

STEM Connections

Drug Design
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How are medicines designed

When we as scientists first make medicines, we first select a target (often a protein) we want our medicine to work on. Then, we start to look at chemicals that naturally attract that protein target and where they attach to. By making chemicals that look similar to natural chemicals we can also attract to our target protein's active site. We can then test and tune our molecules to make a medicine that is effective and safe.

MAKING MOLECULES – HOW TO DESIGN MEDICINES

START HERE!

1 When we make medicines, we first select a target (often a protein) we want our medicine to work on

2 We then start to look at chemicals that naturally attach to that protein target and where they attach to (their active site)

3 By making chemicals that look similar to natural chemicals we can also attach to our target protein's active site

4 We can then test and tune our molecules to make a medicine that is effective and safe

How We Design Medicines...

Challenge 1
Can you make this ibuprofen molecule (I) and fit it into COX-2's Active Site?
Note: Red atoms like to go in the blue areas of the Protein Active Site

Challenge 2
Can you make this oseltamivir molecule (O) and fit it into this neuraminidase's Active Site?
Note: Red atoms like to go in the blue areas of the Protein Active Site and blue atoms like to go in the red areas

Challenge 3 – Can you make a molecule that fits better than oseltamivir or ibuprofen?

The chemical kits you are building with are like building blocks but for scientists. Each ball represents a different chemical element – the building blocks of life, the universe – literally everything!
Black is carbon ● red is oxygen ● blue is nitrogen ● and white is hydrogen ●. These chemical elements are important for life and found in all of us!
Each element can attach to another using a chemical bond, the plastic connectors, a certain number of times; 4 for carbon, 2 for oxygen, 3 for nitrogen and 1 for hydrogen.

Be creative and build!

Here are two target proteins of medical interest.

The left one (←) is a protein called cyclooxygenase-2 (COX-2). This protein is involved in inflammation – the painful red swelling you get when you are sick. It is normally targeted by a medicine like ibuprofen.

The right protein (→) is a neuraminidase. It is involved in letting chemicals in and out of your cells. It is also used by viruses to get in and out too, which makes it a good target for stopping viral infections like flu. It is normally targeted by medicines like oseltamivir known as "Tamiflu".

Gibson Group

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6dsh.pdb

3cd1.pdb

How to make your own molecules

Suitable year group: Year 5, Year 6, Year 7, Year 8 and Year 9

Learning Objectives:

- To understand chemical symbols and formulas for elements. (KS2)
- To understand periodic table with ability to identify physical and chemical properties of different elements. (KS3)
- To practice and create molecular structure with use of different types of bonds (e.g. single or double bonds). (KS3)
- To be able to convert molecular formulas into molecular structure. (KS3)
- To understand the structure of cells and the function of active sites. (KS3)

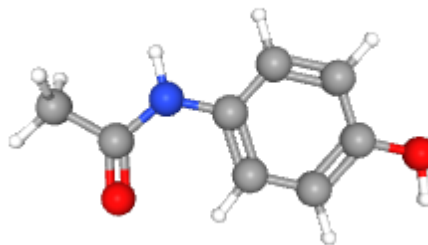
Materials required:

- Dry spaghetti/ cocktail sticks to represent the bonds
- Different coloured sweets/pom pom balls/clay/play dough to represent the atoms

Estimated time: 20 minutes

Step by step instructions:

1. Go onto [PubChem \(nih.gov\)](http://pubchem.nih.gov) and search for a compound e.g. aspirin, ibuprofen. Have a look at medication at home and look up the different compounds that make it up.
2. Scroll down to the structure section of the page where you can find the 3D structure of the compound. The pictures on the right are an example of paracetamol.

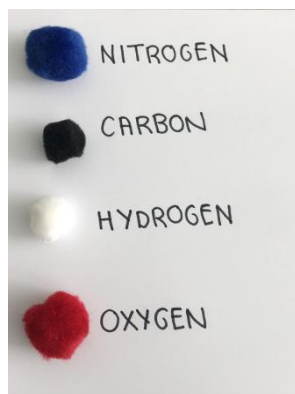


3. Each colour represents a different atom.

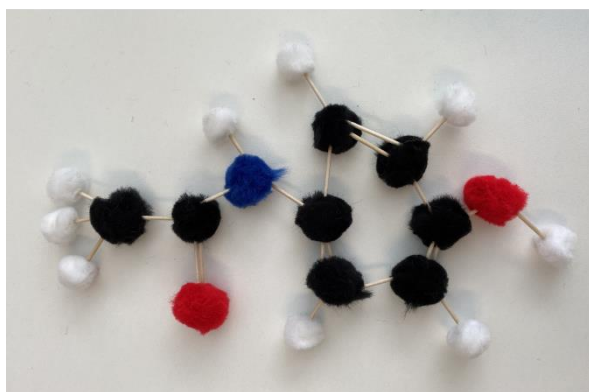
The standard colour system:

- Blue – nitrogen
- Red – oxygen
- Grey – carbon
- White – hydrogen

Use the different coloured materials for the atoms you have available for each different type of atom



4. Put the molecule together, taking care to use the correct amount of bonds based on the diagram



5. Have a look at other compounds that you can find and read more about what they are used for.

Ideas to explore the concept further

- Where can you find these compounds? (e.g. medicine)
- How can you make the model of the molecules stronger?