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!

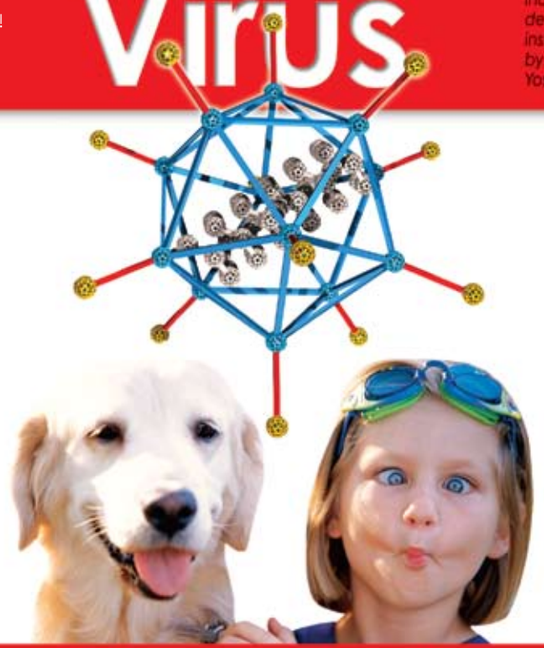
"The mind, once stretched by a new idea, never regains its original dimensions." –Oliver Wendell Holmes

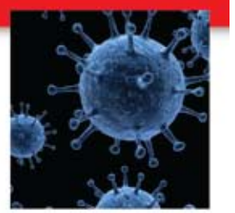
Animal Virus

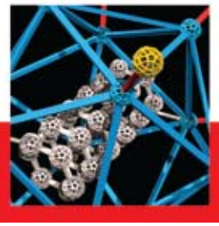
Includes detailed instructions by Dr. Steve Yoshinaga

Parts: 146

33 12 12
2
30
1
32 12
12







A VIRUS is a mobile, modular munitions plant for producing weapons of micro-destruction. This "bio-crystal" is smaller than a speck of dust, and inert as a rock... until it drains your life force to clone itself with robotic precision!

Build an accurate model of this animal virus, and discover:

- *Why it's shaped like a geodesic sphere*
- *Why it's covered with spikes*
- *How it makes you sick*
- *What it does to your DNA*
- *And more cool stuff about viruses!*

MADE IN USA from kid-safe materials

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WARNING: Choking Hazard

SMALL PARTS. NOT for children under 3 years.

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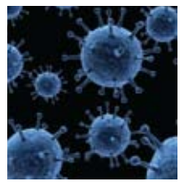
START HERE!

The awesome virus



A virus is a mobile, modular munitions plant for mass-producing weapons of micro-destruction! A microscopic marvel of molecular architecture, it is extremely small. If a virus were the size of a human, its human host would be the size of our planet! You could call it a "bio-crystal." It's as inert as a rock, until it springs into action and drains the life force of its host. Its main mission: Make more viruses. No quarter given!

How do we fight back?

A virus eventually destroys its host cell, and sends thousands of clones to attack other cells. With no defenses, some could kill you in a few days. Fortunately, all plants and animals have immune systems.

Your immune system defends your body from attack. It is an incredibly complex network of cells that identifies, kills, and then remembers foreign invaders in order to prevent future infections. So when these bad boys invade, your immune system not only wipes them out, but also blacklists them.

This immune cell memory makes us better prepared for the next virus invasion.

Are they good for anything?

Viruses have been very useful tools in biology, since a virus is a protein package full of DNA. In research, this simplicity allows scientists to make valuable and insightful observations. For instance, bacteriophages (like the Phage Virus available in another Zometool kit) were used to prove that DNA carried our genes.

Scientists have studied aminal viruses (like the one you'll build here) to help understand gene expression, cancer and virus infection. Many important biological processes have been discovered buy using viruses in research.

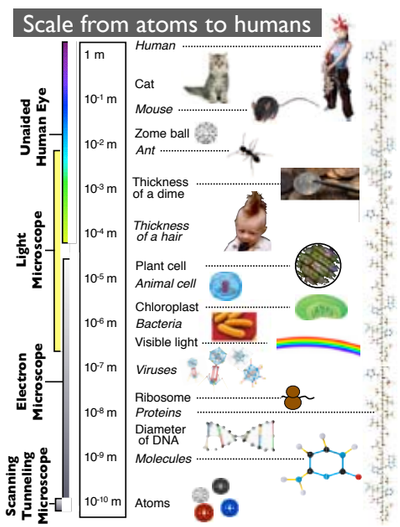
Dead or alive?

Until a living organism comes along, a virus lies dormant — it's effectively dead! Yet it springs into action when it encounters a living cell to its liking. Some scientists don't consider viruses to be alive, because they need a living cell to reproduce. Other scientists believe they are alive because viruses are "smart" enough to find a host, take over its cellular machinery, and reproduce.

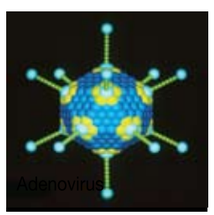
Some scientists fancy the idea that viruses are a link between life and non-life. Viruses may even shed some light on how life began on, or came to, planet earth! They're one of the few forms of "life" that might survive in the cold vacuum of space. More than just a catchy title for a movie, "Viruses From Outer Space" may be part of our biological history.

The Submicroscopic Universe of Viruses

Imagine shrinking yourself by a million times. If you could, you would be about the size of a virus! You'd enter a fantastic realm, where light has no meaning, because a virus is *smaller than light*. You'd have plenty of submicroscopic company. This world is teeming with all kinds of viruses: practically every form of life has a virus that relies on it to "live". This world is also very beautiful, as viruses use simple, but elegant, symmetry in their structures. The Animal Virus project recreates a bit of this invisible world so you can visualize incredible creatures too tiny for any eye to see!



The Animal Virus



Animal viruses range from being harmless, to annoying (rhinovirus, which causes colds), to fatal (HIV, Human immunodeficiency Virus, which causes AIDS). In this kit, you will make a model of an adenovirus (i.e., animal virus). Adenoviruses are medium-sized viruses at 100 nm (100 nanometers = 10^{-7} meters; see scale figure). They cause upper respiratory tract infections (a type of cold) in children and adults.

Viral Building Blocks

If you were to build an atom-by-atom model of a virus, it would be dazzlingly complex. But as far as life forms go, viruses have very simple structures. They are basically just a container (capsid) for genetic information (genome).

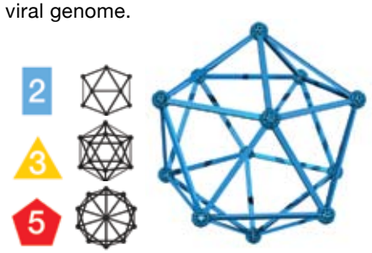
This light bulb is helical.

Capsids are protein shells, and they usually come in one of two kinds of shapes: helical (like a spring) or icosahedral (like this model).

Viruses use these shapes because they are highly efficient. In the adenovirus, for instance, two proteins make up most of its capsid. That's like building the outside of your house with two types of bricks. Furthermore, the viral building blocks self-assemble. That means they don't need mortar to hold them together. In fact, they don't even need a bricklayer!

Symmetry in Nature

Unlike a house made of bricks, the capsid is more like a geodesic dome (actually, a geodesic *sphere*.) But it's not a perfect sphere. The proteins fit together using elegant relationships among the numbers 2, 3 and 5, called *icosahedral symmetry*. The shape makes a great package for the viral genome.



In our model, the capsid is a regular icosahedron, like Step 3 in the instructions on the other side. **2-**, **3-** and **5-**fold symmetries all are embodied in the icosahedron. To see how the numbers 2, 3 and 5 are found in this special shape, see "The shadow knows…" on the other side.

An icosahedron is a *minimum energy* configuration, which means that it is an extremely stable structure. That's what makes geodesic domes so strong. The icosahedral capsid makes the adenovirus a tough little critter – tough enough to remain in a state of suspended animation for perhaps millions of years!

Virus Attack!

Spikes, or fibers, protruding from each vertex (corner) of the capsid help the adenovirus attach to its "host" cell, like little grappling hooks (see Step 7, opposite side). The protein at the end of the spike (represented by a yellow ball) specifically connects to a protein receptor on the cell membrane it's attacking. Once attached, the virus enters the cell (in a process called endocytosis). The adenovirus proteins stop normal cell activities and direct the cell to make thousands of virus clones. In this process of viral replication, the host cell is usually destroyed. Cellular piracy and pillaging are a way of life in the sub-microscopic viral universe.

A Small Virus Leads to a Big Prize

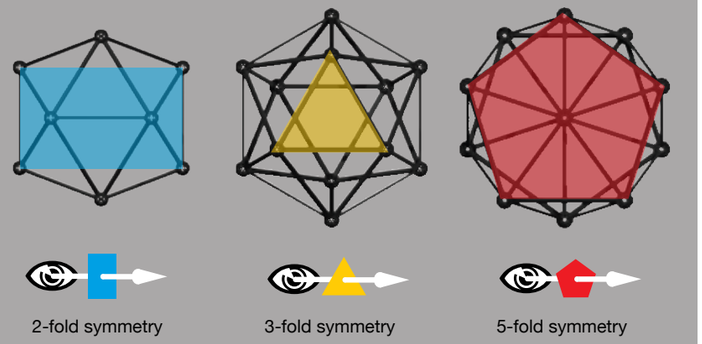
Scientists have studied adenoviruses to help understand gene expression, cancer and virus infection. Many important biological processes have been discovered using adenoviruses in research studies. For instance, scientists used adenoviruses to determine that our RNA, the message of the DNA code, is spliced, like a movie is spliced and edited in production. This discovery resulted in a deeper understanding of how genes are expressed, as well as a Nobel Prize for the researchers. So something really tiny, like the adenovirus, can lead to something really big, like the Nobel Prize. It could happen to you!

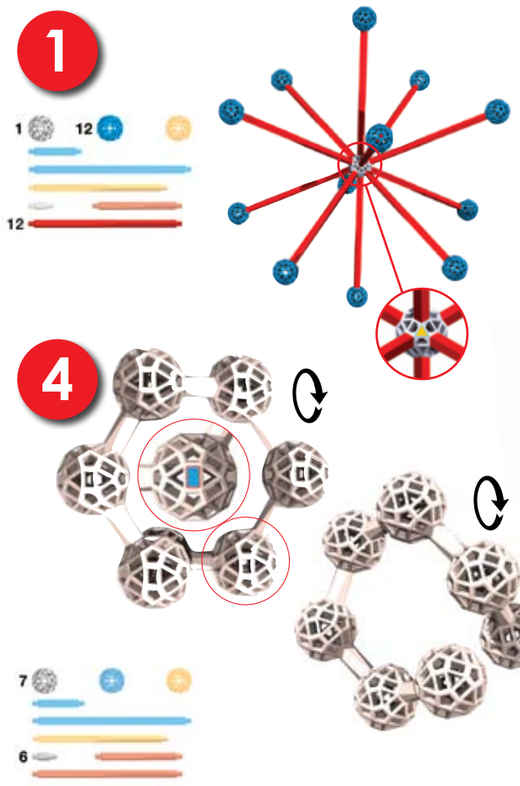
*The shadow knows...

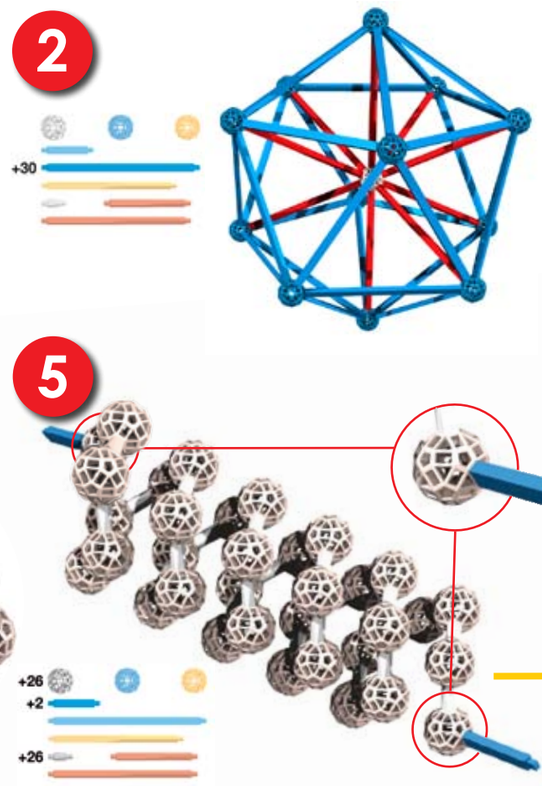
*...how the numbers **2**, **3** and **5** reveal themselves in the shape of the virus! Check it out!*

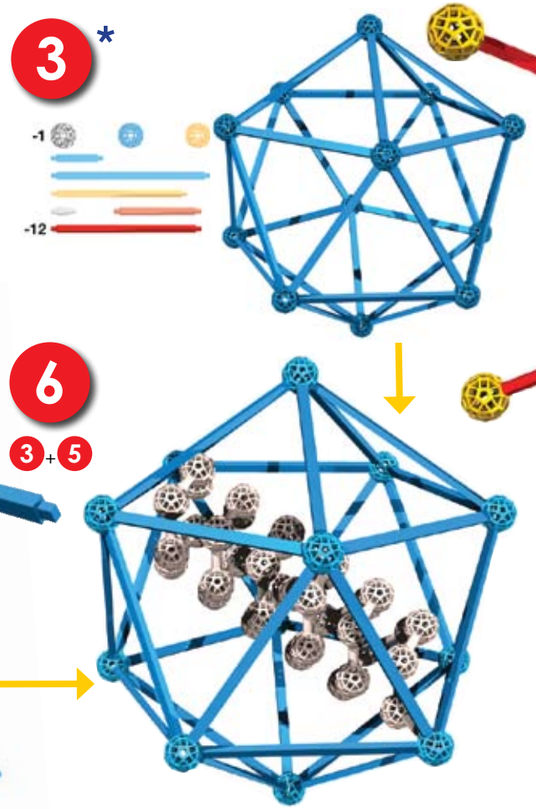
You need:
- The model in Step 3
- a blue, a yellow and a red strut (1 each)
- sunshine
- a projection surface, like a piece of white cardboard at least 30x30 cm (12"x12")

Here's how to do it:
1) Place a blue, yellow, or red strut in any hole, any ball of the model in step 3.
2) Point the strut directly at the sun (the strut won't cast a shadow; it's obscured by the ball!)
3) Cast a shadow of the model onto the board (best if the board is perpendicular to the light rays so the shadow is not distorted -- see pictures!)









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

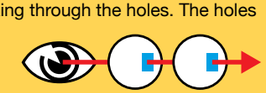
Discover more! Please visit **zometool.com** or call **888-966-3386** or **303-297-3387**.

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

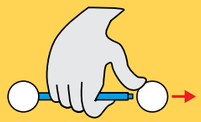
ZOMETOOL RULES!

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 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!* To disassemble a large model quickly, remove all the longest struts of one color first, and work your way down!

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

It's always a good idea to clean up when you're done, so the next person can enjoy Zometool too. If we work together, we can make the world better for all.

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