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

DNA

Includes detailed instructions by Dr. Steve Yoshinaga

Parts: 71		
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	2	
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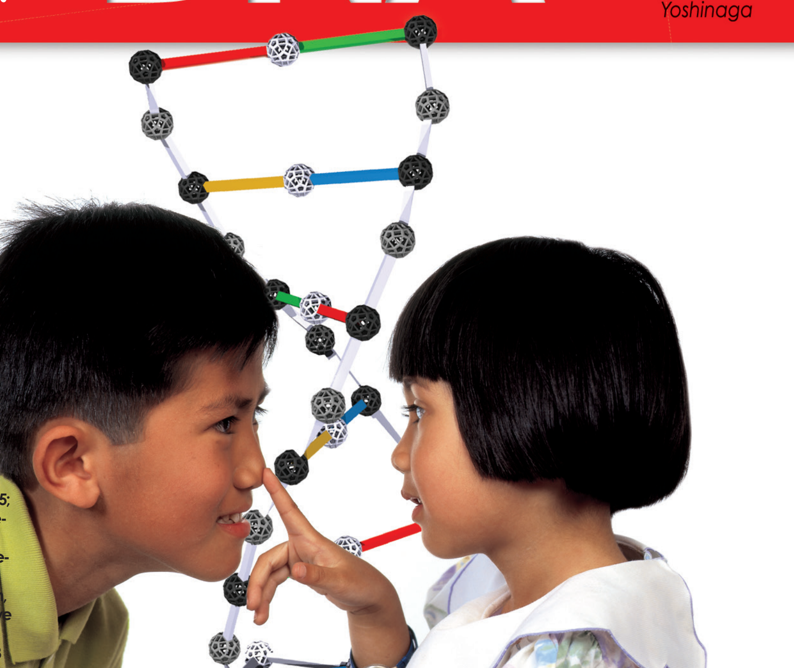

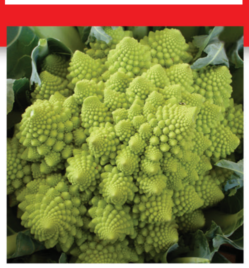

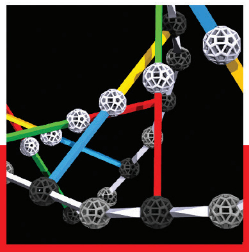

More than just a pretty molecule, DNA contains all the information needed to create life. Now you can construct the molecule that's responsible for constructing you!

Find out:

- *How your nose knows how to grow*
- *Why DNA is found in every living thing on earth*
- *How DNA "clones" itself*
- *And much more!*

Created by a molecular biologist for future molecular biologists!

MADE IN USA from kid-safe materials

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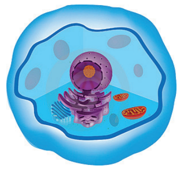
WARNING: Choking Hazard
SMALL PARTS. NOT for children under 3 years.

art and science at play ZOMETOOL®

START HERE!

What is DNA?

DNA* is the code of life! All living things — you, me, your dog and my plants — are made of tiny building blocks called cells. Cells do all sorts of things to keep you alive. Your body is made of about 100 trillion cells, and even though there are close to 200 different kinds of cells in your body, there's one thing they all have in common: every cell in your body contains a full, identical set of blueprints for how to build a complete... *you!* This information is encoded by your DNA.



**Deoxyribonucleic Acid*

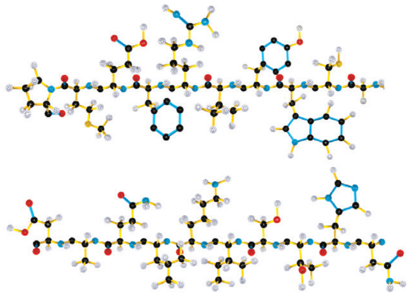
Vintage genes!

You can think of genes as chapters in a book of blueprints (your DNA.) If you look like someone in your family, that's because parts of your plans are identical. You inherit them from your parents. Your genes are not only shared with your parents, but also with worms, monkeys, reptiles and whales, to name a just few species. We don't inherit them from whales, but nature has been recycling genes for a long time.

If DNA is the thread of the fabric of life, then genes are the patterns that have emerged after millions of years of weaving.

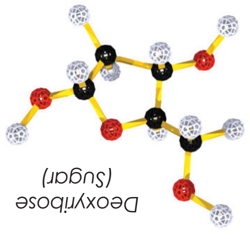
The DNA code

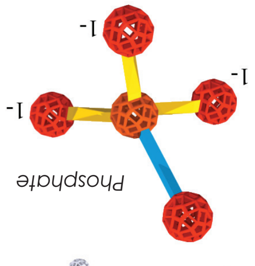
The cells that make up your body are themselves made up of smaller parts — chiefly proteins, which are encoded by your DNA. Whether your cell needs a wall, a copier, or a chemist, chances are it uses a protein. The building blocks of proteins are called amino acids, and by carefully combining 20 different amino acids, our cells build over 25,000 different proteins! These protein combinations are the crown jewels of the treasures encoded in your DNA.



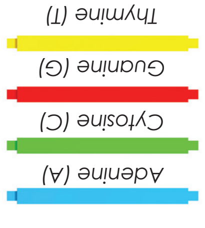
Simple and beautiful

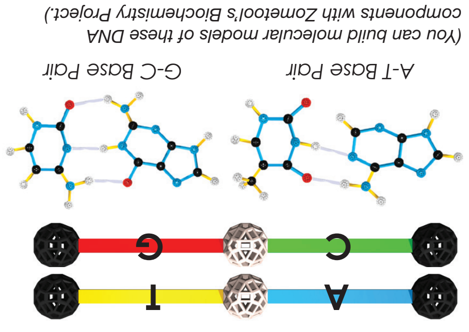
One would imagine that a system to store all of the information required to create life would be complex, but at its essence, DNA is as simple as it is powerful. DNA and other life molecules achieve incredible diversity of form and function by making polymers (a polymer is a chain made of similar or identical molecules). DNA is a *polymer* of *nucleotides*. Each nucleotide has three distinctive parts: a sugar, a phosphate and a base. If we picture DNA as a ladder, the sugar and phosphate molecules link to form the sides of the ladder, (called sugar-phosphate backbones). And the bases (one from each chain) link to form the rungs of the ladder (now just add a twist). The precious code of life is in the bases. Here's how it works:





There are only 4 types of bases in DNA: A for adenine, T for thymine, G for guanine and C for cytosine, but it turns out they only work in complementary pairs: A only bonds with T, and G only bonds with C. All of the coding information in DNA depends on the sequence of the rungs in our ladder, the sequence of complementary base pairs A/T and G/C.





(You can build molecular models of these DNA components with Zometool's Biochemistry Project.)

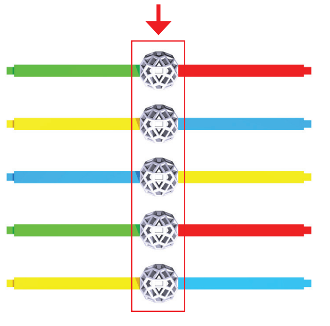
The DNA double helix

In 1953, scientists James Watson and Francis Crick revealed the double helix structure of DNA. It was an awesome discovery, even though they didn't do much experimental work themselves. They collected information from others and put it together in a revolutionary way. The critical data were from the work of Rosalind Franklin and Maurice Wilkins. Franklin's data on crystals of DNA helped Watson and Crick work out the structure using molecular models (like this kit, only without instructions!). They determined the complementary base-pairing, and found that the ladder, with its sugar-phosphate sides and the base-paired rungs, had a "right-handed" twist. This means that if you grab an ice cream cone with your right hand, your fingers wrap around the cone in the same direction as your DNA is twisted. The description of DNA's structure dramatically changed biology. Many feel it is one of the greatest discoveries of all time, because the structure helps explain how DNA works — and DNA is central to life.

Speak DNA?

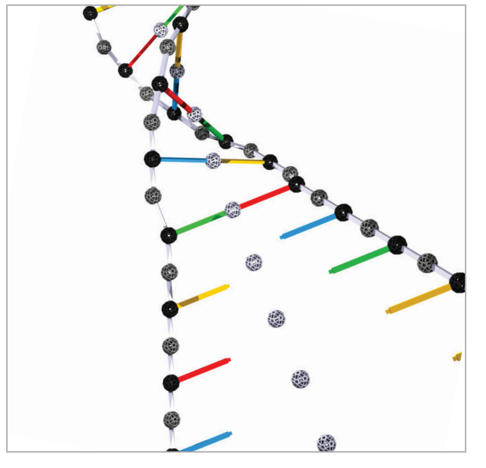
So how does your body read DNA? It's a bit like surfing the web: if you go to a web-site on your browser, the server holds all kinds of information, but it will send only a copy of the specific page you requested to your computer. Reading DNA is not too different. Our DNA has a complete set of plans to make us — in theory, you could clone yourself from just one cell! But normally, each cell only reads, or *expresses*, the portion of the plan it needs at the time.

The base pairs are linked together by weak forces called hydrogen bonds, which form a zipper right down the middle of the ladder. When your body needs to read a gene, a special "reader" enzyme uncoils the appropriate section of DNA and "unzips it". Now, unlike a regular zipper, this one has 4 kinds of teeth, but because of complementary base pairing you always know that if you have an A tooth on one side, you'll have a T tooth on the other (same with G and C). So by reading one side of the "zipper", you automatically know what will be on the other side.



The greatest complement

After unzipping, the "reader" reads one half of the zipper from the DNA sequence and creates a complementary strand of ribonucleic acid (RNA), using the DNA as a template. Creating this RNA message is a process called *transcription*. Once the message is complete, it is exported to a protein factory (*ribosome*) where the message is translated into the appropriate amino acid sequence, thus making the desired protein.



Complementary base-pairing is also important in cell replication. When a cell divides, the double stranded DNA molecule splits in two, and each strand acts as a template to create new complementary strands. The end result is two identical, double strands of DNA. Each has one of the original strands. Once again, complementary base-pairing is the key to this essential biological process.

Would you fit on a CD?

How much information does it take to make one of you? Well, it takes about 10,000 bits to make a virus (about a page's worth of information), and a bacterium would be more like 1,000,000 bits (100 pages). A human would require about 5 billion bits, (or about 1,000 500-page volumes), so your blueprints would be like a 60 MB file, easily stored on a CD!

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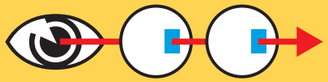
ZOMETOOL RULES!

1 *If it works, it works perfectly.*

…and if it doesn't work, it doesn't work at all. Don't force Zometool components. You can bend a strut to fit it into a tight spot, but struts in finished models are always straight, never under tension.



Hint: you can tell which strut fits between two balls in a model by lining up the balls and looking through the holes. The holes show you the shape of the strut that fits!

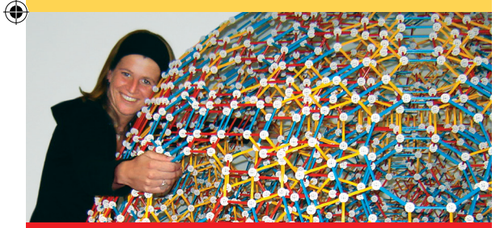
2 *Don't break it apart; take it apart!*

Take Zometool models apart by grasping a strut with your fingers and pushing the ball straight off with your thumb. Twisting balls, pulling models apart or crushing them can cause parts to break!*

3 *Leave the place cleaner than you found it.*

It's always a good idea to clean up when you're done. If we work together, we can make the world better.

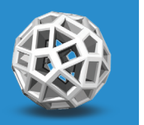
**We replace accidentally broken parts for free: visit www.zometool.com/warranty for details.*



ZOMETOOL®

Whether you want to ask better questions or learn better answers, Zometool is your ticket to discovery and fun. From numeracy to nanotechnology, quasicrystals to quantum mechanics, the destination is always the same: understanding our amazing universe.

Our mission:
- make learning fun
- create value
- build a better world



Discover more at **zometool.com**

Zometool DNA Project — thanks to Dr. Steve Yoshinaga, concept and copywriting; Dr. Brenda Yoshinaga, editing; Dr. Scott Vorthmann, vZome software used for renderings; Anni Wildung and Tara Brouwer, graphic design; Paul Hildebrandt, project management. Contact paulh@zometool.com. Based on the 31-zone system discovered by Steve Baer, Zomeworks Corp., USA.

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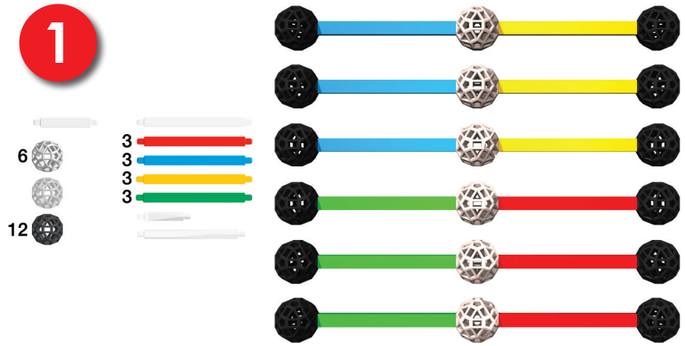

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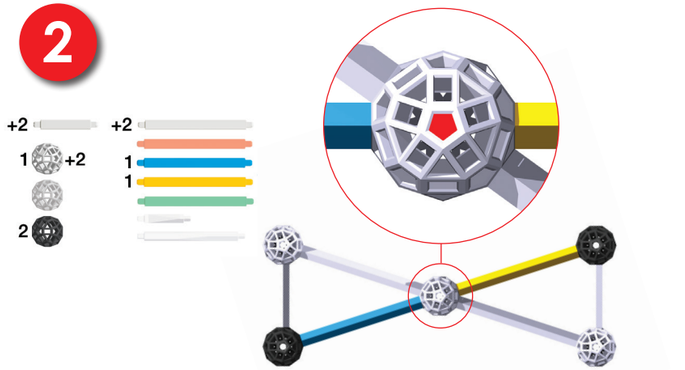

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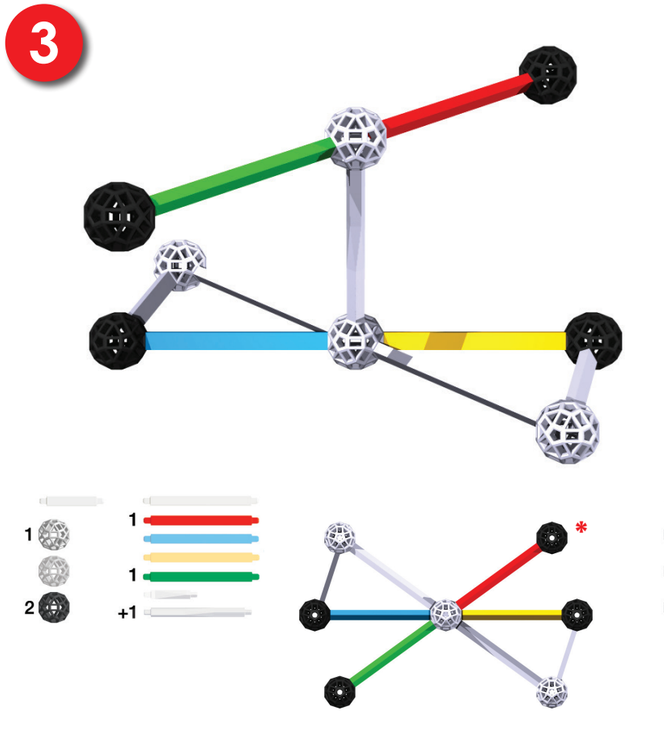

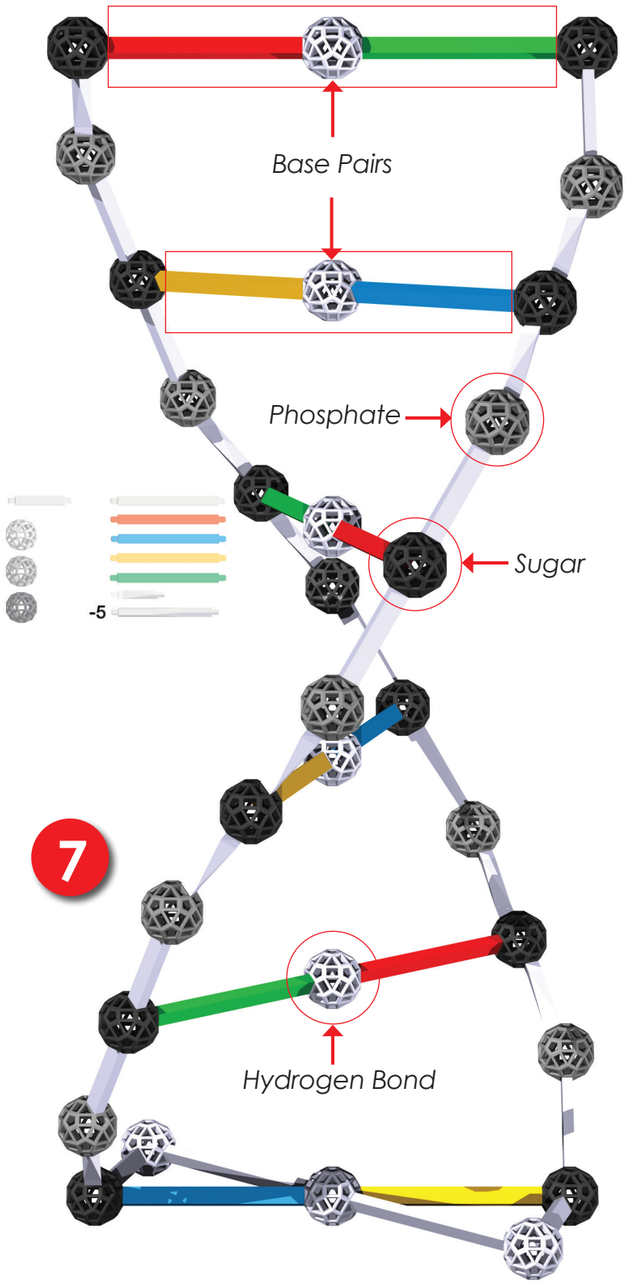

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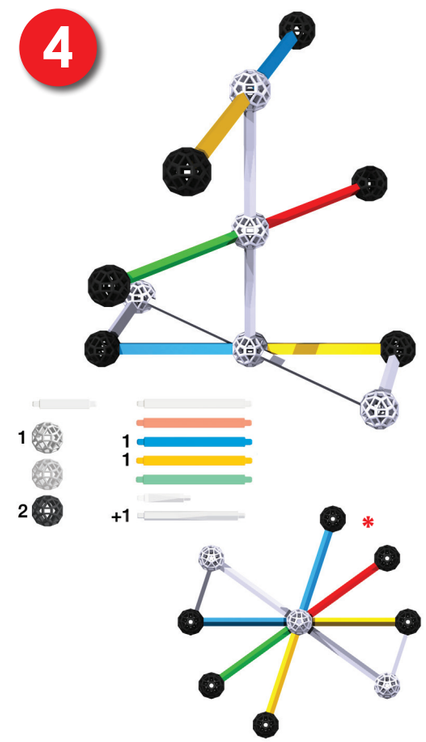

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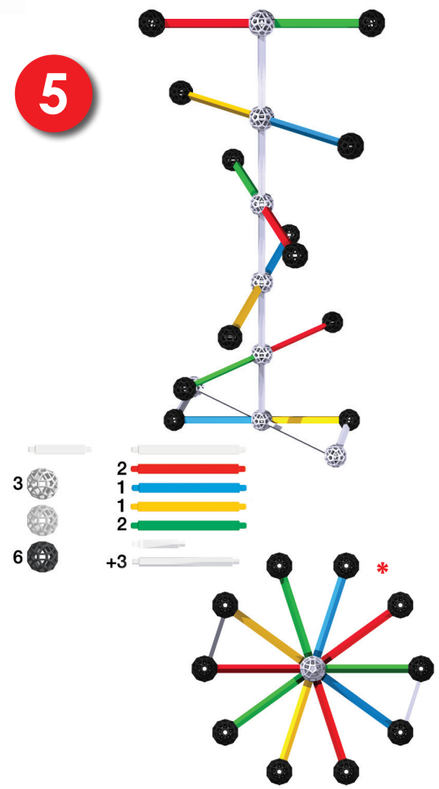

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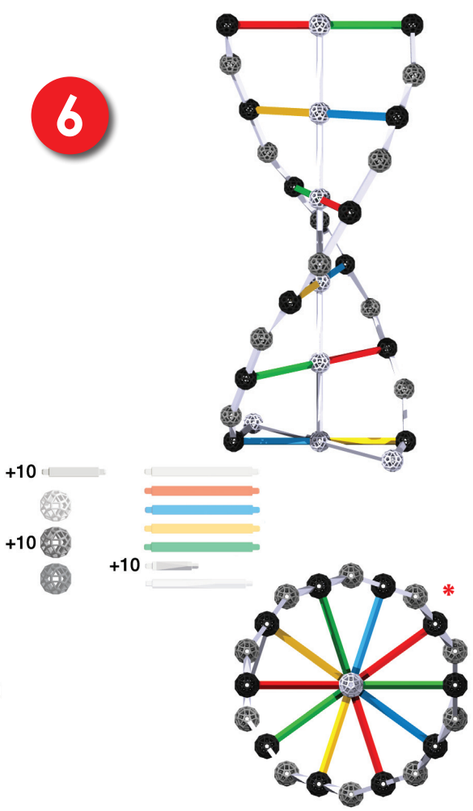

7

FUN FACT: Although an average human cell is only about 0.00001 meter long, if you stretched out all the DNA in one of your cells, it would be about 2 meters long. If you stretched out all the DNA in ***all*** of your cells, it would reach the moon and back — 200,000 times.

***TOP VIEW:** This model accurately represents the 5 base pairs per half turn of the double helix. DNA is built around the number 5!*