

## MAKE YOUR OWN ADENOVIRUS – ACTIVITY NOTES FOR TEACHERS

In this activity, students use a template to make a model of an adenovirus (common cold virus) and investigate the shapes of different viral diseases and the similarities and differences between viral families.

### MATERIALS

Each student will need:

- Adenovirus template
- A length of yarn
- Tape or glue

*NB: Copying the adenovirus template on to lightweight card will produce the best results*

### ENGAGE

Ask students to work with a partner to brainstorm as many names of different types of viruses as possible. Ask them what viral diseases they know. You could distribute the 'Meet the viruses' cards (*available to print on this website*) to help students explore the characteristics of different viruses.

### EXPLORE

Explain to the students that they will create a model of an icosahedral virus—a biological nanomachine. The icosahedral shape is very common. Besides adenovirus, other viruses with the same shape include the polio virus and the virus that causes hepatitis A.

Discuss the features of viruses highlighting that DNA or RNA is found in the centre of the virus capsid.

### INSTRUCTIONS FOR MAKING AN ADENOVIRUS

1. Make a copy of the adenovirus template.
2. Cut along the outer edge of the template.
3. Fold and crease or score the bold lines.
4. Glue the edges together, leaving one side open.
5. Cut lengths of yarn to represent the DNA and place it inside your virus.
6. Close the virus model with the tabs labelled 'fold'.

### EXPLAIN

Review the components of the virus. Describe the different shapes of viruses and the process viruses use to infect a host cell, replicate, and infect new viruses. Discuss theories about why viruses are symmetrical and have repeated faces composed of regular subunits.

Encourage your students to add to their virus model to more accurately represent specific viruses. What would it take to make the model look like HIV or herpes simplex?

Ask students to decide if a virus is living or nonliving. What defines life in this context? If a human engineered nanomachine could self-assemble and self-replicate, would it be considered living or not?

Explore how viruses recognise and attach to specific types of host cells. How does a virus know when to penetrate a cell?

## WHAT IS A VIRUS?

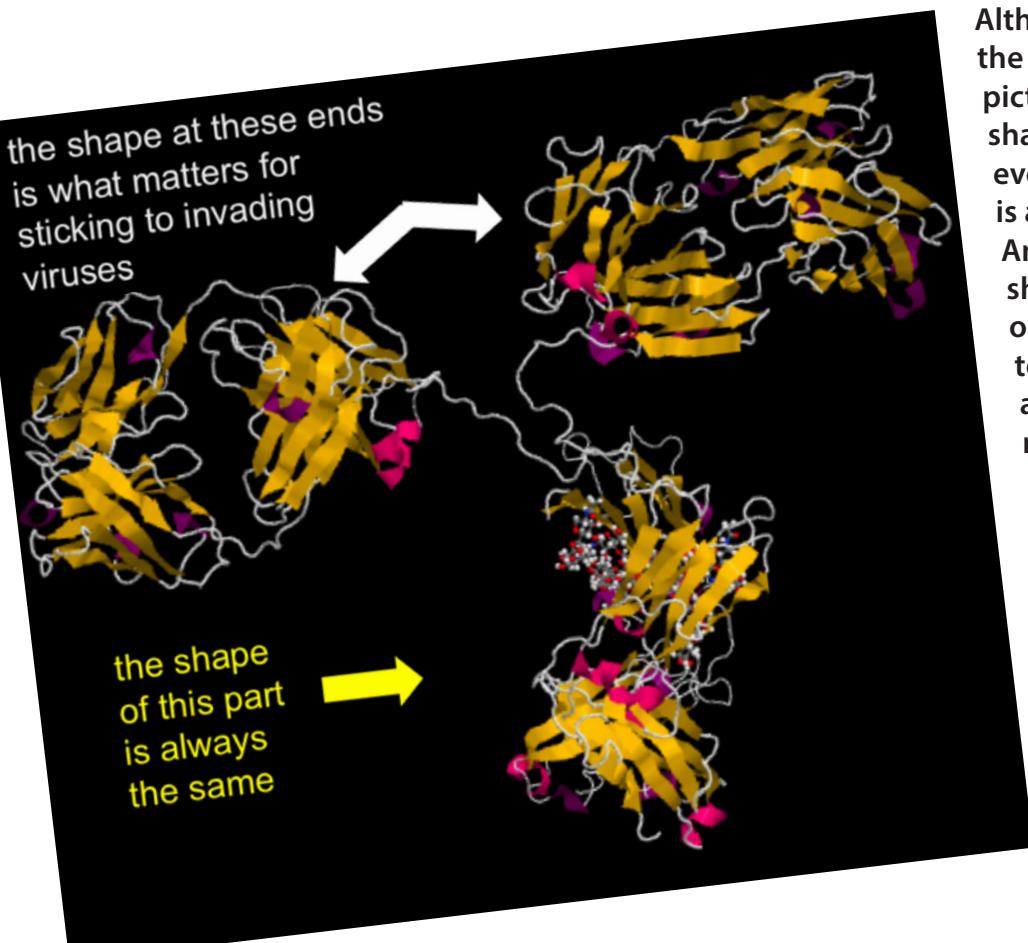
All viruses are very simple, they are made up of an outer shell of protein which carries the virus' DNA (or RNA) – the genetic code with the instructions for making new copies of the virus. Some viruses have an extra layer around the shell, but that's about it. Despite being so simple there are many different types of virus that can cause diseases from the common cold and flu to chicken pox and AIDS.

Viruses are all around us – everyday we each breathe in over 100,000,000! Most of these are harmless, but some can make us sick. Viruses are tiny agents that invade the cells of our bodies and hijack the microscopic machines inside our cells to produce millions of copies of the virus, assembling a viral army which bursts out of the cell, spreading the invasion through the body.

Viruses aren't actually alive – they don't grow or move themselves, or eat or use energy, and they can't reproduce on their own. This is why they must invade our cells – so that they can take advantage of the complex machinery, nutrients and energy in our cells, and force the cell to make millions of copies of the virus using the genetic blueprint carried in the virus.

## ANTIBODIES STRIKE BACK!

Antibodies are one of the key weapons against viruses in our immune system's arsenal – they are molecules made by our white blood cells to fight off invaders and keep us healthy. Each of us has more than 10 billion different kinds of antibody – that means there are more different antibodies inside you right now than there are people in the world.



Although antibodies all have the same basic 'Y' shape (see picture), they can have any shape at their 'ends', so for every shape of virus, there is an antibody to match. Antibodies with the right shape for a virus will stick onto it and alert your cells to destroy the virus. This also turns the cell that is making the right shaped antibody into an incredible antibody-making factory, churning out 2,000 antibodies every second!

## FASCINATING FACTS ABOUT VIRUSES

- ◆ You are constantly exposed to viruses – in the air you breathe and things you touch and water you drink.
- ◆ Viruses can cause a huge range of diseases. From viruses that give you a cold to viruses that quickly kill you (rhinovirus – common cold; flu; VZV – chicken pox; SARS; Ebola;)
- ◆ During an infection viruses invade your cells in order to reproduce.
- ◆ Each cell becomes a virus factory, which eventually bursts, releasing **10,000 new viruses** which can go on to infect other cells (adenovirus).
- ◆ During an infection you may have several million viruses in every millilitre of your blood.
- ◆ The human body makes use of antibodies to fight disease. You have  $\sim 3 \times 10^7$  unique antibodies.
- ◆ The **shape** of the antibody determines what it can bind to. Because you have so many different antibodies, almost any shape can be recognised.

## MATERIALS

- ◆ After recognising an invading virus, the cells (B-cells) that produce the individual binding antibody are stimulated to divide.
- ◆ Each antibody producing cell can produce 2000 antibody molecules per second. After **4-7 days**, antibody (IgG) is detectable in blood.
- ◆ Antibodies bind to viruses, marking them as invaders so that white blood cells can engulf and destroy them.
- ◆ Until recently, antibodies were thought to protect on the outside of cells. **TRIM21 binds to viruses on the inside of cells.**
- ◆ TRIM21 sends viruses to the cell's recycling system (the proteasome) where the virus is destroyed.
- ◆ An antibody is **1,000 times smaller** than a virus particle (adenovirus).
- ◆ **Two antibodies per virus** are enough for TRIM21 to send the virus for destruction.
- ◆ Understanding how TRIM21 and antibodies work may help scientists devise new therapies for virus infection.

## ANTIBODIES, ANTIGENS AND ANTIBIOTICS

### They may all start with 'Anti', but they mean very different things...

Antibodies are proteins that recognise and bind parts of viruses to neutralise them. Antibodies are produced by our white blood cells and are a major part of the body's response to combatting a viral infection.

#### **Remember me by: Antibody – Body protection**

Antigens are substances that cause the body to produce antibodies, such as a viral protein. Antibodies bind antigens very specifically like a lock and key, neutralising the virus and preventing its further spread.

#### **Remember me by: Antigen - Antibody Generator**

Antibiotics are substances that kill bacteria. They are not able to neutralise viruses. Bacteria can become resistant to antibiotics, so misusing them for non-bacterial infections could have serious consequences rendering the antibiotic ineffective.

#### **Remember me by: Antibiotic- Antibacteria**

## ARE VIRUSES ALIVE?

This is actually a really hard question to answer. Viruses are much simpler than other organisms that we definitely consider alive. For instance, you have about 25,000 genes, whereas HIV has eight. But simple doesn't necessarily mean not alive.

Viruses must also use a host cell – and all its complex machinery – in order to replicate. This means that a virus can't replicate without a host. But then you could say the same thing about a head louse, and we would definitely call a louse alive. So where do we begin?

First of all, you have to be really clear by what we mean by alive. Some of these discussions border on philosophy, but the easiest way is to list characteristics that all living beings share. Coming up with a list that includes all recognised life forms but excludes other replicating things (like fire) is tricky. However, here is a commonly used list of features that most accepted living beings share:

- ◆ Growth
- ◆ Reproduction
- ◆ Metabolism (extracting food from the environment and turning it into self)
- ◆ Homeostasis (keeping a regulated internal environment)
- ◆ Responding to stimuli
- ◆ Organisation (having some kind of internal structure, like cells)
- ◆ Evolution

Humans do all these things but viruses do, at best, four of them. Viruses do not grow, metabolise or maintain a constant internal environment. So by this definition, viruses are not alive.

Viruses are the ultimate freeloaders – they sneak into our cells, eat our food and rely on our homeostasis (their favourite temperature just happens to be body temperature!)

## VACCINATION - GIVING YOUR IMMUNE SYSTEM A HEAD START

**Have you ever wondered what exactly is in the needle when you get a vaccine, or how that works to protect you against a disease?**

A vaccine against a virus actually contains virus – usually either a dead, weakened, or slightly different version of the virus it protects you against.

Deliberately injecting a virus may seem like a very strange approach to preventing infections, but is a really effective strategy, because your immune system reacts to the vaccine and makes lots of specific antibodies with the right shape for the vaccine virus.

Once you've made antibodies to a target, your immune system 'remembers' the shapes of antibodies that were effective. This means that if you've had the vaccine and then get infected by the real virus, your immune system has a head start and quickly makes lots of the right kind of antibodies, which destroy the virus before it has the chance to spread through your body and make you sick.

The first successful vaccine was developed in 1796 against the smallpox virus, which killed about 500 million people in the 20th century. The vaccine was extremely good at protecting people from infection, and was given to people around the world, so that in 1979 smallpox was officially declared to be extinct. This is an amazing example of how powerful vaccines and antibodies can be in protecting us against infection.

