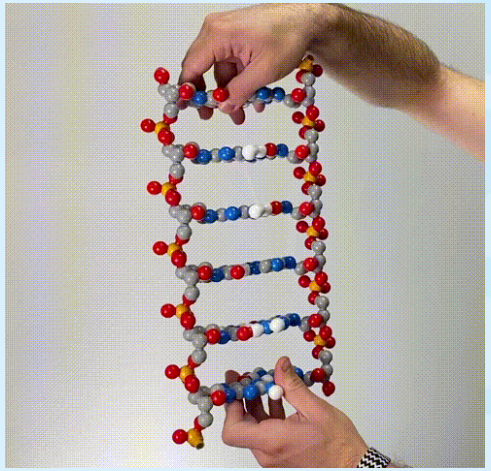
3d molecular designs
Transforming Science Learning

DNA Structure



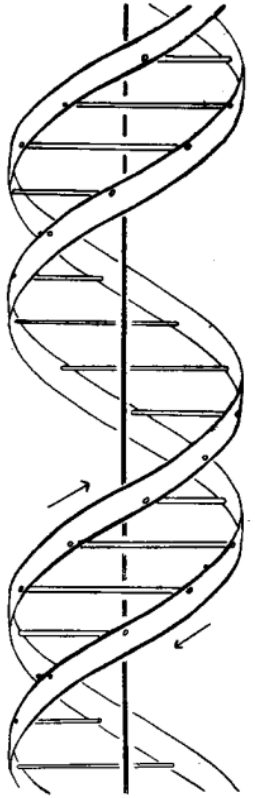
What's so special about April 25, 1953?

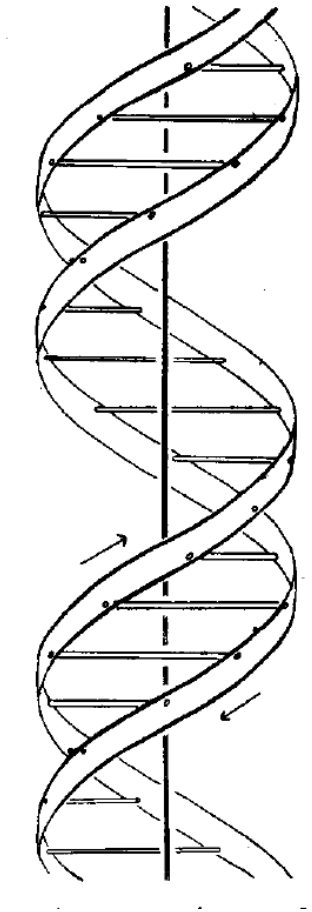
MOLECULAR STRUCTURE OF NUCLEIC ACIDS

A Structure for Deoxyribose Nucleic Acid

WE wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has novel features which are of considerable biological interest.

Nature, 171, pp737-738 (1953)





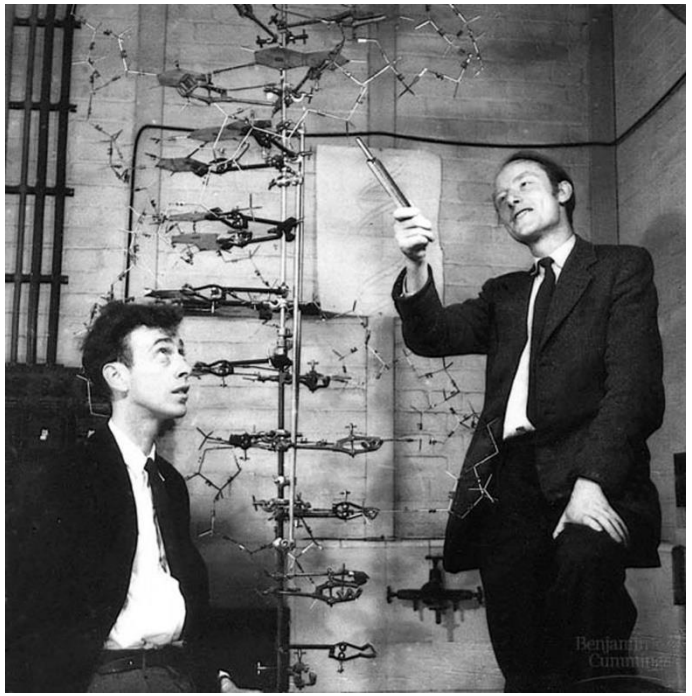
It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material

Nature 171, 737-738, 1953 (April 25)
Molecular Structure of Nucleic Acids

Nature 171,964-967 1953 (May 30)
Genetical Implications of the Structure of Deoxyribonucleic Acid

***Whether a special enzyme is required to carry out the polymerization**, or whether the single helical chain already formed acts effectively as an enzyme, remains to be seen.*

Since the two chains in our model are intertwined, it is essential for them to untwist if they are to separate: As they make one complete turn around each other in 34. A., there will be about 150 turns per million molecular weight, so that whatever the precise structure of the chromosome a considerable amount of uncoiling would be necessary. ***It is well known from microscopic observation that much coiling and uncoiling occurs during mitosis, and though this is on a much larger scale it probably reflects similar processes on a molecular level.*** *Although it is difficult at the moment to see how these processes occur without everything getting tangled, we do not feel that this objection will be insuperable.*



The MRC Laboratory of Molecular Biology

…. a Nobel fellow on every floor….

Courtesy of Cold Spring Harbor Laboratory Archives and Svenskt Press Photo, Stockholm, Sweden.
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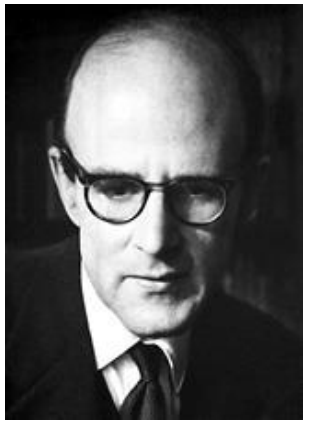
1962 was a very good year….

The 1962 Nobel Prizes…



…in Chemistry – **Max Perutz** and **John Kendrew**
"for their studies of the structures of globular proteins“

…in Physiology or Medicine – Francis Crick, James Watson and **Maurice Wilkins**
"for their discoveries concerning the molecular structure of nucleic acids and its significance for information transfer in living material“

in Literature – John Steinbeck
"for his realistic and imaginative writings, combining as they do sympathetic humor and keen social perception“

The Nobel Peace Prize – Linus Pauling

Teaching DNA Structure

Several things your students need to know…

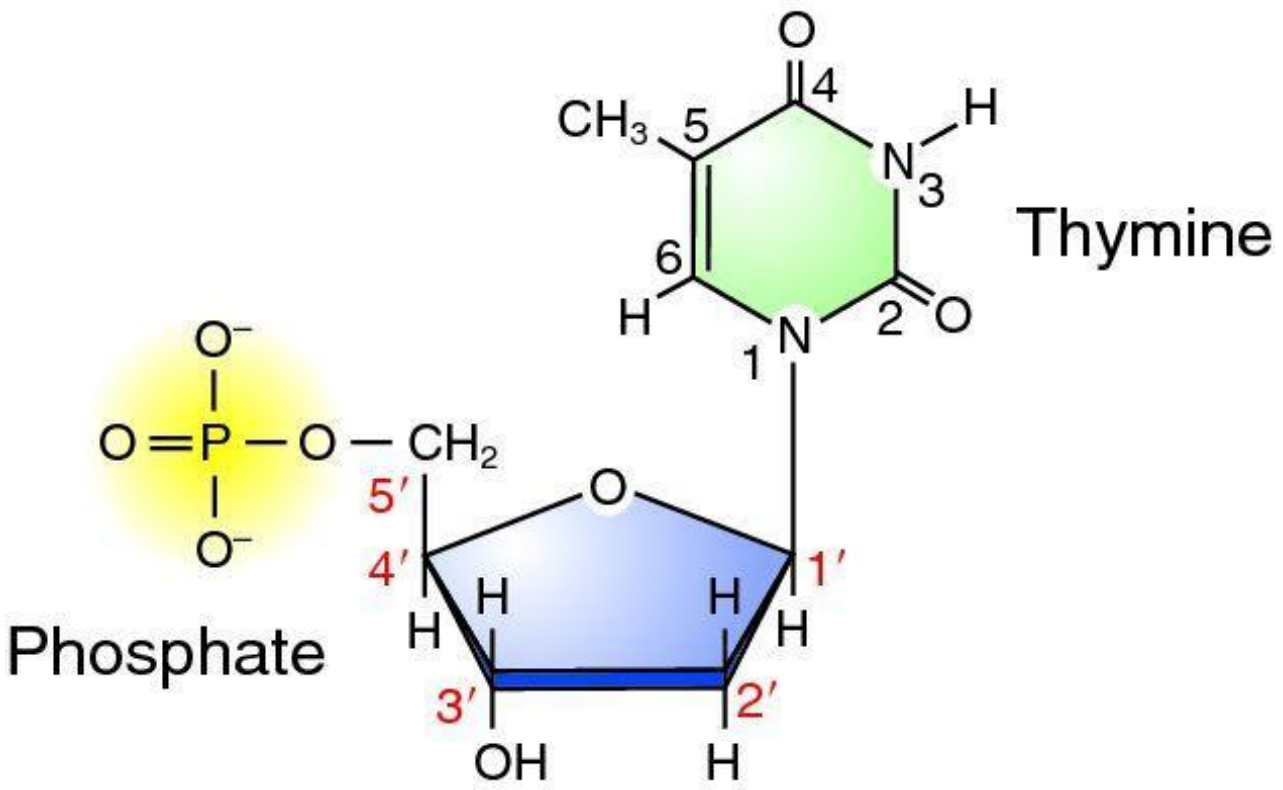
1. **A DNA strand has a <u>polarity</u> …..i.e., a 5’ to 3’ direction.**

2. **The two strands of double-stranded DNA are <u>antiparallel</u>.**

3. **The two strands are joined by complementary Watson-Crick base pairs.**

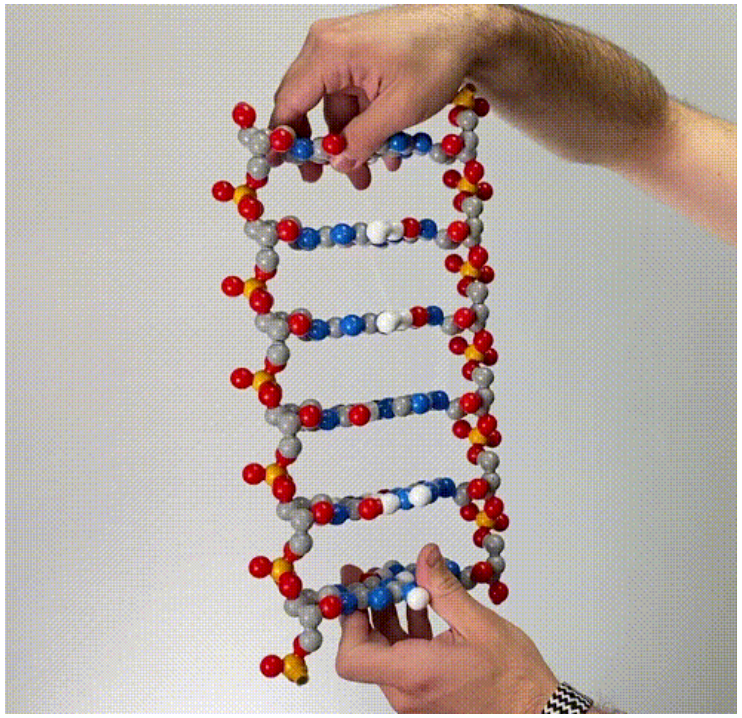
A = T G ≡ C

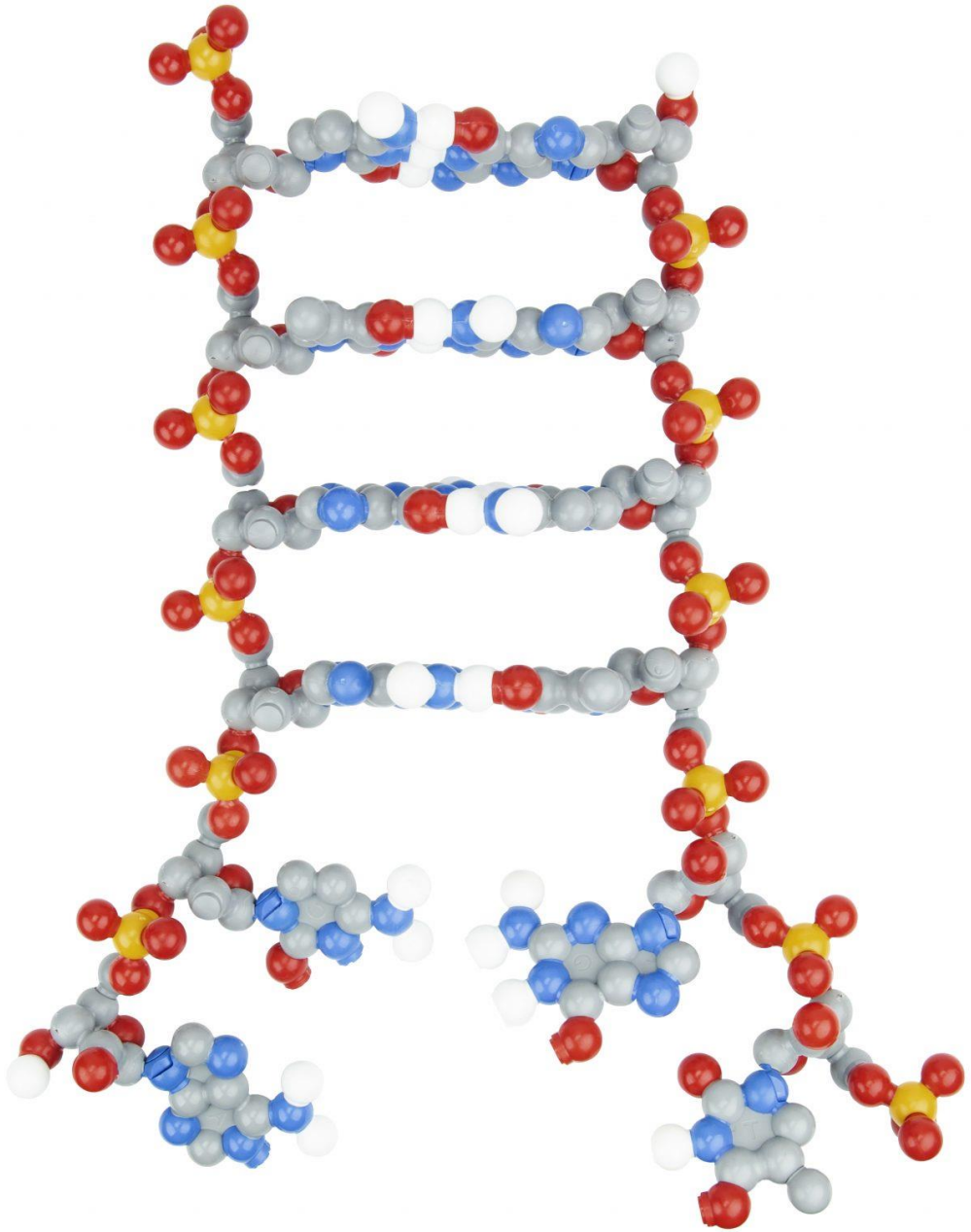
What does "prime" mean?,… and do I have to teach it?

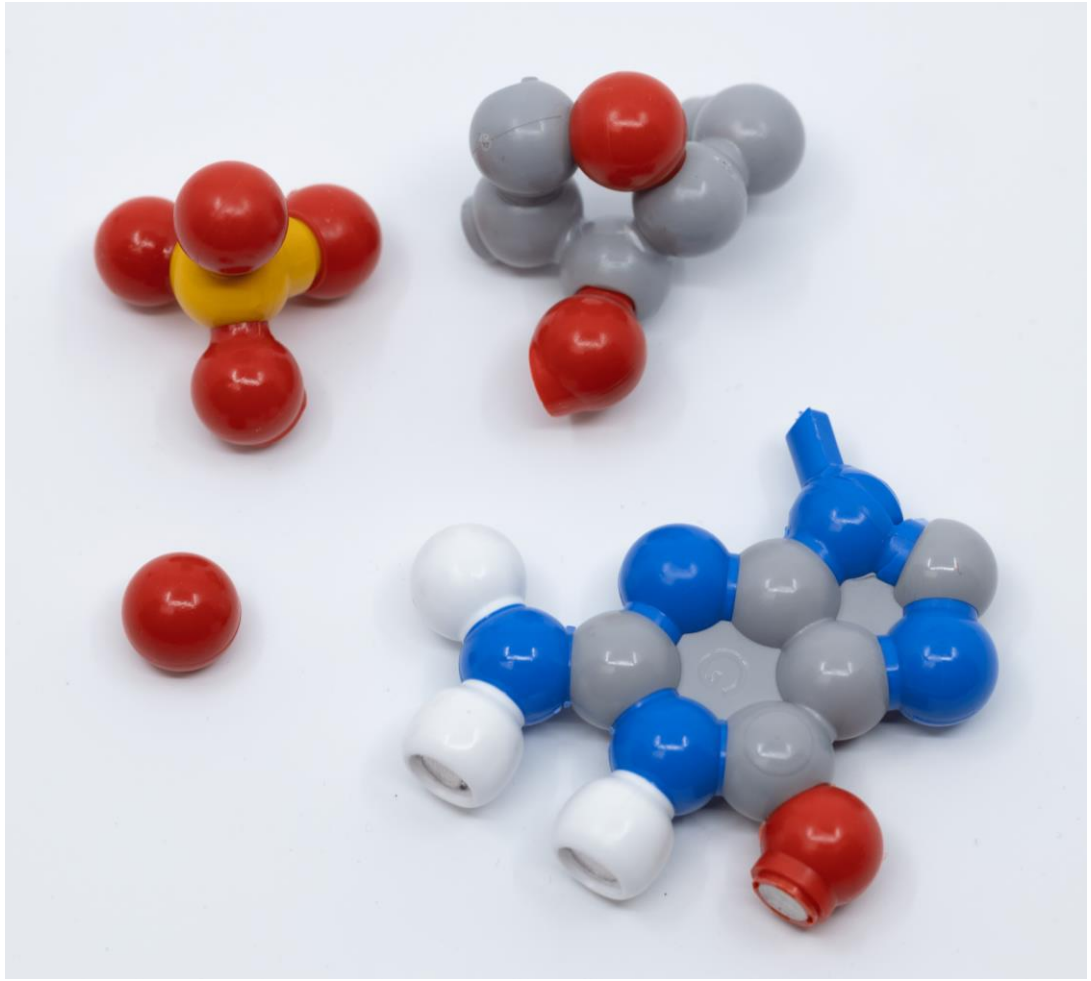


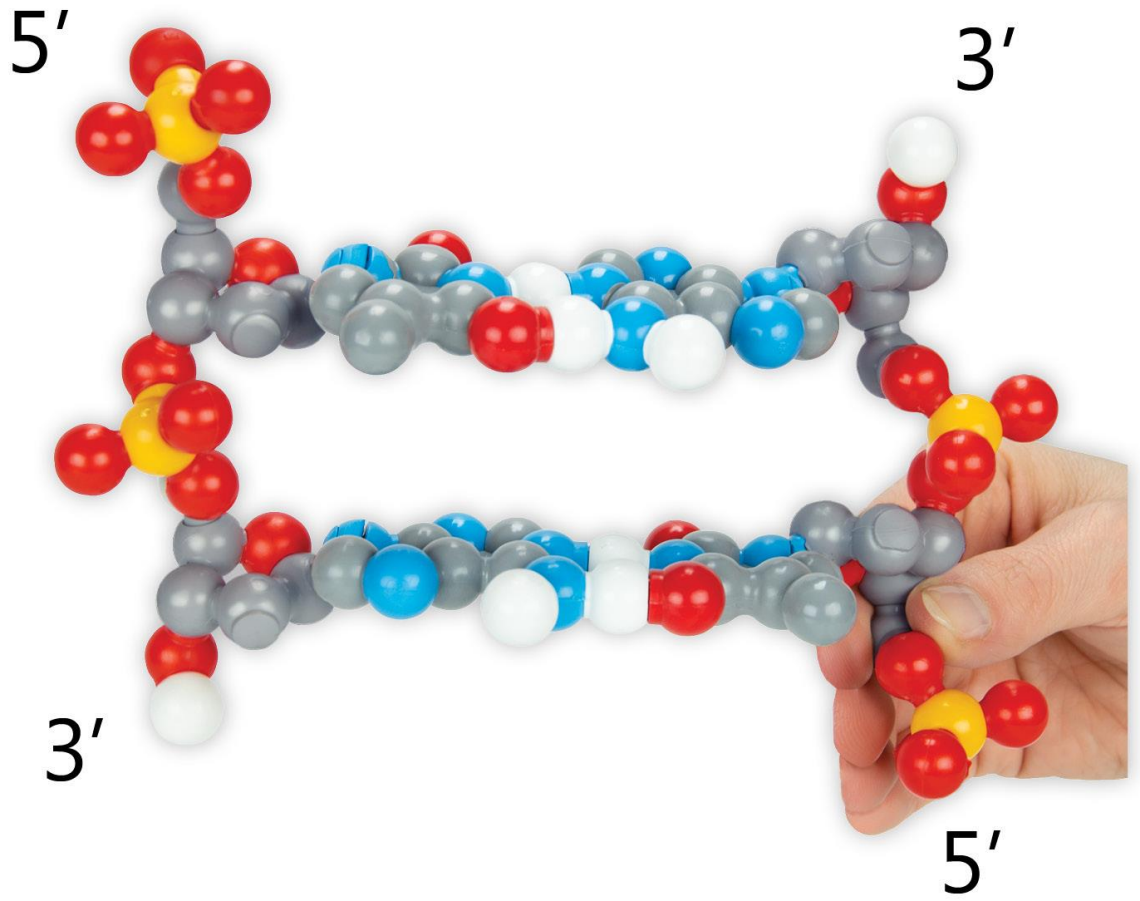
YES!

The Dynamic DNA Kit



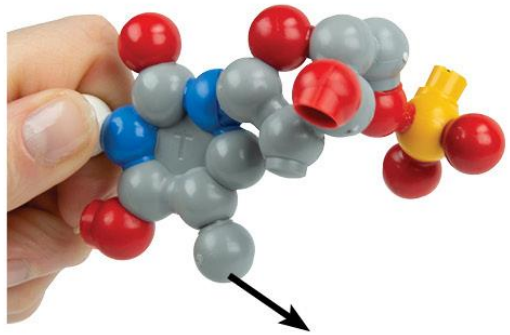


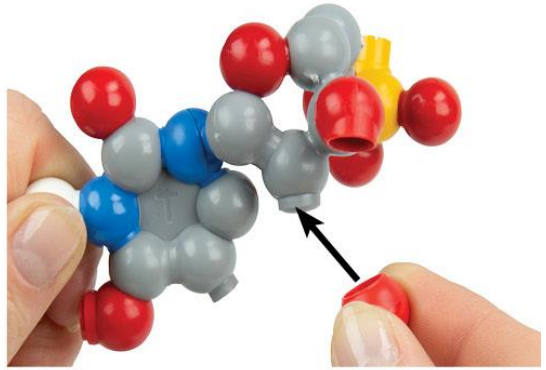


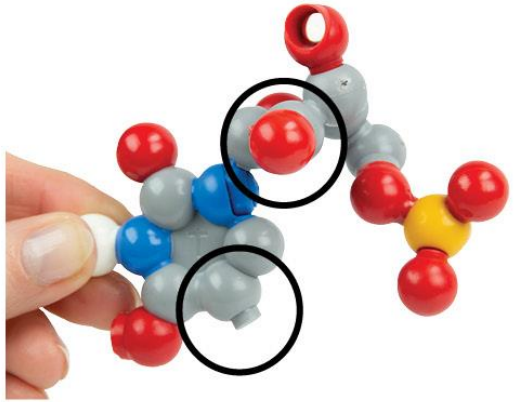

5′
3′
3′
5′

Minor Groove

Major Groove







Converting DNA to RNA

(deoxyribo-TMP to ribo-UMP)

STEP 1: Remove the #5 carbon from Thymine. (This converts T to U)

STEP 2: Add an oxygen to the 2'carbon of the deoxyribose sugar. (this converts deoxyribose to ribose)

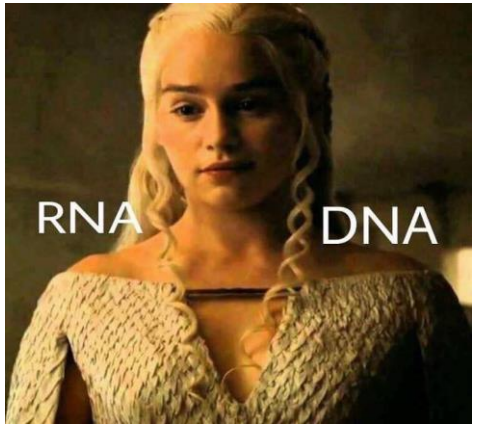
Making ATP

Teaching your kids to think……

As you reflect on your teaching, you may notice that you ask your students a lot of ”what” questions,……. like:

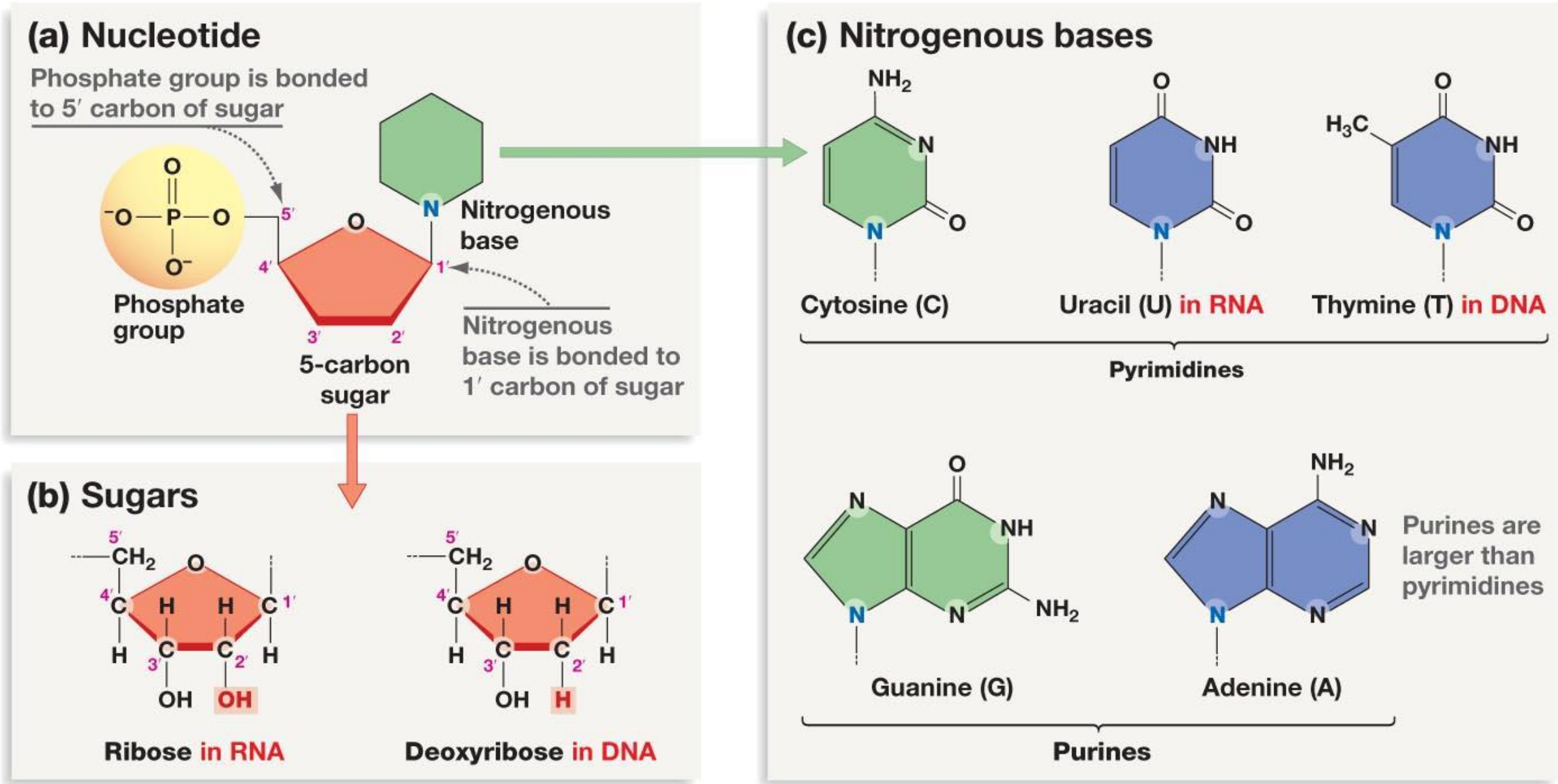
What is the difference between DNA and RNA?

- ***RNA has U’s and DNA has T’s***
- ***DNA has deoxyribose,….RNA has ribose***
- ***RNA is single-stranded; DNA is double-stranded***



Let's think about teaching the "*why*" of these subjects, such as:

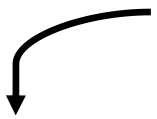
Why does T replace U in DNA?



WHY…did T replace U in DNA?

…if we had not switched…

spontaneous oxidative deamination of C



AGUCGAAGUCAACCGAGGCUGCGCUAC
UCAGCUUCAGUUGGCUCCGACGCGAUG

AGUCGAAGU$^{U}_{x}$AACCGAGGCUGCGCUAC
UCAGCUUCA$_{G}$UUGGCUCCGACGCGAUG

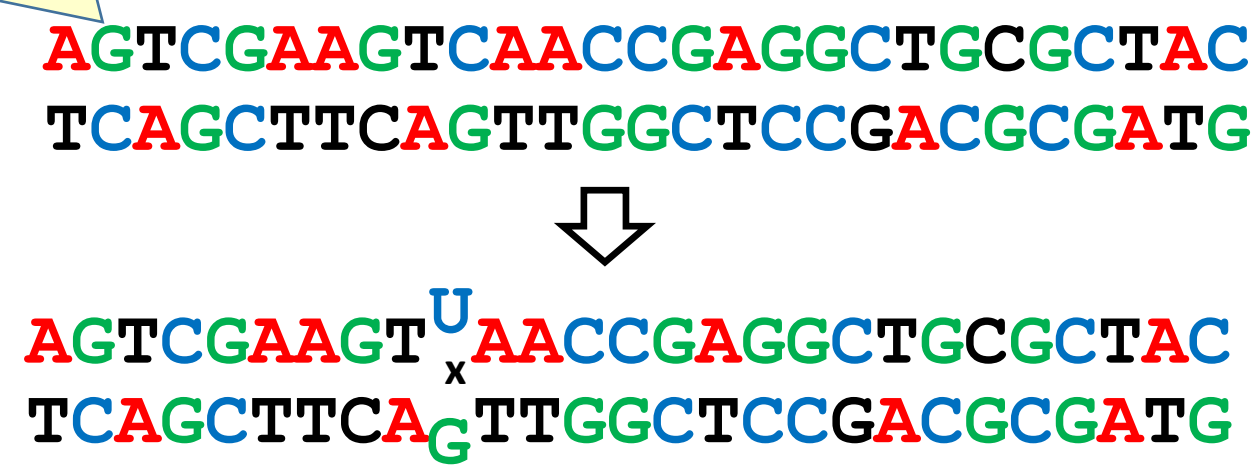
A DNA repair system can remove “U” from DNA.
But,…how can we distinguish between a
“deaminated C” and a normal U?

ANSWER: We can’t.

WHY…did T replace U in DNA?

…but after we switched…

spontaneous oxidative deamination of C



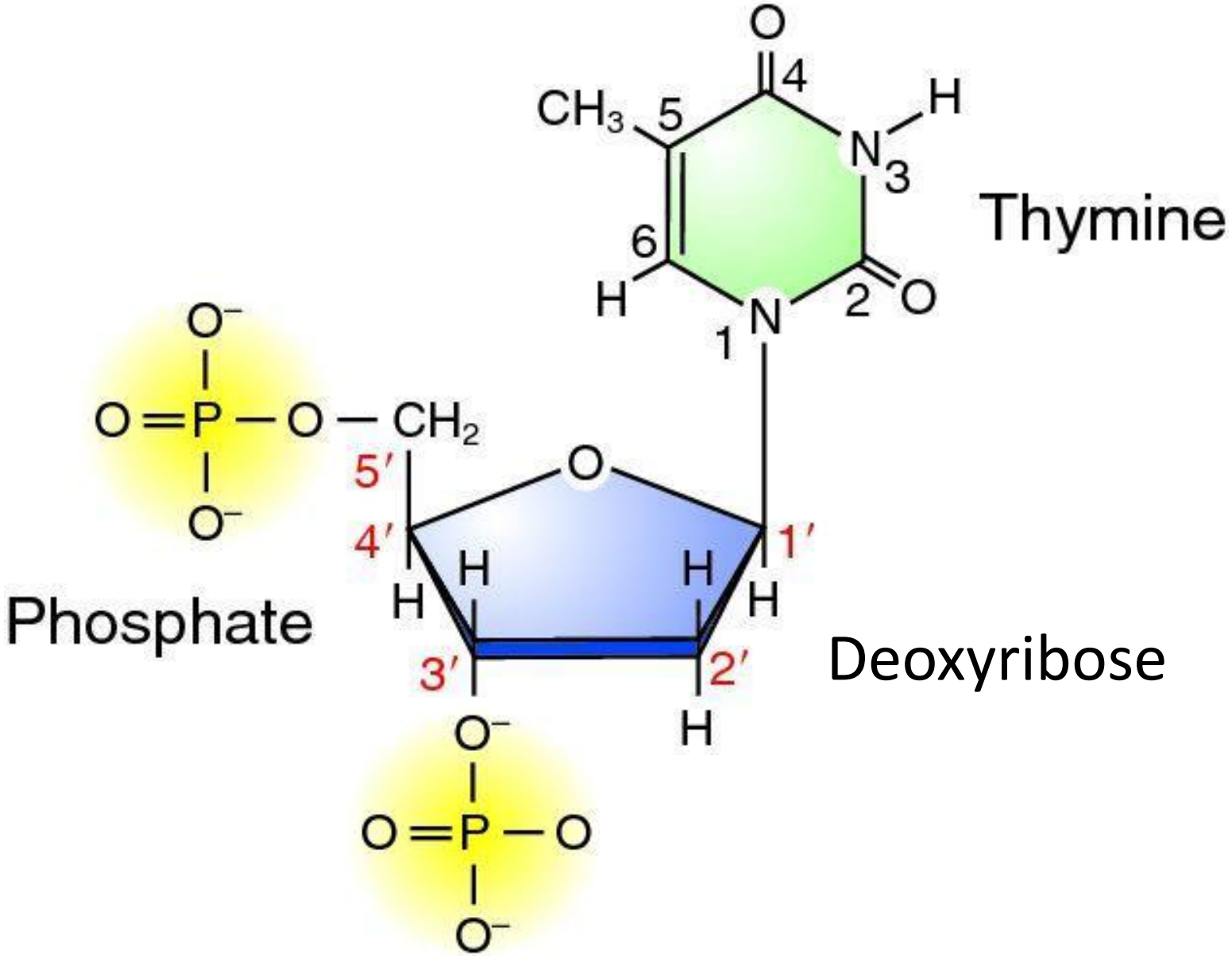
Uracil glycosidase constantly scans the DNA….looking for U's.
Any U … is a bad U…and should be repaired.

Let's think about teaching the "*why*" of these subjects, such as:

Why does T replace U in DNA?

Why is RNA single-stranded?

….but wait,….RNA is not single-stranded…

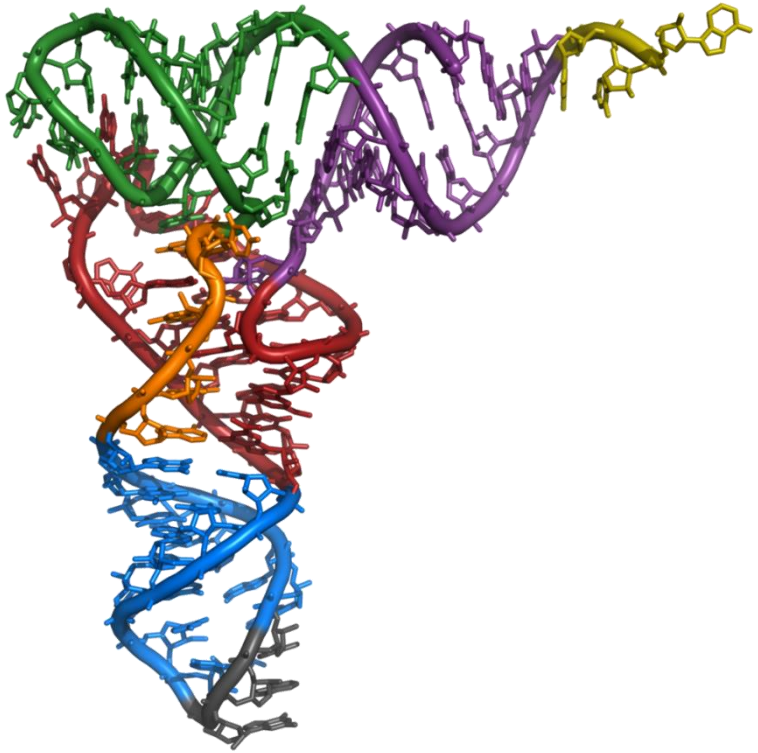

Thymine
Phosphate
Deoxyribose

But wait,… we are not done with DNA Structure.

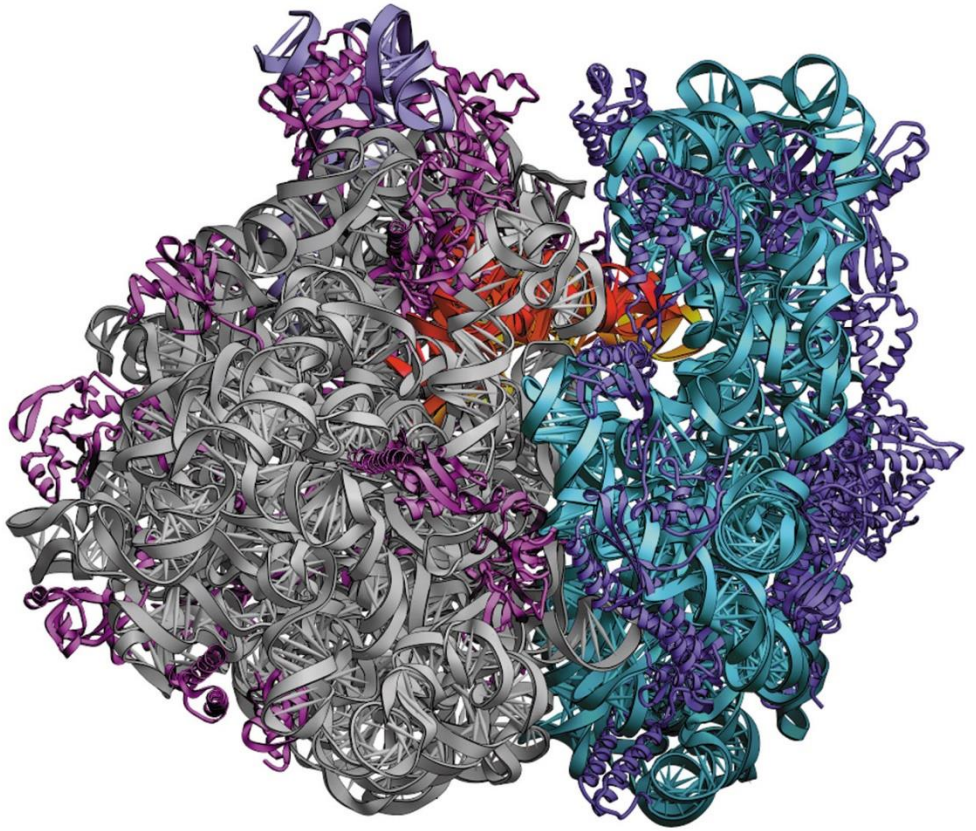
We now need to introduce Epigenetics,…
and how chemical modifications to the DNA bases
can regulate gene expression.

Stay Tuned…

RNA folds up into a compact 3D shape,… following the same principles of chemistry that drive protein folding.



tRNA



ribosome