Zometool Project Series: the world's most powerful (and fun!) modeling system. Kids, educators, and Nobel-prize winning scientists all love Zometool:

- it's unique, brilliant, beautiful
- all kits are compatible—more parts, more power!
- guaranteed for life!

"The mind, once stretched by a new idea, never regains its original dimensions." *–Oliver Wendell Holmes*

Molecular Mania

Includes detailed instructions by Dr. Steve Yoshinaga

Parts: 42
3
13
2
28 cards
5
2
12
5

Discover the building blocks of nature! Zometool Molecular Mania has everything you need to build 28 important molecules, including:

- *Water*
- *Carbon Dioxide*
- *Acid, alcohol and many more!*

The 28 molecule cards and precision Zometool components in this project are compatible with Zometool Biochemistry project and Molecule Creator game.

MADE IN USA
from kid-safe materials

7 09743 20032 5

US Patents RE 337,85; 6,840,699 B2
Zometool is a registered trademark of Zometool Inc.

Based on the 31-zone system discovered by Steve Baer, Zomeworks Corp., USA

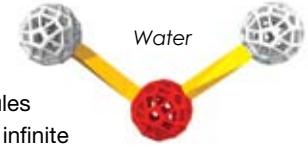
WARNING:
Swallowing Danger
CONTAINS SMALL PARTS that are NOT suitable for children under 3 years of age.

zometool.com

• 888-966-3386 • www.zometool.com •

START HERE! BUILDING BLOCKS OF THE UNIVERSE

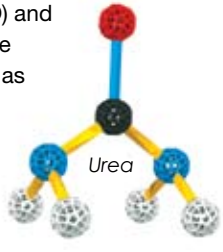
Atoms are the building blocks of the universe. When two or more atoms are connected, or bonded together, a **molecule** is formed. Molecules have an almost infinite variety of sizes, shapes and functions. You will learn to use atoms as building blocks to make models of many of your favorite molecules, starting with water (H_2O), oxygen (O_2) and carbon dioxide (CO_2).


Water

Many elements, few used in nature's molecules

All of the known atoms are categorized in the Periodic Table of the Elements. Even though there are over 100 different elements, most of the molecules in the world are made from only a handful of these atomic building blocks. In particular, life molecules are unbelievably diverse, even though they are composed mainly of carbon (C), hydrogen (H), oxygen (O) and nitrogen (N) atoms. To be sure, other atoms, such as phosphorus and sulfur, are found in life molecules, but the chief building blocks are C, H, O and N.


Oxygen Gas


Urea

Why model?

When we build a model car, we make a likeness of the car, but it is only a small fraction of its real size. In molecular modeling, we visualize what we cannot see by making a replica billions of times bigger than the real molecule. Atoms and molecules are too small to see, but that doesn't mean they aren't real. In fact, in a way, they are more real than what we can see, because most reactions occur at the molecular level! To know what's really happening, you have to think small. Using color codes and a few simple bonding rules, you will soon be making beautiful molecules.

HOW TO MODEL

Molecular modeling with this kit is easy. The colored balls, or nodes, represent a particular atom. For instance, carbon is black and hydrogen is white. The molecular bonds are the connectors, or struts. They are also color coded. The yellow struts are single bonds, the blue struts are double bonds, and the red struts are triple bonds.

Color codes

ATOMS (NODES)

Carbon (C) is black, hydrogen (H) is white, oxygen (O) is red, and nitrogen (N) is blue, as indicated in the figure. In advanced kits, phosphorus (P) is orange, sodium (Na) is green, and sulfur (S) is yellow.

ATOMIC COLOR CODES		
C	Carbon	4
H	Hydrogen	1
O	Oxygen	2
N	Nitrogen	3

BONDS (STRUTS)

A single bond is yellow, a double bond is blue, and a triple bond is red.

BOND COLOR CODES
Single Bond
Double Bond
Triple Bond

Different atoms make different numbers of bonds

The main building block of nature is the carbon atom. Carbon makes four bonds with other atoms to stably fill its electron orbitals. Nitrogen makes three bonds, oxygen makes two and hydrogen makes one bond. Single, double, and even triple bonds can be combined to satisfy the bonding requirement of each individual atom. For instance, carbon can make a double bond and two single bonds to satisfy its four-bond requirement, but it can never make three double bonds. Hydrogen, on the other hand, only makes a single bond. The number of bonds formed by a particular atom is critical, that is C (4), N (3), O (2) and H (1). Refer to the Atomic Color Codes box or the back of a Molecule Card.

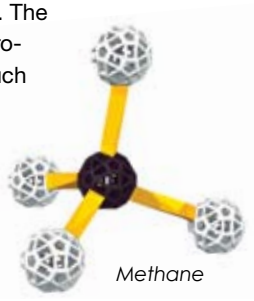
Carbon Dioxide

Ethane with staggered Hydrogens

NATURE'S ARCHITECTURE

The tetrahedral carbon

When carbon makes four single bonds, the bonds repel each other and are forced into a tetrahedral structure, as seen in the model of methane. Carbon atoms with four single bonds always have the bonds in this type of tetrahedral formation. The carbon atoms in hydrocarbon molecules, such as ethane, propane, butane, and in sugars all form these tetrahedral bonds. Practice making these tetrahedral carbons. Life is full of them, and so are you! Due to the unseen electrons in the non-bonded orbitals, the bonds in oxygen and nitrogen also assume angles consistent with tetrahedral angles. For example, the bonds in H_2O bend the molecule into a wide "V", not a straight line. When carbon-carbon single bonds are formed, the other bonds on the two adjacent carbons assume a staggered structure or conformation, due to slight repulsion.

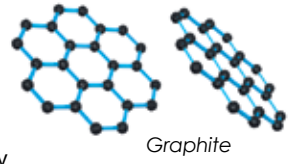


Methane

The double-bonded carbon and graphite

Whenever carbon forms double bonds or partial double bonds, as in carbon rings, the molecule assumes a planar, or flattened, structure, as compared to the tetrahedral structure of single-bonded carbons. In carbon rings, like the ones that are in DNA, the blue struts represent only partial double bonds. Graphite contains molecules with a large number of carbon rings connected together. These rings lie and slide on top of each other and give graphite a slippery character. Whenever a carbon double bond is involved, the molecule assumes a more two-dimensional, or flat, shape. DNA, the blueprint of life, is made of many small, flat molecules call nucleotides or bases. These flat molecules compactly stack on top of each other in the DNA double helix.

Carbon Ring



Graphite

HOW TO BUILD MOLECULES WITH ZOMETOOL

1. Welcome to molecular modeling with Zometool balls and struts!

- Making molecules is simple.
- Colored balls represent different atoms and struts represent chemical bonds (see ***Color Codes***).
- Carbon, the chief molecular building block, makes 4 bonds with other atoms.
- Other elements make different numbers of bonds: Nitrogen (3), oxygen (2), hydrogen (1), sulfur (2), and phosphorus (3).
- With Molecule Cards and these easy rules in mind, you will soon create beautiful models of your favorite molecules.

2. ***The Molecule Card:*** A Molecule Card has all the information needed to make a particular molecule. The picture gives you an idea of how the molecule looks. Make what you see, but in 3-D. The molecular formula tells which atoms are in the molecule. The atoms and bonds you need to make the molecule are found in the parts bar. Lastly, the facts box gives you some information about the molecule.

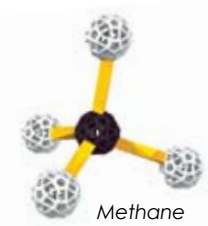
Hydrogen Gas *Oxygen Gas* *Nitrogen Gas*

3. If you are new to Zometool, make three gases to familiarize yourself with the strut connectors. The three types of connectors are represented in the single, double, and triple bonds of hydrogen gas, oxygen gas, and nitrogen gas, respectively.

4. Read the ***How to Model and Nature's Architecture*** sections. Make methane and ethane for practice with tetrahedral angles and staggered bonds. Nature is filled with these types of molecular architecture.

5. Practice making simple molecules before moving on to more complicated ones.

6. When creating your own molecules remember to follow the rules of molecular modeling. If you deviate from these rules, you may create a reactive molecule, or worse, a molecular abomination.



Methane

Ethane

It's time to explore the molecular world!

THE MOLECULE CARD