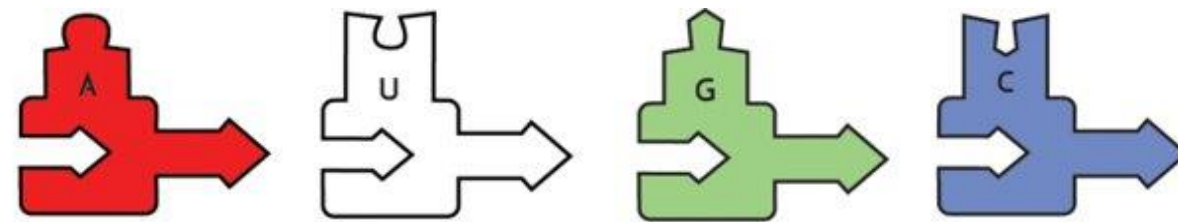


This image is an excerpt from *Tour of a Human Cell* by David Goodsell, as shown in 3D Molecular Designs' *Tour of a Human Cell*© poster and David Goodsell's book, *The Machinery of Life*

Transcription

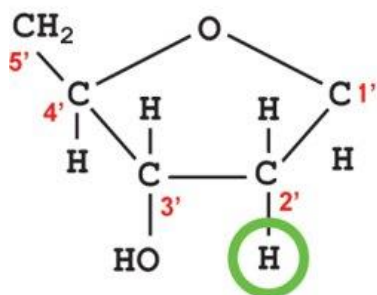


DNA

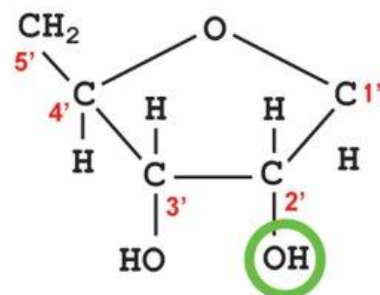


RNA

Deoxyribose
found in DNA

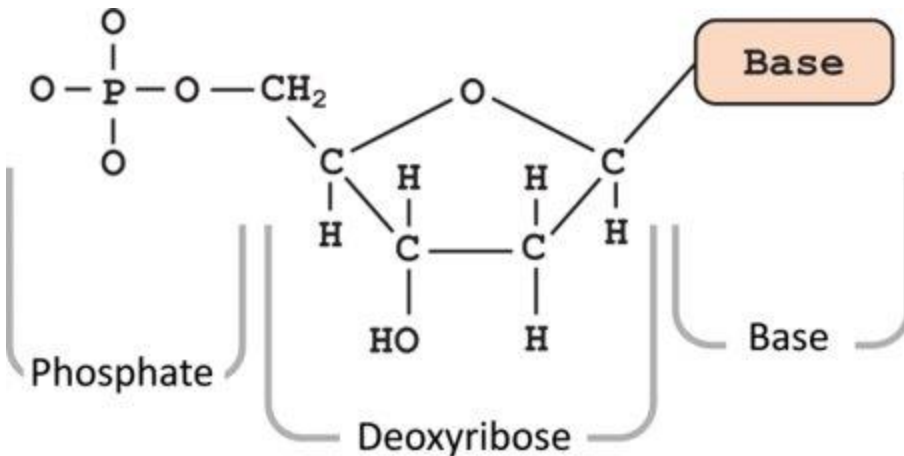
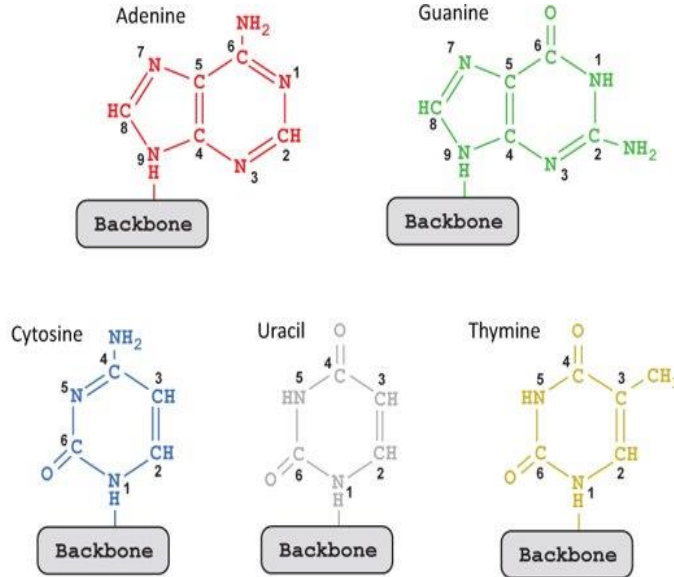
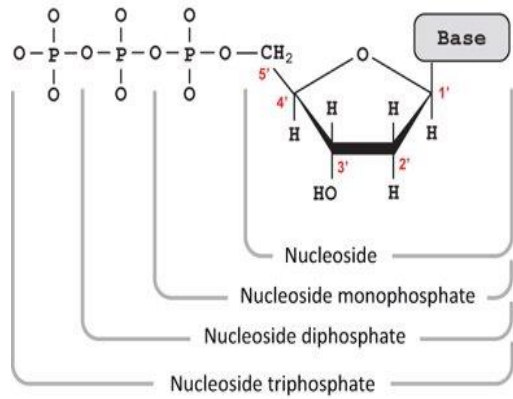


Ribose
found in RNA



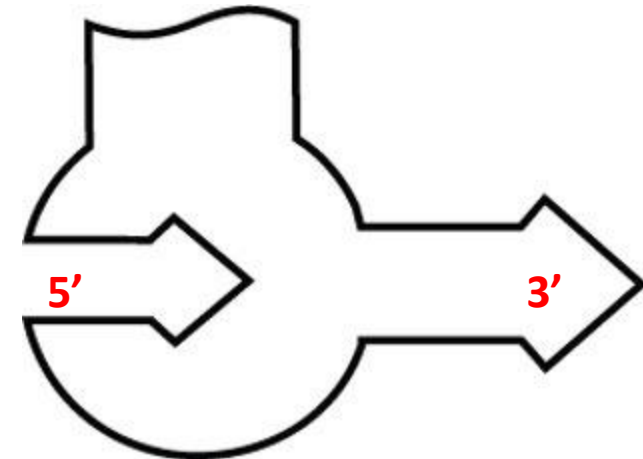
Notice:
The DNA pieces are different
than the RNA pieces.

Transcription

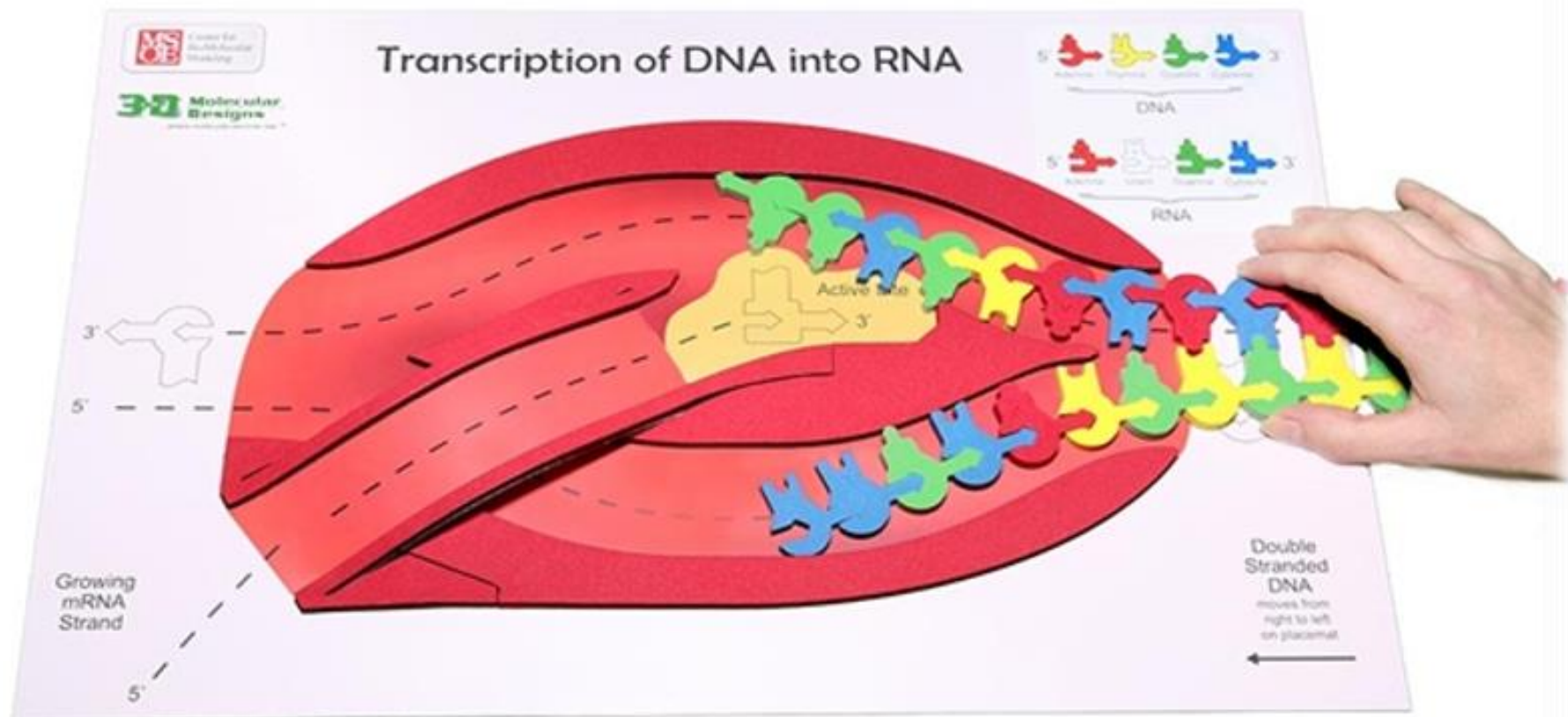


Helpful Hints:
Take care when loading the DNA in the RNA polymerase.

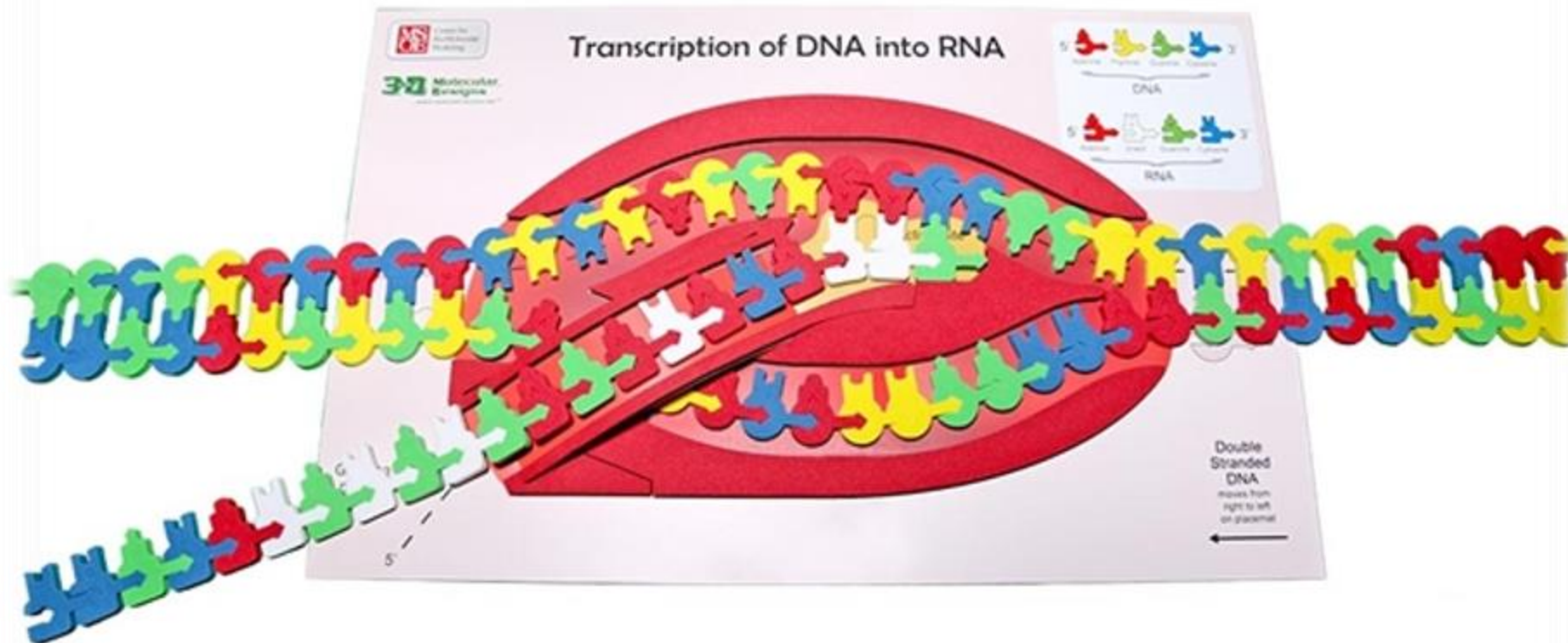
Remember RNA is synthesized from the 5' to the 3' end.



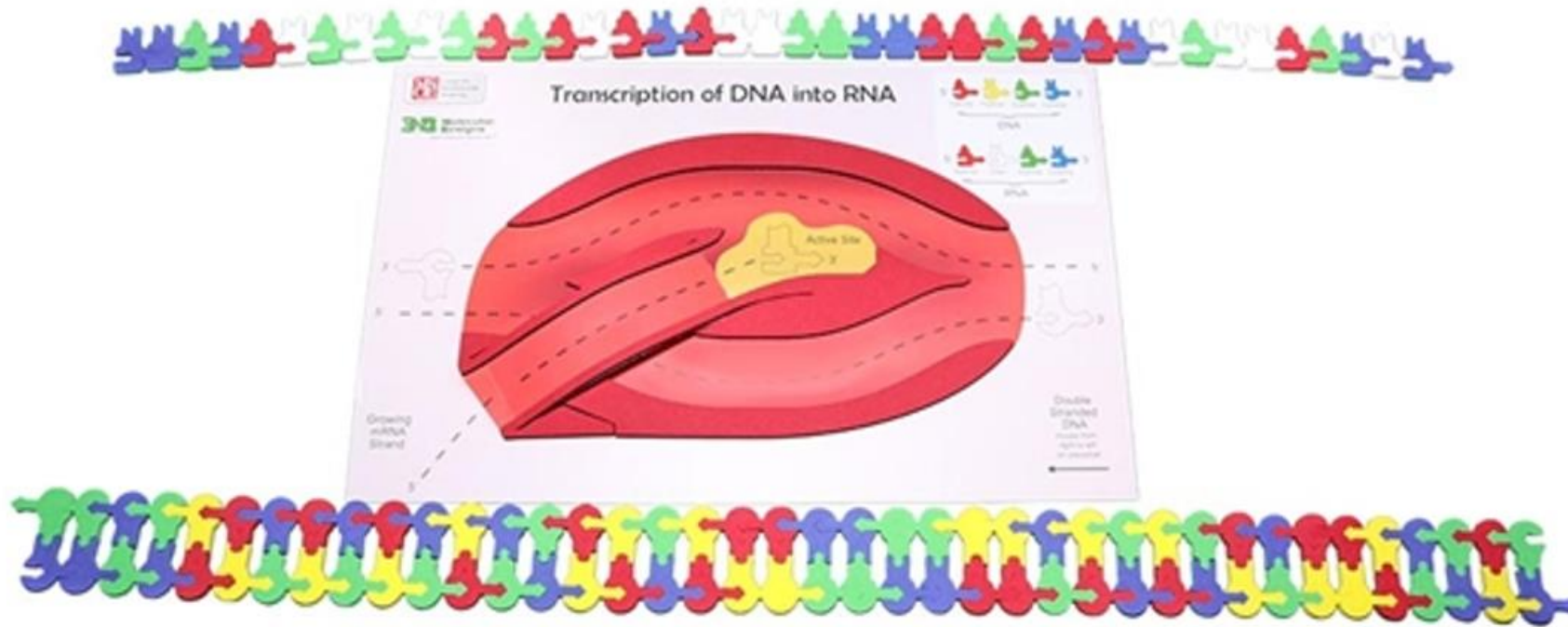
Transcription: Initiation



Transcription: Elongation



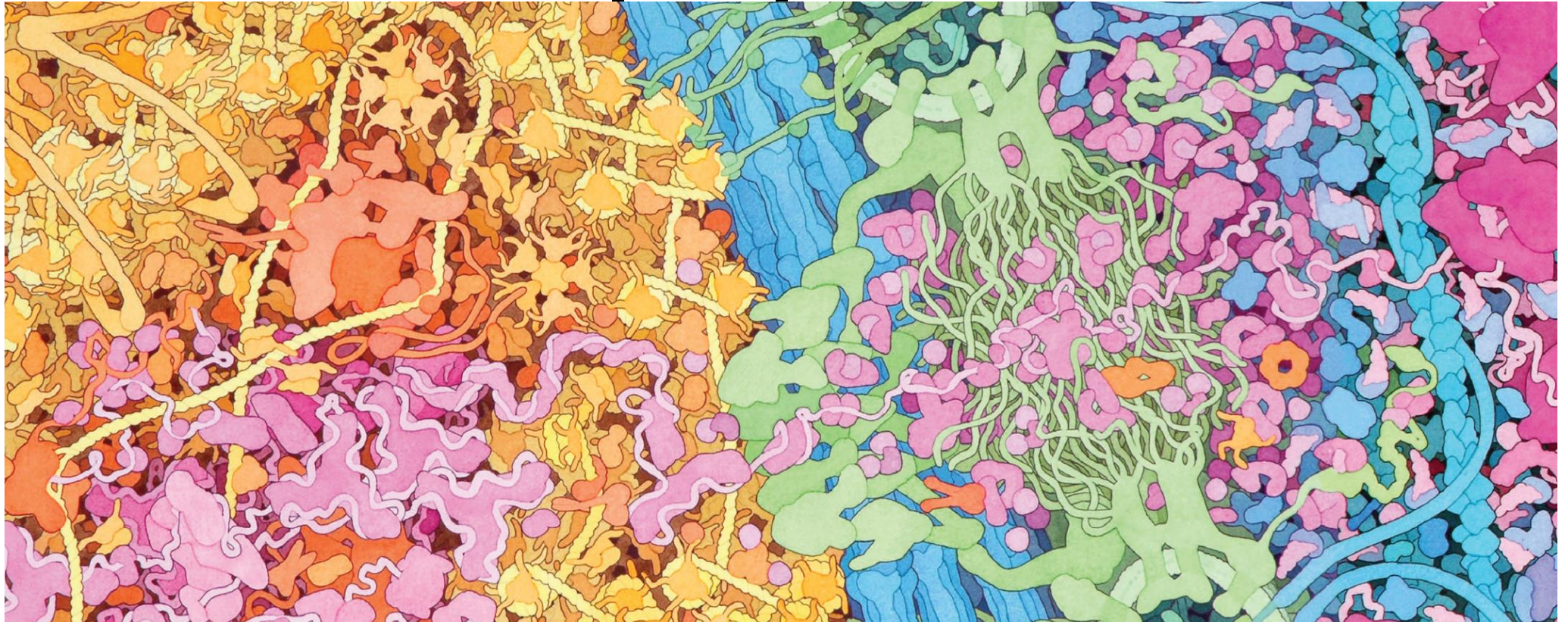
Transcription: Termination



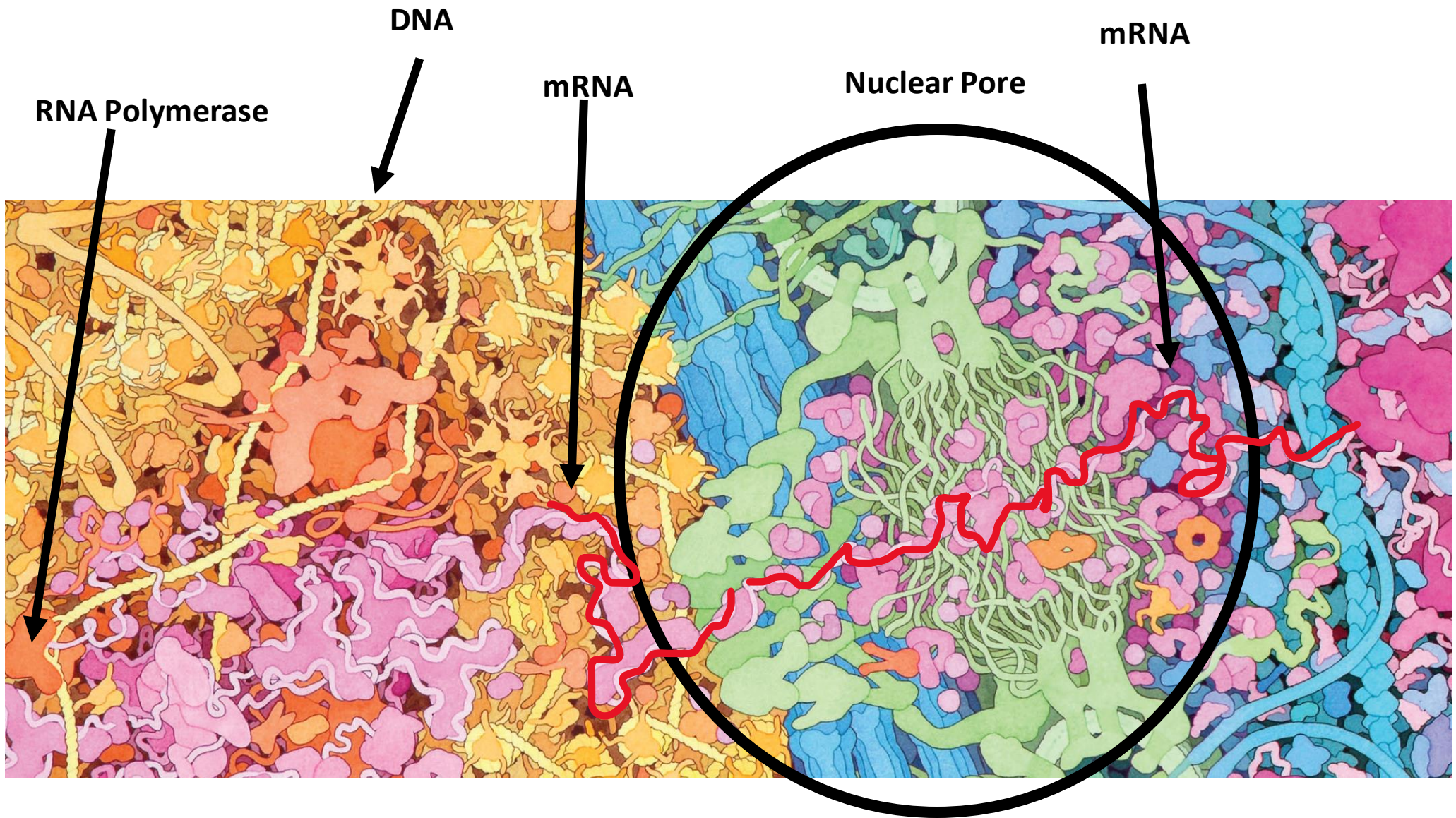
Nucleus

Nuclear
Membrane

Cytoplasm



This image is an excerpt from Tour of a Human Cell by David Goodsell, as shown in 3D Molecular Designs' Tour of a Human Cell© poster and David Goodsell's book, *The Machinery of Life*.



This is a vertical strip of a highly detailed and colorful abstract artwork. The composition is dense and layered, featuring a variety of organic and geometric forms. At the top, there's a circular motif with a green border and a yellow center. Below this, a blue, shell-like structure with a hexagonal pattern is visible. The middle section is dominated by a large, green, elongated shape with a yellow center, surrounded by smaller, similar shapes. The bottom section features a mix of blue, green, and yellow forms, with a prominent orange and yellow area at the very bottom. The overall texture is intricate, with many small details and a rich color palette.

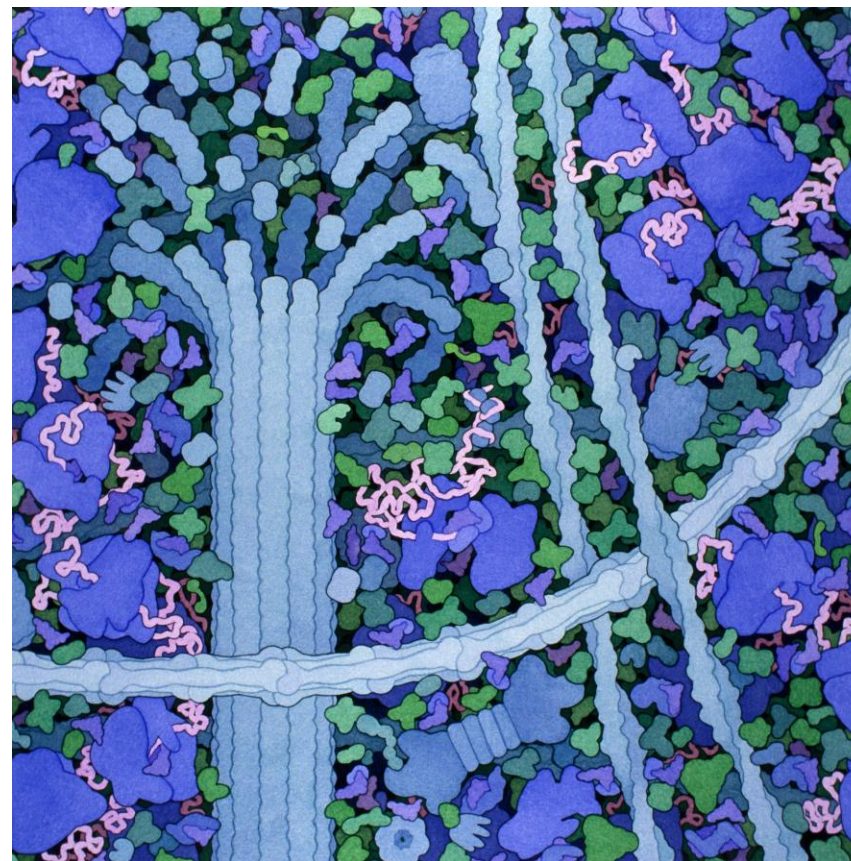
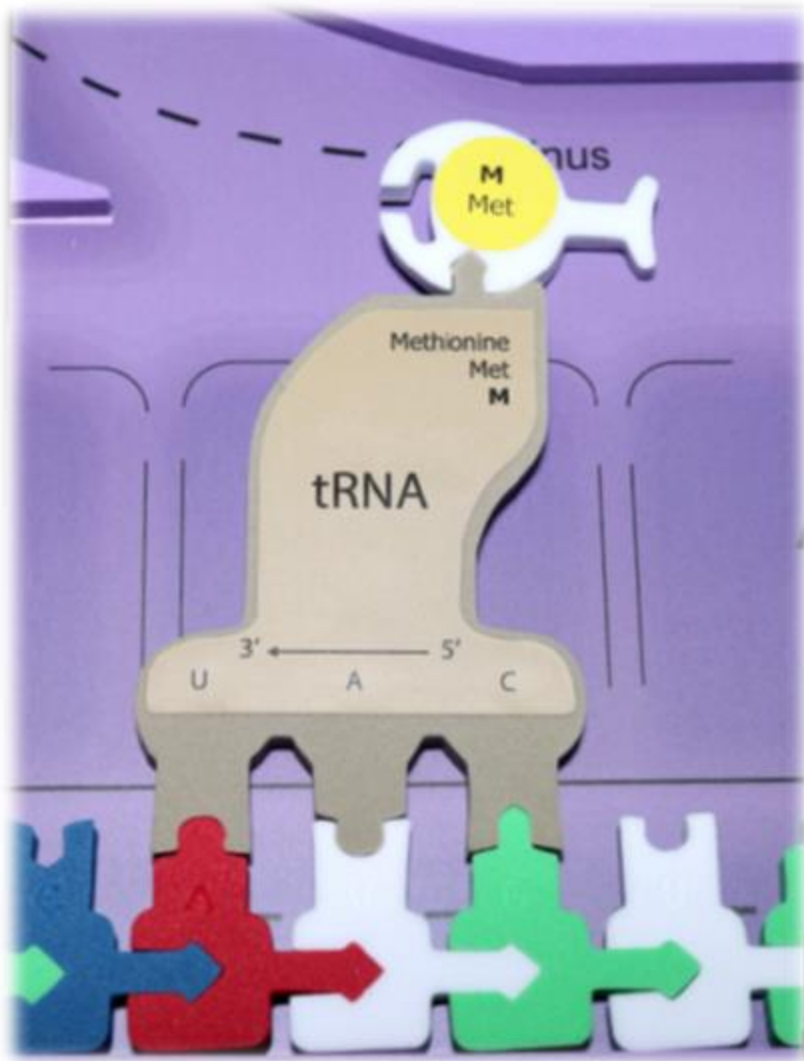
The Genetic Codon Chart®

	U	C	A	G	
U	UUU → Phe F UUC → Phe F UUA → Leu L UUG → Leu L	UCU → Ser S UCC → Ser S UCA → Ser S UCG → Ser S	UAU → Tyr Y UAC → Tyr Y UAA → Stop UAG → Stop	UGU → Cys C UGC → Cys C UGA → Stop UGG → Trp W	U C A G
C	CUU → Leu L CUC → Leu L CUA → Leu L CUG → Leu L	CCU → Pro P CCC → Pro P CCA → Pro P CCG → Pro P	CAU → His H CAC → His H CAA → Gln Q CAG → Gln Q	CGU → Arg R CGC → Arg R CGA → Arg R CGG → Arg R	U C A G
A	AUU → Ile I AUC → Ile I AUA → Ile I AUG → Met M	ACU → Thr T ACC → Thr T ACA → Thr T ACG → Thr T	AAU → Asn N AAC → Asn N AAA → Lys K AAG → Lys K	AGU → Ser S AGC → Ser S AGA → Arg R AGG → Arg R	U C A G
G	GUU → Val V GUC → Val V GUA → Val V GUG → Val V	GCU → Ala A GCC → Ala A GCA → Ala A GCG → Ala A	GAU → Asp D GAC → Asp D GAA → Glu E GAG → Glu E	GGU → Gly G GGC → Gly G GGA → Gly G GGG → Gly G	U C A G

Amino Acid Properties

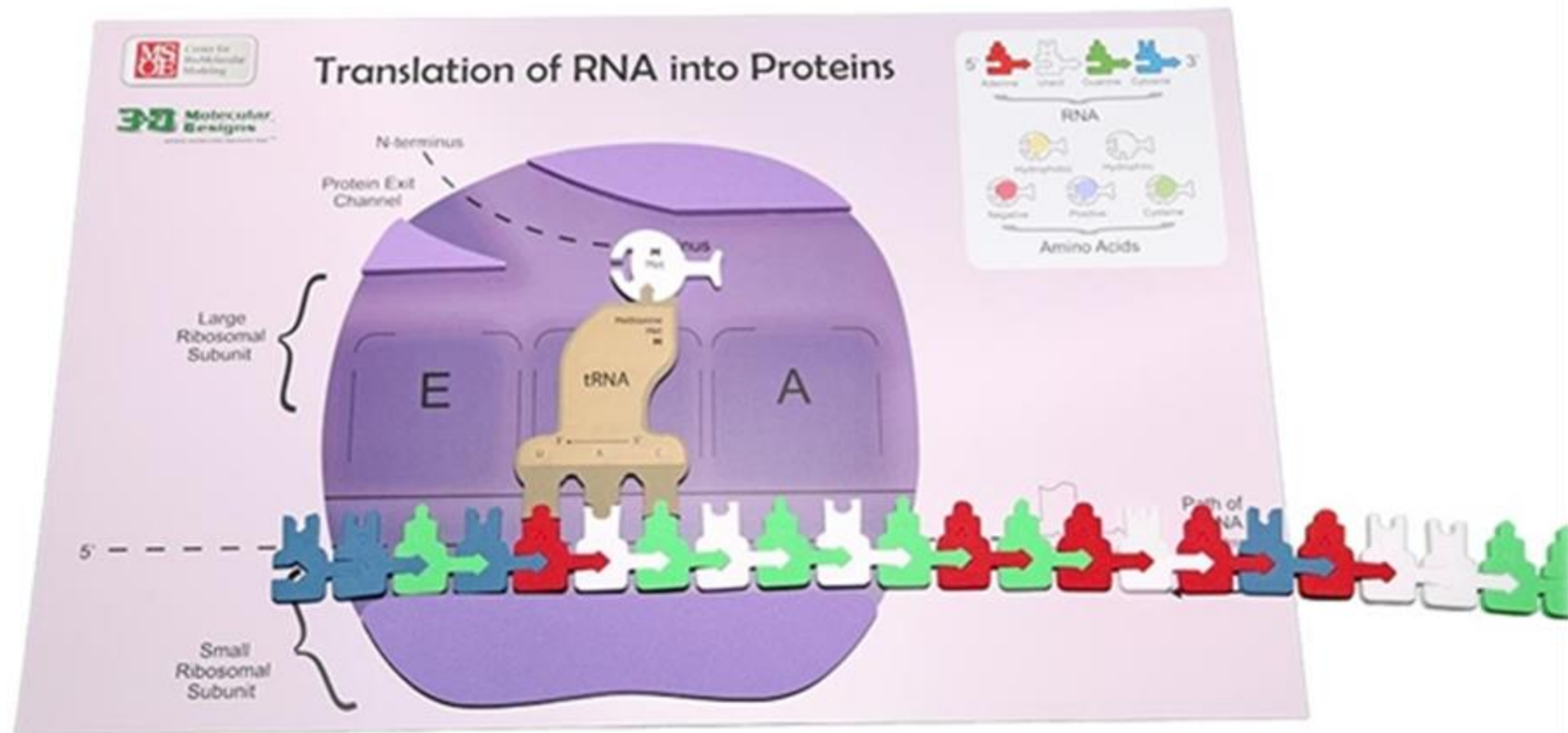
 Translation Start Codon	 Hydrophobic / Non-polar	 Negative Charge	 Cysteine
 Translation Stop Codon	 Hydrophilic / Polar	 Positive Charge	

Translation



Acknowledgement: Illustration by David S. Goodsell. doi: 10.2210/rcsb_pdb/goodsell-gallery-006

Translation: Initiation



Translation: Elongation

The diagram illustrates the process of translation elongation. A large purple ribosome is shown with a small ribosomal subunit (bottom) and a large ribosomal subunit (top). The mRNA strand is threaded through the ribosome, with a 5' end on the left and a 3' end on the right. The mRNA is being translated from left to right. The growing polypeptide chain is shown as a string of colored beads (amino acids) attached to the tRNA. The chain is being extended by the addition of new amino acids. The tRNA molecules are shown with their anticodons (3' ends) base-pairing with the mRNA codons (5' ends). The tRNA molecules are labeled with their amino acids: Methionine (Met), Cysteine (Cys), and Alanine (Ala). The tRNA molecules are shown in the E (exit), P (peptidyl transfer), and A (aminoacyl) sites. The A site is the site where the new amino acid is added to the growing chain. The P site is the site where the growing chain is transferred to the new tRNA. The E site is the site where the tRNA exits the ribosome. The diagram also shows the path of the growing chain as it moves through the ribosome. The chain is shown exiting the ribosome through a protein exit channel. The diagram is titled "Translation of RNA into Proteins" and includes logos for MSOE (Center for BioMolecular Modeling) and 3D Molecular Designs.

MSOE Center for BioMolecular Modeling

3D Molecular Designs

Translation of RNA into Proteins

N-terminus

Protein Exit Channel

Large Ribosomal Subunit

Small Ribosomal Subunit

5' 3'

RNA

Amino Acids

Hydrophobic

Hydrophilic

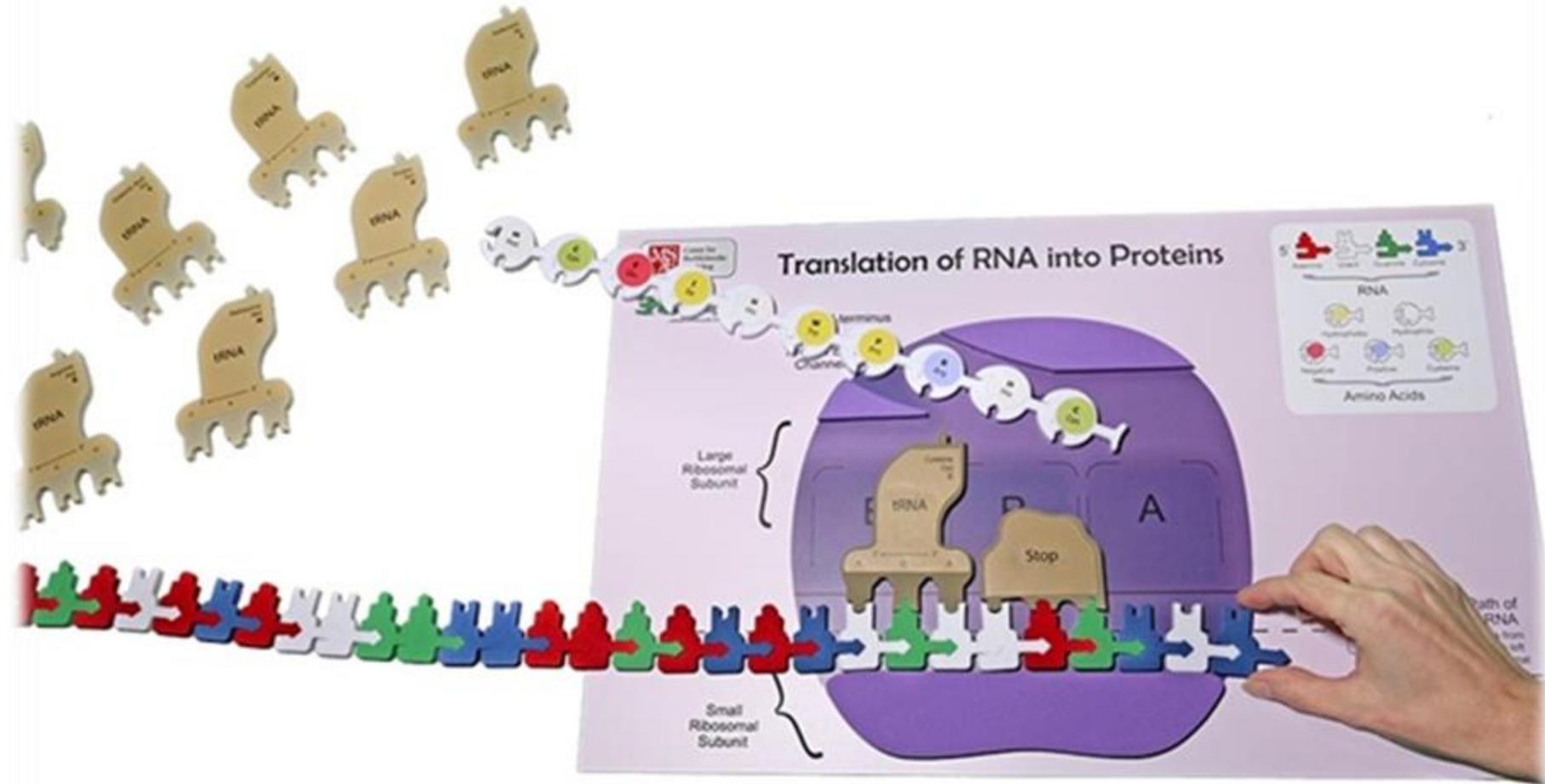
Negative

Positive

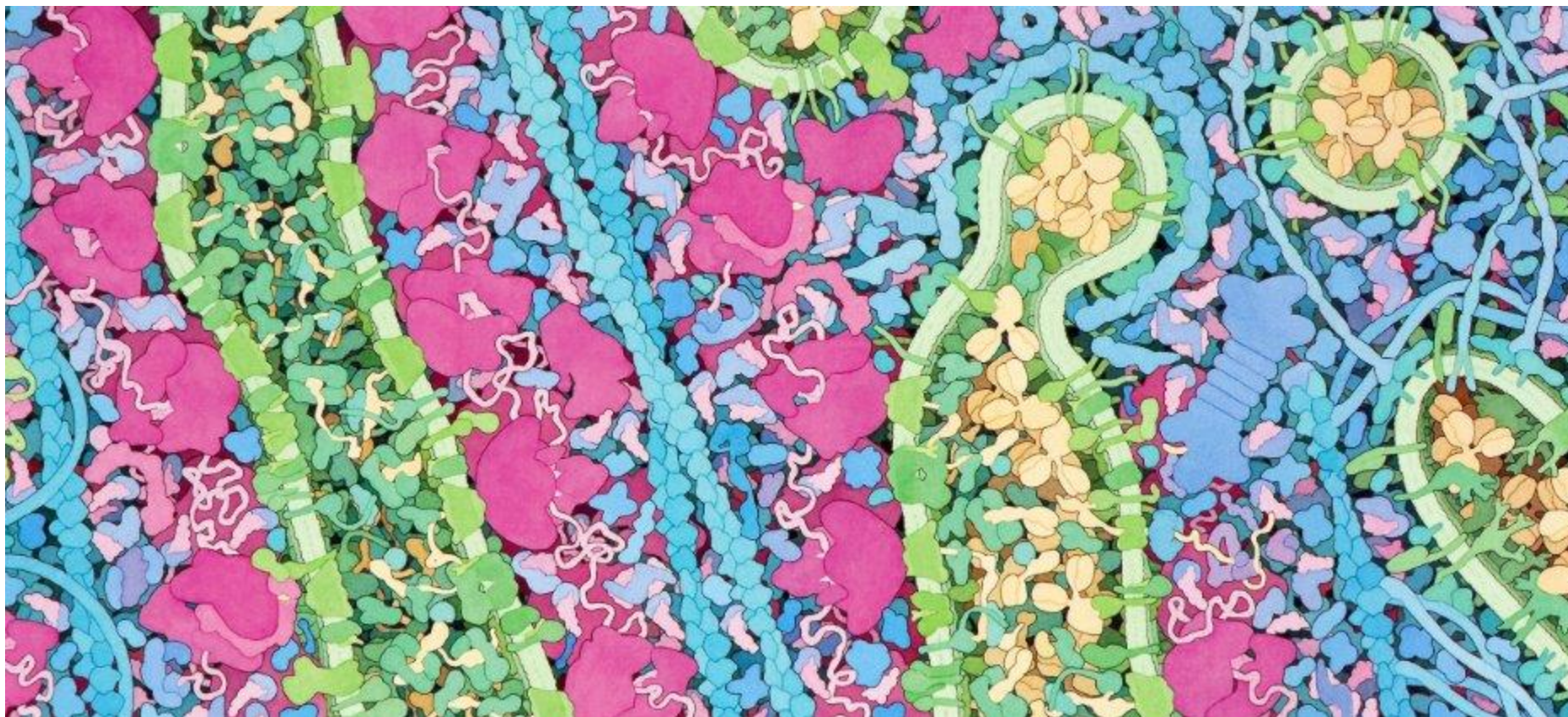
Cysteine

Path of A

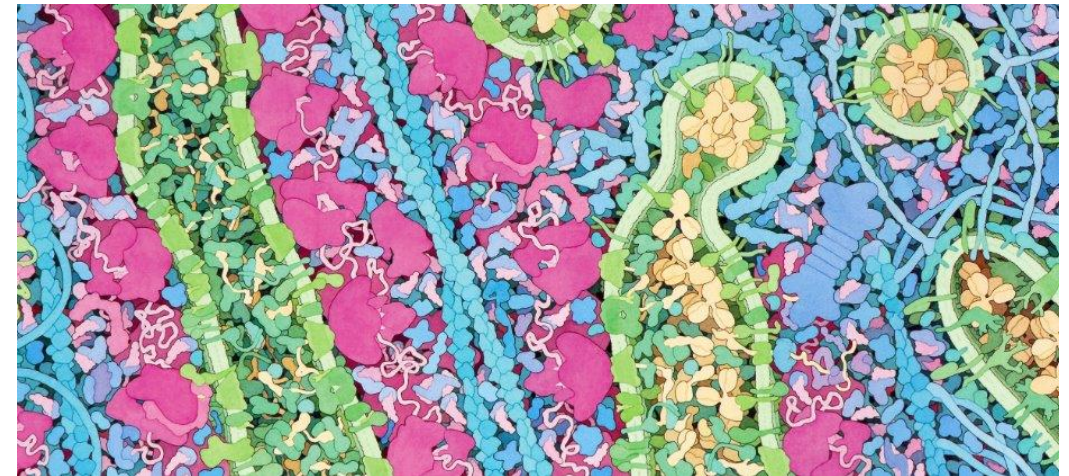
Translation: Termination



Revisit the panorama



Protein Folding in Cytoplasm or Rough ER



Protein Folding in Cytoplasm or Rough ER



KEY

Hydrophobic Side Chains are **Yellow**

Hydrophilic Side Chains are **White**

Acidic Side Chains are **Red**

Basic Side Chains are **Blue**

Cysteine Side Chains are **Green**

SIX HYDROPHOBIC

THREE HYDROPHILIC

TWO ACIDIC

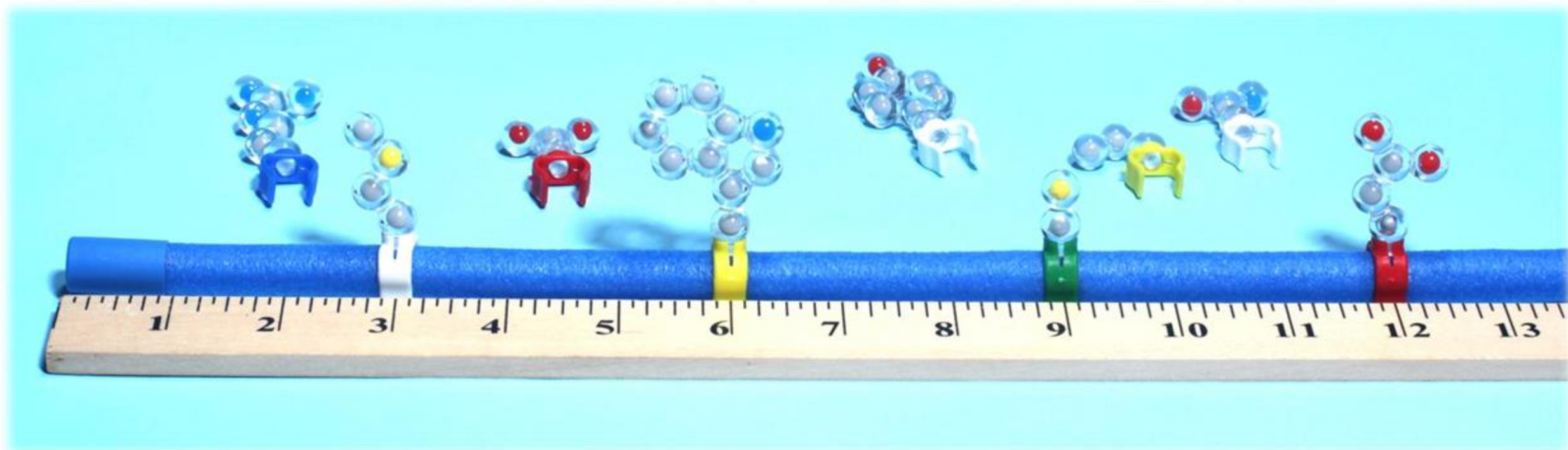
TWO BASIC

TWO CYSTEINE

A TOTAL OF FIFTEEN SIDE CHAINS

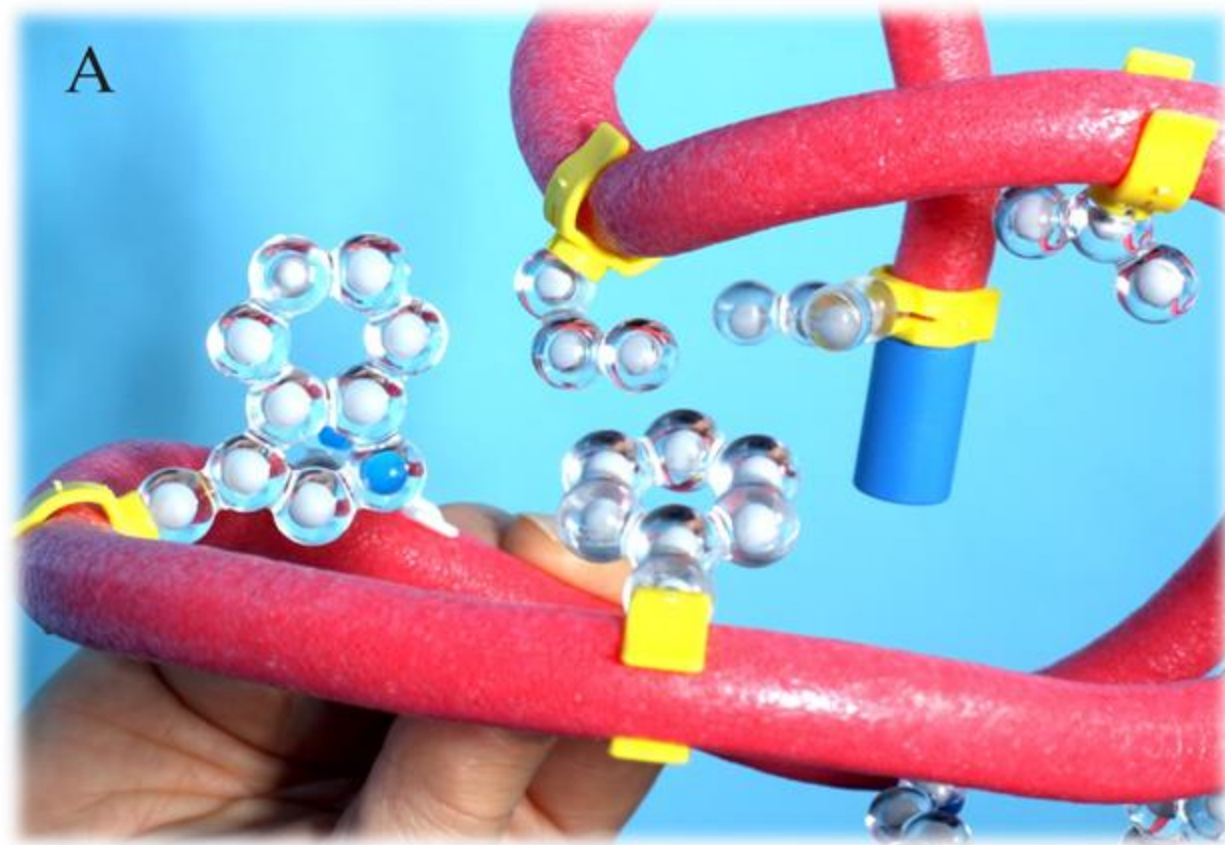
In any order arrange your amino acids so they are equidistant from each other.

You have made a polypeptide.



“Fold” the polypeptide into a protein.

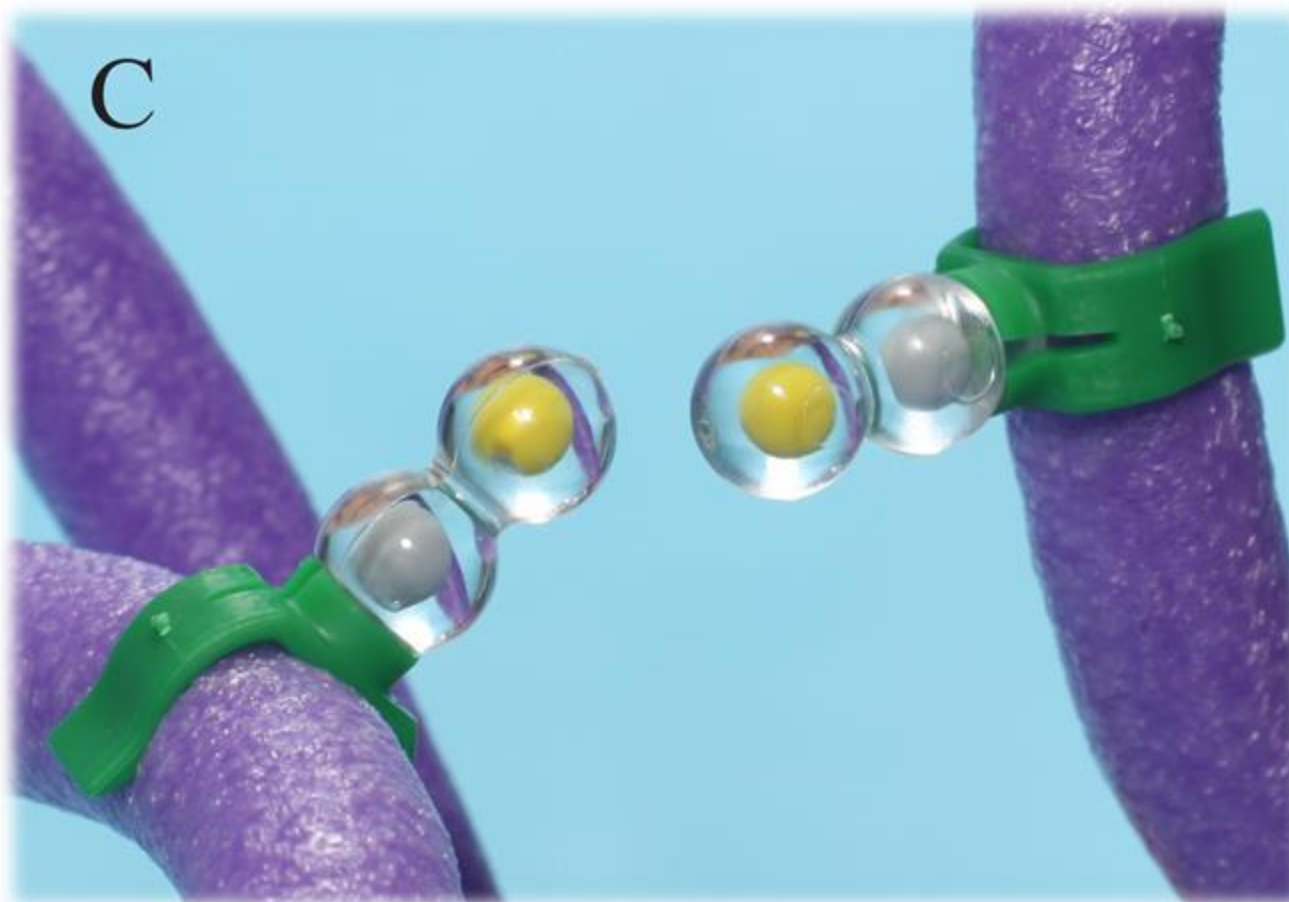
Rotate hydrophobic amino acids to the inside.



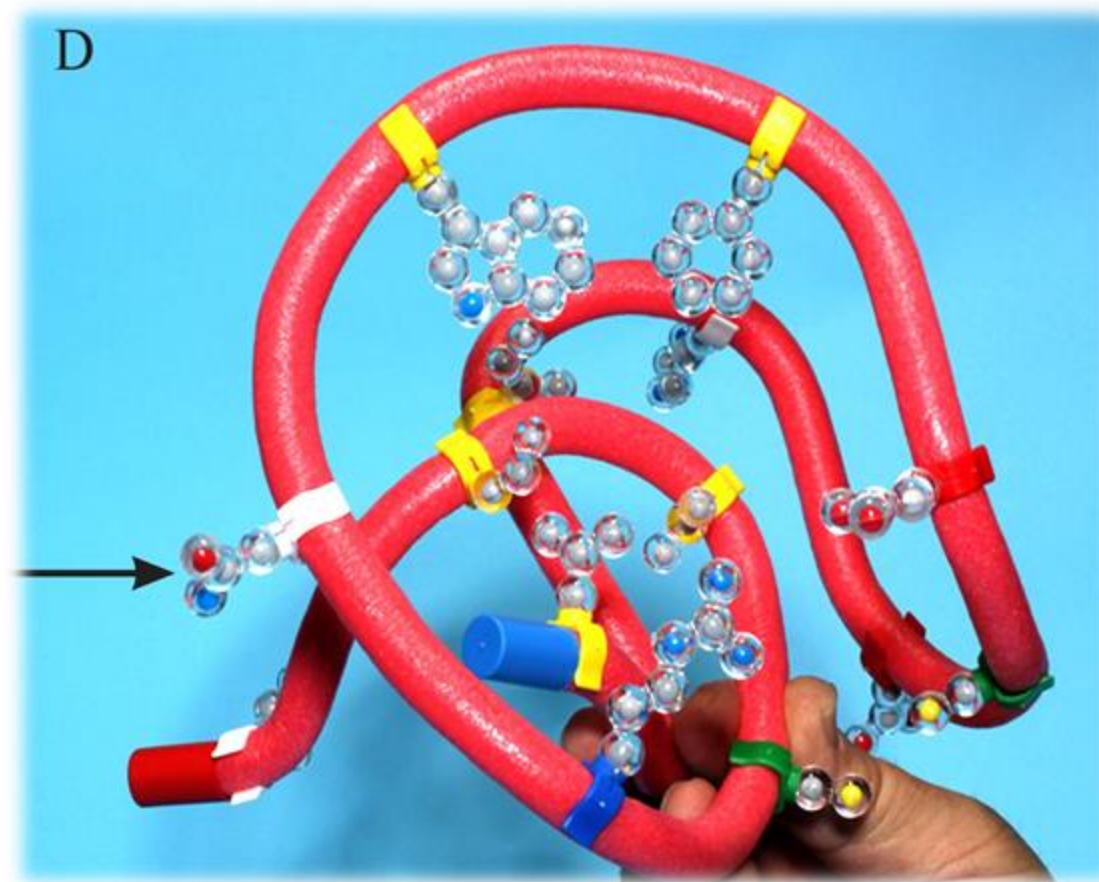
Continue “folding” by bringing the acidic and basic side chains until they are 2 cm apart.



Continue “folding” by positioning cysteines so they are opposite each other.

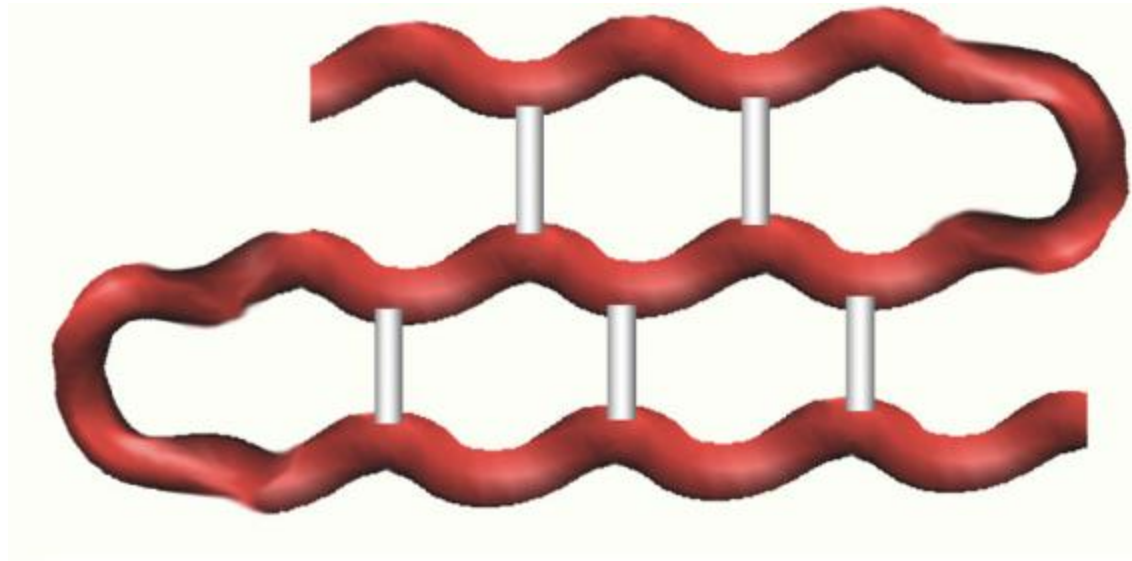
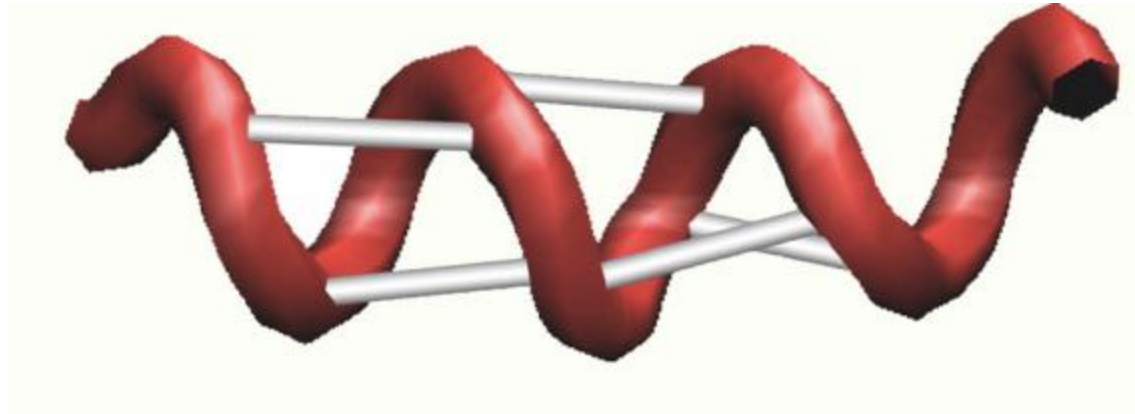


Continue “folding” by rotating the hydrophilic side chains so they are on the outer surface of the protein.



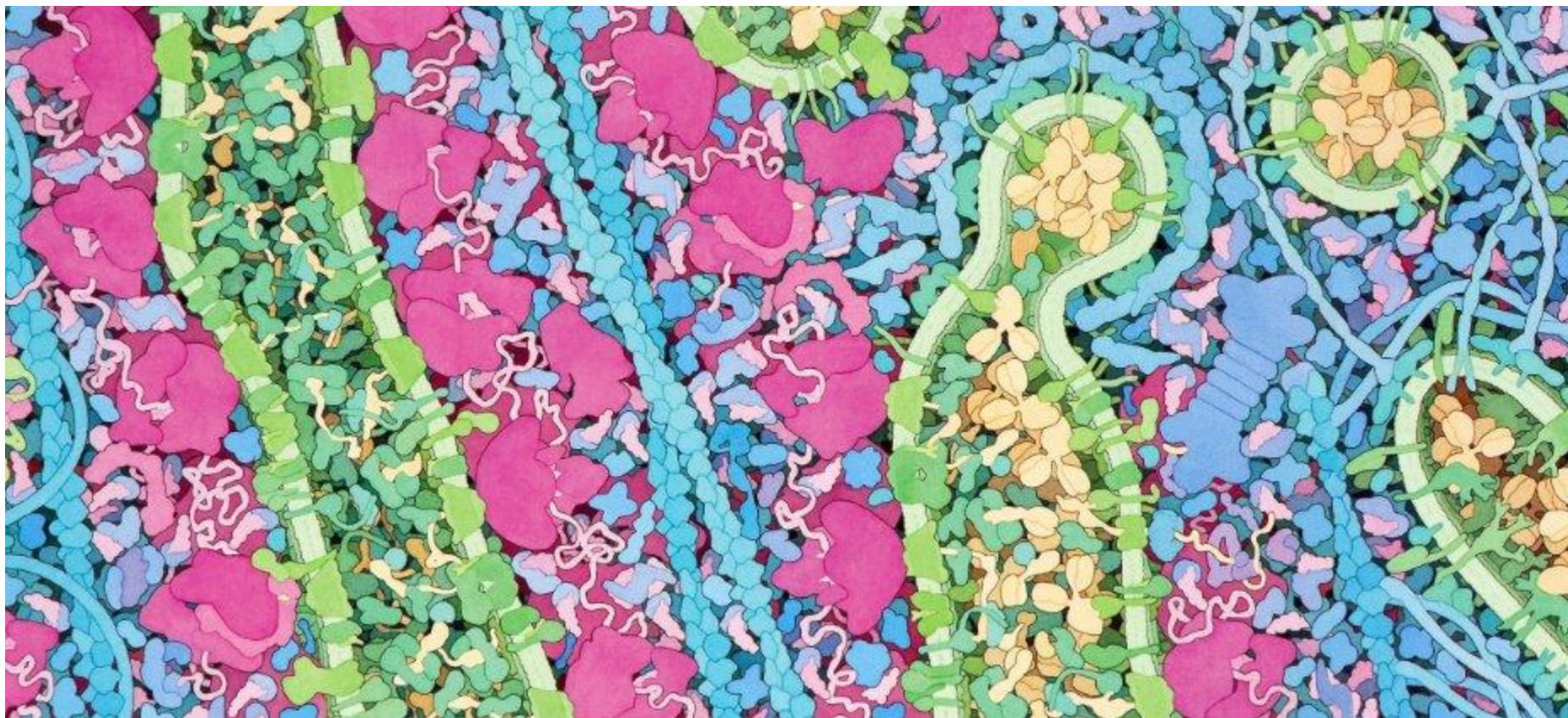
Review of secondary structure

Alpha Helix

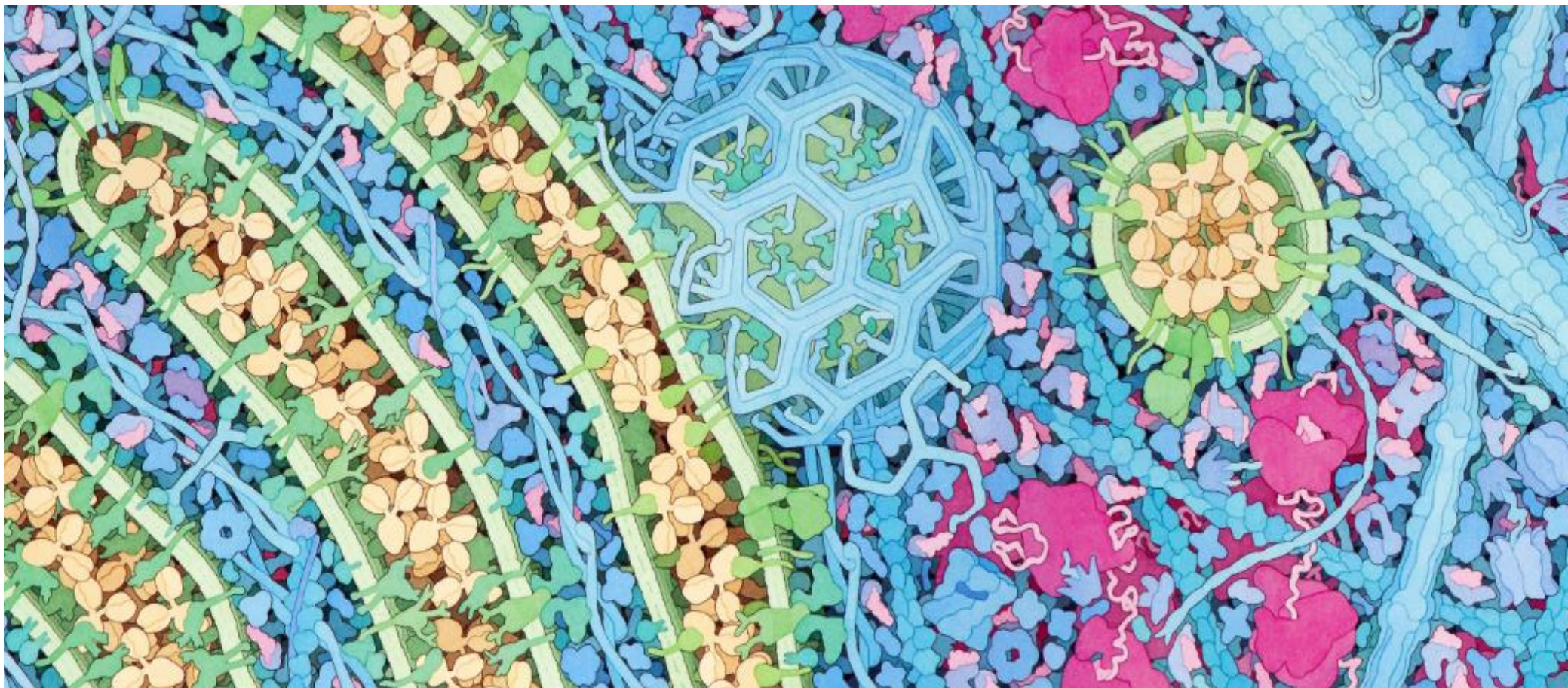


Beta Sheet

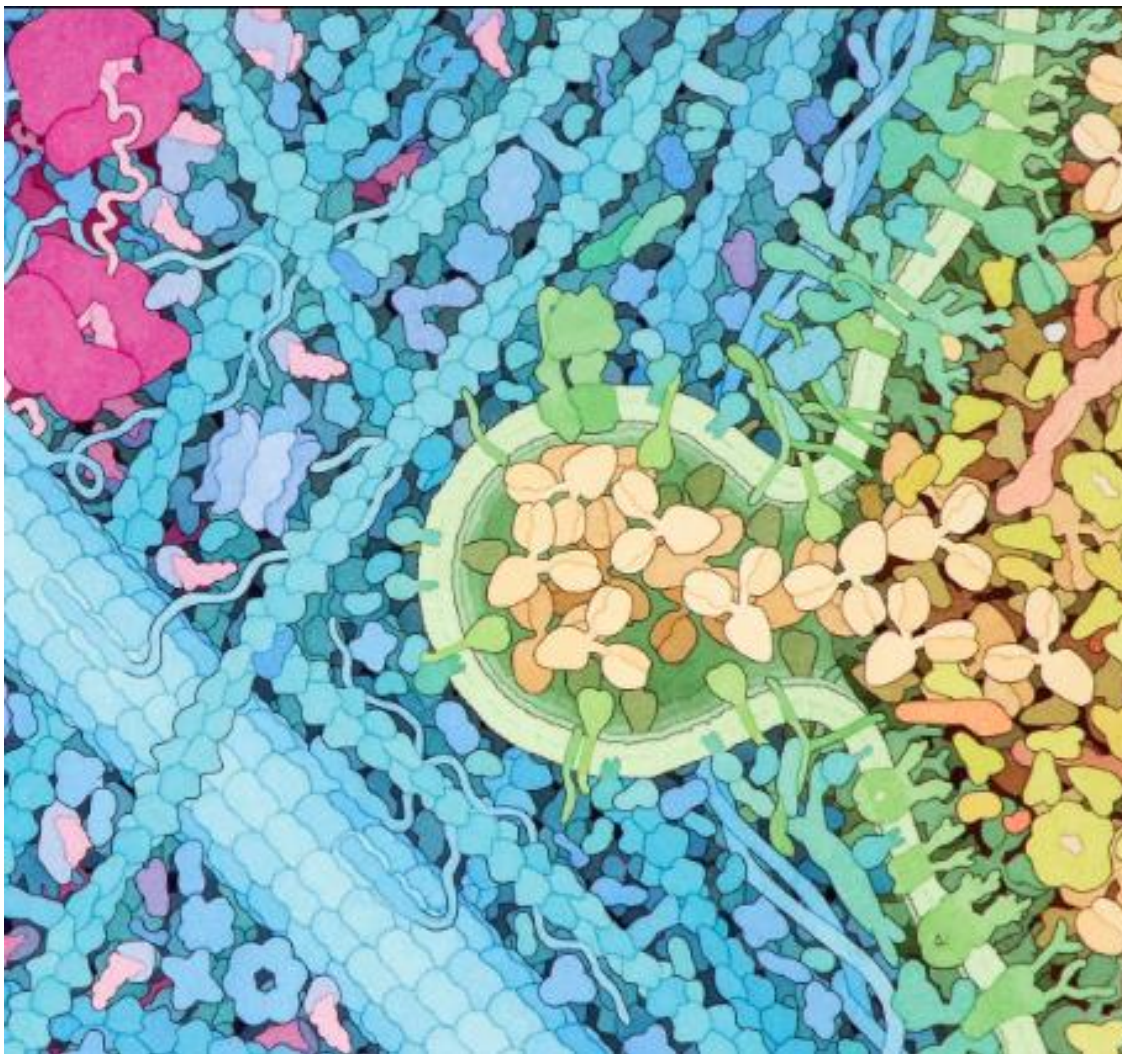
Revisit the panorama



Revisit the panorama



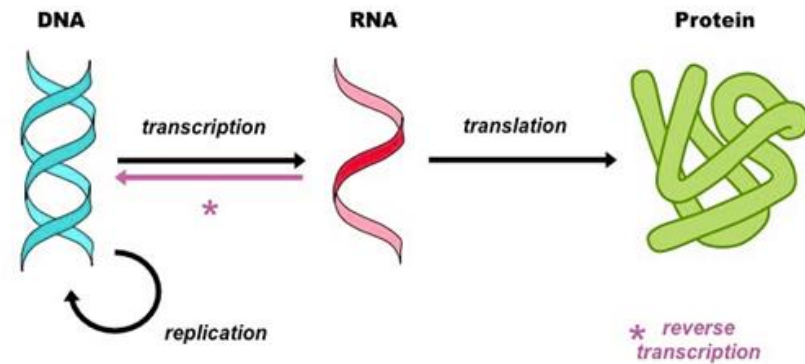
Revisit the panorama



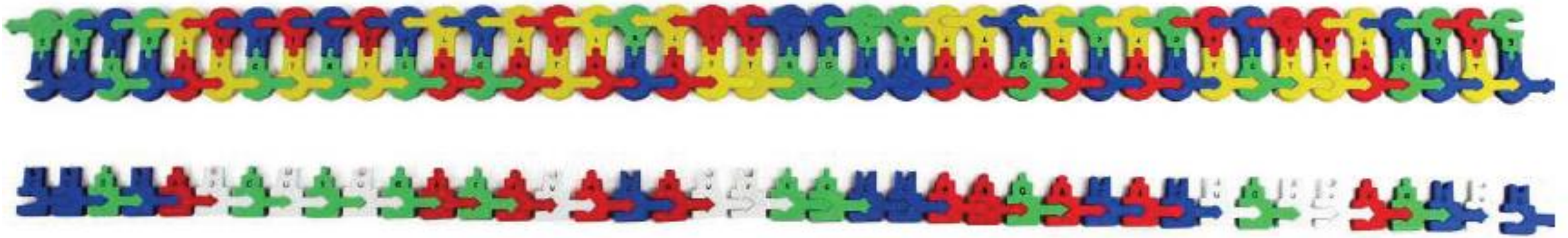
Let's review

DNA Base	RNA Base
T	A
G	C
C	G
A	U
C	G
A	U

CENTRAL DOGMA



DNA and RNA



Helpful Resources

- [Tracking the Resolution of Student Misconceptions about the Central Dogma of Molecular Biology - PubMed \(nih.gov\)](#)
- [DNA → RNA: What Do Students Think the Arrow Means? - PMC \(nih.gov\)](#)
- [What's in a cell? — young people's understanding of the genetic relationship between cells, within an individual: Journal of Biological Education: Vol 34, No 3 \(tandfonline.com\)](#)
- [Teaching More by Lecturing Less | CBE—Life Sciences Education \(lifescied.org\)](#)
- [Eukaryotic cell panorama - Goodsell - 2011 - Biochemistry and Molecular Biology Education - Wiley Online Library](#)

Workshop NGSS Connections

SEPs	CCCs	DCIs
Asking Questions	Scale, Proportion, and Quantity	HS-LS1-1
Developing and Using Models	Patterns	MS-LS1-2
Constructing Explanations and Designing Solutions	Structure and Function	Georgia Standards: SB1 and SB2

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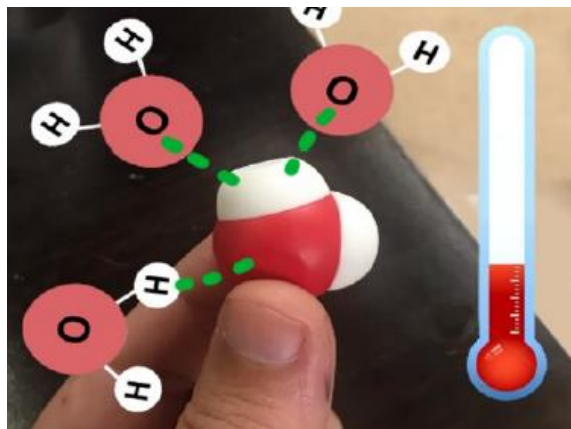
Visit Our Booth!

Continue your exploration of our dynamic kits and models at **Booth 3** !



AR Enhancements

We're enhancing our kits and models to inspire more hands-on learning with new augmented reality features!



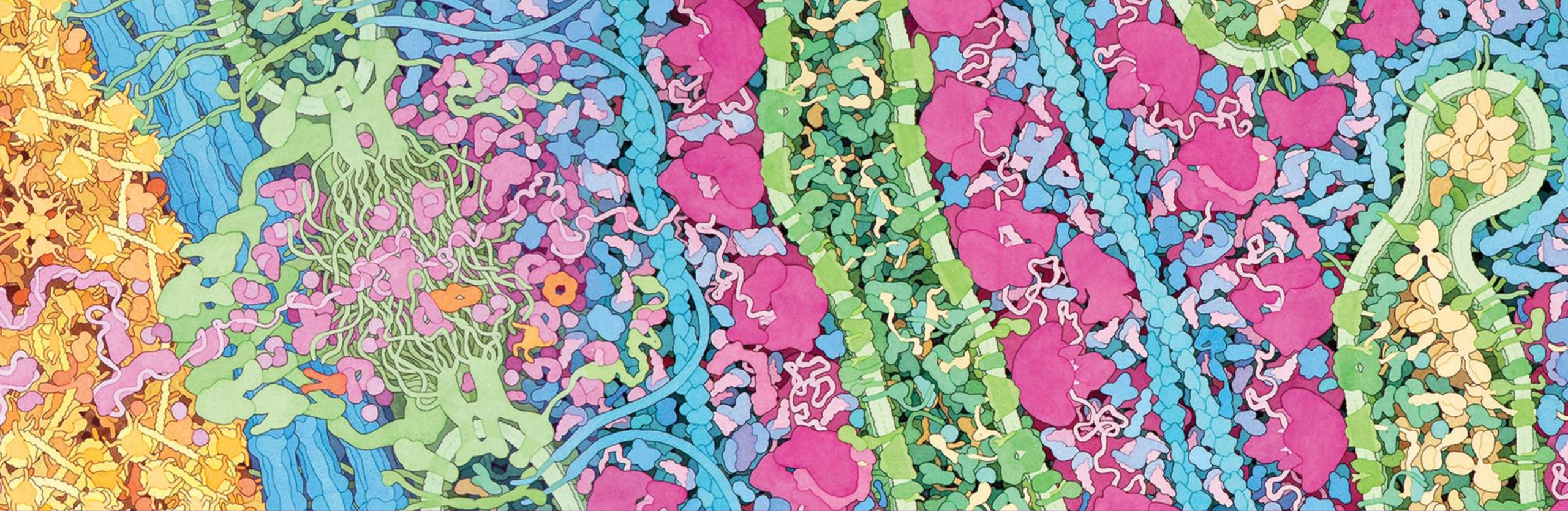
Stop by **Booth 3** to
check out our new
Augmented Reality Enhancements!



We value your opinion!
Let us know what you
think.

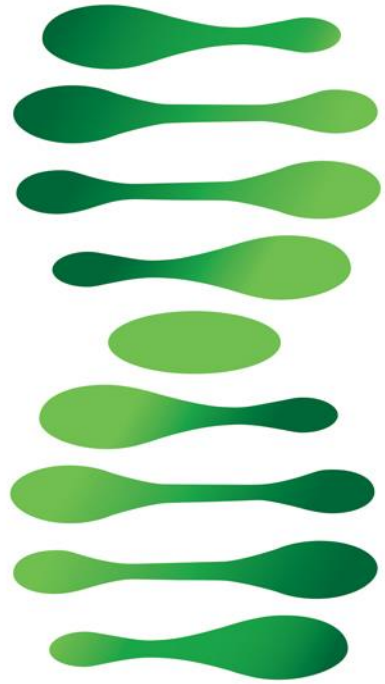
Scan the QR
Code and
complete this
short survey.





3d molecular
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