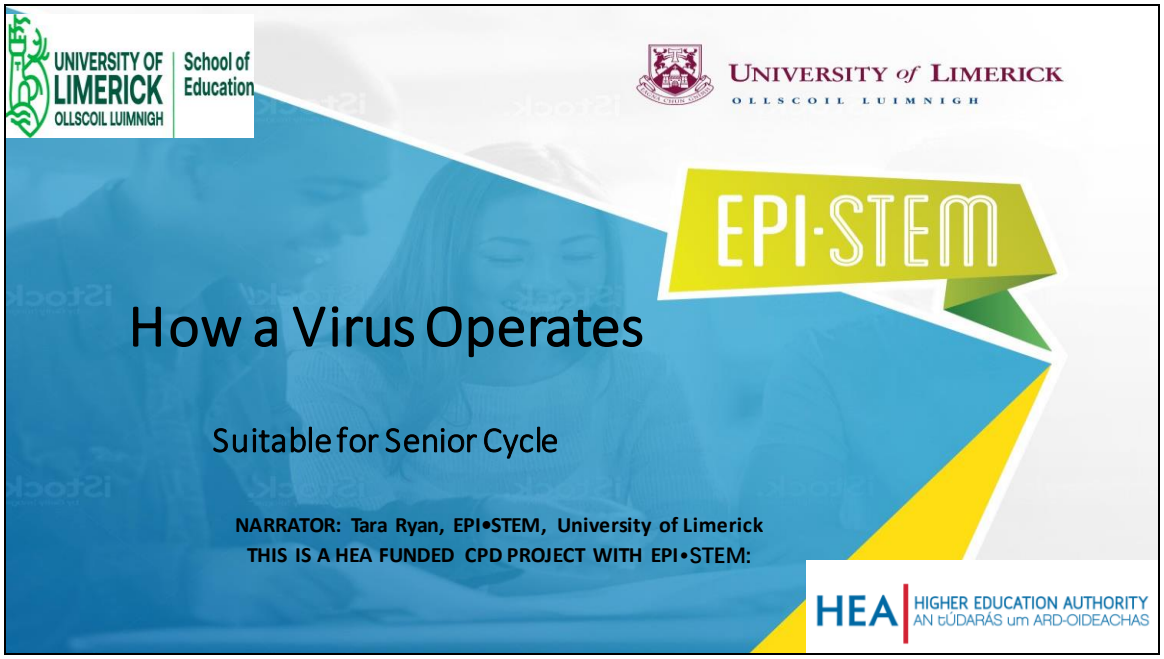
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EPI·STEM
How a Virus Operates
Suitable for Senior Cycle
NARRATOR: Tara Ryan, EPI•STEM, University of Limerick
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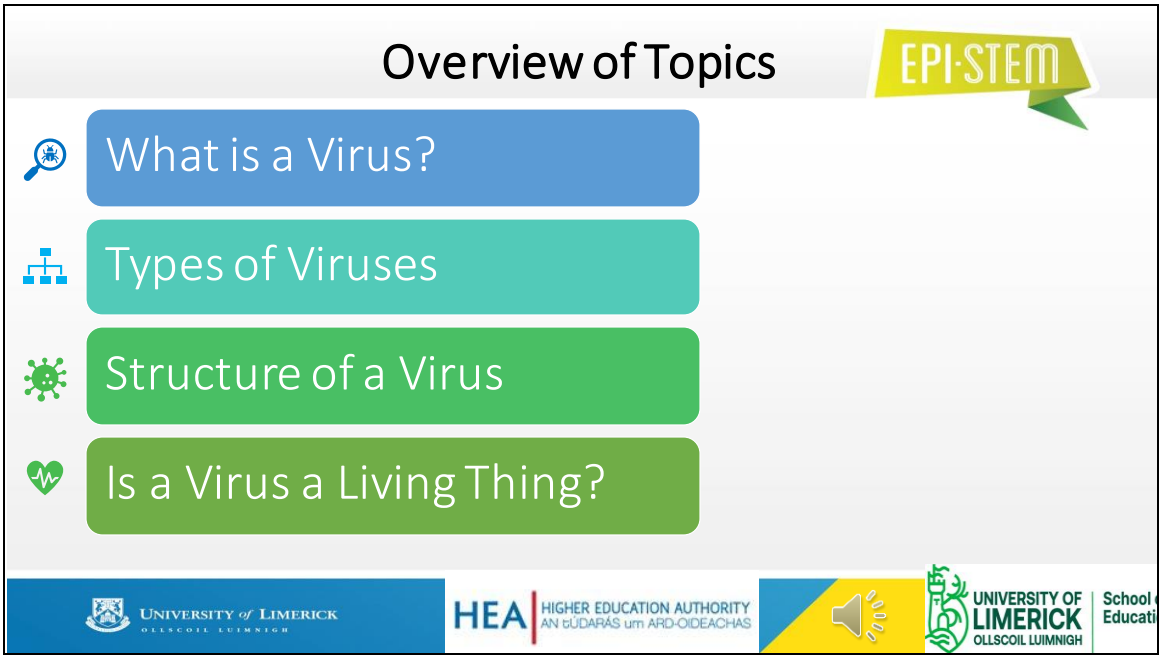
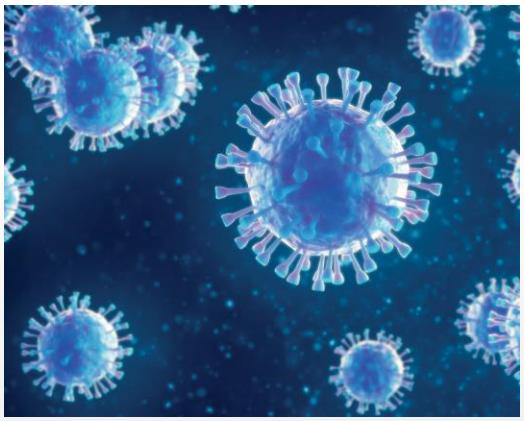
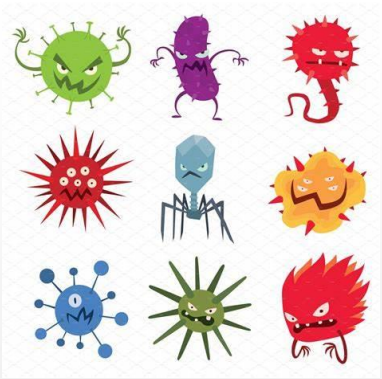
Overview of Topics

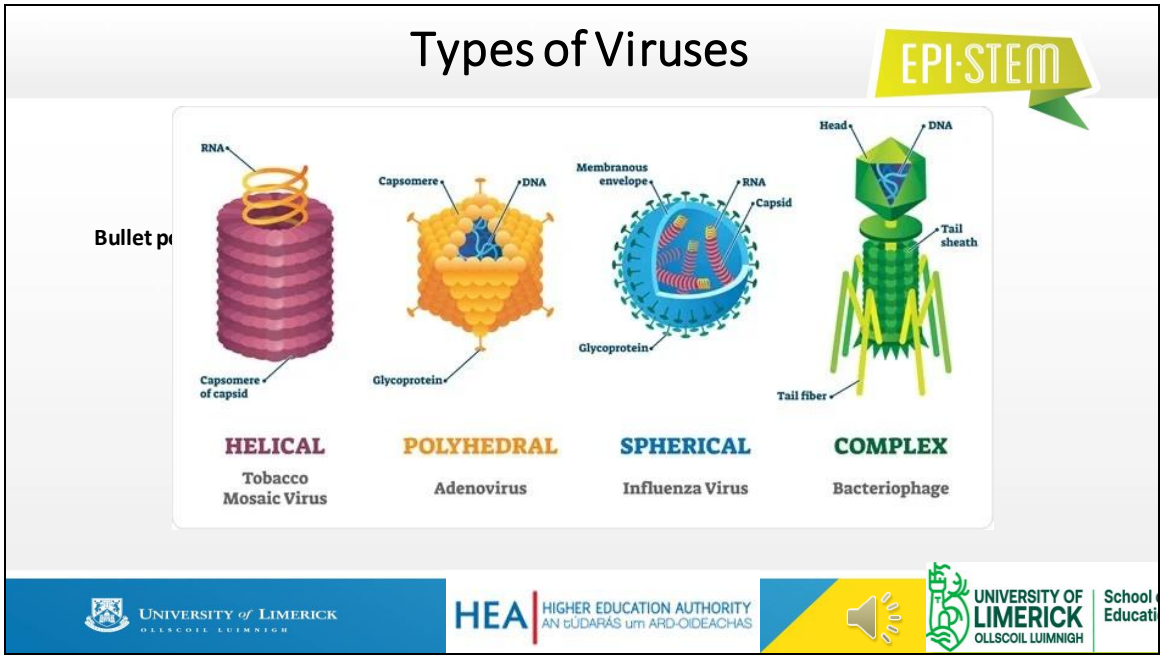


What is a Virus?



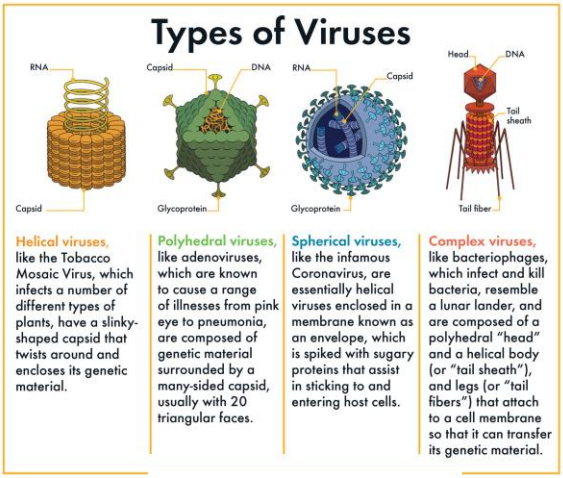


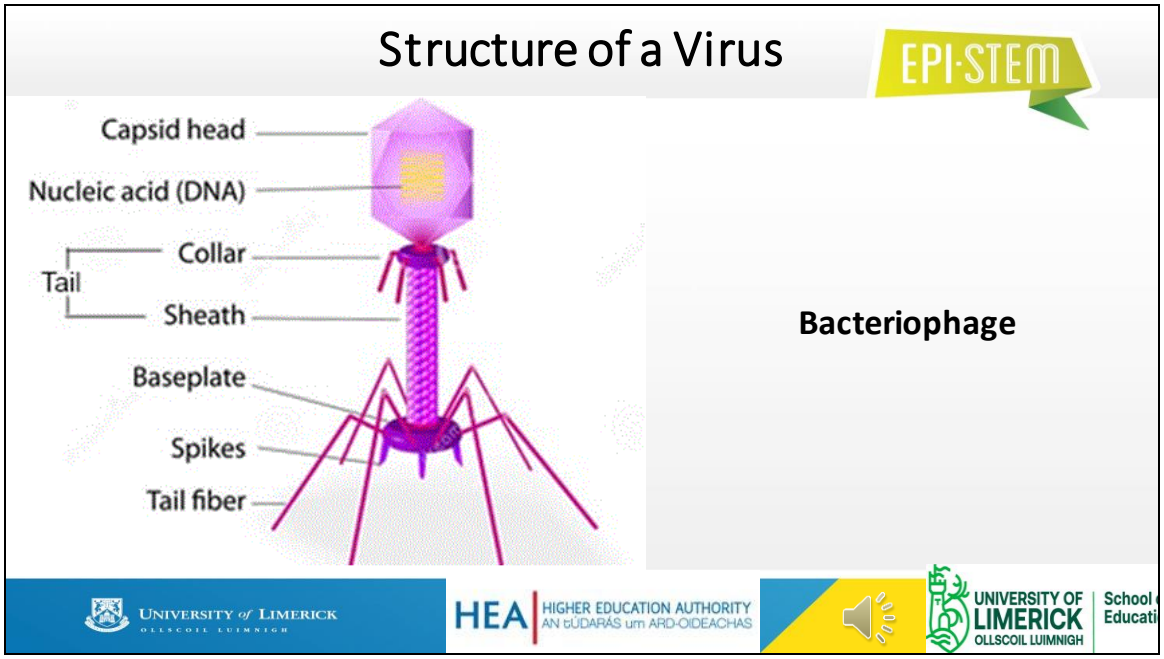
A virus is an infectious submicroscopic creature that only reproduces inside of live cells. All kinds of life, including animals, plants, and microbes like bacteria, can be infected by viruses.



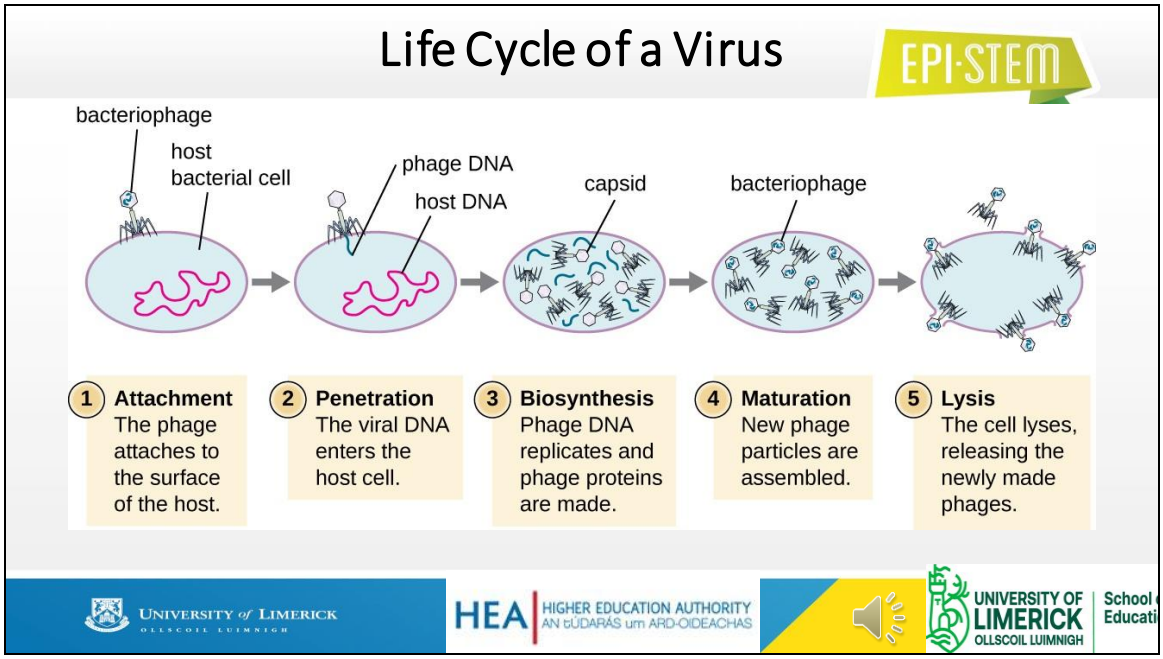
Viruses can have different shapes, such as helical, polyhedral, spherical, and complex.

Types of Viruses





Viruses comes in lots of shapes. The virus shown here is a bacteriophage. It consists of tail fibers, spikes, a tail, and a capsid head, which stores the nucleic acid.

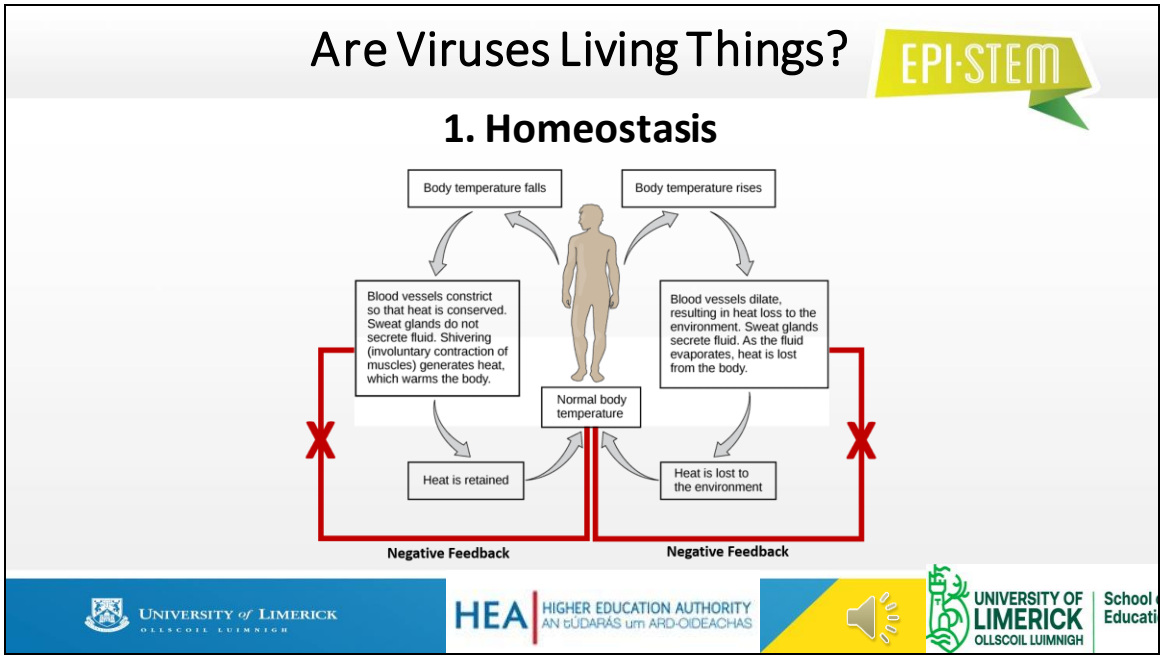


A virus will go through five stages during its life cycle.

Shown here, is a bacteriophage first attaching to the surface of the host cell. The long phage tails will then penetrate the host cell and inject it with its own DNA. During biosynthesis, the phage DNA replicates within the host cell and will then consume the host cell's DNA and reassemble during maturation. Finally, the host cell will burst during lysis and the newly made phages are released to repeat the process all over again.

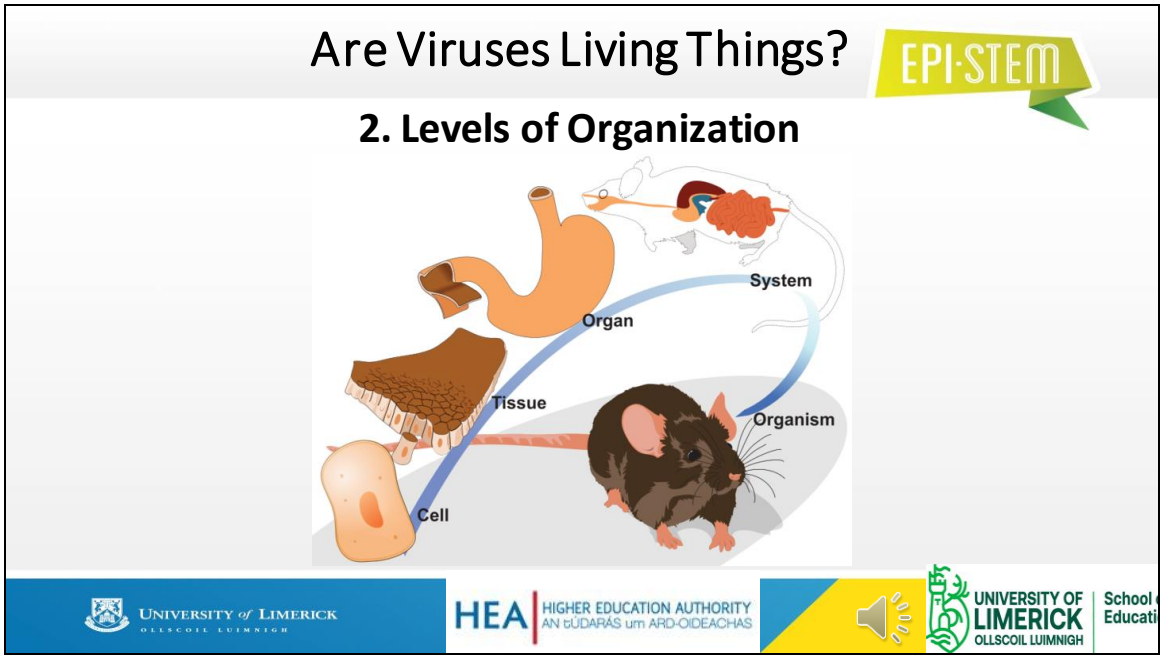
There has been some debate in the scientific community about whether or not viruses are living things. Encourage your students to do a class debate based on the information provided.

In order to determine if something is living, there are 7 criteria it must meet:



1. Does it maintain homeostasis?

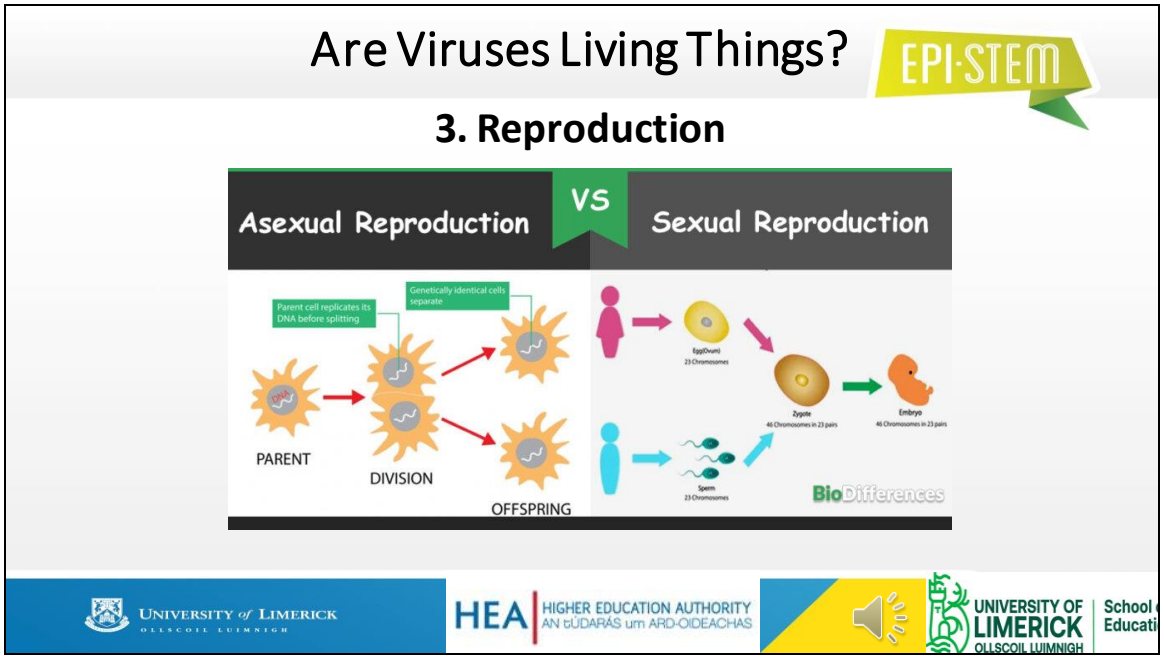
Homeostasis is a self-regulating process by which biological systems maintain stability while adjusting to changing external conditions. The internal temperature of the human body is the best example of homeostasis. Typically, viruses are incapable of maintaining homeostasis.



2. Living things have different levels of organization.

For example, cells make up tissue, which make up organs, which make up organ systems, which make up an animal.

Smaller building blocks come together to make a larger product.
Viruses do this. They have genes made from nucleic acids and a capsid made of smaller subunits called capsomeres.



3. Living things Reproduce.

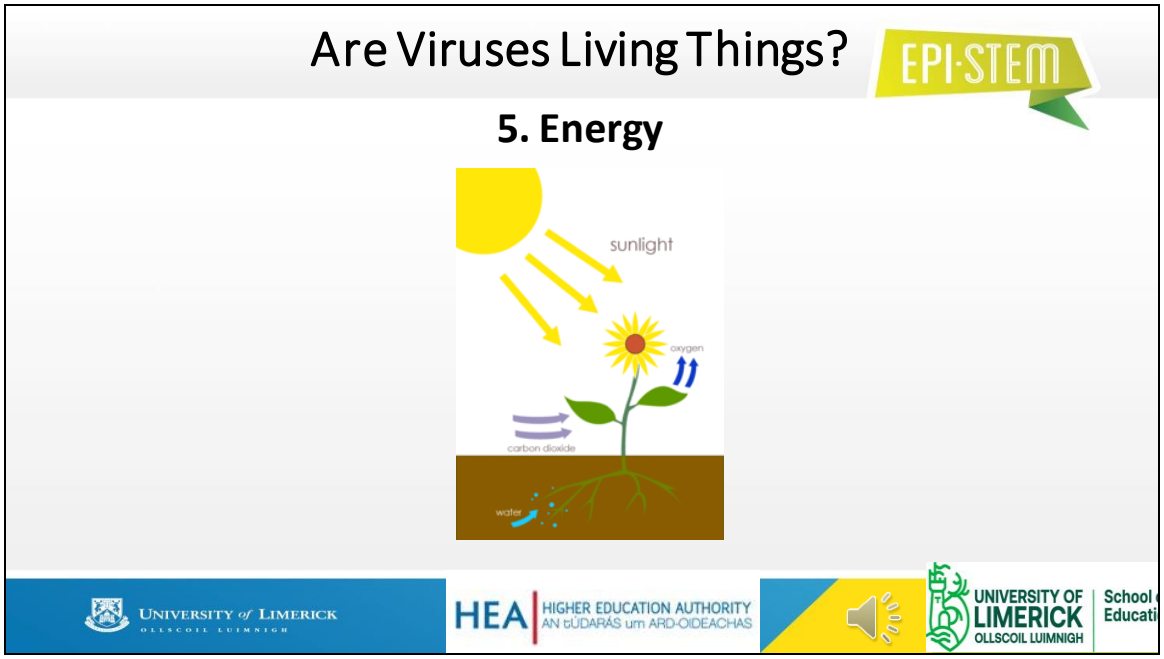
Reproduction is the process by which new living things are created. The two main types of reproduction are asexual reproduction and sexual reproduction. In asexual reproduction, an organism passes a copy of all of its DNA to its offspring, creating a genetically identical individual. In sexual reproduction, two parents each contribute a copy of half of their DNA.

Viruses lack organelles, nuclei, and ribosomes, so they don't have the tools they need to copy their genes, meaning they can't reproduce. However, they can replicate by entering living cells and hijack the host's cellular equipment to copy viral genetic information, build new capsids, and assemble everything together.

4. Living things Grow.

Living things take in nutrients and use energy to grow. For example, plants require nitrogen, phosphorus, and potassium, as well as sunlight to make energy to help them grow.

Viruses manipulate host cells into building new viruses which means each virion is created in its fully-formed state, and will neither increase in size nor in complexity throughout its existence. So, viruses do not grow.



5. Living things use Energy

As previously mentioned, living things require energy to perform any function. Living organisms must take in energy via food, nutrients, or sunlight in order to carry out cellular processes. The transport, synthesis, and breakdown of nutrients and molecules in a cell require the use of energy.

Creating new virion units is a major undertaking, from building nucleic acids to putting capsids together – that costs a lot of energy. However, all the energy that goes into this construction comes from the host. While viruses will definitely benefit from the use of energy, they are latching onto the host's metabolism to get to it.

6. Living Things Respond to Stimuli

For example, living things respond to changes in light, heat, sound, and chemical and mechanical contact. To detect stimuli, organisms have means for receiving information, such as eyes, ears, and taste buds.

Viruses haven't yet shown to provide any immediate response to stimuli, however there isn't enough research done yet to say that they definitively don't.

7. Living things adapt to their environment.

Animals adapt to their environment in a variety of ways; an animal's color, behavior, defense or diet, for example, may serve adaptive functions. Adaptation and evolution happen through unintentional changes (mutations) that are advantageous to an entire species.

Viruses definitely adapt to their surroundings. Unlike the previous requirement, which required an immediate response, adaptation is a process that takes place over time. A virus can live in two different phases – the lytic phase (where the virus actively replicates in a host cell) and the lysogenic phase (where the viral DNA incorporate itself into the cell's DNA and multiples whenever the cell multiplies). Sometimes a host does not have enough energy or supplies to support the virus to actively replicate, so it will switch to the lysogenic phase. The virus can eventually reenter the lytic phase when conditions are right.

This ability to adapt is what makes human immunodeficiency virus (HIV) as hard to treat as it is. HIV mutates quickly because it makes frequent mistakes while replicating its genome. Because the virus is constantly changing, it makes it very hard

to design drugs and vaccines against it. One drug might prevent a large number of virions from replicating, but just a few will be unaffected. Those surviving virions will continue to infect more cells, making copies of the resistant strains.

Are Viruses Living Things?

Criteria of Living Things	Yes	No
Maintain homeostasis		X
Have levels of organization	✓	
Reproduce	?	?
Grow		X
Use energy	?	?
Respond to stimuli	?	?
Adapt to their environment	✓	

As we've discovered, it is still unclear whether or not viruses are living things, and a lot more research needs to be done to understand them better.

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Contact Details

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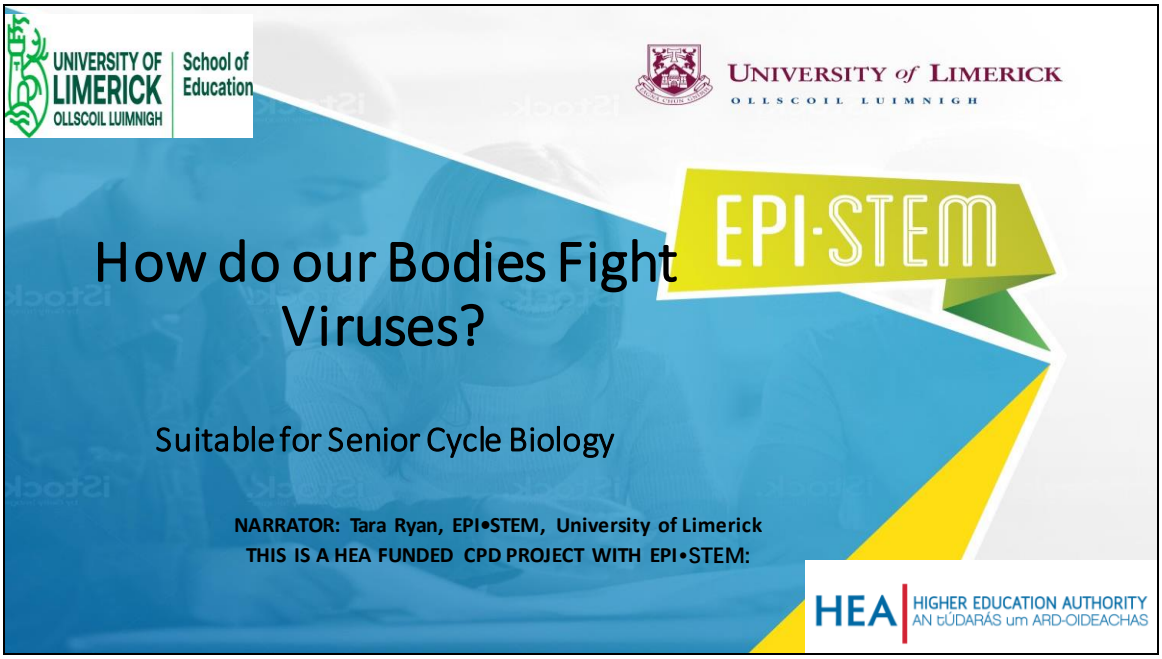
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EPI·STEM
How do our Bodies Fight Viruses?
Suitable for Senior Cycle Biology
NARRATOR: Tara Ryan, EPI•STEM, University of Limerick
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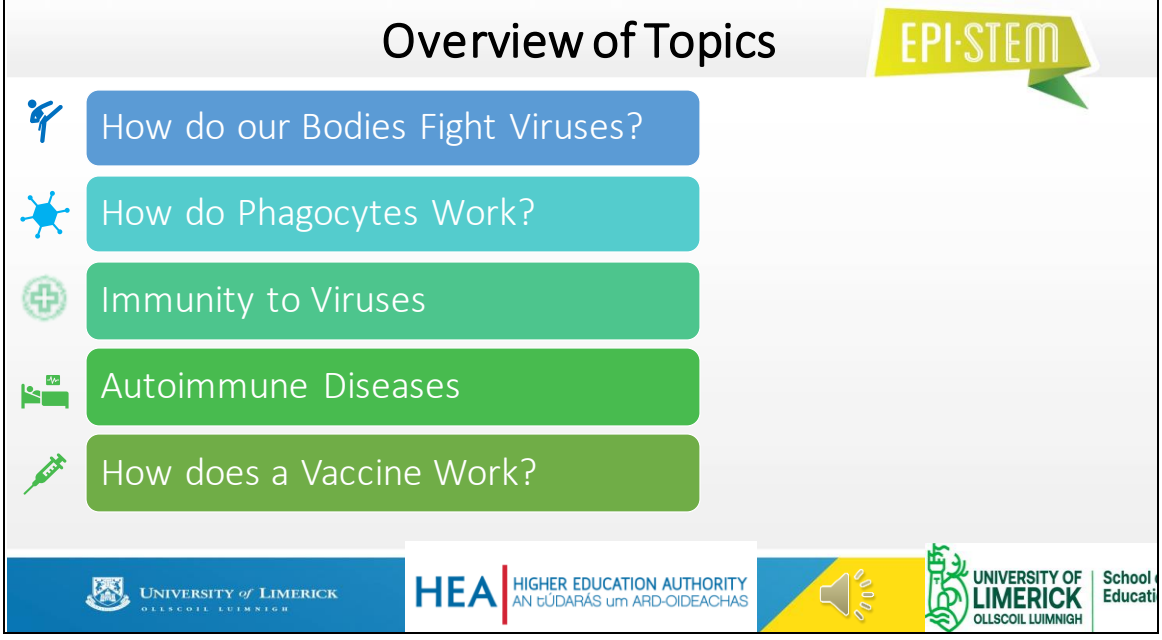
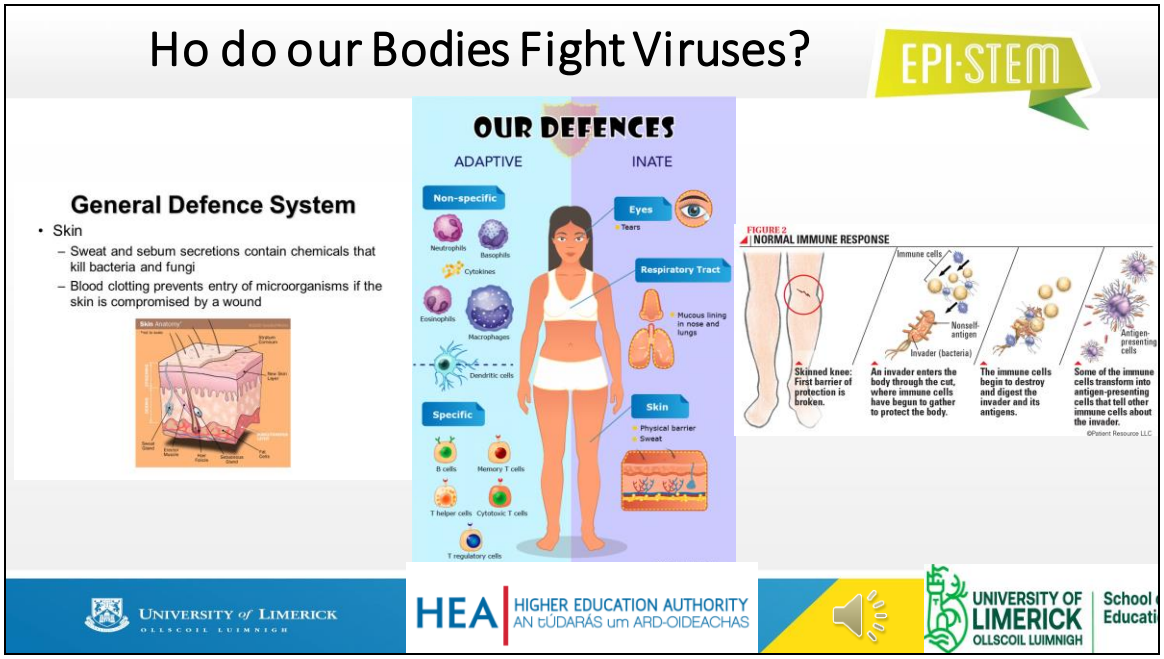
Overview of Topics

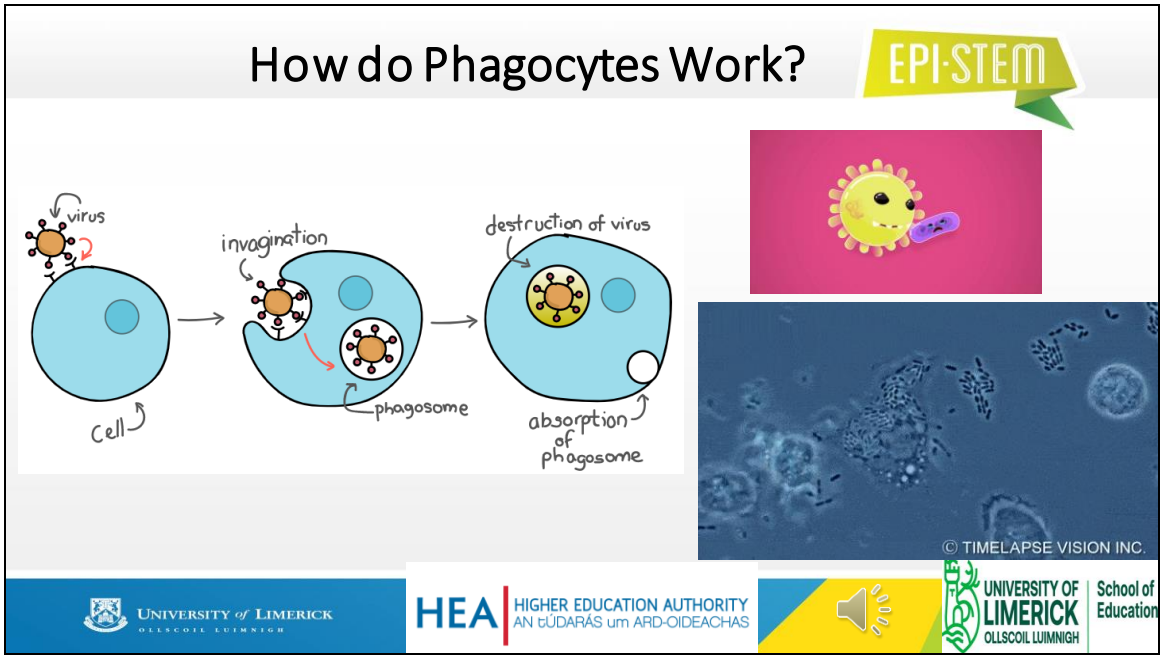




The human defense system protects the body from bacteria, fungi, and viruses that cause disease. A pathogen is an organism that causes disease. Immunity is the ability resist infection. The human defense system is composed of the general and specific defense system.

The general defense system is non-specific, meaning that it will fight against all pathogens. The general defense system consists of skin and mucous membranes to prevent the entry of pathogens, and white blood cells to destroy any cells that have already penetrated the body.

The specific defense system, also called the immune system, attacks a particular pathogen by producing antibodies or killing the infected cell. An antigen is a foreign molecule that stimulates the production of antibodies. An antibody is a protein produced by a type of white blood cells called lymphocytes in response to an antigen.



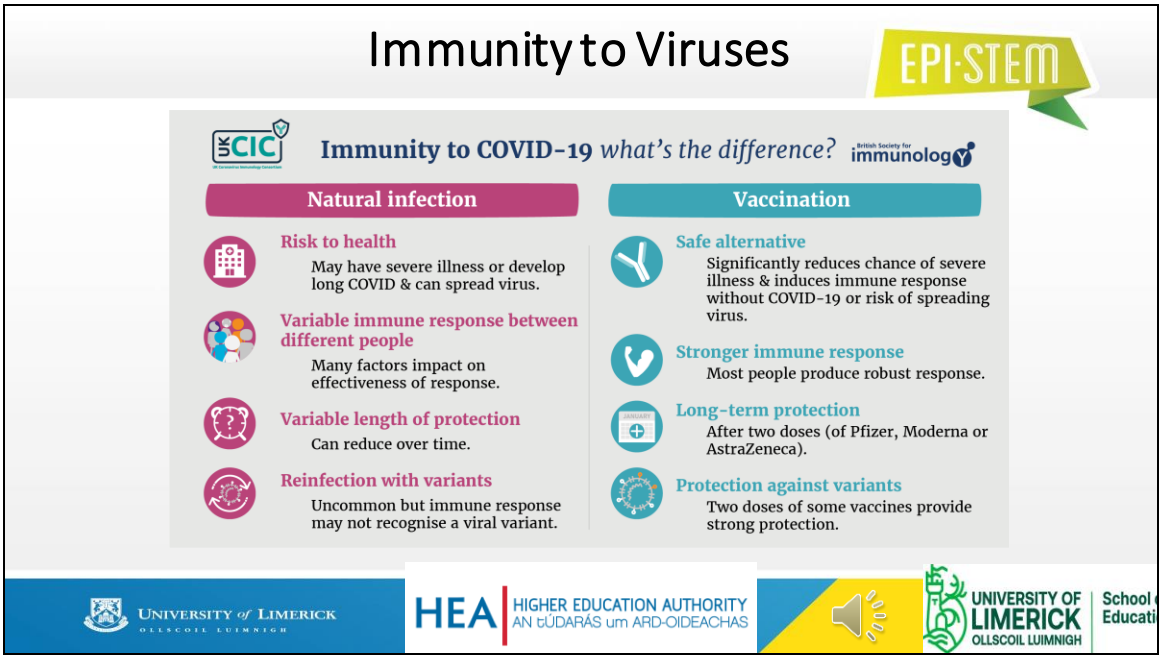
White blood cells, or phagocytes, surround and attack pathogens that have entered the body.

A collection of proteins called complement is present in plasma. The activation of complement by an infection results in the rupture of bacterial cell walls.

Another group of proteins are interferons. They are created by bodily cells that have contracted viral infections. Interferons stop viruses from multiplying.

Heat, redness, and swelling around the infection site are signs of inflammation. As a result, there are more white blood cells in the infected region. It is called a fever if the body is experiencing widespread inflammation.

Immunity to Viruses



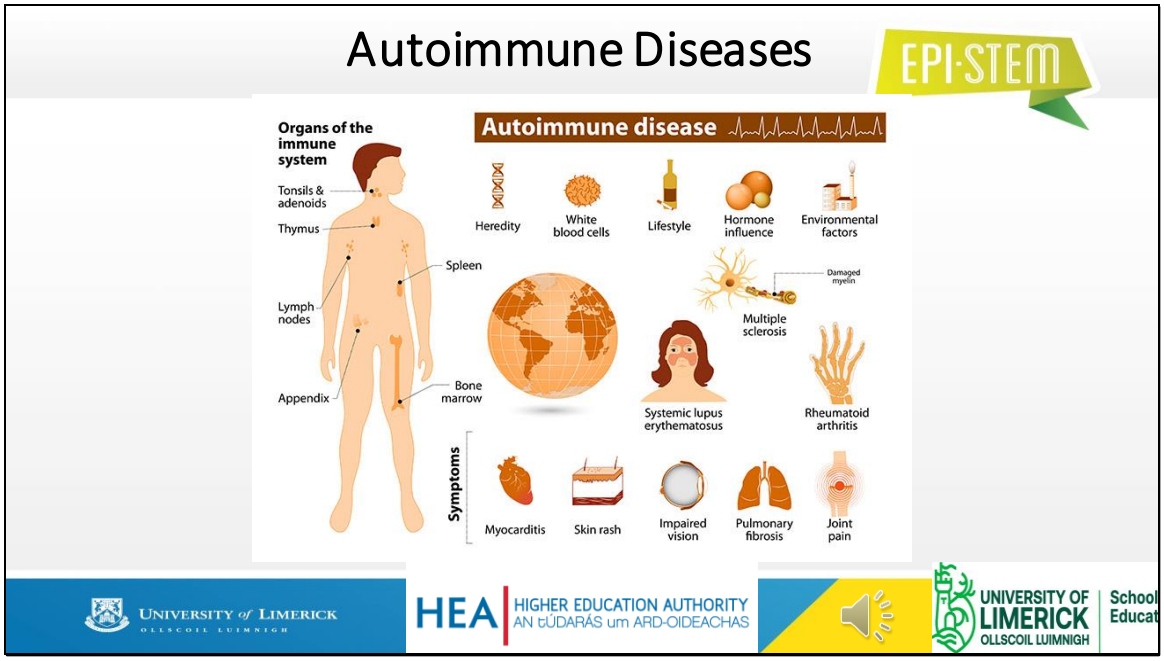
Immunity is the ability to resist infection. The different types of immunity are as follows.

Induced immunity is the ability to resist disease caused by a specific pathogen by the production of antibodies. This can be achieved two ways.

The first is active immunity, which involves the production of a person's own antibodies in response to antigens that enter the body. Active immunity occurs either naturally after a person has already gotten sick, or artificially when a pathogen is medically induced into the body in the form of a vaccine.

Immunity can also be achieved passively. Passive immunity occurs when a person is given antibodies that were formed by another organism.

This can also occur naturally when a child receives antibodies from its mother, or artificially when a person is given an injection containing antibodies made by another organism.



An autoimmune disease is a condition in which your immune system attacks your body.
The immune system usually guards against bacteria and viruses. When it senses these foreign invaders, it sends out an army of fighter cells to attack them.

Usually, the immune system can tell the difference between foreign cells and your own cells.
In an autoimmune disease, the immune system mistakes part of your body, like your joints or skin, as foreign. It releases proteins called autoantibodies that attack healthy cells. This makes it even more difficult for a person's body to fight actual foreign cells like viruses.

Some autoimmune diseases target only one organ. Type 1 diabetes damages the pancreas. Other diseases, like lupus, can affect the whole body.

1. Type 1 diabetes
The pancreas produces the hormone insulin, which helps regulate blood sugar levels. In type 1 diabetes mellitus, the immune system attacks and destroys insulin-producing cells in the pancreas.

High blood sugar results can damage the blood vessels and organs, including the heart, kidneys, eyes, and nerves.

2. Rheumatoid arthritis (RA)

In rheumatoid arthritis (RA), the immune system attacks the joints. This attack causes redness, warmth, soreness, and stiffness in the joints.

How does a Vaccine Work?

A vaccine is a non-disease-causing dose of a pathogen or its toxin, which triggers the production of antibodies.

A vaccine may contain pathogens that have been killed or rendered incapable of reproducing. In certain instances, the pathogen's exterior wall or coat is all that is required because it contains the antigens that make antibodies.

A vaccination induces the production of antibodies without causing the recipient to experience all of the infection's symptoms. Long-term immunity is provided by the body's ability to produce these antibodies. To improve the impact of the initial treatment, booster immunizations may be advised.

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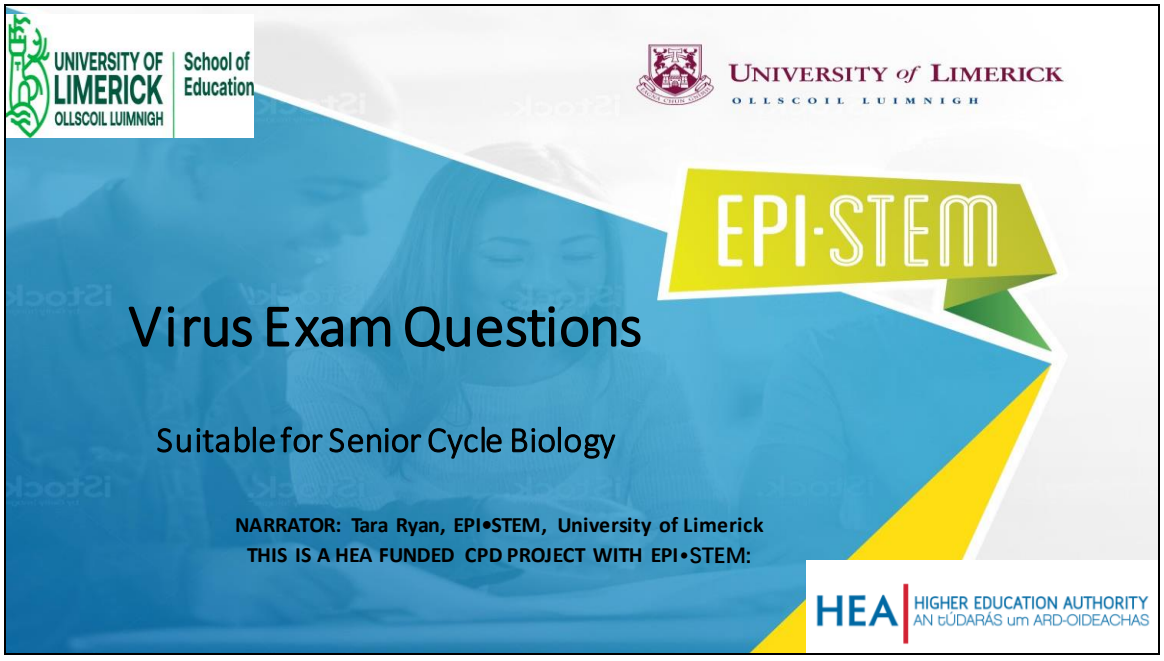
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Virus Exam Questions
Suitable for Senior Cycle Biology
NARRATOR: Tara Ryan, EPI•STEM, University of Limerick
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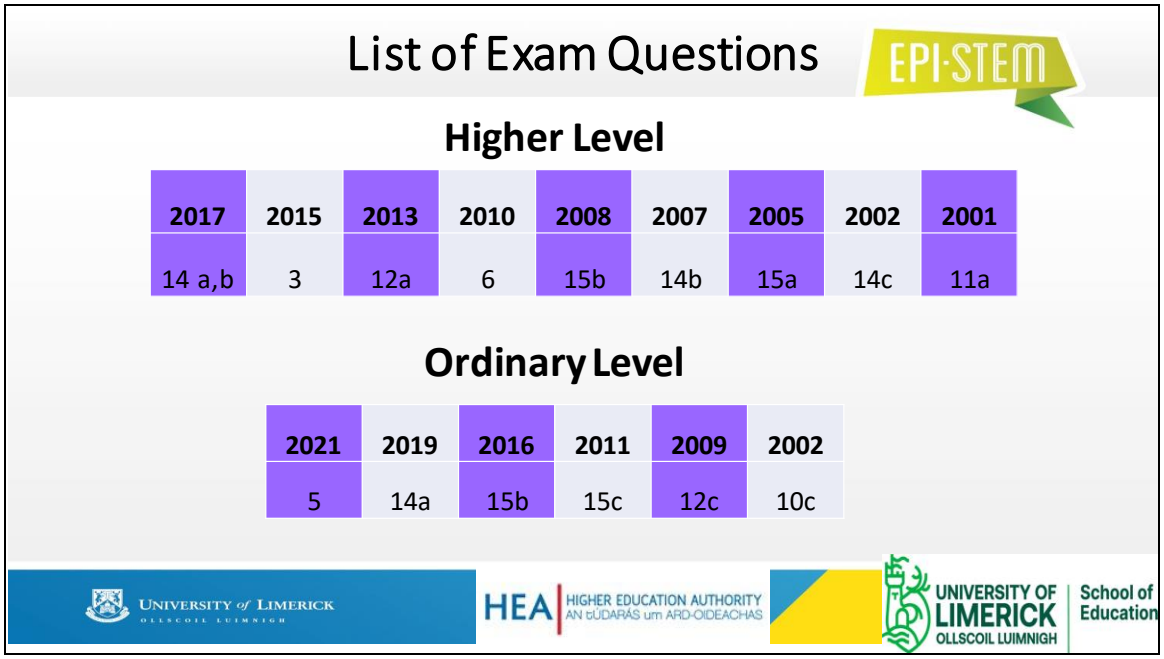
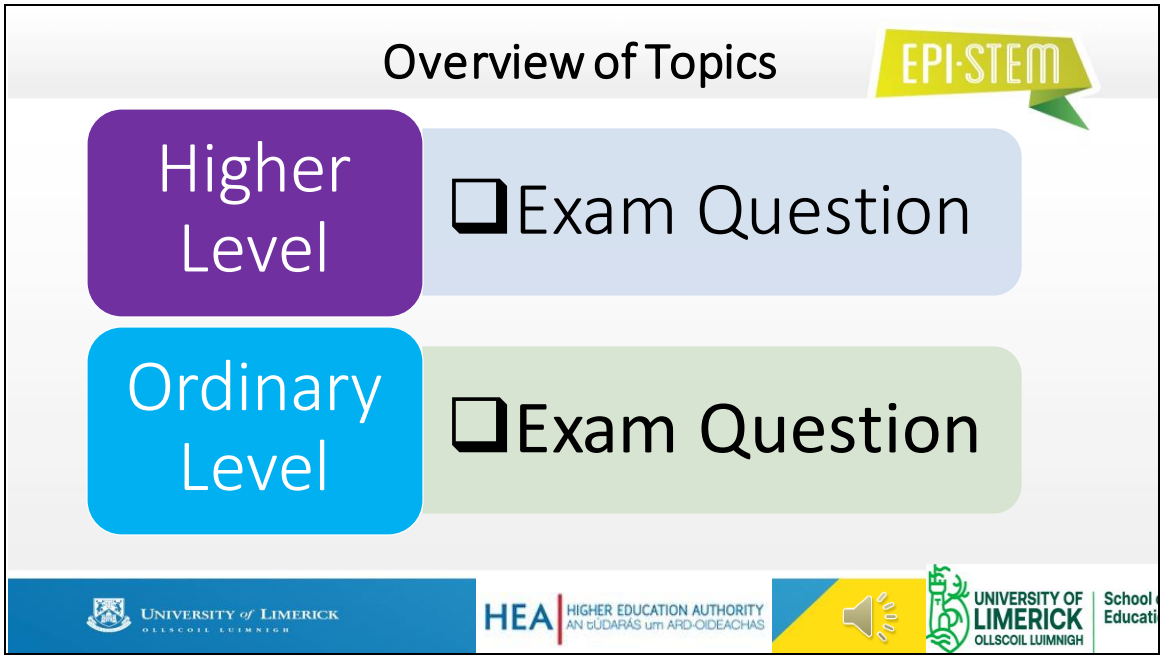


Provided here are lists of exam questions for both higher and ordinary levels.


Overview of Topics
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Higher Level
❑Exam Question
Ordinary Level
❑Exam Question
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2017 Q14 a) HL

Zika virus is a mosquito-borne virus. Mosquitoes usually bite during the day, peaking during early morning and late afternoon or evening. Researchers are studying a potential link between Zika virus infection and a surge in microcephaly cases. Microcephaly is a condition in which a baby is born with a small head or the head stops growing after birth. Rio de Janeiro, was an area with ongoing Zika virus transmission during the 2016 summer Olympic Games.

(i) Suggest a reason why the World Health Organisation (WHO) advised women of childbearing age or those who were pregnant not to travel to areas where a Zika virus outbreak was occurring.

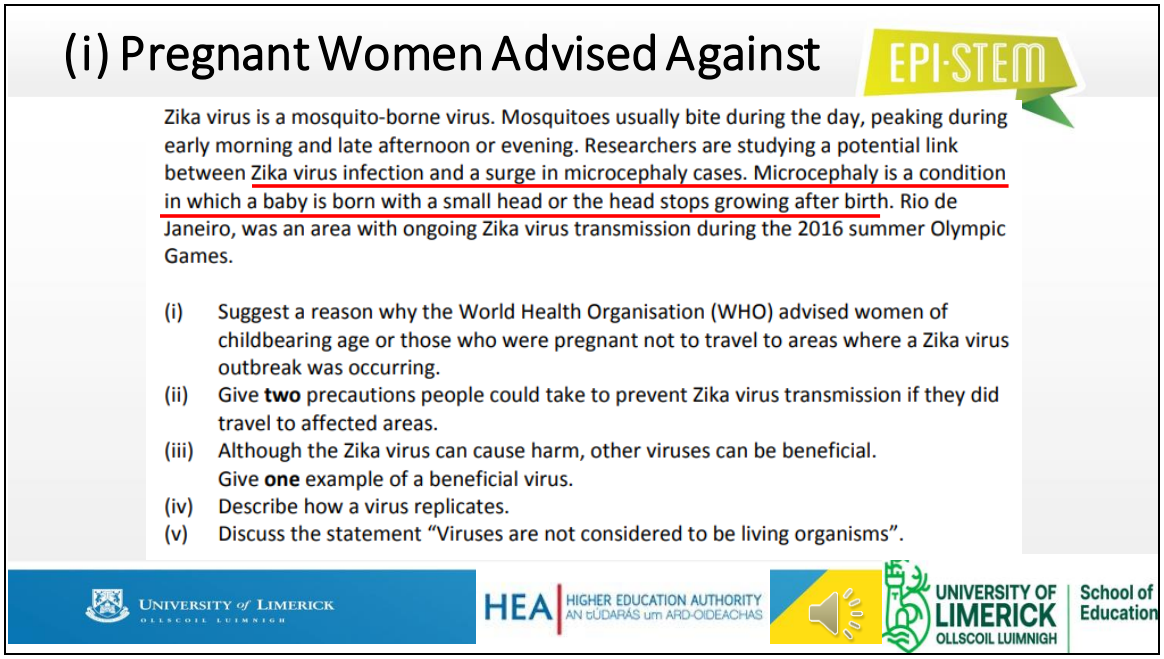
(ii) Give **two** precautions people could take to prevent Zika virus transmission if they did travel to affected areas.

(iii) Although the Zika virus can cause harm, other viruses can be beneficial. Give **one** example of a beneficial virus.

(iv) Describe how a virus replicates.

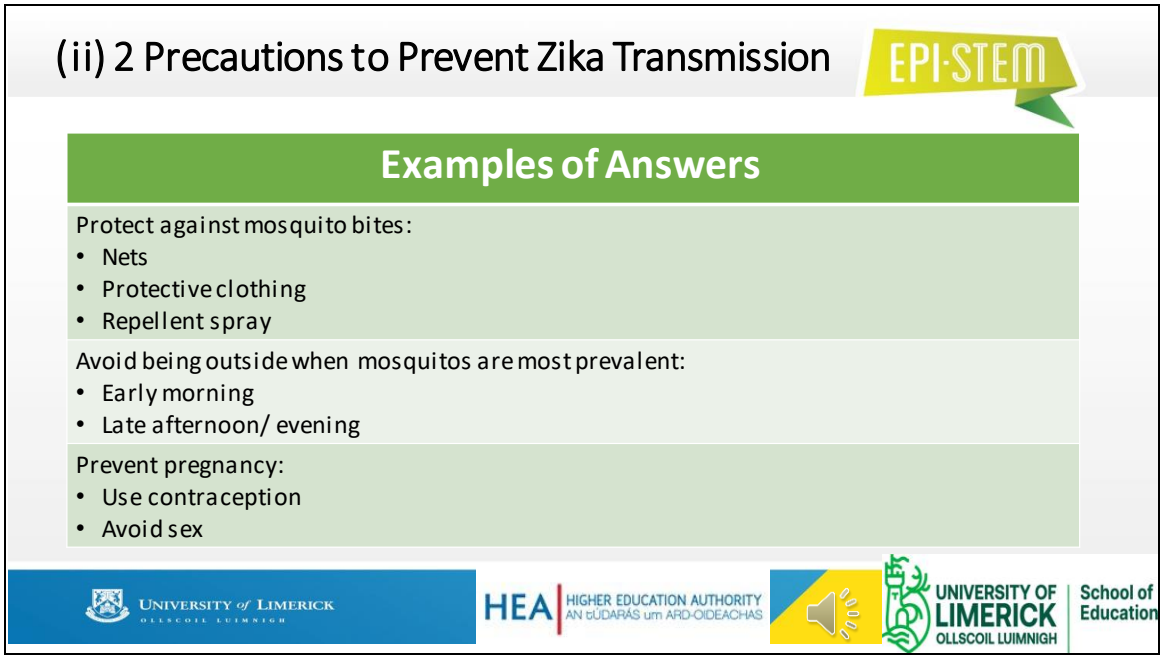
(v) Discuss the statement "Viruses are not considered to be living organisms".

Shown here is question 14 a) taken from the 2017 higher level exam.



The first part of the question asks students why the world health organisation advised pregnant women against travelling to areas where the Zika virus outbreaks were occurring.

Any time there is a passage of text before a question, we would advise students to read it, as it is usually helpful when answering the questions below.
The paragraph above informs students that there may be a potential link between a zika virus infection and cases in microcephaly, which is a condition that causes babies heads to be small.

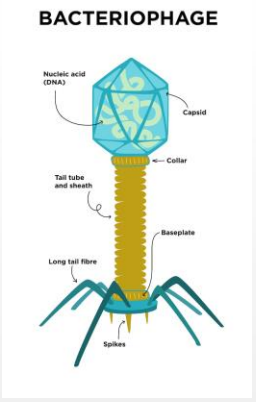


The student was then asked to give 2 precautions that could be taken to avoid the transmission of zika virus.
Some examples are:

Protect against mosquito bites using nets, clothing or repellent spray.
Avoid being outside when mosquitos are most prevalent, such as early morning or evening time.
Or prevent conception by using contraception or by avoiding sex.

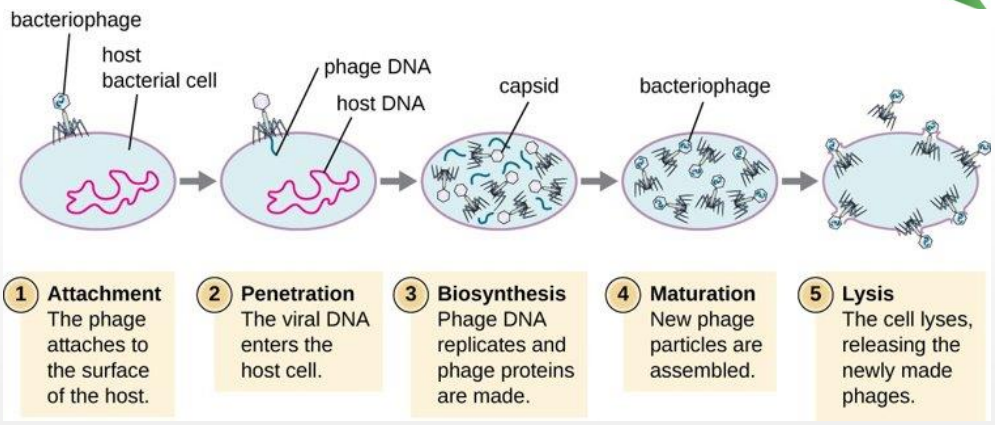
(iii) Example of Beneficial Virus

Bacteriophages
Kill bacteria.
Used to treat tumours.
Vectors: • Gene therapy • Genetic engineering



The third part of the question asks students to give an example of a virus that can be beneficial. Students could have chosen any relevant virus.
The example we selected was bacteriophages, as they can be used to kill bacteria, treat tumours, or as vectors in gene therapy and genetic engineering.

(iv) How do Viruses Replicate?



A virus will go through five stages during its life cycle.

Shown here, is a bacteriophage first attaching to the surface of the host cell.
The long phage tails will then penetrate the host cell and inject it with its own DNA.
During biosynthesis, the phage DNA replicates within the host cell and will then consume the host cell's DNA and reassemble during maturation. Finally, the host cell will burst during lysis and the newly made phages are released to repeat the process all over again.

(v) Reasons why Virus are Not Considered Living

Examples of Answers
Cannot reproduce independently • Obligate parasites • Need host to replicate
Non cellular • No cell organelles
No metabolism
Only 1 type of nucleic acid

2017 Q14 b) HL

(i) An outbreak of measles occurred in Ireland during the summer of 2016.
Name a group of people who would be most at risk if exposed to such an outbreak.

(ii) What is a vaccine **and** how does it result in immunity?

(iii) List any **three** types of T lymphocyte active in the human immune response.

(iv) Describe the role of **each** of the T cells referred to in part (iii) above.

Part b of the same question is also related to viruses.

(i) High Risk People if Exposed to Measles

Examples of Answers
Weak immune systems.
Unvaccinated.
Babies.

Firstly, the student is ask to give some examples of people most at risk if they were exposed to measles. They could have said those with weak immune systems, the unvaccinated, or babies.

(ii) Explain Vaccines

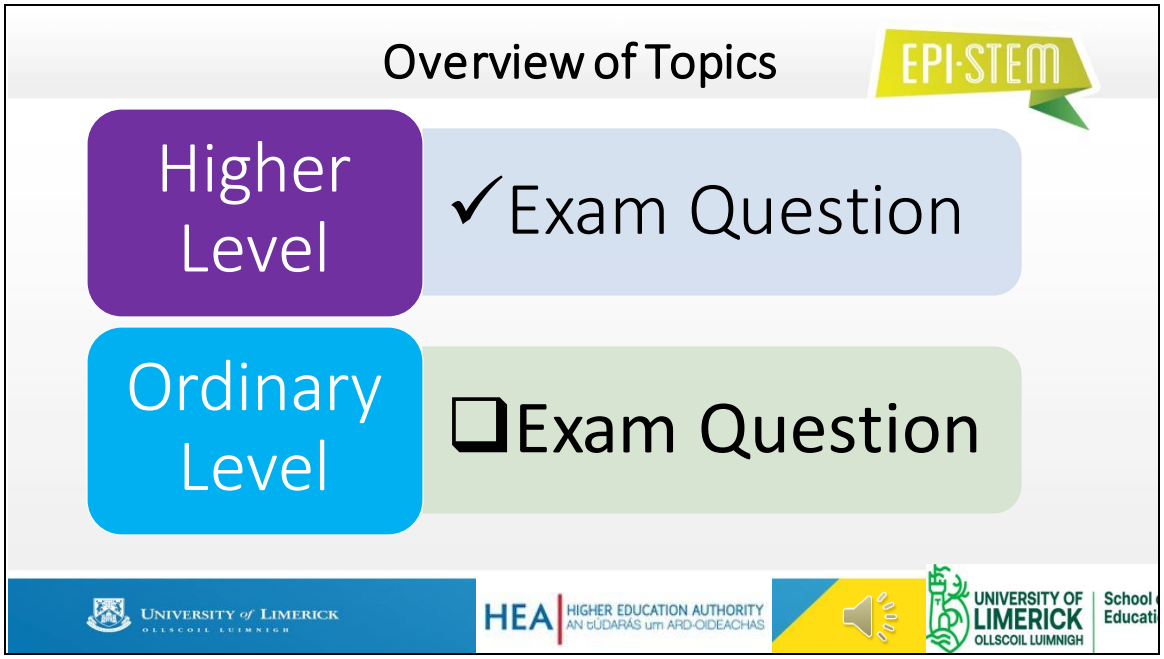
Define Vaccines	How it Provides Immunity
A non-disease-causing dose of a pathogen (or antigen).	The introduction of the antigen stimulates the bodies production of antibodies.

Secondly, students are asked to define vaccines and explain how they function.
A vaccine is a non-disease causing dose of a pathogen or antigen.
It provides immunity to the recipient by introducing the antigen, which stimulates the body to produce antibodies.

(iii) & (iv) Types & Role of T Lymphocyte Cells

Type of T Lymphocyte Cell	Role
Helper	Recognise antigens or activate killer cells or secrete interferon or stimulate B- cells or stimulate antibody production.
Killer	Recognise (or attack or burst) infected cells (or cancer or antigen) or secrete perforin.
Suppressor	s Stop immune response or inhibit B (or T) cell (production).
Memory	Remember antigens or long-term protection.

Finally, the last 2 parts asked the student to list any 3 types of T Lymphocyte cells and describe their role.


Overview of Topics
EPI-STEM
Higher Level
✓Exam Question
Ordinary Level
❑Exam Question
University of Limerick
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HIGHER EDUCATION AUTHORITY
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2021 Q5 OL

(a) Why are viruses not considered to be living organisms?

(b) Identify the **two** parts labelled **A** and **B** that are found in all viruses.

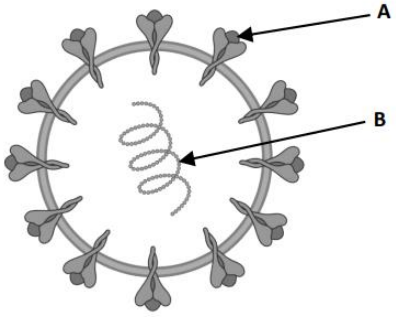
A. | B.

(c) Describe **one** way viruses may be spread from person to person.

(d) State **one** way the body can defend itself against viruses.

(e) Give **one** way in which viruses are beneficial.

(f) Explain why viruses are described as obligate parasites.



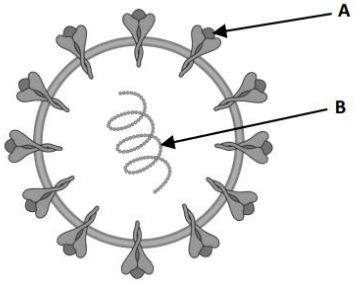
Next, we will look at an ordinary level paper from 2021 and examine Q5.

(a) Why are Viruses Not Considered Living?

Examples of Answers
Cannot reproduce independently • Obligate parasites • Need host to replicate
Non cellular • No cell organelles
No metabolism
Only 1 type of nucleic acid

(b) Label the Diagram

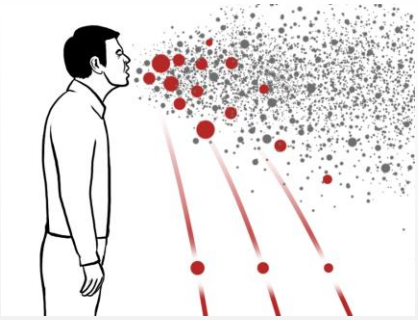
Label	Part of Virus
A	Protein/ Capsid
B	DNA/ RNA/ Nucleic Acid



The second part of the question asks the student to identify the labels on the diagram.
Component A is a protein or capsid
And part B is DNA/ RNA/ Nucleic acid.

(c) Describe 1 Way Viruses Can Spread

Examples of Answers
Coughing.
Sneezing.
Touching contaminated surfaces.
Shaking hands with an infected person.



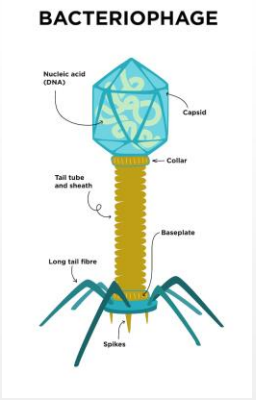
Coughing or sneezing or droplets through the air or shaking hands or touching contaminated surfaces

(d) State 1 Way Body can Defend Itself

Barrier System	Immune System
Skin	White blood cells
Mucus	Antibodies

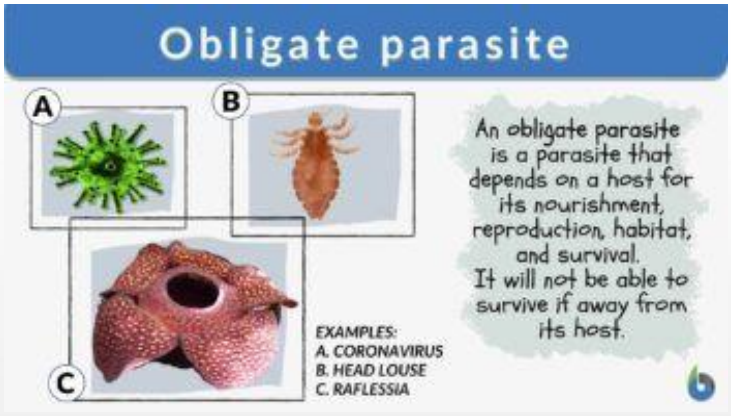
(e) Example of Beneficial Virus

Bacteriophages
Kill bacteria.
Used to treat tumours.
Vectors: • Gene therapy • Genetic engineering

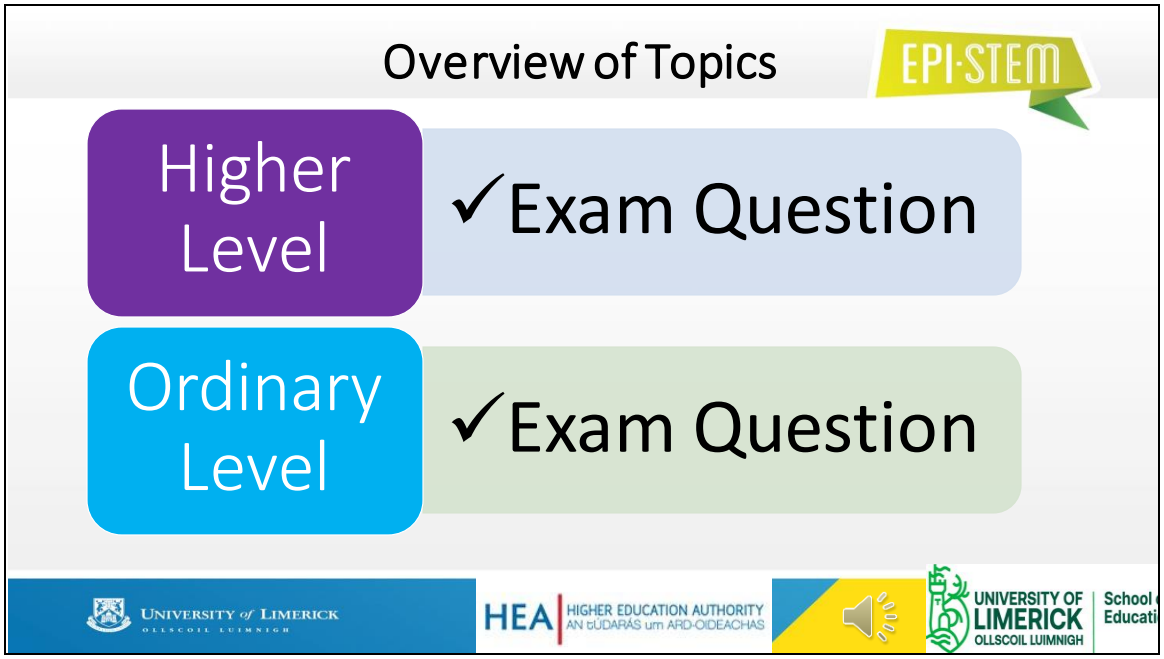


Part E of the question asks students to give an example of a virus that can be beneficial. Students could have chosen any relevant virus.
The example we selected was bacteriophages, as they can be used to kill bacteria, treat tumours, or as vectors in gene therepy and genetic engineering.

(f) Viruses are Obligate Parasites



Finally, the student is asked to explain why viruses are described as being obligate parasites. Viruses are only able to replicate in a living host cell.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Contact Details

Register for on-line CPD resources: https://epistem.ie
EPI•STEM project: Resources
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Email: helen.fitzgerald@ul.ie

This on-line CPD project [HEA funded] is an initiative with EPI•STEM for science and mathematics secondary teachers in Ireland. The research-led development team include:

Geraldine Mooney Simmie, Niamh O'Meara, Merrilyn Goos, Stephen Comiskey, Ciara Lane, Tracey O'Connell, Vo Van De, Tara Ryan, Martina Scully, Jack Nealon, Daniel Casey, Keith Kennedy, Annette Forster, Céren O'Connell, Martha Cosgrave, Veronica Ryan, Gemma Hemstock