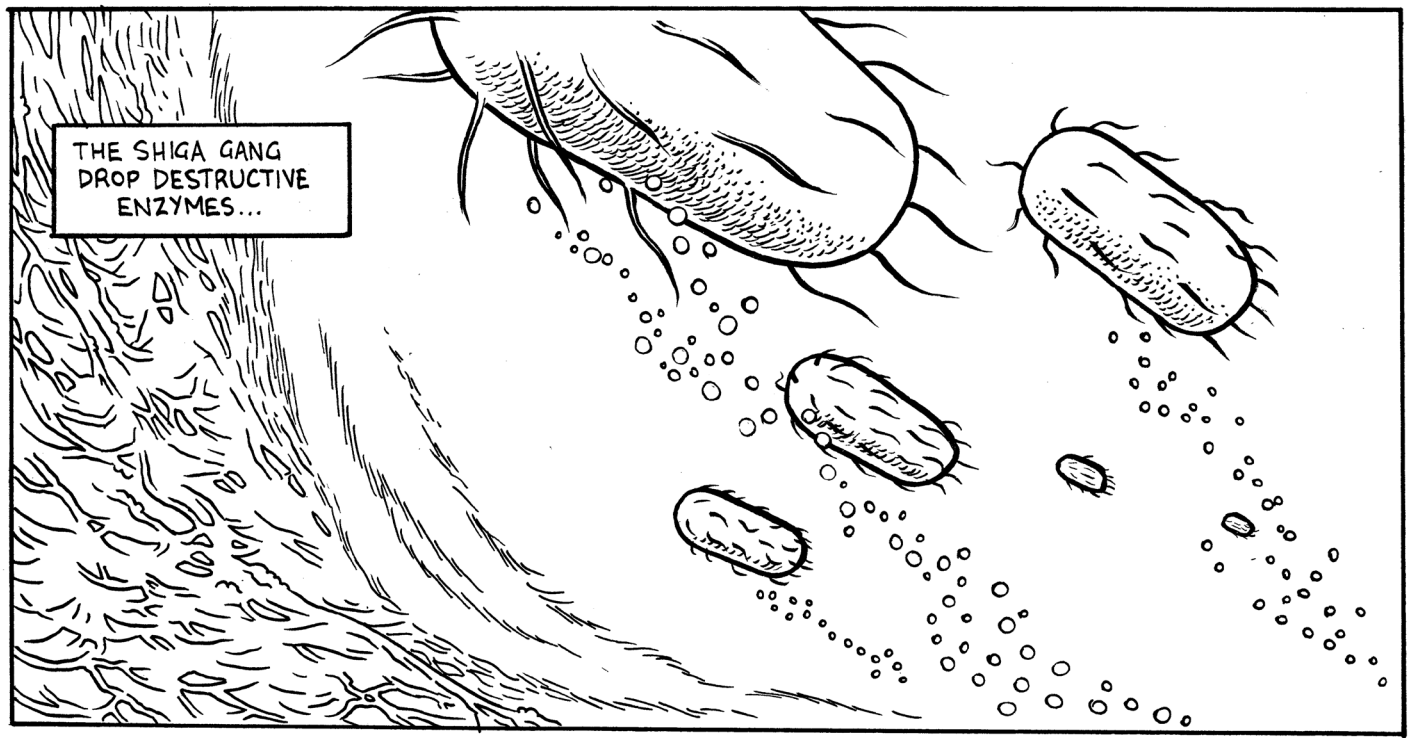

THE
INVISIBLE WAR
A Tale on Two Scales

SCIENCE TEACHING ACTIVITIES

THE INVISIBLE WAR SCIENCE TEACHING ACTIVITIES:
A *Scale Free Network* art-science learning resource.

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All URLs were checked for currency at the time of publication.
We apologise if any URLs have changed since this time.

scale free network
art–science collaborative

THE INVISIBLE WAR: SCIENCE TEACHING ACTIVITIES

INTRODUCTION

The reading of *The Invisible War* will give rise to many specific questions and general curiosity about aspects of the scientific content embedded within the story. These questions provide teachers of Science with opportunities to facilitate a range of individual and whole-class interactions and learning within their classrooms.

This booklet presents a bank of activities designed to encourage readers of *The Invisible War* to engage with concepts relating to:

- cells & classification – interactions between different types of cells and life forms, including bacteria and viruses;
- the human microbiome – types, sizes and roles of different microbes in health and disease;
- human cells and systems – particularly responses of human body to disease causing microbes – through systems (such as the digestive and immune systems) and human cells (such as epithelium and goblet cells);
- genetics - including DNA and the role of mutation in adaptation.

The activities are not presented in any specific order, nor are they intended to cover an entire unit of work. They do not represent any particular approach to teaching, rather are intended for broad use by teachers with different styles and in different learning settings.

While these activities are primarily directed for use in Science classrooms, there are many elements of Literacy, Numeracy, Critical and Creative Thinking, Interpersonal Development, Personal and Social Capabilities, Ethics, Communication and ICT.

Links to relevant knowledge and skills within year 9 Science are presented for current versions of the Australian curriculum and the Victorian curriculum. However, we are confident that *The Invisible War* and these accompanying activities can be easily adapted for use in any secondary school science classroom.

Gregory (co-Director of *Scale Free Network*)
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TABLE OF CONTENTS

READING *THE INVISIBLE WAR*

Reading *The Invisible War* will facilitate student learning in the areas of:

- how the interdependent cells and systems within the human body coordinate and respond to disease, including those within:
  > the digestive system (such as epithelium and goblet cells);
  > the immune system (such as neutrophils);
  > the human microbiome;

- the roles of the human microbiome (e.g. bacteria, fungi, viruses) in maintaining the health of its host, including a greater understanding of:
  > the different types, sizes and of microbes within the human large intestine (gut);
  > the different strategies for metabolism, survival and reproduction;
  > the different roles of these microbes in maintaining health and preventing disease;

- the contestability of scientific models and theories, and role of technology in exploiting new scientific discoveries.

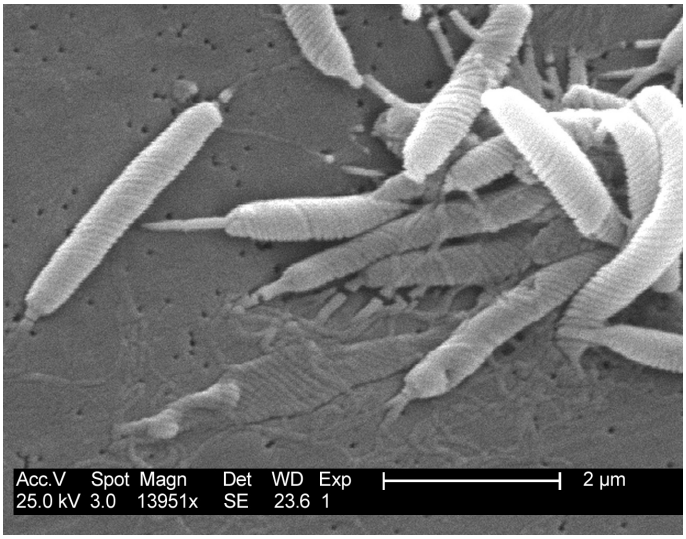


Image: Helicobacter bacteria embedded in mucus.
Source: Dr. Patricia Fields and Dr. Collette Fitzgerald.

Image: Digital Illustration of Shigella bacteria.
Source: James Archer, U.S. Centers for Disease Control and Prevention.

Image: Digital illustration of a T4 (myophage) bacteriophage by Mike Smith.

THE INVISIBLE WAR: SCIENCE QUIZ

WHICH IS BIGGER?

Compare each of the following pairs of characters from *The Invisible War,* and CIRCLE the character that is larger:

1.	Annie	*or*	Shigella bacteria
2.	Shigella bacteria	*or*	the Fly
3.	DNA	*or*	Myophage
4.	The Western Front	*or*	France
5.	Neutrophil	*or*	bacteria
6.	Red Blood Cell	*or*	bacteriophage (phage)
7.	Red Blood Cell	*or*	Shigella bacteria
8.	Podophage	*or*	Myophage
9.	Epithelium cell	*or*	Shigella bacteria
10.	Neutrophil	*or*	bacteriophage (phage)

TRUE OR FALSE

Answer true (T) or false (F) to the following statements:

1. ____ Shigella is a type of bacteria.
2. ____ All viruses are dangerous to humans.
3. ____ Bacteria cannot live in the human stomach.
4. ____ Humans are a type of animal.
5. ____ Bacteria can survive outside of the human body.
6. ____ Viruses cannot infect bacteria.
7. ____ When viruses self-replicate, they make many copies at once.
8. ____ Most of the bacteria in our body live in the small intestine.
9. ____ Bacteria can make vitamins to help their human host.
10. ___ Food usually contains bacteria.

THE INVISIBLE WAR: SCIENCE QUIZ

SHORT ANSWERS

1. Are bacteria uni-cellular (single-celled) or multi-cellular organisms? _____

2. Which of the following types of cell does NOT have a nucleus:
   a) plant
   b) bacteria
   c) animal

3. In the story, which of the Shigella (bacteria) and the Bacteriophage (virus) is the predator and which is the prey?
Predator = _____ Prey = _____

4. Where in Annie's body did most of the action take place?

_____

5. Describe one of the ways that Annie's immune system tried to fight off the invading Shigella bacteria?

_____

_____

6. In your own words, describe the relationship between Annie and the bacteriophage?

_____

_____

7. Describe how the bacteriophage eventually killed most of the Shigella bacteria?

_____

_____

8. How did Shigella bacteria and the disease they cause threaten Annie's life?
(*that is – what do you normally die from, when you have dysentery?*)

_____

_____

THE INVISIBLE WAR: SCIENCE QUIZ

MEASURING UP

Microbiologists often present a scale bar on the bottom of microscopic images. The scale bar is a line that helps people determine the size of the objects within the image.

Use the 100 nm scale bar in the bacteriophage (virus) image below to measure:

1. the approximate length of the entire bacteriophage _____ nm

2. the approximate width of the bacteriophage capsid (head) _____ nm

3. What unit of measurement does nm represent? _____

4. There are 1000 micrometres in a millimetre, and 1000 millimetres in a metre. If *Shigella* bacteria are 3 micrometres long, how many *Shigella* would you need to stack end to end to be the same height as a human 1.8 metres tall?

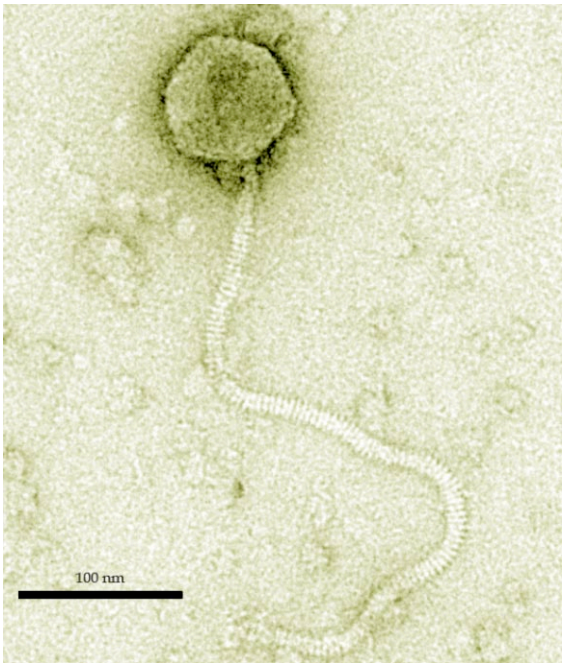
_____

_____

_____

_____

_____



GROWING EXPONENTIALLY

REPLICATE OR DIE

Bacteria and viruses can self-replicate (that is, make identical copies of themselves) very quickly. Their populations grow in size exponentially (until an essential nutrient is exhausted), so they can often dramatically increase in number within a few generations.

SHIGELLA (bacteria)
The human gut provides conditions for Shigella bacteria to self-replicate, doubling in number every ***20 minutes.*** Typically the first bacterial cell splits into two daughter cells, who then each split to form four, who split to form eight, and so on.

If just ***one*** single Shigella bacterium enters Annie's gut, how long will it take, in minutes, before there are at least **one billion** (10^9 = 1,000,000,000) of these bacteria devastating Annie's gut?

BACTERIOPHAGE (viruses)
In ideal conditions, ***a single*** bacteriophage (virus) can infect a new bacterium and self-replicate to create ***100*** new bacteriophage every ***30 minutes.***

In a bacteriophage's ideal world of never-ending bacteria to infect, calculate the number of minutes a single bacteriophage would need to create ***one billion*** (10^9 = 1,000,000,000) new bacteriophage?

THE RIDDLE OF THE LILY POND

The following French riddle for children illustrates another aspect of exponential growth - the apparent suddenness with which it approaches a fixed limit:

"Suppose you own a pond on which a water lily is growing.
The lily plant doubles in size each day.
If the lily were allowed to grow unchecked, it would completely cover the pond in 30 days, choking off the other forms of life in the water.
For a long time the lily plant seems small, and so you decide not to worry about cutting it back until it covers half the pond.
On what day will that be?

On the twenty-ninth day, of course…you have one day to save your pond."

GROWING EXPONENTIALLY

Minutes	*Number of Shigella*
0	1
20	2
40	4

Minutes	*Number of Bacteriophage*

SHIGELLA BACTERIA

1. How many minutes until there was a population of one billion Shigella bacteria? ____________________

2. How long is this in hours? ____________________

3. How many generations was this? (*hint = each row represents a generation*) ____________________

BACTERIOPHAGE VIRUSES

4. How many minutes until there was a population of one billion bacteriophage viruses? ____________________

5. How long is this in hours? ____________________

6. How many generations was this? ____________________

THINKING DEEPER

7. In ideal conditions within the human gut, *Shigella* bacteria can potentially double in number every 20 minutes. Based on your reading of the story, list at least two actions of events that might have interrupted the *Shigella* bacteria from reaching a population of one billion?

____

____

8. What actions or events might prevent the rapid self-replication of the bacteriophage?

____

____

ON A SEPARATE SHEET OF GRAPH PAPER, MAKE A GRAPH USING BOTH THE DATA IN BOTH TABLES.

Time (or the generation number) should be along the x-axis and the Total Number (or population size) of Shigella bacteria and the bacteriophage should be on the y-axis.

GROWING EXPONENTIALLY

PLOTTING THE HUMAN POPULATION

The human population is estimated at one million people people at the dawn of civilisation about 10,000 years ago, and reached 7 billion in late 2011.

Plot the growth in the human population over the last 10,000 years, using one of the following sets of data:

Wikipedia: *click here*
United Nations Population Division: *click here*
Worldometers: *click here*

QUESTIONS TO CONSIDER & DISCUSS:

- Can you estimate or calculate the doubling time for the human population?
- Do you think the human population will continue to grow indefinitely?
  > Why/why not?

MORE LINKS ABOUT EXPONENTIAL GROWTH

Limits to Growth (UniWolongong): *click here*

How do Populations Grow?: *click here*

Exponential Growth (blog): *click here*

Exponential Growth (Wikipedia): *click here*

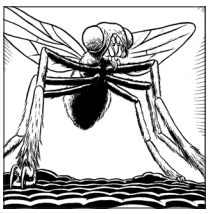
Malthusian catastrophe (Wikipedia): *click here*

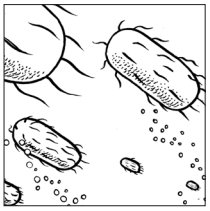
GapMinder World: *click here*

COMMON CHARACTERISTICS OF CREATURES

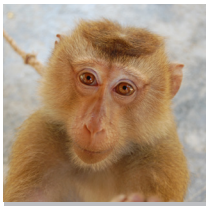

parrot

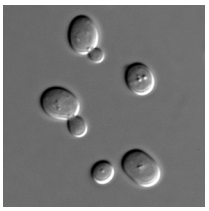

mushroom


fly

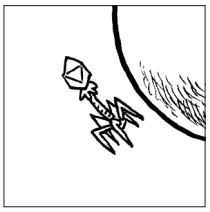

bacteria


human


monkey


yeast


tomato plant


virus

1. Think about these different creatures.
- What do they look like?
- Where do they live and how do they move?
- What else makes them unique?
- Do they share any characteristics with each other?

2. Separate the organisms into three groups based on some of these characteristics.

3. Add your three groups into the table opposite, along with their common characteristics.

4. Give each group a unique name – be creative. Try to make the group name describe their characteristics, so that someone reading it later could guess what the shared characteristics might be.

ALTERNATIVE APPROACH:
– Ask students to collect 20 objects from outside (e.g. home or the schoolyard).
– Place these onto sheets of butcher paper and divide into groups.

Organisms in the group			
Shared characteristics within the group			
Group Name			

Activity adapted from *Science Web Australia.*

TO LIVE, OR NOT TO LIVE?

The truth is rarely black and white. Scientific debate is an essential part of the scientific process. One thing scientists struggle to agree upon is how to define what it means to be alive. Viruses offer the greatest challenge in the debate about what 'living' means.

As a group, discuss the defining features of living creatures…considering:

- What is the difference between living, non-living and dead?
- What is the opposite of life: non-living or dead?
- Based on your discussion (or the below definitions), what are some characteristics of life?

SOME DEFINITIONS OF 'LIFE'

Miriam-Webster

a: the quality that distinguishes a vital and functional being from a dead body
b: a principle or force that is considered to underlie the distinctive quality of animate beings
c: an organismic state characterized by capacity for metabolism, growth, reaction to stimuli, and reproduction

Wikipedia

Life is a characteristic distinguishing physical entities having biological processes (such as signalling and self-sustaining processes) from those that do not, either because such functions have ceased (death), or because they lack such functions and are classified as inanimate.

Google

The capacity for growth, reproduction, functional activity, and continual change preceding death.

CHALLENGES TO THE DEFINITIONS OF LIFE

Stem cells

Stem cells can morph into any type of cell found in the body. Other cells, such as muscle cells, keep replicating as muscle cells and will not change. Test tube meat is an example of muscle cells dividing to create many new muscle cells.

- Would you eat a test-tube hamburger?
  > Why/why not?

HeLa cells are a type of cancer cell taken from a Henrietta Lacks in 1951 and used in medical research. They can grow indefinitely and are essentially immortal.

- But they are a human cell – so shouldn't they have human rights?

Artificial Intelligence (AI)

Programmed machines (robots) already have the potential to move, respond to stimuli, create more copies of themselves and make some decisions for themselves. However, many different fields of science and engineering are currently trying to develop Artificial Intelligence (AI), in the hope that these machines can operate independently to create solutions to many of our current global problems. In anticipation of AI, the scientist Alan Turing developed the Turing Test in 1950 to measure and distinguish whether a machine's ability to exhibit intelligent behaviour is equivalent to that of a human, and possibly no longer be just a machine.

- Do you think machines can be alive?
  > Why/why not?

Virus

Viruses also challenge our understanding of what it means to be alive. On the one hand, viruses do not breathe, metabolise or move independently. However, viruses can replicate, evolve and adapt, 'sense' changes and make simple 'choices' about their actions. In 2013, the Australian scientist Jeremy Barr proposed the BAM model (see p103 of The Invisible War), which describes the hunting strategies of viruses.

- Do you think viruses are alive?
  > Why/why not?

LIVING OR NOT - ACTIVITY

Use the information about the objects listed below to complete the table. The first one has been done for you.

Icicle: I am made of water and grow longer in cold weather. As I warm up I am able to move freely. I do not need to breathe to survive.

Parrot: I live high in the trees but eat seeds I find on the ground. I like to live with other birds and can often be heard making noise with my flock if anyone threatens my eggs. I love to breathe in the fresh air of the trees although my faeces can often make a mess underneath.

Sunflower: I can follow the Sun in the sky as I use water, carbon dioxide and sunlight to make my own energy. I grow quickly when I have enough nutrients and water, and produce oxygen as waste. My children grow from seeds I make when the weather is warm enough.

Iron nail: I am usually a shiny, silver colour although I can become a red-brown when oxygen is around. Water can make this happen faster.

Fire: I can move and grow if provided with fuel, along with the oxygen I need to breathe.

Human Stem Cell: I can breathe and grow like normal cells. But my special ability is that I can change into any type of cell within the human body.

AI Robot: While I can't breathe air or consume nutrients, I have the potential to move, respond to stimuli, make decisions and create new copies of myself.

Virus: Like robots, I can't breathe air and have no need for nutrients. Instead, my strategy is to infect other cells to self-replicate. While I can't move independently, I can sense changes in the nearby environment and make decisions to adapt quickly. I can also have DNA which evolves like larger organisms.

NAME	*Move*	*Respond*	*Nutrients*	*Grow*	*Reproduce*	*Exchange Gases*	*Water*	*Alive*
Icicle				●			●	No
parrot								
sunflower								
iron nail								
fire								
stem cell								
AI robot								
virus								

Activity adapted from *Science Web Australia.*

THE USES AND ABUSES OF TECHNOLOGY

TECHNOLOGY HAS MANY SIMILAR DEFINITIONS:

- "the practical application of knowledge especially in a particular area"
- "the use of science in industry, engineering, etc., to invent useful things or to solve problems"
- "the collection of techniques, skills, methods and processes used in the production of goods or services or in the accomplishment of objectives"

Many different technologies have been developed on the back of new scientific discoveries to produce something, solve a problem or fulfil a need. But not all technologies are used for good.

WORKING IN GROUPS, LIST FIVE DIFFERENT TECHNOLOGIES USED IN *THE INVISIBLE WAR*.

> These technologies could involve transport, medicine, warfare, food or housing.

> Then describe what the technology was designed to achieve (Objective) and any Advantages or Disadvantages.

> Chemical weapons and bandages are provided as examples.

	TECHNOLOGY	OBJECTIVE	ADVANTAGES and/or DISADVANTAGES
	Example: chemical weapons	Kill enemy combatants	Advantages = cheap, low risk to own troops Disadvantages = causes pain and death of other humans
	Example: bandages	Stop loss of blood and keep wounds clean from infection	Advantages = cheap, portable, flexible, etc Disadvantages = Restricts movement, risks infection by keeping wound moist
1.			
2.			
3.			
4.			
5.			

THE HUMAN MICROBIOME

The collection of all of the microscopic creatures (bacteria, protists, viruses, fungi and archaea) that live in and on the human body is called the 'human microbiota'.

These creatures, along with their genes are called the 'human microbiome'.

CHOOSE FROM ONE OF THE BACTERIA PRESENTED IN THE INFOGRAPHICS (LINKED BELOW) TO WRITE A RESEARCH REPORT:

- List five benefits provided by resident human microbes
- List three ways to encourage a healthy human microbiome
- List two ways to create a poor human microbiome

OR

CHOOSE A SPECIFIC BACTERIUM FROM THE HUMAN MICROBIOME FOR FURTHER RESEARCH:

- List the full name of the bacterium
- Describe a habitat within the human body which the bacterium calls home
- Describe a potential benefit to the human body
- Describe any potential harmful effects this microbe might cause the human body

EXPLORE THE HUMAN MICROBIOME FURTHER:

Scientific American: *click here*

Genetic Science Learning Center (University of Utah)

The Human Microbiome: *click here*

What are Microbes?: *click here*

Infographic: *click here*

Simulator: *click here* (requires plugin)

Video Resource: *click here*

American Museum of Natural History

Meet your Microbiome: *click here*

The Microbiome of your gut: *click here*

News Reports

BBC: *click here*

Telegraph: *click here*

LiveScience: *click here*

ScienceDaily: *click here*

NPR: *click here*

LISTENING TO YOUR GUT BRAIN

The human gut has its own autonomous nervous system, called the gut brain.

While not quite as large our the massive bundle of nerves inside our skull, our gut brain is thought to contain a similar level of complexity, especially when you add the dialogue between the microbes in our gut with the nerves around them.

By size, the nerves of the gut brain creates a gigantic inner network that gathers information from a massive surface area (~30m^2) – that's as big as a room 5 metres by 6 metres wide…double the size of an average bedroom.

The gut brain surveys all the molecules in the food you've just eaten, monitors hormones as they are pumped through the bloodstream around your body, senses the pulsations of your gut microbiome and examines how your many gut immune cells are coping in response.

The gut brain plays a strong role in regulating your emotions (and actions through gut feelings), and feeding information to key the self-awareness centre in your brain (the insular cortex).

This plays a critical role in your feeling of well-being and in defining your sense of self.

Scientists have recently discovered that the microbes in your gut are largely responsible for creating many of your mood hormones, such as serotonin (the happy hormone) and GABA (Gamma-AminoButyric Acid), an important neurotransmitter which helps calm your nervous system – reducing anxiety and increasing relaxation, motor control and focus.

When you are placed under stress, your brain borrows additional energy from the gut. However, if this drain continues for a long period, your gut will send unpleasant signals back to your brain, potentially causing fatigue, changes in appetite, nausea and even, diarrhoea.

Many common phrases reflect the close link between our emotions and our gut, such as:

> *Butterflies in your stomach* – when you feel nervous or in love
> *Pooing your pants* – when you feel scared
> *Can't get your butt into gear* – when you feel unmotivated
> *Swallowing your disappointment* – when you feel setback or regret
> *Leaving a bad taste in your mouth* – when you hear bad or nasty news
> *Feeling a warm inner glow* – when you feel content

WRITE A SHORT MONOLOGUE FROM THE PERSPECTIVE OF YOUR GUT BRAIN, CONSIDERING:

- How it is feeling today?
- What did you feed your gut microbes this morning?
- Food your gut might want you to eat?
- Something else your gut might be happy or unhappy about? (e.g. an infection, antibiotics, too much sugar or fatty foods, other pharmaceuticals…?)
- Other feelings?

YOU ARE NOT ALONE

Your body is an ecosystem.

The coordination of the different cells, tissues and organs within the human body and other multicellular animals is understood to have emerged from the interaction of cells in colonies of simple animals, such as corals and sponges.

However, it has not been until the early 21st Century, that we have finally come to understand that our bodies are a complex ecosystem – made up of both human cells and microbes, such as bacteria, fungi and viruses – in a vast web of interaction and feedback. It is thought that the bacteria in the typical human gut outnumber the entire number of cells in the human body by as much as ten to one. Our bacteria also have about 150 times more genes than those found in our own human genome.

We depend on our gut microbes for a range of tasks, much like an organ. This includes the absorption and production of essential nutrients and vitamins from our food, as well as the regulation of our emotions and the training our immune system.
In return, our microbes depend on us to provide a regular supply of food and a home.

This interdependent relationship between humans and the microbes can be described as a mutualistic symbiosis. It also challenges our notion of what it means to be an individual, our sense of what it means to be human, and what makes you, you.

AS A CLASS, DISCUSS:

- Where does the human body begin and end?
  > are your microbes part of you?
  > if so - each day when you poo, do you lose a little of yourself?

- In the story, the bacteriophage (viruses) living in Annie's mucus save her from the Shigella bacteria.
  > are the bacteriophage part of Annie?
  > perhaps a part of her immune system?

- Every time you take a course of antibiotics, you devastate many of the populations of bacteria within the communities of microbes in your gut.
  > after learning more about the importance of your gut bacteria, are you more or less likely to avoid antibiotics?

- As scientists identify more and more roles that gut bacteria play in maintaining a healthy equilibrium within our bodies, they are also discovering some types of foods we should eat to feed these bacteria. Foods that feed our gut bacteria are called *prebiotics*, and include green leafy vegetables and resistant starches found in cold potato and rice;
  > Would you be prepared to eat more prebiotics foods to feed your good gut bacteria, even if it meant eating a lot more salad?

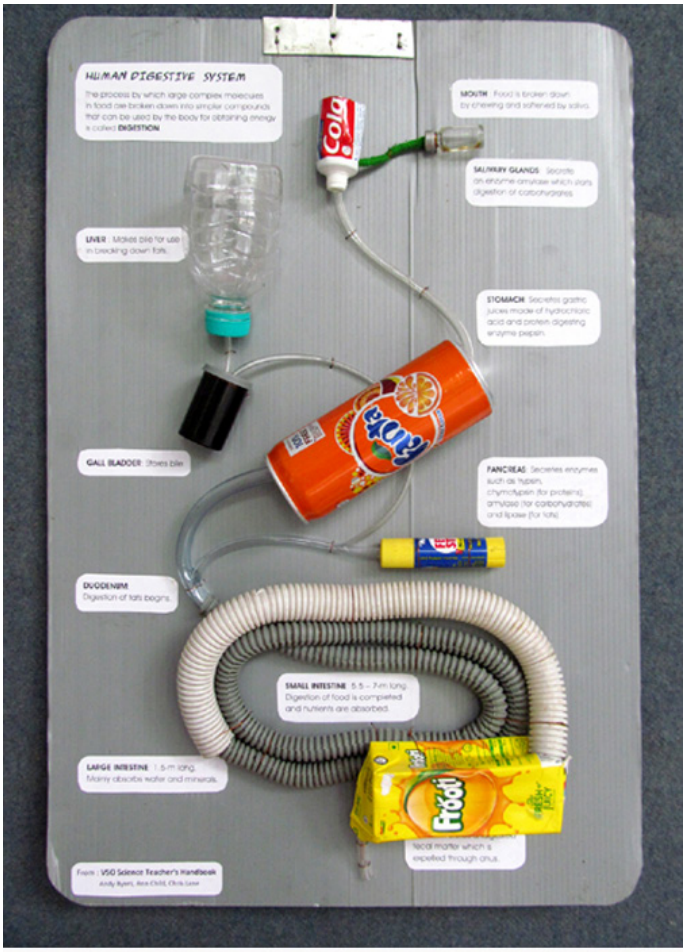
- Swallowing doses of good bacteria, called *probiotics*, can boost human health – especially after major disruptions to our gut from bouts of diarrhoea or taking antibiotics.
  > Would you be prepared to swallow pills containing probiotic bacteria?

- Scientists have discovered that one possible cure to certain chronic intestinal disorders (such as Crohns disease, ulcerative colitis and Inflammatory Bowel Disease) is to perform a faecal transplantation. That is, to inject a small amount (e.g. 50 millilitres) of faeces or poo from a healthy person into the large intestine (i.e. colon or bowel) of the disease sufferer.
  > Would you be prepared to have someone else's poo injected into you?

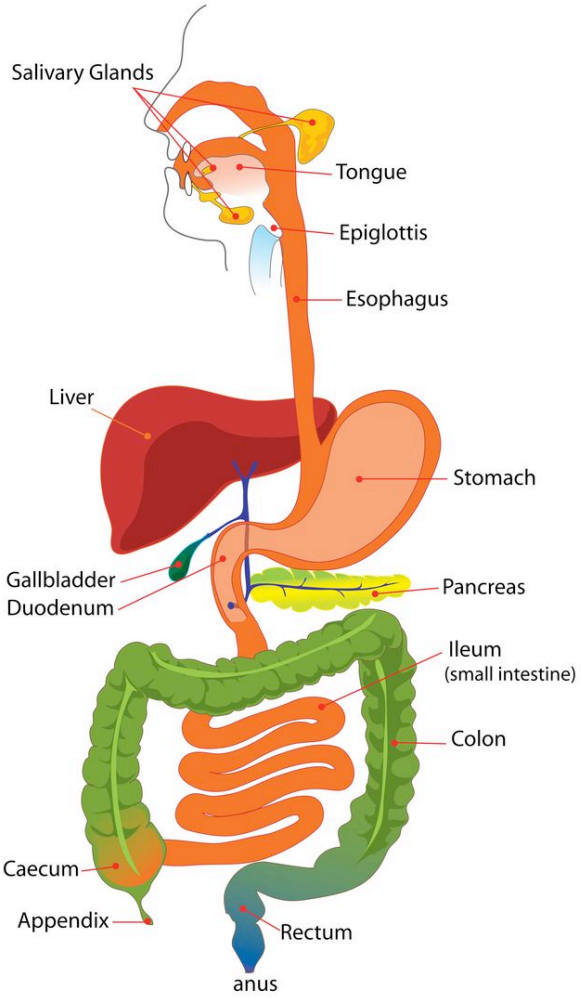
BUILD A MODEL OF THE HUMAN DIGESTIVE SYSTEM

Use recycled bottles, cans, tubing or whatever craft materials you can find to create a model of the human digestive system

- Label all parts of the digestive system
- Briefly describe (in one sentence) the major role of each organ within the digestive system
- Label where any microbes live live within the digestive system?



Model of Digestive System
Inspired by: VSO Science Teachers Handbook



Example model from: *click here*

PHAGE THERAPY

Bacteriophages – commonly called phages – are viruses that can infect and kill bacteria.
Anywhere you can find bacteria, you can find phage – the soil, water and air, as well as on the surface of and inside of most creatures, including plants, animals and fungi.

In fact, it has been estimated there are 10^{31} phage on Earth, outnumbering the total of all other creatures combined.

Phages rely on their ability to infect and self-replicate inside bacteria, and are therefore labelled alongside other viruses (such as influenza and the common cold) as a type of parasite. However, new scientific research is suggesting a possible important beneficial role for phage inside animals, including humans.

WRITE A SHORT NEWS STORY BASED ON THE FOLLOWING QUESTIONS:

- When were phages first discovered?
- Have they ever been used before to treat bacterial infections?
- Why are many scientists now exploring the use of phage therapy?

ALTERNATIVELY - WRITE AN ADVERTISEMENT TO PROMOTE PHAGE THERAPY.

STORIES ABOUT PHAGE THERAPY

Wikipedia: *click here*

Phage Therapy Center (Georgia): *click here*

BBC News: *click here*

Nature News 'Phage Therapy gets Revitalized': *click here*

USA Today: *click here*

The Scientist 'Bacteriophage Boom?' *click here*

Phages 'Everything about Bacteriophage': *click here*

Nature Biotechnology story: *click here*

OTHER LINKS & ACTIVITY IDEAS

EXPLORE MORE OF THE CHEMISTRY BEHIND *THE INVISIBLE WAR:*
Chemical Warfare: *click here*
Camembert Cheese: *click here*

MAKE A HOME FOR MICROBES
Build a Winogradsky Column ecosystem for microbes to see how they separate into their own habitats:
How to Make: *click here*
Activities: *click here*
Poster: *click here*

MICROBES COLOURING BOOK AND SCAVENGER HUNT
Various Activities: *click here*

MICROBIOME QUIZ
Human Microbe Quiz: *click here*

GUTSY – the Card Game about the microbes that make you!
Print Cards: *click here*

COLLECTION OF IMAGES ON PINTEREST
Scale Free Network Pinterest: *click here*

AUSTRALIAN CURRICULUM: SCIENCE

	Reading The Invisible War	Science Quiz	Growing Exponentially	Drawing From The Invisible War	Common Characteristics Of Creatures	To Live, Or Not To Live?	The Uses And Abuses Of Technology	The Human Microbiome	Listening To Your Gut Brain	We Are Not Alone	Build A Model Of The Human Digestive System	Phage Therapy
SCIENCE UNDERSTANDING												
Biological Sciences Multi-cellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment (ACSSU175)	●	●				●		●	●	●	●	●
Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (ACSSU176)	●	●	●	●		●		●	●	●	●	●
SCIENCE AS A HUMAN ENDEAVOUR												
Nature and Development of Science Scientific understanding, including models and theories, is contestable and is refined over time through a process of review by the scientific community (ACSHE157)	●				●	●	●					●
Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (ACSHE158)	●				●	●	●	●				●
Use and influence of science Values and needs of contemporary society can influence the focus of scientific research (ACSHE228)	●				●		●	●		●		●
SCIENCE INQUIRY SKILLS												
Processing and analysing data and information Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies (ACSIS169)			●		●	●						
Communicating Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (ACSIS174)		●	●	●				●	●		●	●

VICTORIAN CURRICULUM: SCIENCE

	Reading The Invisible War	Science Quiz	Growing Exponentially	Drawing From The Invisible War	Common Characteristics Of Creatures	To Live, Or Not To Live?	The Uses And Abuses Of Technology	The Human Microbiome	Listening To Your Gut Brain	We Are Not Alone	Build A Model Of The Human Digestive System	Phage Therapy
SCIENCE UNDERSTANDING												
Biological Sciences Multi-cellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment (VCSSU117)	●	●				●		●	●	●	●	●
The transmission of heritable characteristics from one generation to the next involves DNA and genes (VCSSU119)	●											
The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence (VCSSU120)	●					●						
Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (VCSSU121)	●	●	●	●		●		●	●	●	●	●
SCIENCE AS A HUMAN ENDEAVOUR												
Nature and Development of Science Scientific understanding, including models and theories, is contestable and is refined over time through a process of review by the scientific community community (VCSSU114)	●				●	●	●					●
Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (VCSSU115)	●				●	●	●	●				●
Use and influence of science The values and needs of contemporary society can influence the focus of scientific research (VCSSU116)	●				●		●	●		●		●
SCIENCE INQUIRY SKILLS												
Analysing and Evaluating Analyse patterns and trends in data, including describing relationships between variables and identifying inconsistencies (VCSIS138)			●		●	●						
Recording and processing Construct and use a range of representations, including graphs, keys, models and formulas, to record and summarise data from students' own investigations and secondary sources, to represent qualitative and quantitative patterns or relationships, and distinguish between discrete and continuous data (VCSIS137)			●		●						●	
Communicating Communicate scientific ideas and information for a particular purpose, including constructing evidence-based arguments and using appropriate scientific language, conventions and representations (VCSIS140)		●	●	●				●	●		●	●

SCIENCE QUIZ ANSWERS

WHICH IS BIGGER?

(*answers can also be found in the Big to Small scale bar on page 68*)

1. Annie
2. the Fly
3. Myophage
4. The Western Front
5. Neutrophil
6. Red Blood Cell
7. Red Blood Cell
8. Myophage
9. Epithelium cell
10. Neutrophil

TRUE OR FALSE

1. *Shigella is a type of bacteria* = True
2. *All viruses are dangerous to humans* = False
3. *Bacteria cannot live in the human stomach* = False
4. *Humans are a type of animal* = True
5. *Bacteria can survive outside of the human body* = True
6. *Viruses cannot infect bacteria* = False
7. *When viruses self-replicate, they make many copies at once* = True
8. *Most of the bacteria in our body live in the small intestine* = False
9. *Bacteria can make vitamins to help their human host* = True
10. *Food usually contains bacteria* = True

MEASURING UP

1. 500-600 nm
2. 50-100 nm
3. nanometres
4. Shigella = 3 μm (micrometres)
   Human = 1.8 m x 1000 mm x 1000 μm = 1,800,000 μm (micrometres)
   Therefore 1,800,000 μm /3 μm = 600,000 Shigella

REPLICATE OR DIE

SHIGELLA BACTERIA
1. 600 mins
2. 10 hrs
3. 31 generations

BACTERIOPHAGE VIRUSES
4. 150 mins
5. 2.5 hrs
6. 6 generations

THINKING DEEPER
7. *Answers might include:*
> infection by bacteriophage (i.e. phage lysis)
> running out of food/energy (i.e. depleted nutrients)
> mass removal from gut (i.e. volcanic eruptions of mucus)
> attack from other bacteria (e.g. Roidey and Tella)
8. *Answers might include:*
> running out of *Shigella* bacteria to infect
> *Shigella* bacteria changing their surface protein 'locks'
> mass removal from gut (i.e. volcanic eruptions of mucus)