# MATHEMATICS IN CAREERS

## Investigation - Cell sizes

**Key career focus for this investigation:** Biologist, zoologist, environmental scientist
**Related career areas:** Health and biological sciences



## THINKING ABOUT CAREERS

- Brainstorm biological sciences professions you can think of where maths is frequently used.
  Use https://joboutlook.gov.au to explore biological sciences related career pathways that include use of mathematics. *How is maths used in these scenarios? What maths is used in these scenarios?*

- This task focuses on how maths is used in biology through investigating cell size.

- The tasks specifically looks the surface area of cells and how this impacts on passive diffusion of materials through the cell wall.

- Explore careers such as biologists, zoologist, research scientists to discover how maths is used in these. For a more extensive list of careers related to this task, with a maths/science focus, refer to the table at the end of the task and explore the maths used in these jobs.

## MATHEMATICS IN EVERYDAY LIFE AND CAREERS

### Mathematical focus for this investigation

- Using formulas to solve problems.
- Re-arranging expressions to make a specified variable the subject.
- Using authentic situations to apply knowledge and understanding of surface area and volume

Scientists including health professionals use various measurement formulas. They apply their knowledge and understanding of surface area and volume to see the relationship between volume and surface area, in various situations. In this case specifically looking at size of cells and the effect on surface area if volume increases.

- Many people use various measurement formulae every day. For example, they do the area calculations in their head to calculate carpeting or tiling floor surface.

- Brainstorm and share scenarios where this mathematics may be used in health and biological sciences to solve problems.

# MATHEMATICAL INVESTIGATION
# CELL SIZES

## LINKS TO VICTORIAN CURRICULUM

| Mathematics links to Victorian Curriculum Level 10 | Application to work and life |
|---|---|
| **Measurement and Geometry**<br>Using units of measurement<br>Solve problems involving surface area and volume<br>for a range of prisms, cylinders and composite solids<br>(VCMMG343) | Units of measurement are used in many workplaces.<br>This may include<br>• Using formulas to solve problems<br>• Solving problems involving surface area and volume.<br>Investigating the relationship between volume and surface area.<br>Making predictions, testing how increasing volume effects the surface area to test hypothesis.<br>Many people use various measurement formulae every day. For example, they do the area calculations in their head to calculate carpeting or tiling floor surface. |

| Mathematics links to Victorian Curriculum Level 10A | Application to work and life |
|---|---|
| Solve problems involving surface area and volume of right pyramids, right cones, spheres and related composite solids (VCMMG365) | Apply knowledge and understanding of surface area and volume. |
| Further example of other maths used<br>Substitute values into formulas to determine an unknown and re-arrange formulas to solve for a particular term (VCMNA333) | Re-arranging expressions to make a specified variable the subject such as calculating the radius of a sphere to produce a given volume. |

## PROFICIENCY FOCUS: VICTORIAN CURRICULUM

| This investigation focuses on: Fluency, Understanding, Problem Solving | | |
|---|---|---|
| **Fluency** describes students developing skills in choosing appropriate procedures, carrying out procedures flexibly, accurately, efficiently and appropriately, and recalling factual knowledge and concepts readily.<br><br>This investigation focuses on:<br>• Recall definitions and use these<br>• Solving simple equations arising from formulas<br>• Manipulate (re-arranging) expressions to make a specified variable the subject to find solutions. | **Understanding** refers to students building a robust knowledge of adaptable and transferable mathematical concepts and structures.<br><br>This investigation focuses on:<br>• Describe their mathematical thinking<br>• Interpret mathematical information | **Problem Solving** is the ability of students to make choices, interpret, formulate, model and investigate situation, select and use technological functions and communicate solutions effectively.<br><br>This investigation focuses on:<br>• Students applying their existing strategies to seek solutions. |

# MATHEMATICAL INVESTIGATION
# CELL SIZES

## INVESTIGATION BACKGROUND

There is a physical limitation to the maximum size of cells. This is due to the surface area of the cell to allow for passive diffusion of materials through the cell wall. What is the relationship between volume and surface area that may limit this? Given,

- A cell has a spherical volume, and that it generates waste at a rate of a molecules per cubic micron per second.
- It removes the waste through its surface by passive diffusion at a rate of b molecules per square micron per second, where 1 micron is 0.000001 metres.

## YOUR INVESTIGATION

You will need to create a model: recognising that there is a stable relationship between surface area and volume. Note:

- The cell has spherical volume.
- The cell removes waste through its surface.

## PART 1

Find the equation that defines the rate, $R$, at which the organism changes the amount of its net waste products.

$$\text{Volume} = \frac{4}{3}\pi r^3 \qquad \text{Surface area} = 4\pi r^2$$

Relationship between volume and surface area.

$$\frac{4}{3}\pi r^3 a = 4\pi r^2 b$$

$$R = \frac{4}{3}\pi r^3 a = 4\pi r^2 b$$

## PART 2

Derive the equation to describe a relationship where the value for the cell's radius will have a net change of zero, meaning that the cell is in equilibrium. (Hint: $R$ = 0)

When $R$ = 0, $\quad \frac{4}{3}\pi r^3 a = 4\pi r^2 b = 0 \qquad (\div\ 4\pi r^2 \text{ both sides})$

$$\frac{r}{3}a = b = 0$$

$$\frac{r}{3}a - b = 0$$

$$\frac{r}{3}a = b$$

$$r = \frac{3b}{a}$$

## PART 3

What is the relationship between volume increase and surface area of a sphere?

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## ENABLING PROMPTS

You will need to create a model: recognising that there is a stable relationship between surface area and volume.

You may need to provide the following prompts to students:
To do this you will need to combine the formulas for surface area and volume and then derive the equation.
Note:  The cell has spherical volume so you will need the formula for volume of a sphere.
The cell removes waste through its surface, so you will need the formula for the surface area of a sphere.

You may need to provide students with the formulae for volume and surface area of spheres.

$$\text{Volume} = \frac{4}{3}\pi r^3 \qquad \text{Surface area} = 4\pi r^2$$

## EXTENSION OR ADVANCED INVESTIGATION

Pelagibacter ubique is one of the smallest known free-living bacterium with a length of 0.37-0.89 $\mu m$, does this bacterium fall within the functional limitations for the size of cells based on your formula?

Thiomargarita namibiensis has cells can typically reach 750 $\mu m$ diameter, does this bacterium fall within the functional limitations for the size of cells based on your formula?

# MATHEMATICAL INVESTIGATION
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## CAREERS RELATED TO THIS INVESTIGATION

Refer to the student investigation, it provides:
- An extensive table of careers related to this investigation
- Further career references

## CAREERS ACTIVITIES

Refer to the student investigation, it provides:
- A table of the top 10 rated jobs of 2021. This data comes from careercast.com. Have students investigate the jobs specific to this investigation.

## INDUSTRY PARTNER

**This project was produced collaboratively between The Mathematical Association of Victoria (MAV) and the Victorian Space Science Centre (VSSEC).**

The Victorian Space Science Education Centre (VSSEC) is a specialist STEM learning facility, one of six established by the Victorian State Government. Since its official opening in 2006, VSSEC has used the context of space to enhance the learning experiences in Mathematics, Science, Technology and Engineering for both teachers and students.
VSSEC is located in the grounds of Strathmore Secondary College. The spiral galaxy shaped building provides a stimulating environment which encourages students to be fully engaged in problem-solving and scenario-based learning.
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