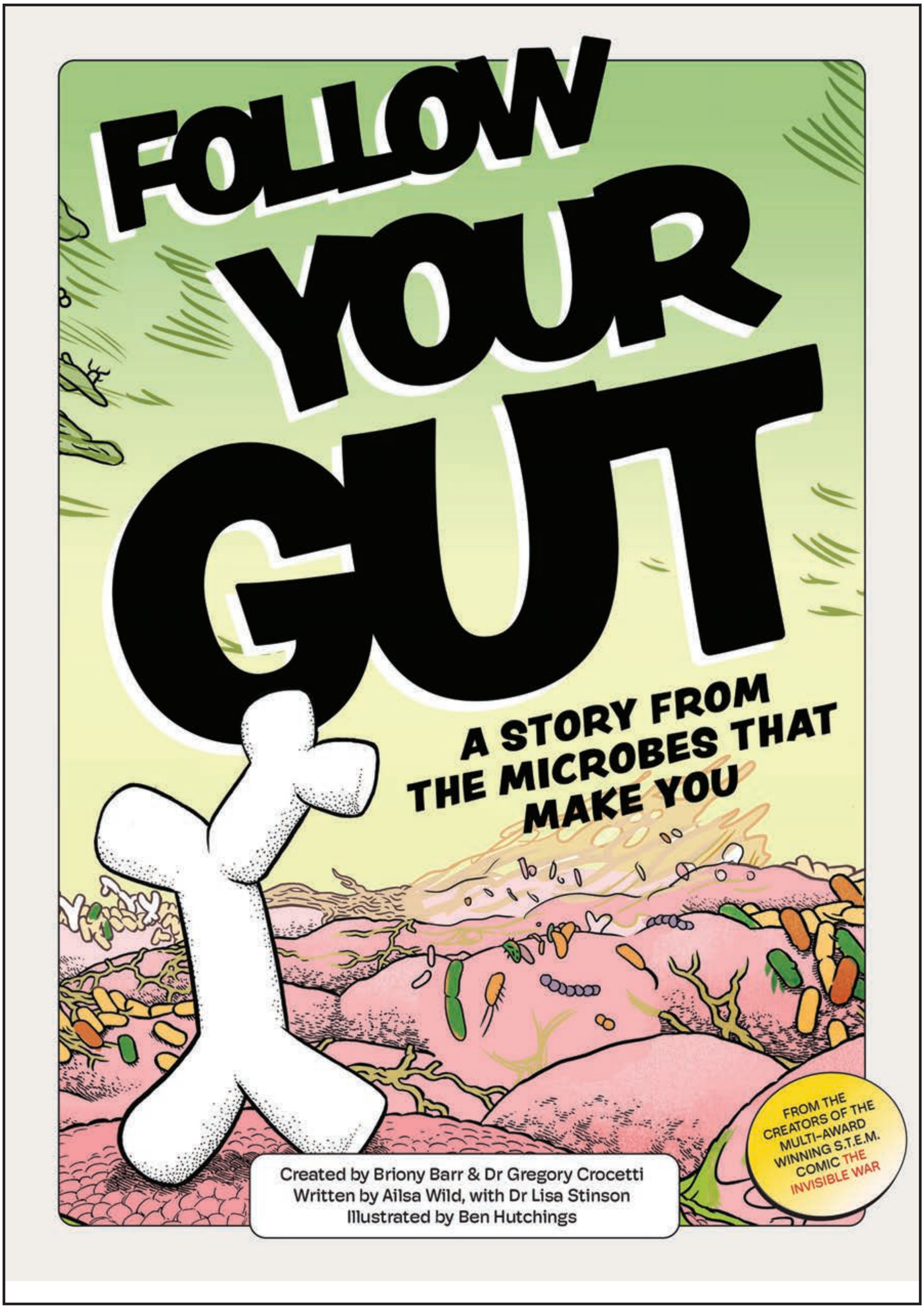


Teaching Notes

Written by Dr. Gregory Crocetti

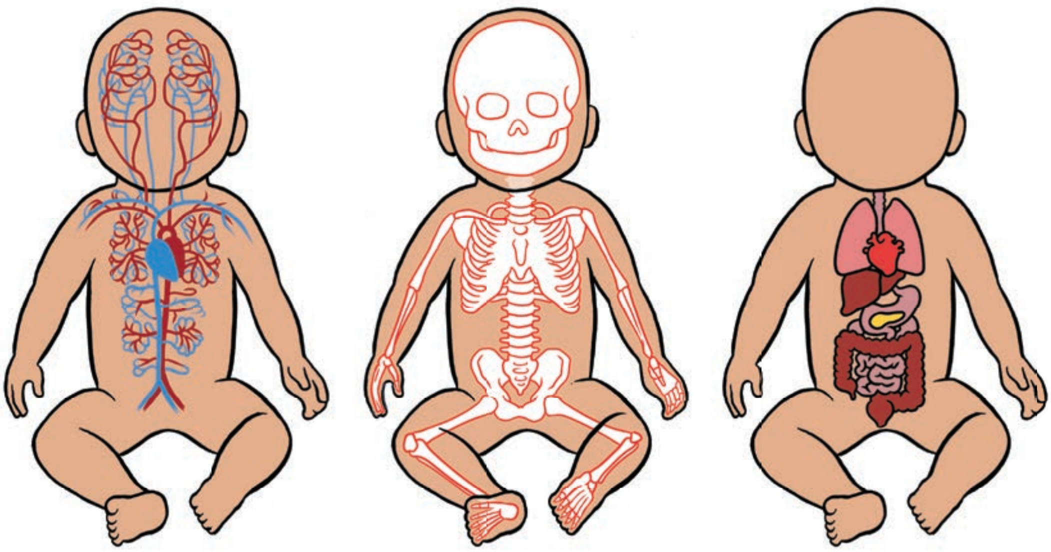
scale free network
art-science collaborative

Follow Your Gut: Teaching Notes

INTRODUCTION

Follow Your Gut takes readers on an amazing journey around the human body, focusing on some of the microbes that call your body home. The story specifically looks at the role of different bacteria and other microbes in our gut, otherwise known as our gut microbiome.

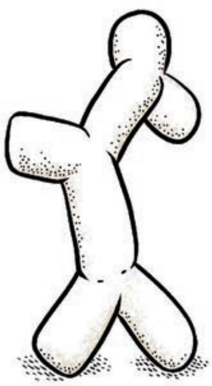
In addition to the graphic novel, *Follow Your Gut* includes a 75-page Appendix that uses a mixture of text, photos, and diagrams to help explain the science behind the story. Small numbered circles within the illustrations link from the story to further information in the Appendix, answering helpful questions such as: *what do all these microbes do*; *how fast does Biffy travel down the small intestine;* or *why do parts of the lungs look like tree branches*?



KEY CURRICULUM AREAS

Learning areas: Science; English; The Arts

General capabilities: Literacy; Numeracy; Personal and Social Capability; Ethical Understanding; Critical and Creative Thinking



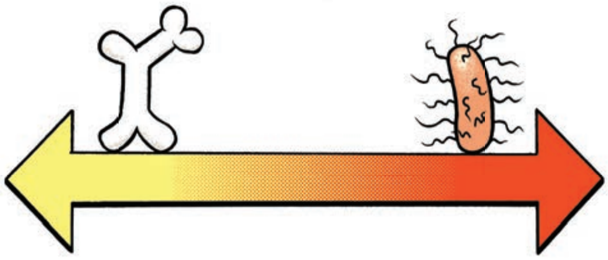
The following activities are designed to suit school year levels 5 – 10 but can adapted to different learning ranges and abilities.

TABLE OF CONTENTS

KEY SCIENTIFIC TOPICS

Follow Your Gut incorporates a number of scientific topics including:

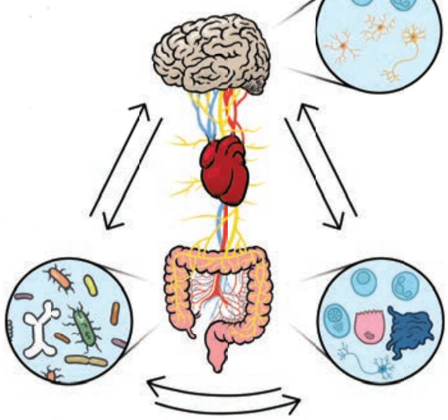
- the human gut microbiome
- the human digestive system
- the human immune system
- how breastfeeding works
- how cells communicate (chemical conversations)
- how different cells consume energy and remove waste (metabolic biochemistry)
- the beneficial symbotic partnership between humans and their microbial residents
- some of the ways microbes (both good and bad) are transmitted to a new human
- some of the ways microbes can live in our gut and what they do there
- how our immune system learns to live with the microbes living in our gut.



SCIENTIFIC CONCEPTS

Through reading *Follow Your Gut*, readers will better understand that:

- it is natural and healthy for bacteria and other microbes to live in the human gut
- our gut microbes come from different environments such as food, people, and pets
- after birth, breastfeeding brings important health benefits to babies and infants, including introducing many of our early gut microbes
- most of our gut microbes are beneficial and many play essential roles in maintaining our physical health
- some of our gut microbes also play a powerful role in our mental health, affecting our emotions, memories, motivation, and more
- our parternship with our gut microbiome is interdependent (we rely on each other)
- eating a healthy diet supports the important work of our gut microbes
- the relationship between human cells and our gut microbes is a dynamic process (they are in constant negotiation)
- during the first years of life, our digestive and immune systems learn to live alongside our gut microbiome.

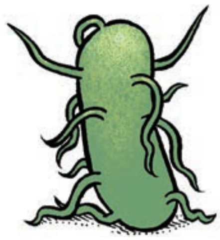


Reading & Comprehension: For Students

Reflections **before** reading

1. Look at the cover of the book and take a quick look inside.
   - Does it look more like a picture book, a graphic novel, or a textbook?
   - Do you think it is a fiction or non-fiction book...or something in-between?

   The authors suggest this graphic novel fits into the genre of 'narrative non-fiction'.
   - What do you think this means?

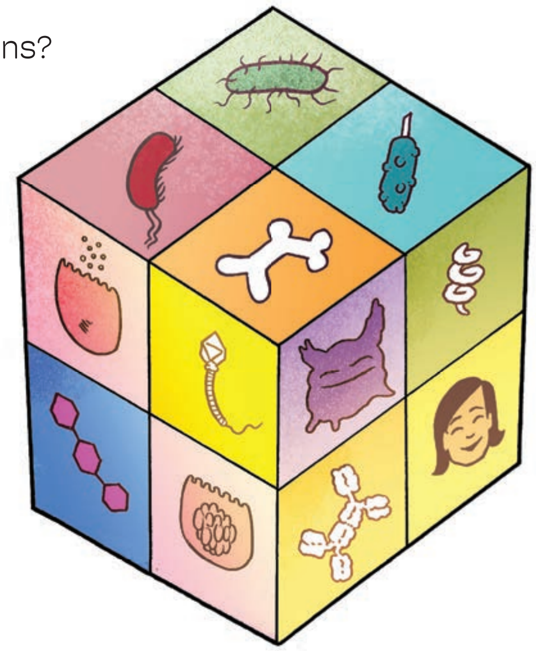


2. The subtitle of the book is: *A Story from the Microbes That Make You.*
   - Do you know what a microbe is?
     - What do you think this subtitle is trying to suggest?

3. The gut is part of your digestive system.
   - What do you already know about digestion?
     - Which part of your digestive system do the authors describe as your gut?

4. Why is it important to understand digestion?

5. Some people think it's rude to talk about pooing, farting, and vomiting.
   - Why do you think this is?
     - Do you think it's rude to discuss these body functions?
       - Why/Why not?



During reading

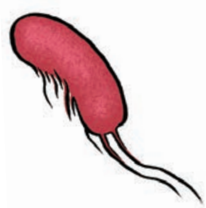
While reading the story, write down:
- Any words you don't understand
- Any concepts you don't understand
- Anything you'd like to discuss or learn more about.

Check the appendix to see if any of your questions are answered there.

Reflections **after** reading

After reading the story, consider:*
- What is a microbe?
- Can you name any microbes (either their character name or scientific name)?
- What are three ways that our gut microbes can help make us healthy?
- What are three surprising things you learned in the book?
- What are three surprising things about the immune system you learned in the story?
- Do you think differently about your gut now? . . . How?

* This could be a whole of class discussion, small group conversations, or individual written activity



Reading & Comprehension: For Teachers

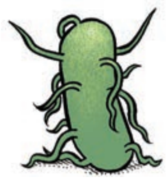
What is a microbe?

Microbes, also known as microorganisms, are microscopic organisms that are typically too small to be seen with the naked eye. They can be unicellular (a single cell) or more complex, multicellular organisms. Microbes include a range of life forms with different sizes and characteristics, such as bacteria, fungi, protists, viruses, and archaea.

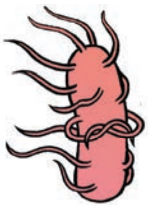
Can you name any microbes (either their character name or scientific name)?

Microbes that featured in the story include:

Biffy & Fido (*Bifidobacterium* bacteria)

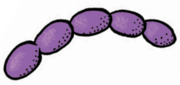


Escher (*Escherichia coli* bacteria)



Sal (*Salmonella* bacteria)

Rose (*Roseburia* bacteria)



Strep (*Streptococcus* bacteria)

Roidey (*Bacteroides* bacteria)

Staph (*Staphylococcus* bacteria)

Rumi (*Ruminococcus* bacteria)

Lacto (*Lactobacillus* bacteria)

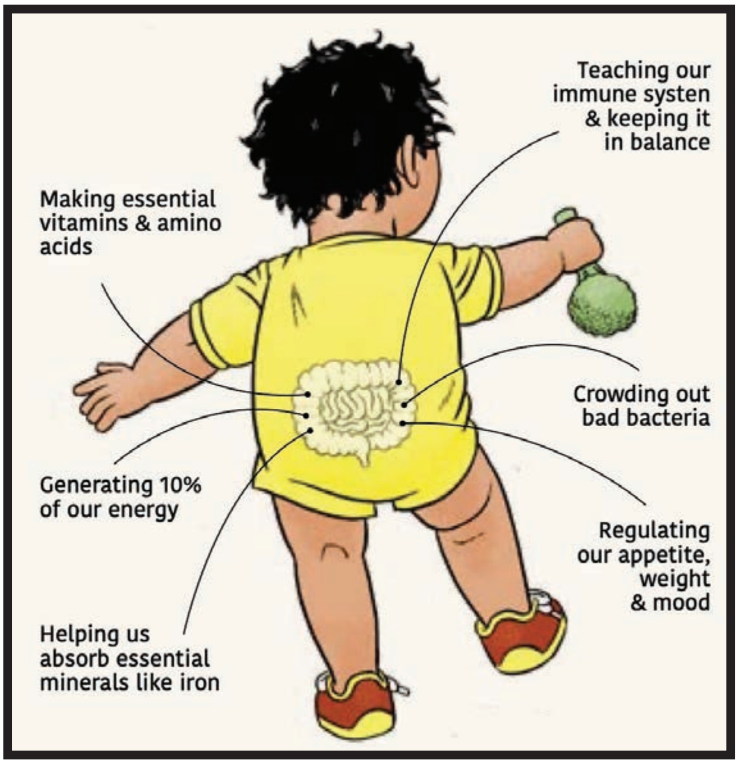
The Phage (bacteriophage viruses)

Reading & Comprehension: For Teachers

What are three ways that our gut microbes can make us healthy?

Our gut microbes (especially bacteria) help us in many ways, including:

- making essential vitmains and amino acids
- generating 10% of our energy
- helping us absorb essential minerals like iron
- teaching our immune system and keeping it in balance
- crowding out bad bacteria
- helping to regulate our appetite, weight, and mood



What are three surprising things about the immune system you learned in the story?

Examples might include:

- there are many different types of immune cells such as: Dendritic Cells (Rangers), T Cells (Managers), Macrophages, and Neutrophils
- the immune system interacts with bacteria in our gut to help learn who is there
- some immune cells (such as Dendritic Cells) can swallow whole bacteria and then display small parts of them on their outside
- the immune system can learn to tolerate and accept many types of gut bacteria (such as Biffy) as part of a healthy body
- immune cells (white blood cells) can carry bacteria around the body (with the example of Biffy being grabbed from the gut and carried to the mammaries)
- Neutrophils can be called in to help when other defences are not enough
- there are antibodies in human milk which can help defend the body

Science Activities

Follow Your Gastrointestinal Tract

After reading the story, teachers can lead students through a discussion of important parts of the human digestive system, by recalling parts of Biffy's adventure.

On page 43, Biffy enters their new host:

- What is the starting point of their journey? (the mouth)
- Where do they end up next? (the stomach)
- What's the tube connecting the mouth and stomach? (oesophagus)

On page 44, Biffy is now in the stomach:

- What's the liquid Biffy is floating in? (hydrochloric acid)
- Where does Biffy exit the stomach? (the pyloric sphincter)

On page 45, Biffy has entered the small intestine:

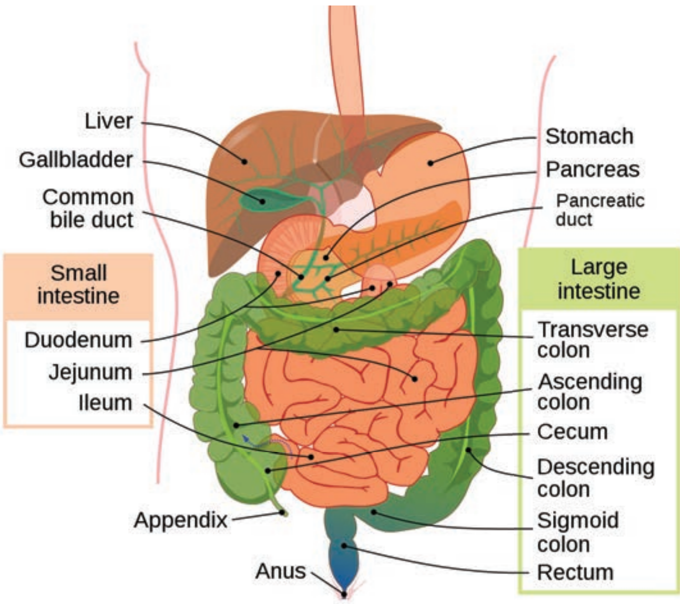
- What do the bile acids do in the small intestine? (break apart fats like a detergent)
- What are the walls of the small intestine lined with? (villi)
- What does the finger-like shape of villi help with? (makes more surface area = absorption)

On page 48, Biffy is about to finish their journey:

- What organ does Biffy arrive into? (large intestine, also called the gut or the colon)

On page 152, a brave *Bifidobacterium* leaves Biffy on an adventure:

- What is the exit of the gut or colon called? (the anus)



Hidden Poo-Tential Quiz

Unleash your inner scientist and get ready to digest some fun facts about your body with this 20 question quiz: https://forms.gle/SRZJ4j5NY898kgPM7

Research Projects

GUT MICROBIOME RESEARCH PROJECTS

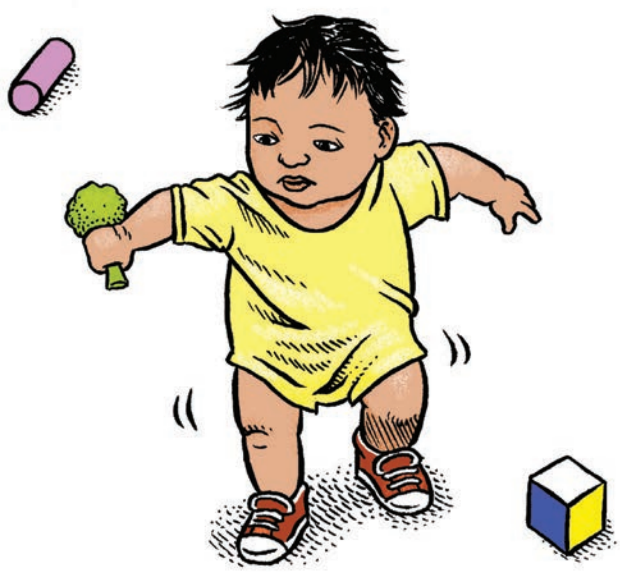
Assign students to research specific aspects of gut microbiome, such as:

- the role of gut bacteria in digestion, immunity, or mental health
- the effects of diet on the gut microbiome
- the role of prebiotics and probiotics in digestive health
- the impact of antibiotics on microbial communities.

They can create multimedia presentations or posters to summarise their findings and present them to the class.

HEALTH CAMPAIGN POSTERS

Task students with creating health campaign posters promoting awareness of the importance of gut health and microbiome diversity. They can design visually appealing posters featuring scientific information, tips for maintaining a healthy gut, and funny slogans to encourage healthy habits, such as eating lots of dietary fibre. Posters could be designed from the microbial point of view and advocate for humans to take better care of their microbiomes.



DIGESTIVE SYSTEM DIAGRAMS OR SCULPTURES

Have students work in groups to create a poster-sized diagram showing the journey of your food from the time it enters your mouth to the time it exits at the other end. Label the diagram with the different parts of the digestive system, including everything they have learned about how digestion works and the microbes found there.

Also, students could work in small groups or as a whole class to make a 3D sculpture of the digestive system using toilet rolls, plastic bags, plastic bottles, rubber bands, or any other accessible recycled materials.
On the right is an example from Arvind Gupta:
https://www.arvindguptatoys.com/toys/Humandigestivesystem.html

Challenge: If you 'feed' the system at one end,
can you successfully get it through to the other end?

This inspirational artwork does something similar:
Cloaca **by Will Devoyle**
https://www.youtube.com/watch?v=NYDgslq6ohk

Research Projects (cont.)

GUT INFOGRAPHIC

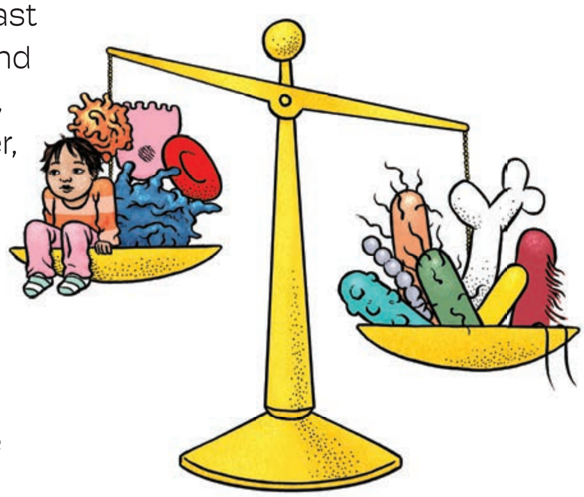
Challenge students to design infographics that visually represent key scientific concepts related to gut bacteria and human health. They could design graphs, charts, or diagrams to illustrate the functions of gut microbes, factors influencing microbial diversity, and strategies for maintaining a healthy microbiome.

SCIENCE AND ETHICS DEBATE

Organise a debate on ethical considerations surrounding gut microbiome research and interventions.
Students can research and present arguments for and against topics such as genetic engineering of gut bacteria, faecal microbiome transplants, the use of probiotics, and the overuse of antibiotics in human medicine and agriculture.

THE HYGIENE DEBATE ("ARE WE TOO CLEAN?")

Hygienic practices and the use of antibiotics over the last century have dramatically reduced the rates of death and disease caused by bacteria. However at the same time, we are seeing epidemic levels of food allergies, hayfever, asthma, and other auto-immune diseases emerging in children, particularly in the Global North.



Some scientists are now questioning whether we have pushed hygiene too far, sometimes described as the 'Hygiene Hypothesis' or 'Old Friends Hypothesis'. Organise students to debate whether we have become too clean for our own good.

THE WIDE WORLD OF POO

Other animals interact with poo very differently to humans. Some animals use poo as a signal, some use it as a food, some as a building material, and there are many more uses!
The shape and quality of poo in nature (also called 'scats') can often tell us a lot about which animal left it there and what they recently ate.
Ask students to research and present an animal poo to their class.

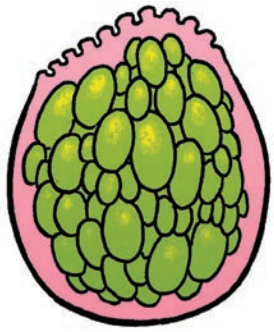
Research Projects (cont.)

KEEP A FOOD AND TOILET JOURNAL

Have you ever wondered why your pee sometimes smells funny or why you sometimes do weird poos?

Over an entire week, write down :

- everything you eat and drink
- the time of day, size, smells, and colour of your pees and poos
  ...the more detailed the better!



Hints:

- Use the Bristol stool chart to help describe your poo.
- Try eating a big serve of beetroot early in the week.
  (Look out for purple poo!)
- On a different day, try eating a bunch of asparagus.
  (The next pee or two will smell weird!)

...What conclusions do you draw after one week of observation?

Bristol Stool Chart

Type 1	Separate hard lumps, like nuts (hard to pass)
Type 2	Sausage-shaped but lumpy
Type 3	Like a sausage but with cracks on its surface
Type 4	Like a sausage or snake, smooth and soft
Type 5	Soft blobs with clear-cut edges (passed easily)
Type 6	Fluffy pieces with ragged edges, a mushy stool
Type 7	Watery, no solid pieces. **Entirely Liquid**

Feedback Loops

BACKGROUND

Ecosystems, organisms, and our own bodies are all systems made of interconnected parts. They are also examples of complex adaptive systems, which means that those interconnected parts are capable of interacting and affecting one another. Changes in one part can ripple throughout the entire system.

Feedback loops play a crucial role in maintaining balance within complex systems; they maintain equilibrium to ensure stability and help adapt to changes.

Feedback loops involve cause-and-effect relationships, where an initial effect can influence itself (or feedback on itself) through a chain of connections, which may then go on to affect other interconnected parts.

POSITIVE AND NEGATIVE FEEDBACK LOOPS

Feedback loops can usually be described as positive or negative, where:

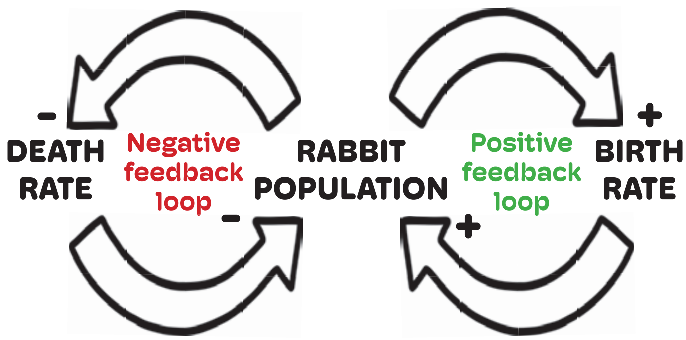
- **Positive feedback loops** are self-reinforcing cycles that **amplify** the original action
- **Negative feedback loops** are self-correcting cycles that **dampen** the original action

There are many examples of **positive** and **negative** feedback loops in nature, which show how interconnected and interdependent everything is on our planet. **Positive** and **negative** do not imply that the feedback causes good or bad effects.

Some examples include:

- the **ice-albedo feedback loop** is a positive feedback loop that involves the reflectivity of ice and snow (called albedo). When ice and snow melt due to global warming, they expose darker surfaces such as land and water, which absorb more solar radiation. This then heats up the planet, which in turn causes more ice to melt.
- The **predator-prey relationship** is a negative feedback loop that involves the interaction between predators and prey in an ecosystem. When the population of prey increases, it provides more food for the predators, which allows them to reproduce and grow. More predators eventually reduce the population of prey, which in turn limits the food supply for the predators, and causes them to decline.
- **Fruit ripening** is a positive feedback loop. The ethylene gas released during fruit ripening triggers more and more ethylene production, accelerating the process until the fruit is ripe.
- **Body temperature regulation** in most mammals is another example of a negative feedback loop. When we get too hot, we sweat (to cool our body), and when we get too cold, we shiver (to warm our body).

Negative feedback loops dominate in nature, acting as stabilisers to maintain equilibrium (balance). When a system shifts from its optimal state, negative feedback mechanisms kick in to bring it back on track. Negative feedback loops are like a thermostat on a heater that keeps the temperature within a narrow range.



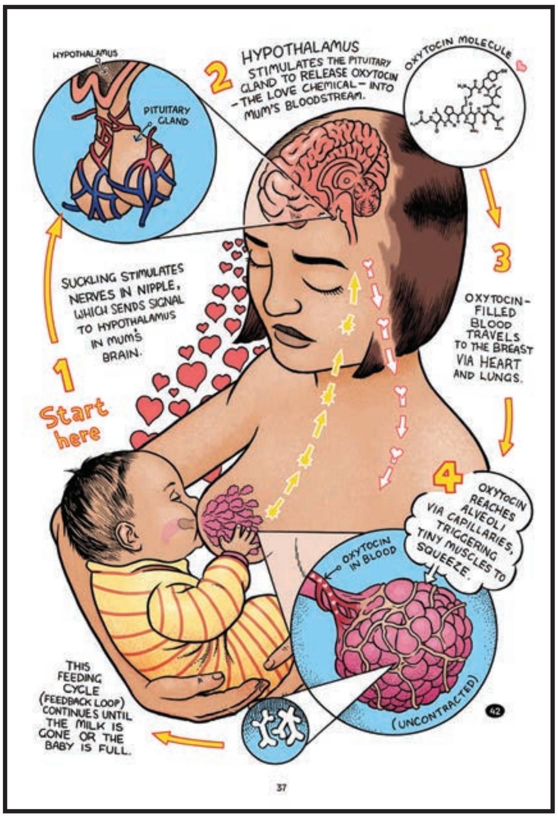
Feedback Loops (cont.)

Negative feedback loops also play a crucial role in homeostasis: your body's ability to maintain stable internal conditions despite external changes. The hypothalamus is your body's 'smart control centre'. Nestled deep within your brain, it helps controls your heart rate, body temperature, appetite, sleep cycles, and more.

And while the hypothalamus helps maintain homeostasis, it can also help manage the release of milk from the mammary glands during breastfeeding (lactation). Also called the oxytocin feedback loop (or Let-Down Reflex), it is described in detail on page 37 (and subsequently Question 42 on p181) of *Follow Your Gut*. It is an example of one of the human body's positive feedback loops, where the release of milk from the breast sends a positive message reinforcing the baby to continue suckling, which in turn sends a positive signal back to the hypothalamus to continue releasing oxytocin – and so on – until the baby is full and stops sucking.

<u>Other examples of feedback loops in the body include</u>:

- Body Temperature Regulation
- Blood Glucose Control
- Blood Pressure Balance
- Oxygen and Carbon Dioxide Exchange
- Thirst and Hydration
- Hunger and Fullness (Energy Homeostasis)
- Immune System Regulation
- Circadian Rhythms (Sleep cycles)
- Heart Rate Control
- Blood Clotting
- The Menstrual Cycle
- Childbirth (Labour)
- Breathing during Exercise
- Blood pH Balance
- Red Blood Cell Production
- Digestive Enzyme Secretion



Group Research Project

Encourage students to work in small groups to:

1. Choose a specific feedback loop related to the human body

- investigate how the loop functions and its significance to homeostasis using a mix of resources (e.g. books, articles, videos, etc)

2. Collect relevant data related to their chosen feedback loop

- conduct simple experiments (e.g. tracking body temperature changes, measuring heart rate during exercise) to collect primary data
- draw on real-world scenarios to collect secondary data
- interpret their findings: Are there patterns? How does the loop respond to changes?
- encourage critical thinking: Why is this feedback loop essential for our well-being?

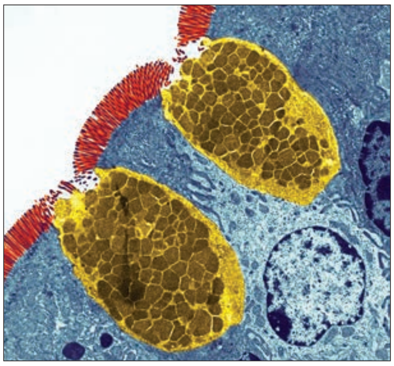
3. Present the feedback loop to the class

- the presentation could take the form of: a poster or infographic; interactive demonstration (e.g. role-playing); physical models; a comic strip; a short video or animation; a mind map; or a creative writing piece
- encourage students to create visual aids (e.g. diagrams, flowcharts) where possible, to illustrate the loop's components and interactions

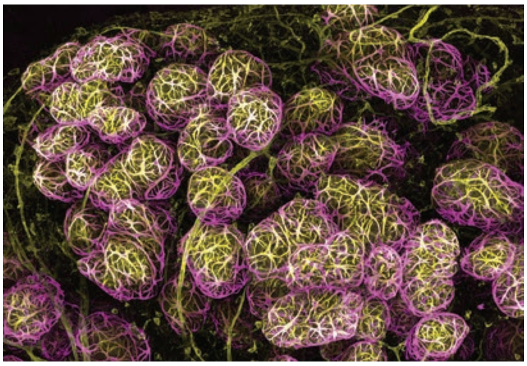
SEEING IS BELIEVING

Scientists use light microscopes and electron microscopes to magnify objects and explore the microscopic world. Many of the images they capture can be abstract and tricky to understand. The following pictures are electron micrographs of creatures and landscapes from inside the human body that helped to inspire characters and scenes from *Follow Your Gut.* Guess what each of the images represents. Discuss answers as a group afterwards.

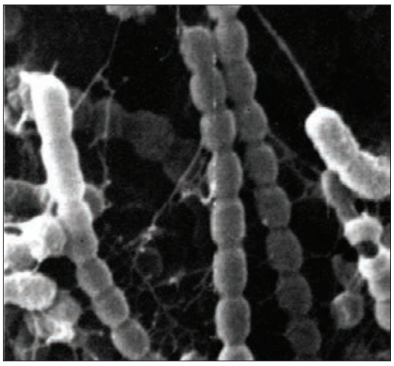
1. ____________________



2. ____________________



3. ____________________



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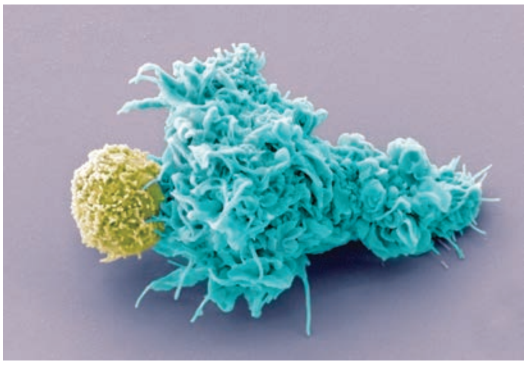
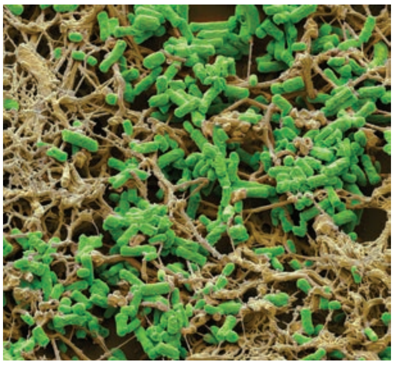


5. ____________________



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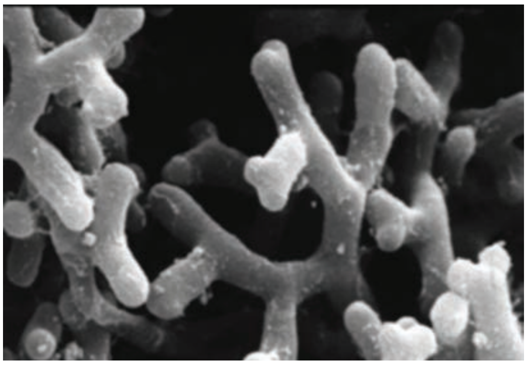

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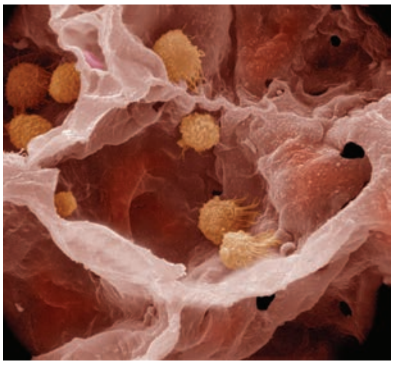


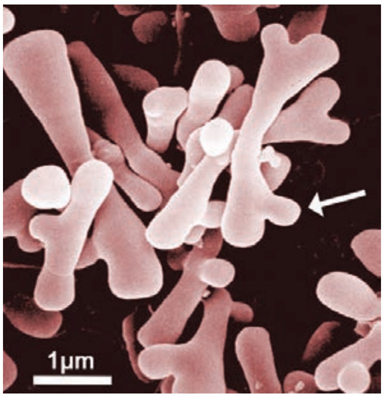
8. ____________________

Measuring the Microscopic

It is impossible to use a normal ruler to measure the actual size of the different cells and molecules featured in *Follow Your Gut*.
The unit used to measure cells is micrometres (µm). One micrometres (1 µm) is one thousandth of a millimetre (0.001 mm) or one millionth of a metre (0.000001 m).
The unit used to measure large molecules is nanometres (nm). One nanometre (1 nm) is one thousandth of a micrometre (0.001 µm).

USING SCALE BARS

Almost all cells are too small for us to see with our naked eye. When scientists present images or diagrams of different cells (such as bacteria), they usually add a scale bar (see below) or a magnification (e.g. 1000x) to give an idea of their real size.



This is an image of *Bifidobacterium* bacteria taken with an electron microscope. The scale bar on the image shows the size of 1 micrometre (1 µm). Using this scale bar, estimate the length (longest dimension) of the bacterium labelled with an arrow?

________µm

MEASURING UP

Use this table to calculate the length (in both micrometres and nanometres) of the molecules, viruses, microbes, and human cells from *Follow Your Gut* on the next page.

	× 1000 →		× 1000 →	
mm		µm		nm
	← ÷ 1000		← ÷ 1000	

	Measurement (mm)	Scale bar	micrometres (µm)	nanometres (nm)
Molecules		10 mm = 2 nm		
CAMPs (p132)				
IgA Antibody (p36)	100		0.020	20
Viruses		10 mm = 50 nm		
Bacteriophage (p109)				
RSV (p82)				
Microbes		10 mm = 1 µm		
Sal	20		2	2,000
Escher				
Lacto				
Biffy				
Roidey				
Rose				
Rumi				
Human cells		10 mm = 2 µm		
Red Blood Cell				
Goblet (mucus) Cell				
T Cell (Manager)				
Dendritic Cell (Ranger)				

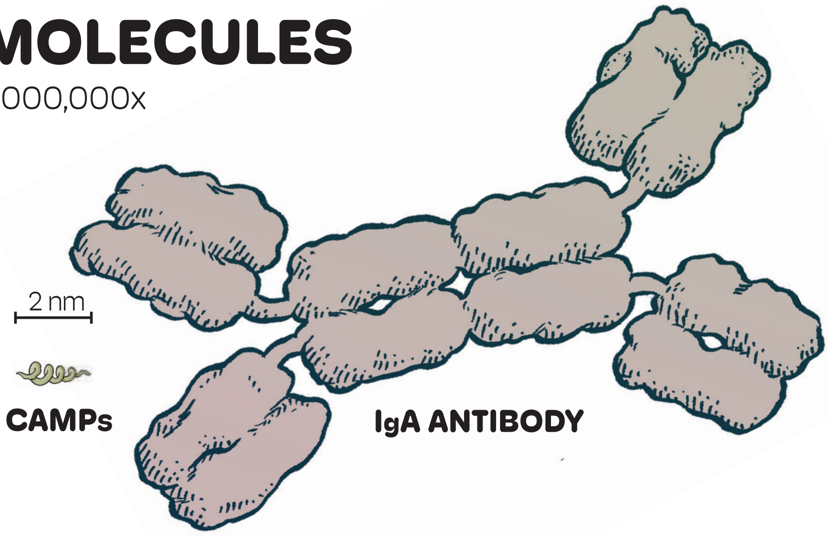
MEASURING UP

COMPARE THE DIFFERENT SIZES OF MOLECULES, VIRUSES, AND CELLS IN *FOLLOW YOUR GUT*

Measure the length (longest dimension) of the molecules, viruses, bacteria, and human cells below. Use the 10 mm (1 cm) scale bar in each category to measure them. Write your measurement in the table on the previous page and use this to calculate their actual sizes.

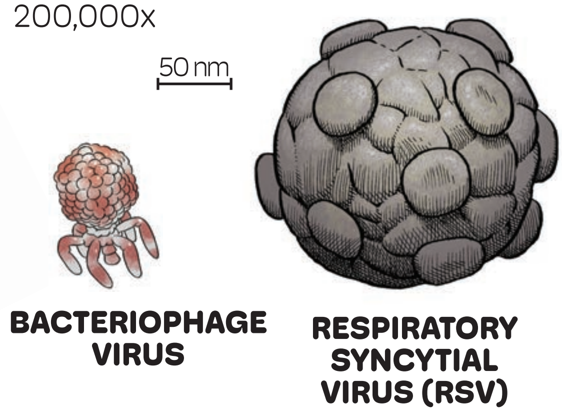
MOLECULES

5,000,000x



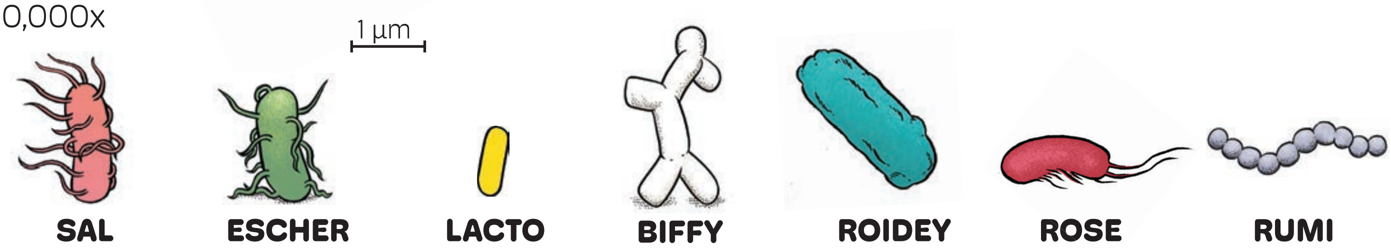
VIRUSES

200,000x



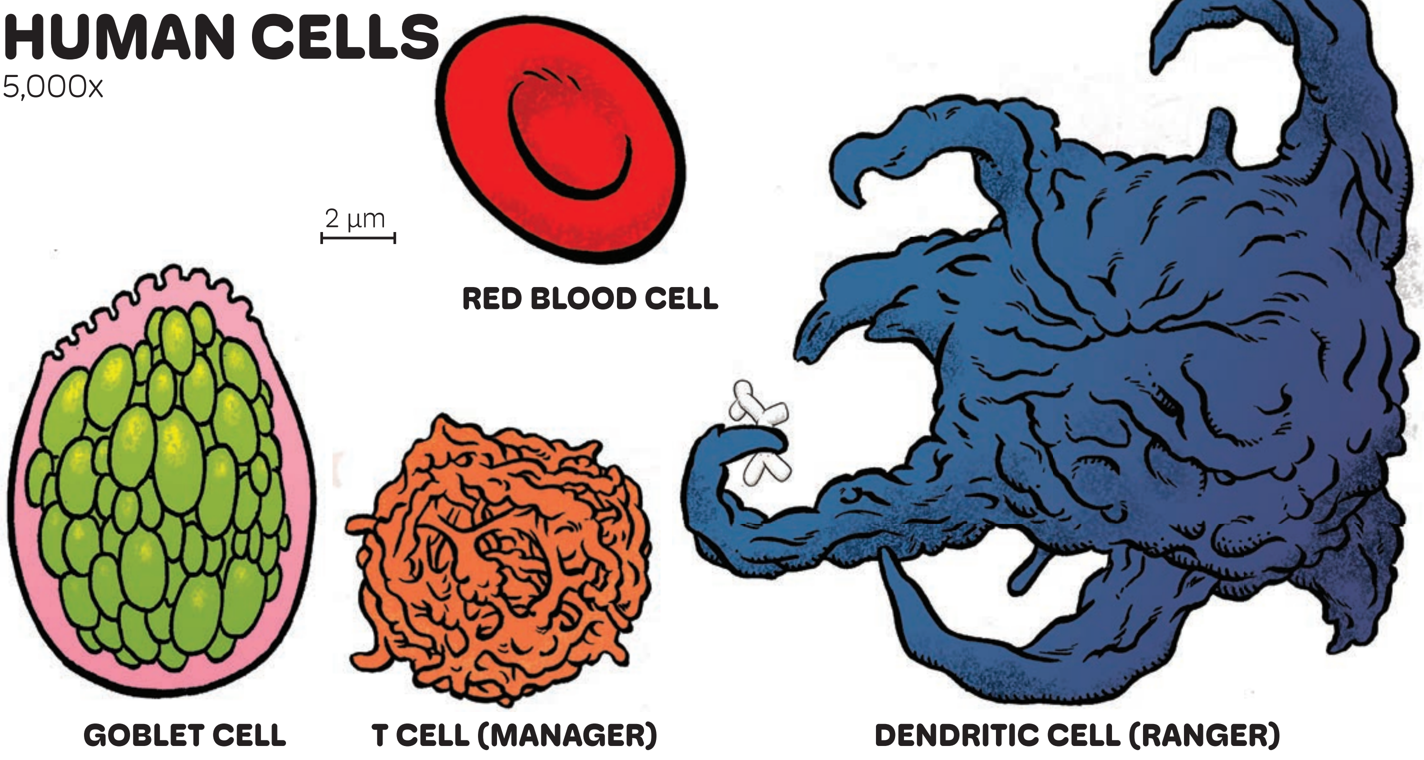
BACTERIA

10,000x



HUMAN CELLS

5,000x



Worksheet Answers

SEEING IS BELIEVING

1. Layers of human skin (150x magnification)
2. Goblet cells full of mucus (5,500x magnification)
3. Alveoli in the human mammary glands (63x magnification)
4. *Ruminococcus* bacteria (20,000x magnification)
5. Dendritic Cell presenting sample to a T Cell (2,000x magnification)
6. Bacteria on a layer of mucus (3,000x magnification)
7. *Bifidobacterium* bacteria (20,000x magnification)
8. Macrophages patrolling alveoli in the lungs (2,000x magnification)

USING SCALES

The bacterium labelled with an arrow is 3 micrometres (3 µm) long.

MEASURING UP

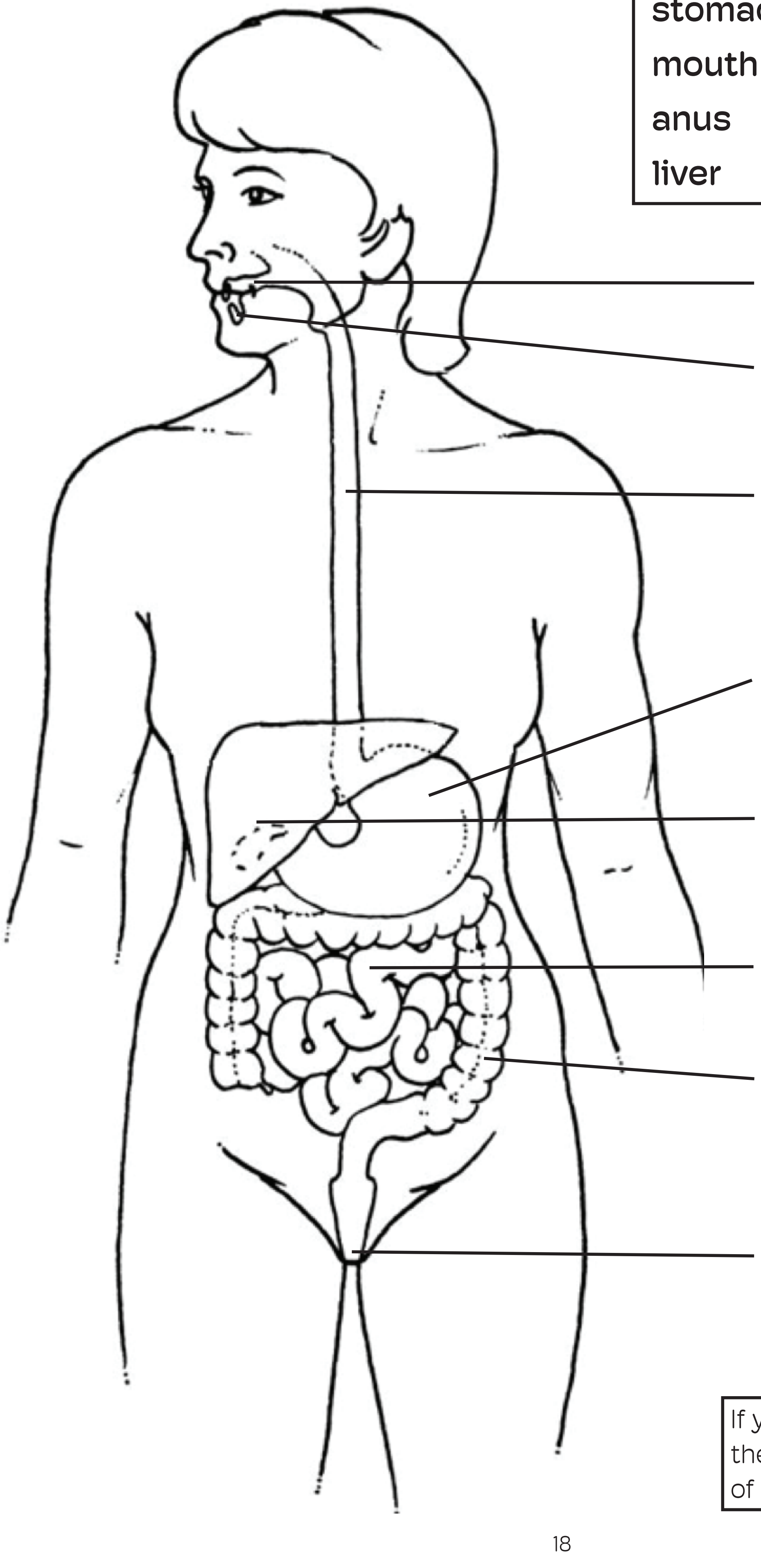
Table comparing the sizes of molecules, viruses, microbes, and human cells in *Follow Your Gut*

	Measurement (mm)	Scale bar	micrometres (µm)	nanometres (nm)
Molecules		**10 mm = 2 nm**		
CAMPs (p132)	0.000002		0.002	2
IgA Antibody (p36)	100		0.020	20
Viruses		**10 mm = 50 nm**		
Bacteriophage (p109)	20		0.1	100
RSV (p82)	40		0.2	200
Microbes		**10 mm = 1 µm**		
Sal	20		2	2,000
Escher	15		1.5	2,500
Lacto	10		1	1,000
Biffy	25		2.5	2,500
Roidey	20		2	2,000
Rose	15		1.5	1,500
Rumi	25		2.5	2,500
Human cells		**10 mm = 2 µm**		
Red Blood Cell	35		7	7,000
Goblet (mucus) Cell	55		11	11,000
T Cell (manager)	40		8	8,000
Dendritic Cell (Ranger)	100		20	20,000

Label Your Gut (student worksheet)

Use the terms in the box to label the main parts of the digestive system.
Then add colours to your diagram.

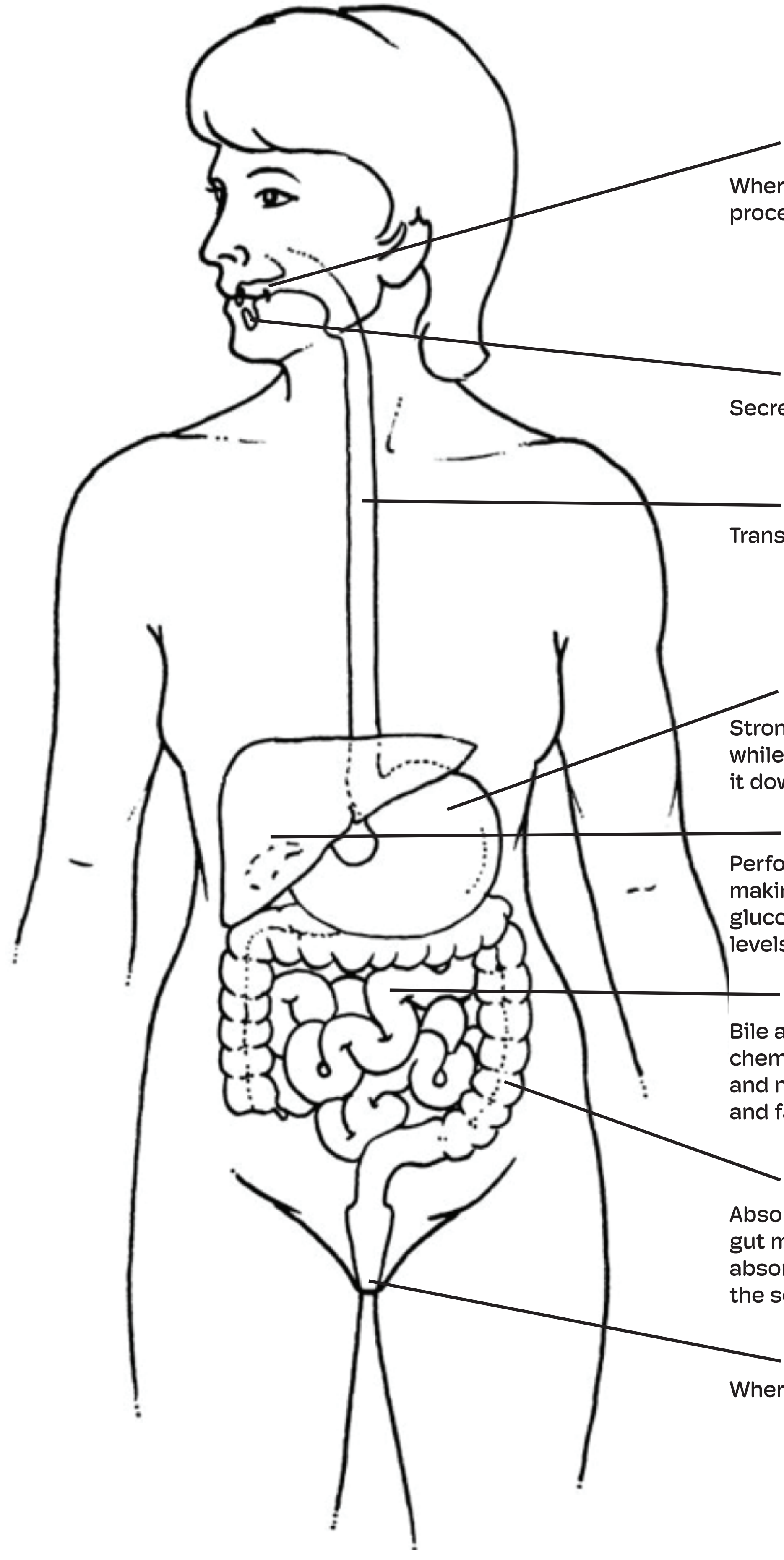
stomach	small intestine
mouth	oesophagus
anus	large intestine
liver	salivary glands



If you have time, summarise the basic function of each part of the digestive system.

Label Your Gut (answers)

Use the terms in the box to label the main parts of the digestive system.
Then add colours to your diagram.



mouth
Where food enters the body. Teeth begin process of breaking apart food.

salivary glands
Secrete saliva to aid in digestion.

oesophagus
Transports food from mouth to stomach.

stomach
Strong muscles churn and mix the food while acid and enzymes chemically break it down.

liver
Performs many functions, including: making bile for fat digestion, storing glucose and iron, regulating cholesterol levels and blood protein levels, etc...

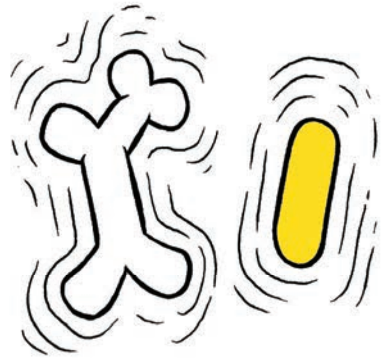
small intestine
Bile and enzymes combine to finish chemical breakdown of food. Most water and nutrients (carbohydrates, proteins, and fats) from food are absorbed here.

large intestine
Absorbs nutrients and vitamins from the gut microbiome. Remaining water is absorbed to help form faeces to remove the solid food waste from the body.

anus
Where food leaves the body.

Literature Activities

After reading *Follow Your Gut*, invite students to investigate features of the book. The following activities explore the format of the graphic novel, the narrative structure of the story, and how the use of different written and visual languages combine to engage and educate readers about the complex scientific concepts and themes.



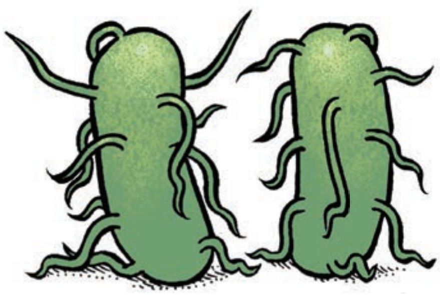
USING STORYTELLING TO TEACH SCIENCE

The authors have attempted to make the story as scientifically accurate as possible, depicting microscopic characteristics with details such as flagella, pili, membranes, and visualising molecular interactions. But they also used their imaginations to help tell the story...

- What elements of the storyworld do you think they made up and why ?

For Teachers:

- The authors chose to have the microbes speak to each other using words, whereas in reality they use molecules to enable certain levels of communication.
- They also represented the microbes and other cells as having and sensing emotions (e.g. 'disappointment', 'excitement', 'amazing', 'terrifying', etc) like humans (however they drew the line at giving bacteria googly eyes).
- These choices are both examples of 'anthropomorphism' – the attribution of human characteristics, emotions, or intentions to non-human (also known as 'more than human') entities or objects.
- The illustrator has used bright colours to define the different microbes whereas in reality, almost all microbes are colourless.
- There is no source of light in the gut, so the whole story would happen in the dark.
- The sounds used in the story are exaggerated and unlikely (e.g. 'POP', 'BOOM').



LITERARY ANALYSIS

Assign students to write a literary analysis essay analysing the themes, symbolism, and narrative techniques used in the graphic novel.

Encourage them to explore how the story's structure and imagery enhance its exploration of scientific concepts and themes related to gut bacteria.

TOOLS OF FICTION

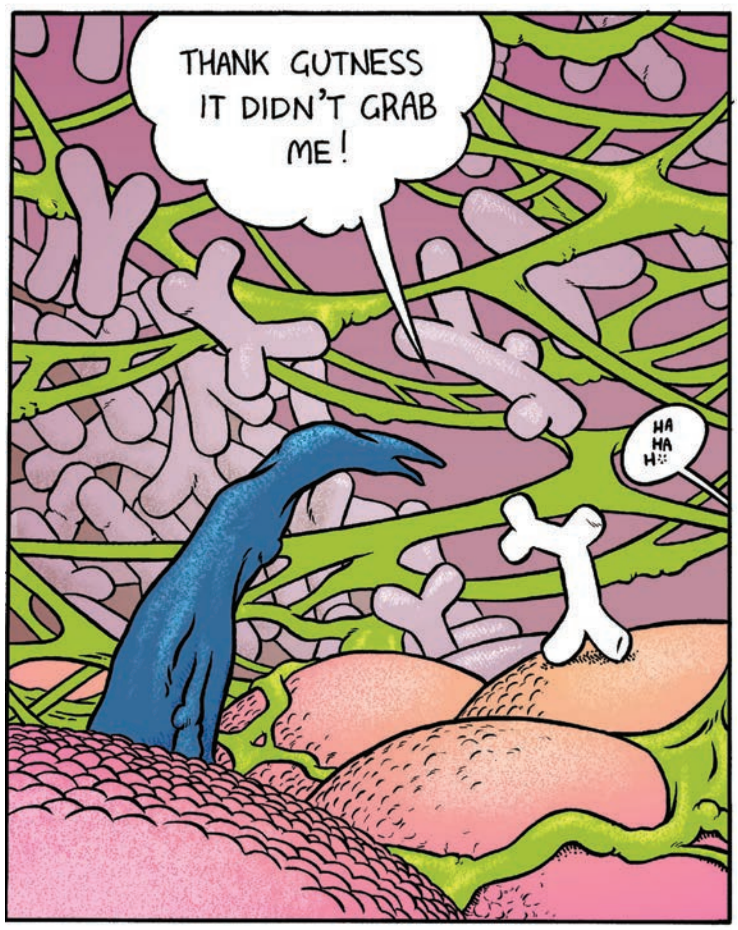
Even though the authors describe this book as narrative non-fiction, the book uses some of the tools of fiction to make much of the scientific knowledge easier to understand .

- What are some of the ways the book does this?
- Did you find anything funny in the story?
- Can you give an example where humour helped you connect with an idea or character in the story?
- Why would the authors try to use humour in this story?

For Teachers:

- The story uses narration, plot, characters, setting, narrative tension, conflict, point of view, resolution, humour, imaginative imagery, sound effects (onomatopoeia), intertextual references, flashbacks, parallel action, scale bars, and diagrams to engage readers and help make the material engaging and the complex science less intimidating and easier to understand.

- Humour can help lighten the mental load, encourage active engagement, and enhance memory retention, making it a valuable tool for understanding complex texts and information.

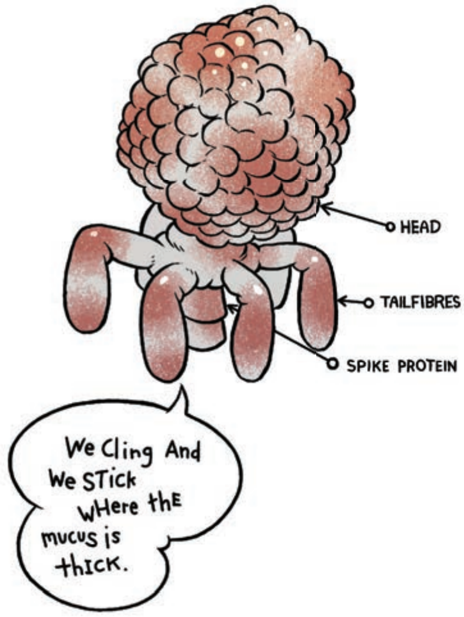


USE OF LANGUAGE

In the context of literacy, 'language' refers to the system of communication used to express ideas, thoughts, and feelings. It encompasses both receptive skills—the ability to listen to and understand language—and expressive skills—the ability to use language to communicate.

Language in literacy is not limited to just written and spoken forms. It also includes visual language, such as images, symbols, and signs. It also involves using and modifying language for different purposes and contexts in the creation and understanding of a literary work.

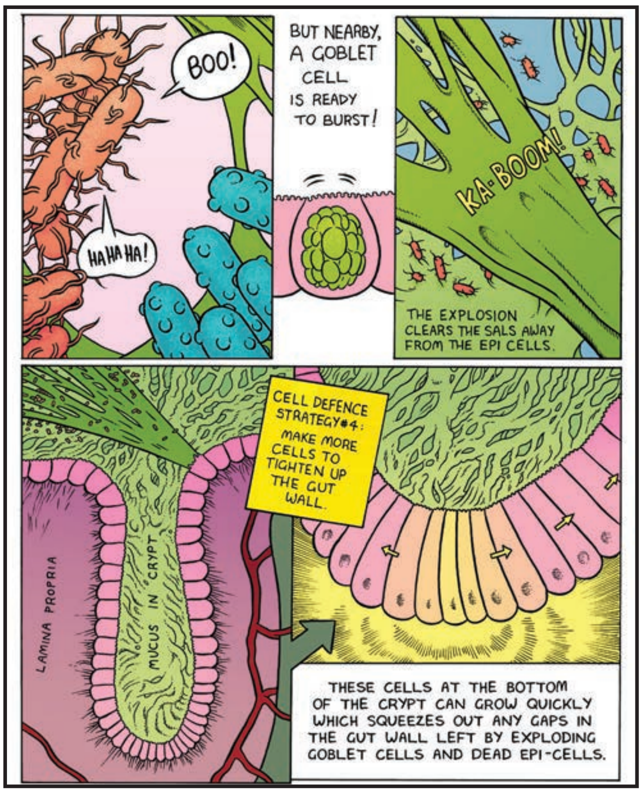
Follow Your Gut uses a mixture of written and visual languages. Explore some of the different kinds of language used across the book and how they work together to engage with the story and convey a wider understanding of the scientific subject matter.



For Teachers:

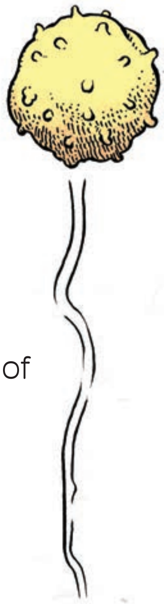
<u>Different uses of text in the story:</u>

- omniscient narrator voice
- character speech bubbles (smooth/jagged edges) and thought bubbles (cloud shaped)
- sound effects (onomatopoeia) such as POP! and SNAP!
- scientific labels
- scientific descriptions
- chapter introduction blurbs
- note to reader marked with a red star (e.g. p11)
- scale bars indicating physical size (e.g. p36)
- magnification label (e.g. p8)
- phage rhyming language (e.g. p109)
- Rumi poetic language (p116–119)



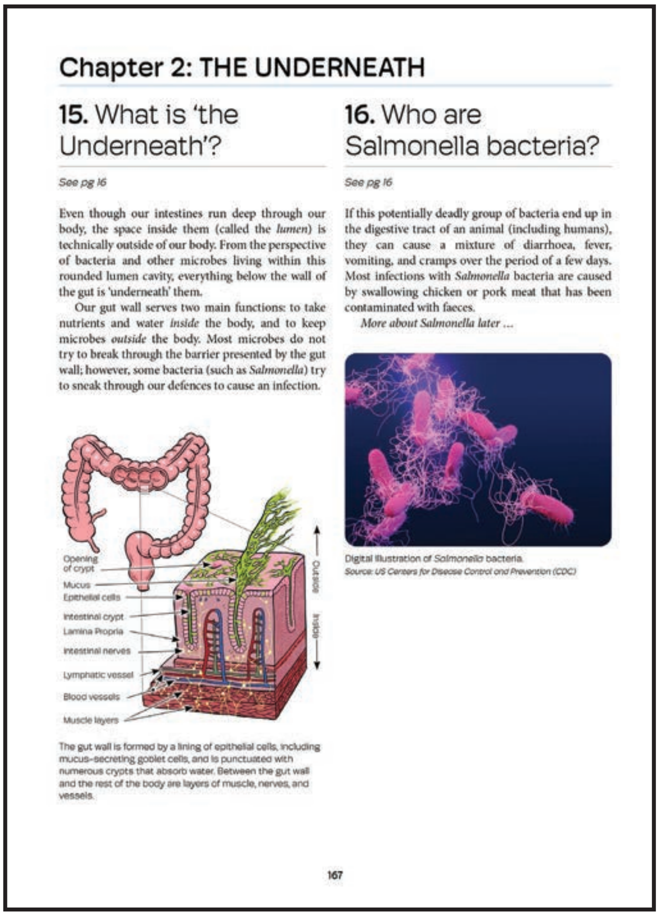
Different visual languages used in the story:

- sequential illustrations
- ideograms (codified symbols commonly used in comics) such as emphasis and action lines, hearts or sweat drops)
- flashback sequences in cloud shaped frame (e.g. p83)
- circular (e.g. p28) or rectangular magnification zooms (p48)
- numbered circles (1–133) linking to more information in the appendix section
- scientific diagrams (e.g. p54)
- graphs (e.g. p124)
- maps locating current action (e.g. p25)
- visual metaphors (e.g. sequence of photos on p. 104 indicating time passing)
- visual parallels (e.g. carpet texture on p93 and microscale cell textures on p45)
- zoom sequences (e.g. macro-scale human landscapes/cityscapes at the start of the story and micro-scale landscapes inside the human body)
- pink cloud-like lines representing a zoomed-out view of large numbers of microscopic HMO molecules (e.g. p55)
- cross-sections showing an 'X-ray' view inside part of an organ (e.g. p24)
- symbols for molecules, such as acetate and butyrate (e.g. p100)
- RSV virus pictorial language (p82–83)



Different languages used in the Appendix and other parts of the book:

- numbered questions (1–133) written from the perspective of a reader
- scientific explanations inside coloured boxes
- 'Did You Know?' information inside pink bubble shapes
- images (e.g. photographs, micrographs, diagrams and illustrations)
- image captions
- book publishing language (e.g. cover design, title page, credits page, about the authors section, back cover blurb, end papers)
- dictionary definition and epigraph



Chapter 2: THE UNDERNEATH

15. What is 'the Underneath'?

See pg 16

Even though our intestines run deep through our body, the space inside them (called the *lumen*) is technically outside of our body. From the perspective of bacteria and other microbes living within this rounded lumen cavity, everything below the wall of the gut is 'underneath' them.

Our gut wall serves two main functions: to take nutrients and water *inside* the body, and to keep microbes *outside* the body. Most microbes do not try to break through the barrier presented by the gut wall; however, some bacteria (such as *Salmonella*) try to sneak through our defences to cause an infection.

The gut wall is formed by a lining of epithelial cells, including mucus-secreting goblet cells, and is punctuated with numerous crypts that absorb water. Between the gut wall and the rest of the body are layers of muscle, nerves, and vessels.

16. Who are Salmonella bacteria?

See pg 16

If this potentially deadly group of bacteria end up in the digestive tract of an animal (including humans), they can cause a mixture of diarrhoea, fever, vomiting, and cramps over the period of a few days. Most infections with *Salmonella* bacteria are caused by swallowing chicken or pork meat that has been contaminated with faeces.

More about Salmonella later ...

Digital illustration of *Salmonella* bacteria.
Source: US Centers for Disease Control and Prevention (CDC)

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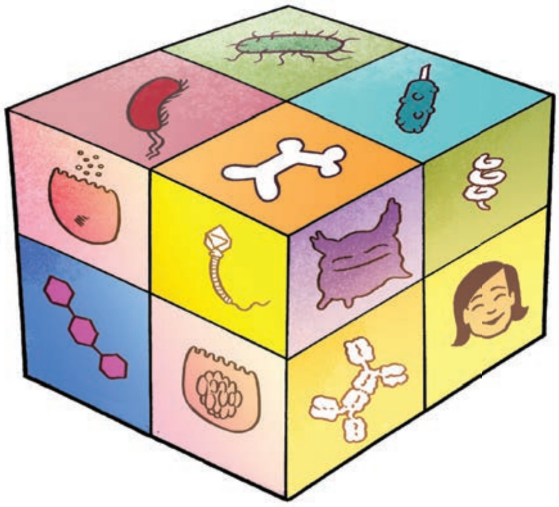
COVER TO COVER: ANALYSING BOOK FORMATS

Picture books, comic books, and graphic novels use a mixture of text and images to tell a story. However, many people consider comic books and graphic novels to be a more sophisticated format for storytelling.

After reading Follow Your Gut, describe 3 differences between a picture book and a comic book / graphic novel.

Follow Your Gut is designed to be educational and contains a lot of science information, much like a science textbook.

Discuss the similarities and differences between a textbook and a comic book.



Follow Your Gut can also be thought of as a kind of alternative textbook; designed as a way to learn about human biology and microbiology through the combination of an illustrated story and detailed scientific explanations (in the appendix). However, unlike a textbook, it uses a fictional narrative as the primary way to engage and introduce new knowledge to a reader.

For Teachers:
Here are some key differences between picture book, comic book, and textbook formats:

<u>Picture Books vs Comic Books</u>

- **Narrative Structure**: Picture books usually tell a complete story in a single book, often with a simple beginning, middle, and end structure. Comic books, on the other hand, often have ongoing narratives that span multiple issues or volumes.
- **Artistic Style**: The illustrations in picture books are often more detailed and can stand alone as individual pieces of art. In comic books, the artwork is typically more stylised and is designed to work in conjunction with the text and other panels to tell a story.
- **Audience**: While picture books are primarily aimed at younger children, comic books cater to a wide range of age groups, including teens and adults.

<u>Textbooks vs Comic Books</u>

- **Content**: Textbooks are primarily informational and educational, providing comprehensive coverage of a particular subject. Comic books, while they can be educational, are primarily narrative and focus on storytelling.
- **Interactivity**: Textbooks often include exercises, questions, and activities to engage the reader and reinforce learning. Comic books, on the other hand, engage the reader through the story and artwork, and the reader's interpretation of the sequential art.
- **Layout**: Textbooks typically have a more formal and structured layout, often with chapters, headings, and subheadings. Comic books use a more flexible layout with panels of different sizes and shapes to create a sense of movement and pacing.

Differences between Comic Books and Graphic Novels

The lines between comic books (or comics) and graphic novels have blurred over time, and the terms are often used interchangeably. Some of the key differences can include:

- **Length, Structure & Format**: Comics are typically shorter and often serialised (that is, published in issues or volumes). They may tell a complete story in a single issue or an ongoing story over several issues. On the other hand, graphic novels are longer and usually tell a complete story in one volume.
- **Content and Themes**: Comics often focus on episodic storytelling and can cover a wide range of genres. They can be used for humour or to tell simple stories. Graphic novels, however, tend to explore more complex themes and narratives. They are generally used for more serious storytelling and can delve into more mature and sophisticated themes
- **Audience**: While both comics and graphic novels cater to a wide range of ages, graphic novels often target an older audience due to their more complex and mature themes.

Based on the above, Follow Your Gut is closer to a graphic novel than a comic. Do you agree?

Similarities between Comic Books and Graphic Novels

1. Both tell stories through the use of sequential images, similar to how meaning is conveyed in animations and movies. A sequence of images can be used in a sophisticated way to tell parallel stories, present multiple viewpoints, jump forward and backward in time, and even talk directly to the reader (this is called 'breaking the fourth wall').
For example in *Follow Your Gut*:

- the story often explores parallel action happening inside and outside the body, over multiple physical scales (for example, on the bacterial scale and on the molecular scale) as well as in time
- early in chapter one, the story jumps from toddler Simi in the present, back in time to her mother's gut before she was born
- each bacterial narrator describes their journey to the gut using flashback sequences
- on the first page of the story (p3), the narrator addresses the audience directly (*Welcome, dear reader, to this tale of a living planet*).

Can you think of any other examples?

2. Through combining different narrative voices, visual languages, and modalities, comics and graphic novels more easily include more complex information and context around a story.
For example, in *Follow Your Gut*:

- the story is told by an omniscient (all-knowing) narrator, as well as by multiple different bacteria (e.g. Biffy, Escher, Rumi) and immune cells (Dendry)
- scientific diagrams, explanations, and labels appear throughout the main story sequence, often written in an authoritative tone but sometimes using humorous language.

3. Both formats include features such as image frames, speech and thought bubbles, marks and symbols that communicate extra information such as arrows to indicate movement or lines to indicate surprise, text as image – especially to indicate sound such as POP!! or SPLAT!!
In *Follow Your Gut*, scale bars are often included in the image to help explain what physical scale the story is taking place on (e.g. micrometres or nanometres).

Interdisciplinary Activities

CHARACTER PROFILES

Ask students to create character profiles for the main characters in the book, including information about their roles, personalities, and relationships. Have them research the real-life scientific counterparts of these characters, such as different types of gut bacteria, and compare and contrast their traits.

CHARACTER INTERVIEWS

Have students imagine they are journalists interviewing characters from the book, based on their experience and knowledge of gut bacteria from the story. They can write interview transcripts or record mock interviews to explore character perspectives and deepen their understanding of the scientific concepts presented. Alternatively, students could imagine talking to microbial or immunological characters from their own gut.

SCIENCE PODCASTS

Challenge students to create podcasts exploring topics related to gut bacteria, such as interviews with scientists, discussions of recent research findings, or explanations of key scientific concepts. They can script and record their episodes, incorporating elements of storytelling and narration.

SCIENCE FICTION WRITING

Ask students to write short science fiction stories inspired by the book. This could involve placing the existing characters into new situations (e.g. the human host taking antibiotics) or new environments (e.g. one or more characters leaving the gut and ending up on the hand of the host or in the gut of a new host – through a faecal microbiota transplantation).

Alternatively, students could write works that explore futuristic scenarios involving advances in gut microbiome research and technology (e.g. introducing genetically-engineered gut bacteria), speculating on the potential implications of manipulating gut bacteria for human health and society.

ART-SCIENCE COLLAGE

Ask students to create collages that combine artistic representations of gut bacteria with scientific diagrams and illustrations. Encourage them to use mixed media (e.g. drawings, photographs, magazine clippings) to convey the complexity and diversity of interconnections within the gut microbiome. Consider the gut microbiome spread on pages 122–123 as a a possible starting point .

Interdisciplinary Activities (cont.)

MICROBIOME THE MUSICAL

Organise students into groups to write a song or a whole script for a musical featuring characters and themes from the story. Students could write lyrics to existing tunes or make up their own melodies.

ART-SCIENCE EXHIBITION

Invite students to create individual or collaborative artwork inspired by the microscopic world of gut bacteria. They can use various media, such as painting, collage, sculpture, or digital art, to depict microbial communities, interactions, and environments. Display the artwork in an exhibition to showcase students' creativity and scientific understanding.

Here are some examples of other artworks inspired by the gut microbiome:

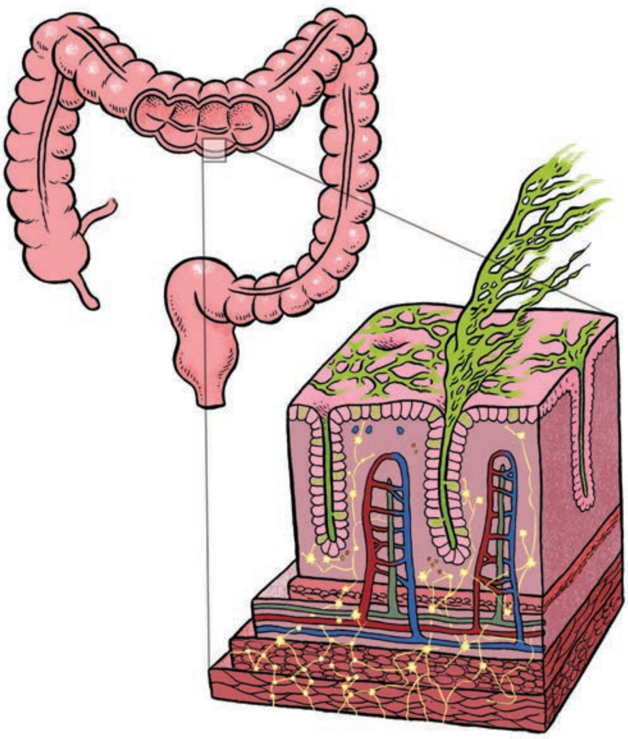
Subvisual Subway: The Art of New York City's Bacterial World
https://www.youtube.com/watch?v=Xxqd985bKi8

Hand and Laser Cut Paper Microbes by Rogan Brown
https://www.thisiscolossal.com/2015/11/new-hand-and-laser-cut-paper-microbes-by-rogan-brown/

Mining the Body for Metals
https://cargocollective.com/victoriashennan/Body-Cartography

Microbial Mouthpiece
https://cargocollective.com/victoriashennan/Mining-the-Body-Microbes-Minerals

Anthropocene (Microbiome Music) by Victoria Shenan
https://vimeo.com/188541584
https://youtu.be/fqulBDpJUqg



More about microbes

Here is a selection of books, videos, and online resources:

MICROBIOME BOOKS FOR YOUNG CHILDREN

Life on Us
Written by Tim Flannery and Emma Flannery

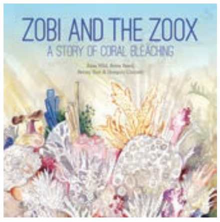
Do Not Lick This Book
Written by Idan Ben-Barak. Illustrated by Julian Frost

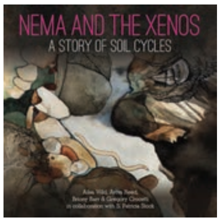
A Garden in Your Belly
Written and Illustrated by Masha D'yans

Gut Garden: A Journey into the Wonderful World of Your Microbiome
Written and illustrated by Katie Brosnan

The Good Germ Hotel: Meet Your Body's Marvellous Microbes
Written by Kim Sung-hwa and Kwon Su-jin. Illustrated by Kim Ryung-eon

Is There Life on Your Nose? Meet the Microbes
Written by Christian Borstlap



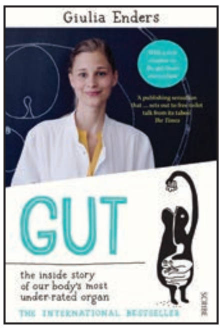


<u>The Small Friends Books series</u>

- **Zobi and the Zoox: A Story of Coral Bleaching**
- **The Squid, the Vibrio & the Moon**
- **Nema and the Xenos: A Story of Soil Cycles**
- **The Forest in the Tree: How Fungi Shape the Earth**

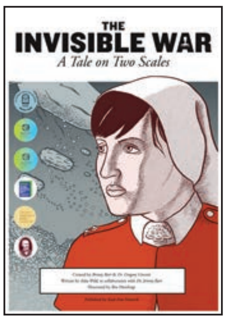
Written by Ailsa Wild, Briony Barr, and Gregory Crocetti
Illustrated by Aviva Reed

MICROBIOME BOOKS FOR OLDER READERS



Gut: The Inside Story of Our Body's Most Under-Rated Organ
Written by Giulia Enders

I Contain Multitudes: The Microbes Within Us and a Grander View of Life
Written by Ed Yong



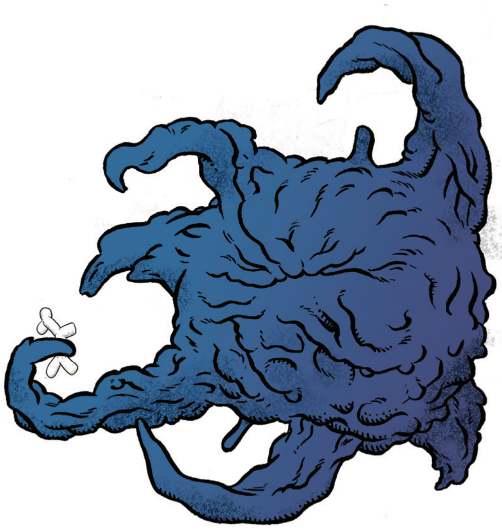
The Invisible War: A Tale on Two Scales
Written by Ailsa Wild, Briony Barr, Jeremy Barr, and Gregory Crocetti
Illustrated by Ben Hutchings

Gut-Themed Videos

The Microbes Within Us (Ed Yong)
https://www.youtube.com/watch?v=UOymDhGxS9Q

Solving Crimes with the Necrobiome
https://youtu.be/B_1HQSxz9GI

The Invisible Universe of the Human Microbiome (NPR)
https://youtu.be/5DTrENdWvvM



An Introduction to Bacteria (Amoeba Sisters)
https://youtu.be/ORB866QSGv8

An Introduction to the Digestive System (Amoeba Sisters)
https://youtu.be/1UvuBYUbFk0

How Bacteria Rule Over Your Body – The Microbiome (Kurzgesagt – In a Nutshell)
https://youtu.be/VzPD009qTN4

Why You Shouldn't Worry About Pooping Once a Day (Dr. Jen Gunter, TED)
https://youtu.be/btQHSDrL1ok

The Hungry Microbiome: Why Resistant Starch is Good for You
https://www.youtube.com/watch?v=NI3KtR3LoqM&t=2s

Microbe & Microbiome Resources on the Web

Joyful Microbe
https://joyfulmicrobe.com/start-here/

Unlocking the 'Gut Microbiome' – and Its Massive Significance to Our Health (The Guardian)
https://www.theguardian.com/society/2021/jul/11/unlocking-the-gut-microbiome-and-its-massive-significance-to-our-health

What Are the Real Signs of a Healthy Gut? A User's Guide
https://www.theguardian.com/lifeandstyle/2023/mar/18/what-are-the-real-signs-of-a-healthy-gut-a-users-guide

Gut Feelings: Why Drugs That Nurture Your Microbes Could Be the Future of Mental Health
https://www.theguardian.com/lifeandstyle/2023/mar/21/gut-feelings-why-drugs-that-nurture-your-microbes-could-be-the-future-of-mental-health

Breast-Feeding the Microbiome (Ed Yong, The New Yorker)
https://www.newyorker.com/tech/annals-of-technology/breast-feeding-the-microbiome

How Miraculous Microbes Help Us Evolve Better, Faster, Stronger (Smithsonian)
https://www.smithsonianmag.com/science-nature/how-miraculous-microbes-help-us-evolve-better-faster-stronger-180959909/

Microbe & Microbiome Resources on the Web (cont.)

Microbes Have No Morals (Ed Yong, Aeon)
https://aeon.co/essays/there-is-no-such-thing-as-a-good-or-a-bad-microbe

Gut Check: The Microbiome Game (free download)
https://microbe.net/gutcheck/download-the-game/

Microbial Myths: Common Misconceptions About Microbes
https://microbe.net/simple-guides/microbial-myths-common-misconceptions-about-microbes-in-the-built-environment/

Fact Sheet: Microbial Ecology in the Built Environment
https://microbe.net/simple-guides/fact-sheet-microbial-ecology-in-the-indoor-environment/

Fact Sheet: DNA-RNA-Protein
https://microbe.net/simple-guides/fact-sheet-dna-rna-protein/

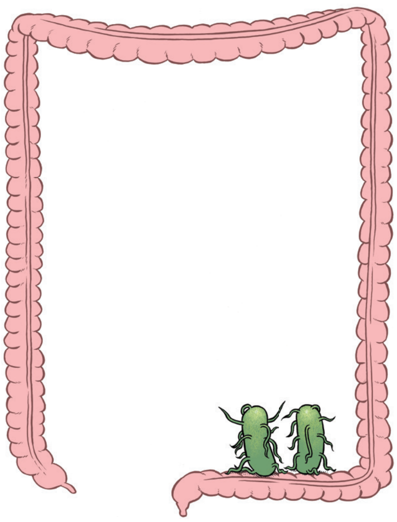
What Are Lymph Nodes? (The Conversation)
https://theconversation.com/what-are-lymph-nodes-and-can-a-massage-really-improve-lymphatic-drainage-209334

Gutsy: The Card Game (American Natural History Museum)
https://www.amnh.org/explore/ology/microbiology/gutsy-the-gut-microbiome-card-game

Human Microbiome Minecraft Map (American Natural History Museum)
https://www.amnh.org/explore/ology/microbiology/human-microbiome-minecraft-map

Make a Home for Microbes: Make a Winogradsky Column (American Natural History Museum)
https://www.amnh.org/explore/ology/microbiology/make-a-home-for-microbes

Microbiome Modelling with Bag 'o Beans (Mostly Microbes blog)
https://www.mostlymicrobes.com/4_microbiome_activities/



scale free network
art-science collaborative