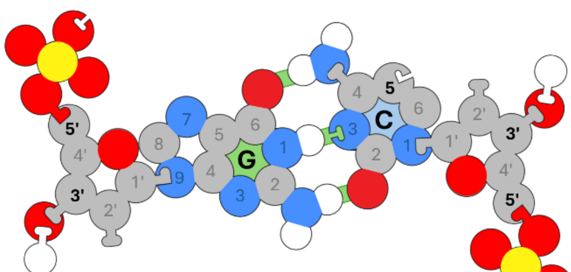
Molecules of Life…

You spoke…and we listened.

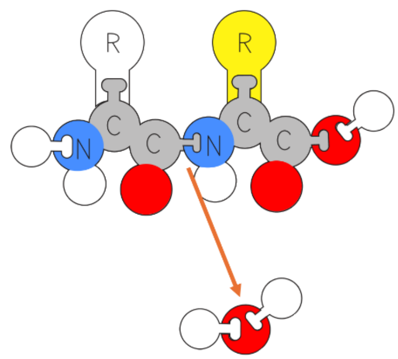
The **Tactile Base Pairs** kit is now part of an expanded **Molecules of Life** kit.

If you ordered the *Tactile Base Pairs* kit,… we are now sending it to you along with foam-based modeling components for *Amino Acids, Carbohydrates* and *Phospholipids*.

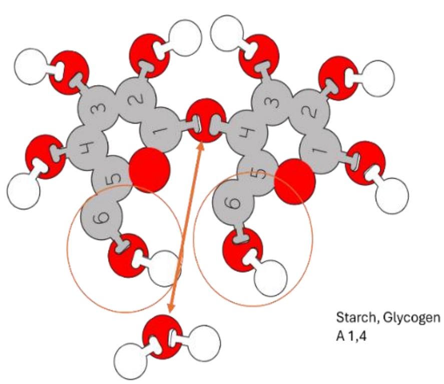
Enjoy. Is this a great country ,… or what?



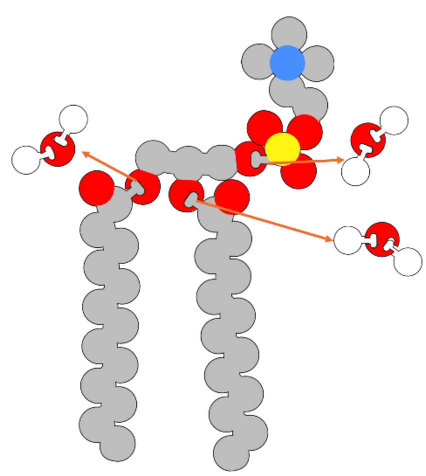
Tactile Base Pairs



Amino Acids

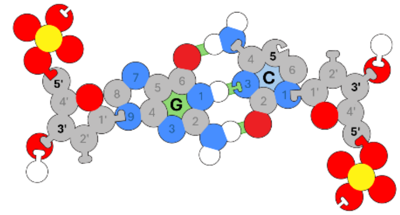


Carbohydrates



Phospholipids

Molecules of Life… Tactile Base Pairs



The **Tactile Base Pair** kit has seen some significant changes since the 2024 *Modeling Infection and Immunity* summer course. Among the changes, we…:

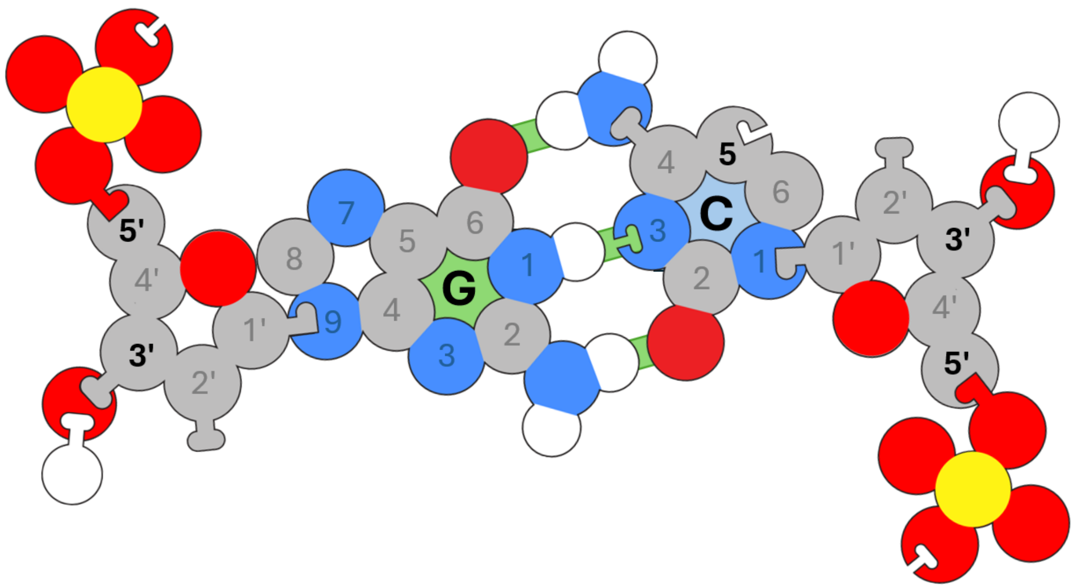
- Reduced the scale of the foam components to make the kit more economical.
- Altered the design of the components so that *the anti-parallel nature of the complementary base pairs is emphasized*.
- Altered the design of the components so that *individual nucleotides can be linked together via phosphodiester bonds to make single-stranded DNA or RNA*…. with 5’ to 3’ polarity.

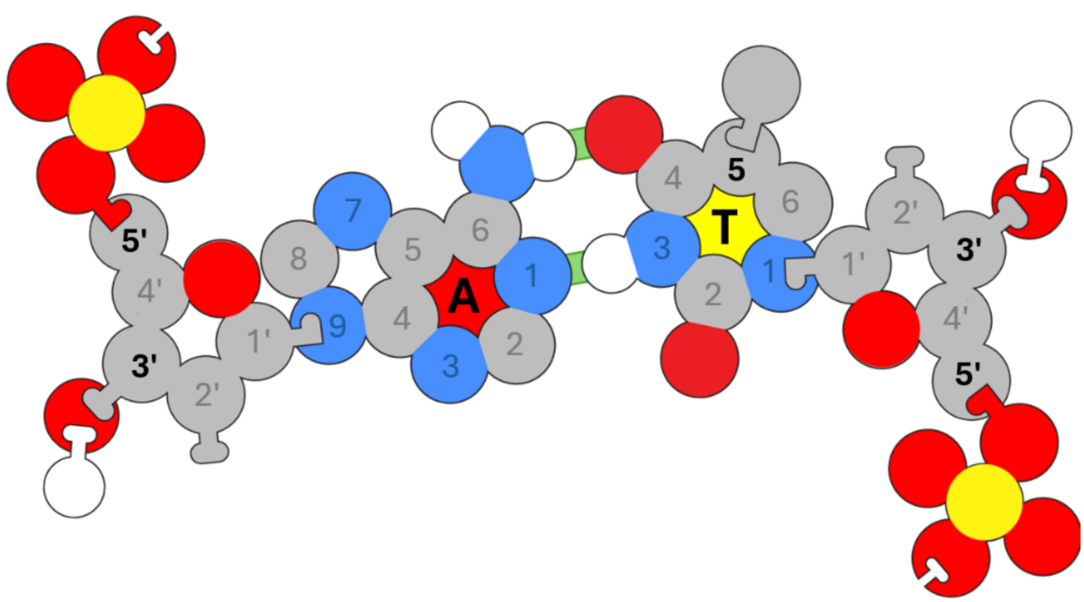
While making the changes noted above, we retained the popular features of the original model including:

- The 5’ to 3’ polarity of each nucleotide is clearly defined on each deoxyribose sugar.
- A hydroxyl group can be added to the 2’C of deoxyribose to make ribose.
- T can be changed to U by removing the methyl group from C5.
- The Cytosine base can undergo oxidative deamination… to form Uracil. This slow conversion of C to U explains why we changed from U’s in RNA to T’s in DNA.
- The Cytosine base of a CpG dinucleotide can be methylated… when talking about epigenetics and the regulation of gene expression.
- When a methylated Cytosine undergoes oxidative deamination… it forms Thymine…which can lead to a mutation that is not easily repaired. This in turn explains why the CpG dinucleotide is under-represented in the human genome.

Here are the initial base pairs… that you saw in the summer course.

(Note that if you print this graphic from the PowerPoint that accompanies this documentation – it will print on an 8.5 X 11 piece of paper at a scale that matches the scale of the foam nucleotides.)





As you field-test this new version of the Tactile Base Pairs kit with your students, we will be especially interested in hearing about ....

- How the anti-parallel nature of the base pairs was appreciated by your students, and .....
- How these individual nucleotides were linked together to make a single-stranded DNA/RNA with 5' to 3' polarity.

And as always, we are interested in your suggestions for other features you would like to see incorporated into this model.

And,.... ***Watch our Digital Modeling Hub for a series of short videos*** addressing how this kit can be used to talk with your students about more advanced topics such as:

- Why did we switch from U to T when we moved from the RNA world to the DNA world.

- How our DNA repair system constantly scans our genome to find any U's that might be there...and removes them.

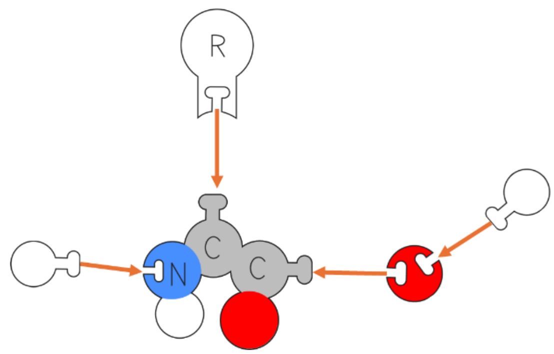
- Epigenetics.... And how methylation of the cytosine in a CpG dinucleotide can modify gene expression.

- Why the CpG dinucleotide is under-represented it the human genome.

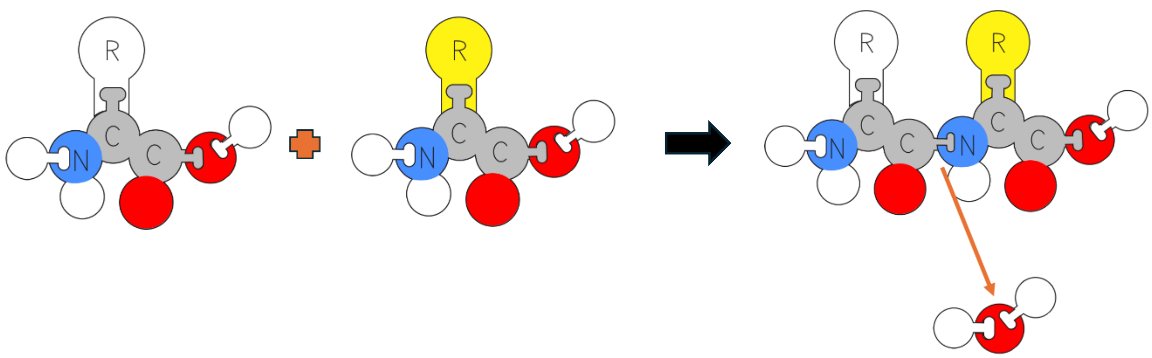
- Pseudouridine,... and its role in stabilizing tRNA structure and mRNA vaccines.

Molecules of Life,…. Amino Acids

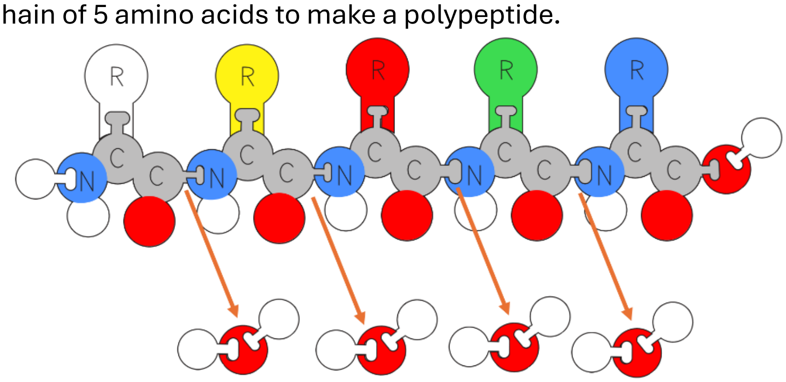
Begin by building five examples of amino acids, each with a different R-group.



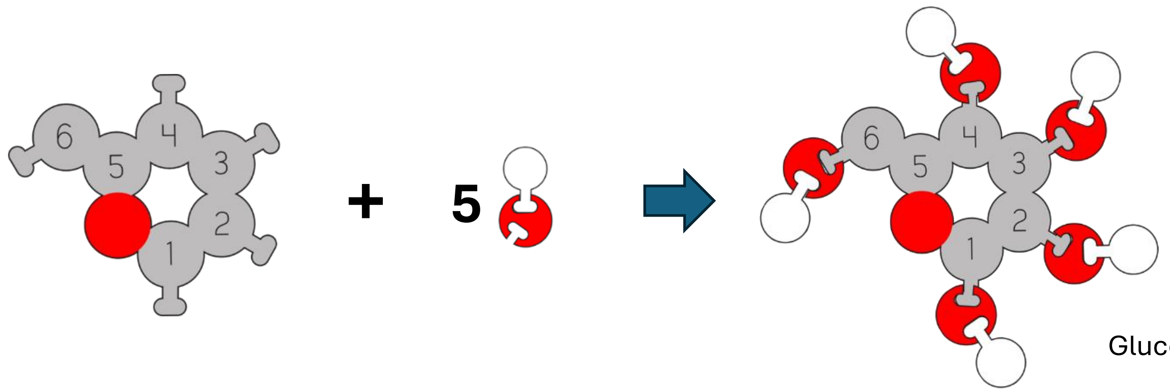
Model dehydration synthesis (condensation) reaction with two amino acids to make a dipeptide.



Next build a chain of 5 amino acids to make a polypeptide.



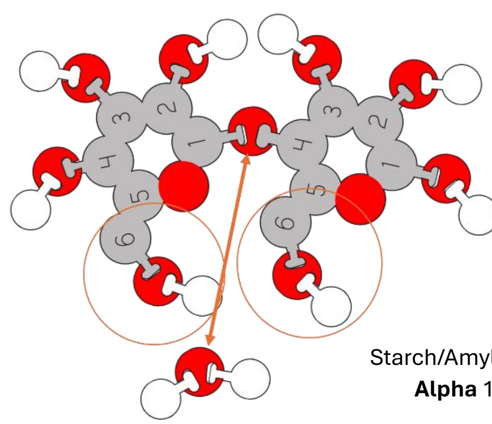
Molecules of Life,.... Carbohydrates



Glucose

Begin by adding hydroxyl groups to the glucose ring,… to make glucose.

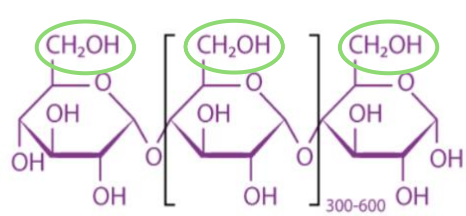
Next,… link two glucose molecules together by forming a glycosidic bond between C1 of one glucose and C4 of the other. This is known as a 1-4 linkage. Note that this is another example of dehydration synthesis.



Starch/Amylose/Glycogen
Alpha 1-4 linkage

But "Life is Complicated". Depending on the stereochemistry of the 1-4 linkage, you can make either a digestible **starch/amylose** or a non-digestible (by humans) **cellulose**.

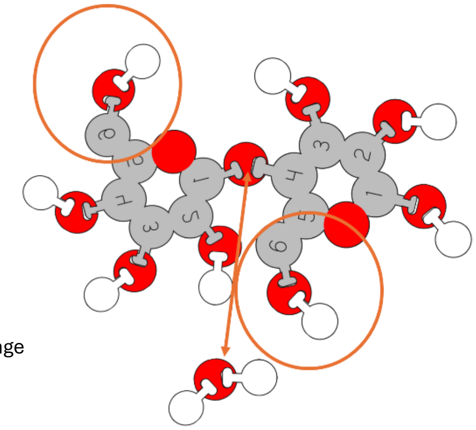
The disaccharide that you made (shown above and in the figure below) is joined by an alpha 1-4 linkage as found in starch or amylose. How can you tell? Look closely at the exocyclic C6. If the C6 atoms are all on the same side of the polymer you can be assured that you have made a



model of a digestible starch/amylose in which the glucose units are joined by alpha 1-4 linkages.

In contrast to digestible starch, cellulose is a non-digestible carbohydrate in which the glucose units are joined by a **beta**-1-4 linkage.

Challenge your students to construct a model of cellulose. If their model is correct, each consecutive C6 atom will be on *opposite sides* of the polymer.



Cellulose
Beta 1-4 linkage

(Note that to model cellulose, you will have to flip one of your glucose units over to mimic the different stereochemistry of this beta-1-4 linkage. And when we say that humans cannot digest cellulose – we really mean the we don't make an enzyme that can recognize a beta-1-4 linkage,... and then break this bond.

Field-test notes: This is our first attempt at generating a carbohydrate kit. So we are expecting lots of suggestions for improvements. Let us know what you teach related to this topic, and what additional models you may need.

Note that after your students have seen that linking two sugars together involves dehydration synthesis,... you could have them remove all the other hydroxyl groups ... in which case the exocyclic C6's will become much from visible.

Molecules of Life … Phospholipids

- Begin with the three-carbon glycerol.
    - Add hydrogens…to complete the hydroxyl groups on the glycerol.
- Find the phosphatidyl choline head group…and add a hydrogen to the phosphate group.
- Complete the fatty acids… by adding a hydroxyl group.
- Join the three components… modeling dehydration synthesis.