**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
- versatile: all kits are compatible — more parts, more power!
- guaranteed for life!

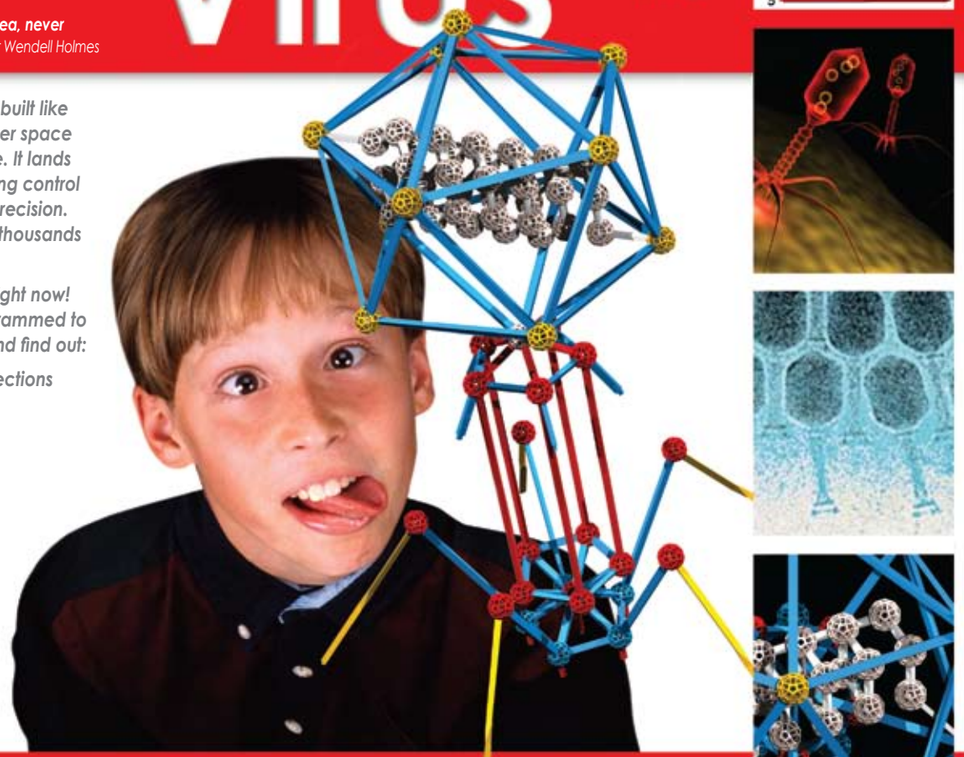
***"The mind, once stretched by a new idea, never regains its original dimensions."*** *– Oliver Wendell Holmes*

# Phage Virus

*Includes detailed instructions by Dr. Steve Yoshinaga*

Parts: 194

| | | | |
|---|---|---|---|
| 32 | | 5 | |
| 12 | | 16 | |
| 30 | | 2 | |
| 35 | | | |
| 5 | | | |
| 5 | | 29 | |
| 6 | | | |
| 12 | | | |
| 5 | | | |









*Microbe wars! – Imagine a virus built like NASA lunar module, probing inner space for a bacterial "moon" to invade. It lands and injects its deadly DNA, seizing control and copying itself with robotic precision. The wasted cell explodes, firing thousands of clones out for fresh victims!*

*It's all happening in your body right now! But don't worry, this virus is programmed to only destroy bacteria. Build it, and find out:*

- *How this virus can combat infections*
- *Why biologists love this virus*
- *Is this virus truly a life form?*
- *And lots more!*

MADE IN USA
from kid-safe materials

7 09743 20053 0



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

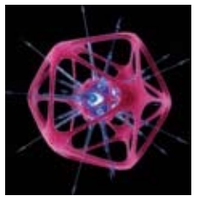
CE

zometool.com

**START HERE!**

# zometool. Phage Virus

## 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, plants and animals have an immune system. 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, small viruses that attack bacteria (bacteriophages) were used to prove that DNA carried our genes.

Before the discovery of antibiotics, Russian scientists used bacteriophages to fight bacterial infections in humans. Given the current overuse of antibiotics resulting in super-resistant strains, there's renewed interest in these anti-bacterial viruses.

## 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.



## Bacteriophage

A bacteriophage (or simply "phage") is a virus that infects bacteria. Bacteria are tiny, single-cell organisms that are found just about everywhere—in air, water, soil, animals, people and food (some bacteria are good, but we call the harmful ones germs.) Since bacteria are just about everywhere, so are phages – they're even inside us (we "host" bacteria on our skin and in our intestines)! But don't worry, phages are genetically programmed to only infect bacteria.

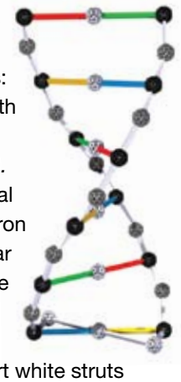
Bacteriophages are some of the smallest viruses – about 20-200 nm in size. A nanometer, or nm, is one billionth of a meter. That means you could line up about 20,000 phages, end to end, on the head of a pin. Like most viruses, phages are chiefly made of a protein body and DNA. Proteins are the building blocks of all living things, and DNA makes up our genes, the instructions on how to make life. But the phage cheats: its DNA just steals the stuff of life in its host bacterium to make more phages.

## Pirates of the microbial world

You could think of a phage as tiny pirate, searching for a bacterial "ship" to invade. It "sees" a ship, boards it, and converts it into a floating phage factory. The pirate uses up everything it can on board to reproduce itself. When there's nothing of value left, it abandons ship, or destroys it.

Some phages (like the one in this kit) are built like NASA lunar modules, with tiny legs, called "tail fibers," to help land on bacteria. Once on the cell surface, the tail's injector shoots genetic material (DNA) into the cell. The DNA makes viral proteins to stop the cell's normal processes and allow the virus to take over. It makes so many baby phages—using the same protein machinery that the cell normally uses to replicate its own DNA—that the cell often explodes.

## Build your own phage!



This model represents a T4 bacteriophage. There are 3 main parts: the head {**A**}, tail sheath {**B**}, and tail fibers {**C**} *(see the picture inside).* The head is icosahedral in shape (an icosohedron is made of 20 triangular faces) and contains the genetic material, DNA {**D**}. A spiral (or helix) of white balls and short white struts represents double stranded DNA.*

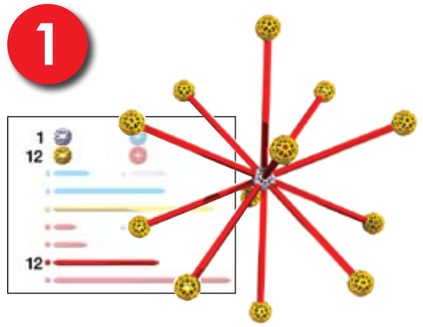
Small "cat" whiskers {**E**}, represented by super-short blue struts, come down from under the head and serve as environment sensing probes. The tail sheath is represented by the pentagonal prism of long red struts, and actually expands and contracts as the phage injects its DNA into the host bacterium. The tail fibers, represented by blue and yellow struts, act as legs to stabilize the phage and bring the injector {**F**}, a super-short red strut in the base plate, closer to the host. *(Note: this model only shows 5 of the 6 tail fibers of the T4 bacteriophage.)* Tiny spikes {**G**}, represented by super-duper short red struts around the base, help attach the phage to the host.

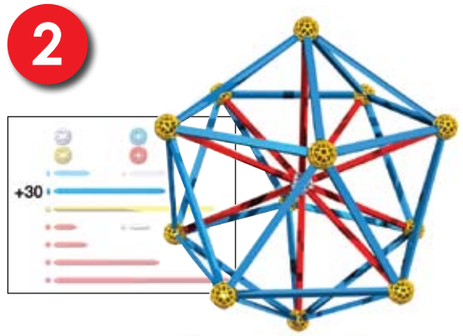
**You can build a more accurate model of DNA with Zometool's DNA Project.*

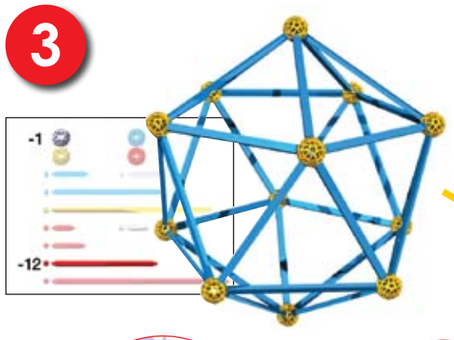
## Bacteriophages in our life

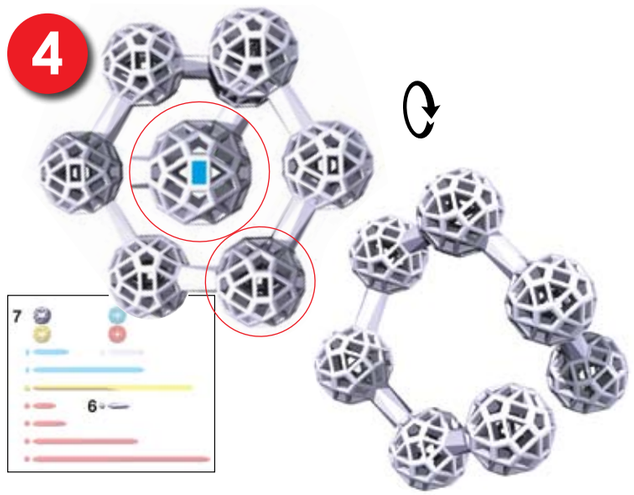
Bacteriophages have been used in research by molecular biologists for years. The simple genetic structure and form of a phage make it a favorite of scientists who study how genes are expressed. In fact, scientists used phages to prove that genes are contained in DNA and not another part of the cell (DNA is a molecule and genes are the instructions contained in the DNA).

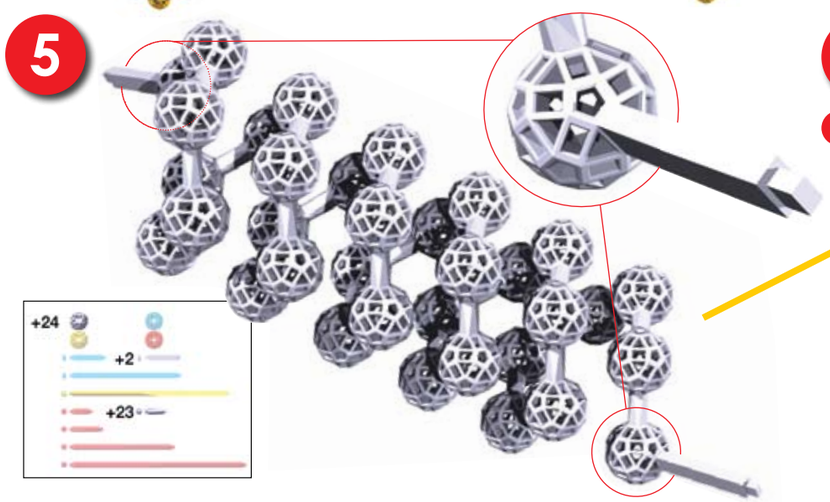
Phages have been used in the past to combat bacterial infections, especially before the advent of antibiotics. Today, there are ongoing efforts to reintroduce phage therapies in medicine.

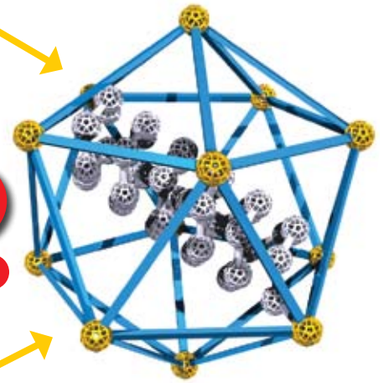


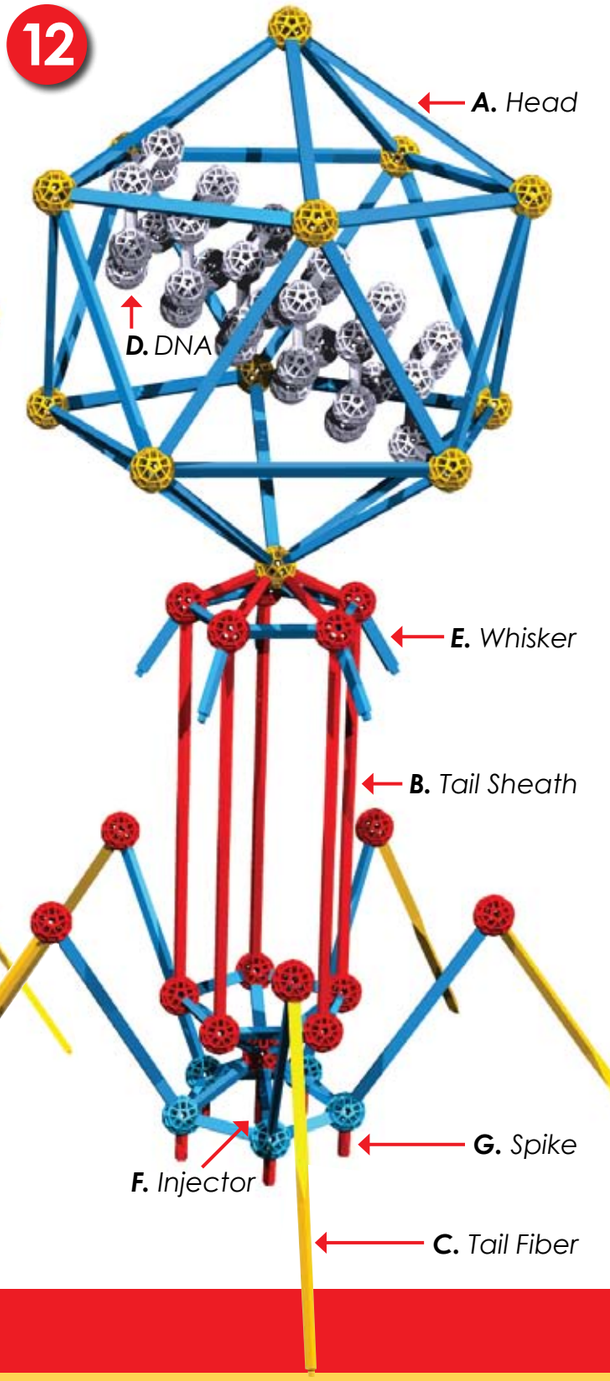



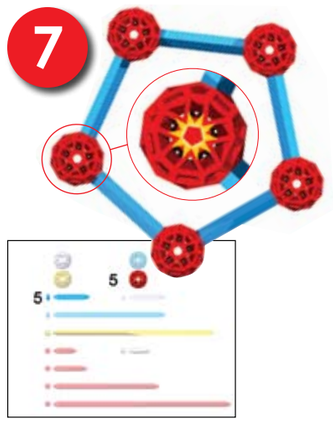



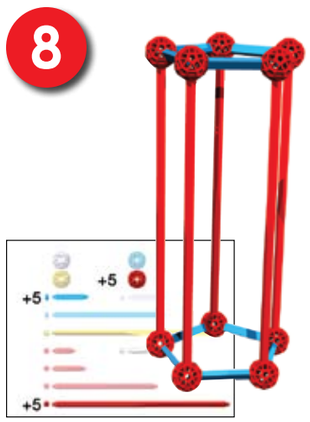



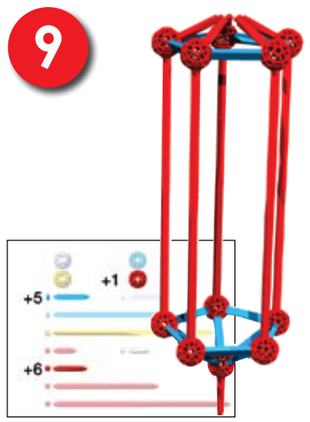



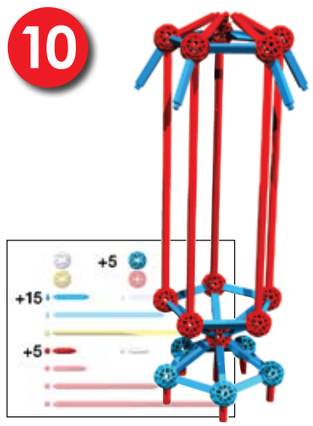





zometool®

**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**.

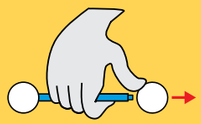
Zometool Phage Virus Project—thanks to Dr. Steve Yoshinaga, concept and copywriting; Dr. Brenda Yoshinaga and Carlos Neumann, editing; Dr. Scott Vorthmann, vZome software used for renderings; Anni Wildung and Tara Brouwer, graphic design; Paul Hildebrandt, project management, etc. Please send questions, comments and suggestions to paulh@zometool.com. 

## 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 dissassemble 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.*