Introductory Biology
Life & Cells

Introduction

Cells were first discovered by Robert Hooke in 1665 who, when examining a very fine slice of cork under an early light microscope, was able to distinguish tiny compartments in a honeycomb arrangement. He gave these the name of 'cells' and we now know that what he was looking at were actually the lignified non-living cell walls of this plant tissue meaning that there was no description of the contents of these cells made in Hooke's observations. It wasn't until Antonie van Leeuwenhoek examined algae under a light microscope almost 20 years later, that a living cell was described. Combining the observations of Hooke, van Leeuwenhoek and others led to the development of cell theory, a widely accepted explanation of the role of cells and their relationship to all living things.

Cell theory is an important concept in biology and has three core principles:

1. Organisms are made up of one or more cells,
2. Cells are the fundamental unit of structure, function and organization for all organisms and
3. Cells come from pre-existing cells.

Some organisms consist of one cell (unicellular) and others of many cells (multicellular) but knowledge of cells, their size and how they function are fundamental and shared across organisms.

Aims of this session:

- To identify types of cells (prokaryote and eukaryote) and some of the similarities and differences between them
- To identify the approximate size of cells, their relative size, basic components and component functions

Why are Cells so Small

Cells need to interact with their environment in order to survive, requiring materials to pass in and out of the cell membrane in sufficient quantities within a certain timescale. In order to understand why cells are small, you need to appreciate the relationship between surface area (i.e. the amount of cell membrane available) and volume (i.e. how big it is inside the cell). This relationship also explains why larger organisms are multi-cellular.

To illustrate this relationship, you will build both single-celled and multi-cellular organisms of various sizes, work out the cellular surface area (i.e. area of cell membrane around the cell) and volume of each organism and the relationship between these measurements.

The building blocks in this case will be small plastic blocks and you will assume that each block is a perfect cube (i.e. all sides have the same length) and so you will be working in imaginary units called 'standard dimensions' (sd). Figure 1 shows these for one cube in the units 'sd' and they are 1 sd for height (h), 1 sd for width (w) and 1 sd for depth (d).

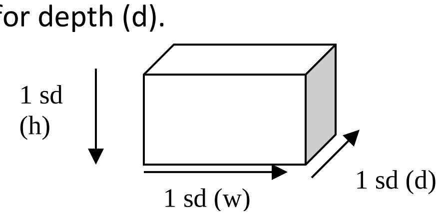


Figure 1. Dimensions of a single plastic cube in sd units.

Single-Celled Organisms

Task 1: Working in groups, use the plastic cubes to build a single-celled organism with the dimensions of 3sd by 3sd by 3sd (see Figure 2). Calculate the cellular surface area of this cell in the units ‘sd^2’, volume in the units ‘sd^3’ and surface area (SA) to volume (V) ratio (SA:V) and complete Table 1 below.

Figure 2. A single-celled organism with side length of 3sd

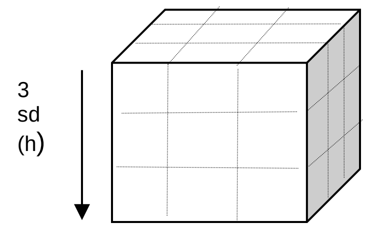


Table 1. Cellular Surface Area, Volume and SA:V of Single-Celled Organisms

Length of cell (sd)	Surface Area (h*w*6) sd^2	Volume (h*w*d) in sd^3	SA:V (SA÷V)
1			
2			
3			

Task 2: Now build a single cell 2sd by 2sd by 2sd and calculate the surface area and volume of this new smaller cell. Add these values to Table 1 and work out the SA:V.

Task 3: Now repeat the same for a single cell 1sd by 1sd by 1sd.

When you have built all of your cells, you should have three models similar to those shown in Figure 3.

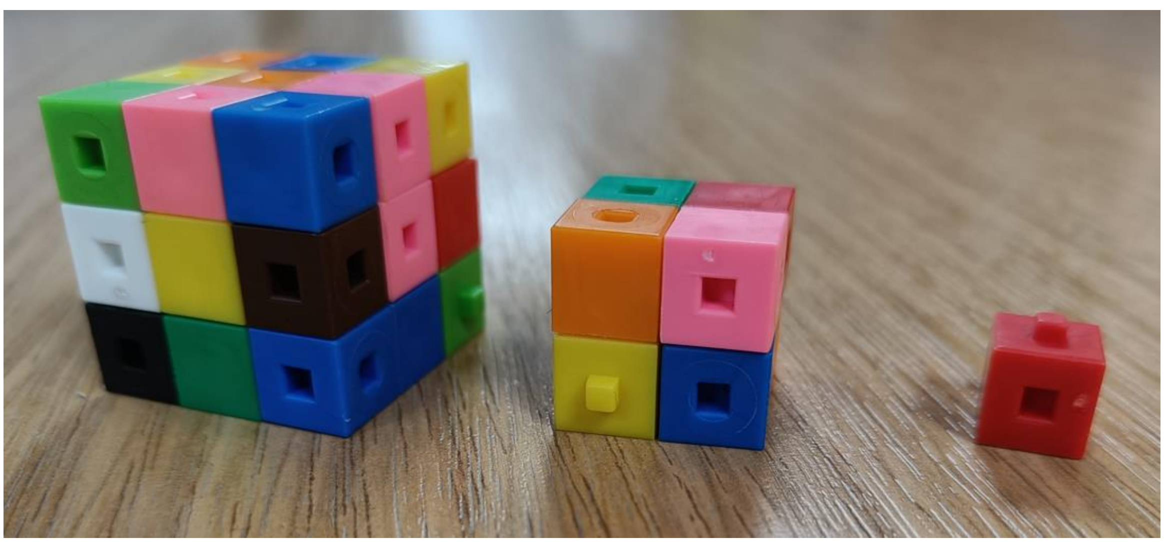
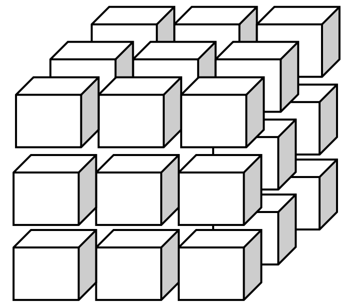


Figure 3. Models of the different sized ‘cells’ built from plastic cubes.

Multi-cellular Organisms

Task 4: Build a multi-cellular organism with the dimensions of 3sd by 3sd by 3sd (see Figure 4). Calculate the total surface area of all the cells in this organism, its total volume and the SA:V and add these values to Table 2 below.

Figure 4. A multi-cellular organism 3sd by 3sd by 3sd



Task 5: Now build a multi-cellular organism with the dimensions 2sd by 2sd by 2sd and work out the cellular surface area, volume and SA:V for Table 2.

Task 6: Now repeat the same for an organism 1sd by 1sd by 1sd.

Table 2. Surface Area, Volume and SA:V of Multi-cellular Organisms

No. of Cells in Organism	Length of Organism (sd)	Total Cell Surface Area for Organism (sd^2)	Total Volume of Organism (sd^3)	SA:V

<u>Relationship between Cellular Surface Area and Volume</u>

Task 7: From Table 1, plot the results on the graph below (Fig 4) for SA:V against cell side length (sd) for each single-celled organism. Now plot the same for multi-cellular organisms from Table 2.

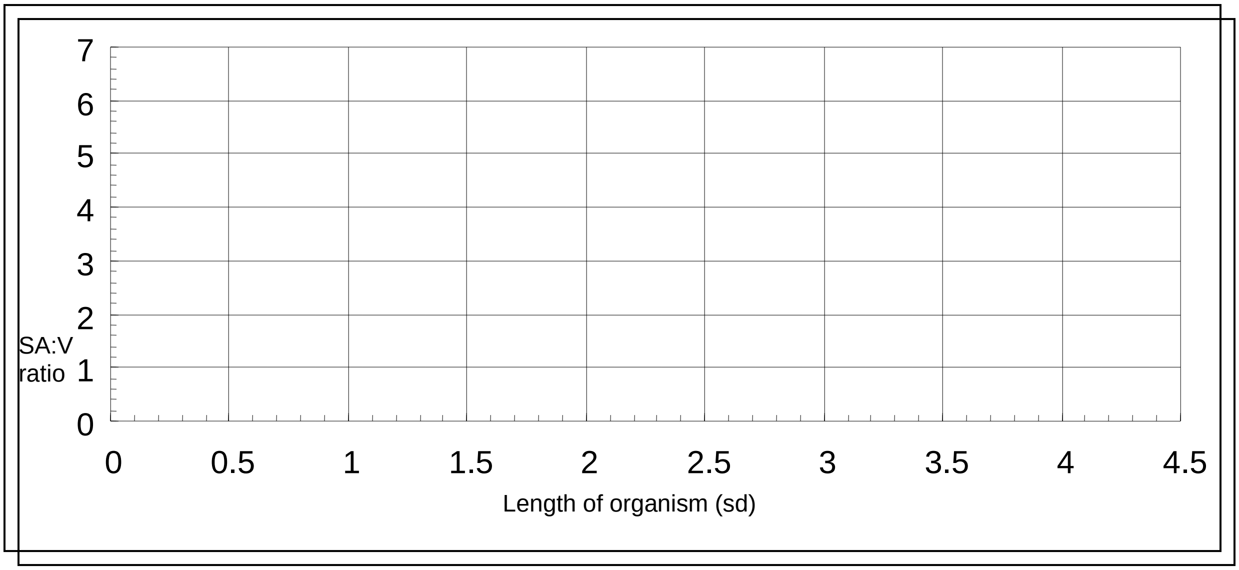


Fig 4. Relationship between SA:V ratio and dimensions sides (i.e. how much surface area there is for every unit of volume).

- What does this graph tell you about the relationship between SA:V ratio and cell dimensions?
- How does this relationship impact on cell size and their ability to function efficiently in real life?
- What does this tell you about size limitations for unicellular versus multicellular organisms?
- Will the shape of the cell impact on the SA:V ratio?