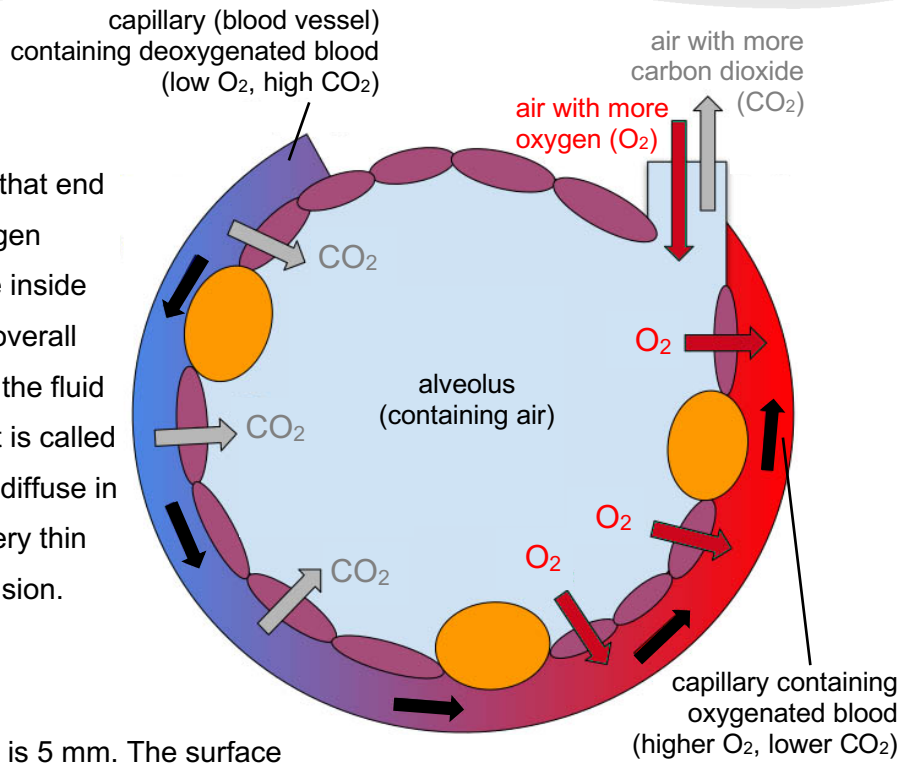
# 4 Surface area & COVID-19

Links:
- *Exploring Science* 8Ae, 8Cb, 8Cc
- *Edexcel 9-1 GCSE* CB8a, SB8a

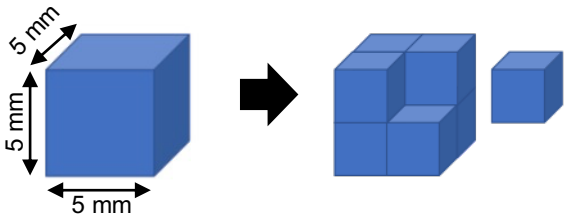
## Alveoli

Your lungs contain 2400 km of tubes that end in miniscule bags called **alveoli**. Oxygen dissolves in a thin layer of fluid on the inside wall of an alveolus. There is then an overall movement of oxygen molecules from the fluid into the blood. This overall movement is called **diffusion**. Carbon dioxide molecules diffuse in the opposite direction. Alveoli have very thin walls (one cell thick) to speed up diffusion.




## Surface area

Each side of the big cube on the right is 5 mm. The surface area of one face is $5 \times 5 = 25$ mm$^2$. It has six faces and so its **surface area** is $6 \times 25 = 150$ mm$^2$. If the cube is split into eight cubes, we increase the total surface area. 500 million alveoli increase the inside surface area of your lungs to that of a tennis court, and so allow faster gas diffusion.




## Surface area : volume ratio (SA:V)

The round shape and tiny size of an alveolus give it a large surface area compared to its volume; it has a high **surface area : volume ratio** (**SA:V**). The higher this ratio, the more surface there is for a given volume of molecules to enter and leave. Diffusion is faster in structures with high SA:V ratios.

In patients with serious forms of COVID-19, the alveoli become swollen and fill with fluid. This slows the diffusion of the gases and patients may need to receive air containing more oxygen.

### *Find out*

1. Find the name of the condition in which:

   a. fluid starts to collect in the alveoli _____

   b. capillaries leak a lot of fluid into the alveoli. _____

## *Test yourself*

| | | |
|---|---|---|
| alveoli | | decrease |
| faster | increase | into |
| nitrogen | | out of |
| oxygen | | slower |

2. Complete these sentences using *some* words from the box.

   The lungs are full of _____, which _____ the surface area of the insides of the lungs. This allows _____ diffusion of gases (carbon dioxide _____ the blood capillaries and _____ into them).

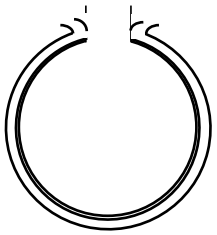
3. The diagram shows an alveolus and a capillary.
   a. Describe two ways in which the alveolus is adapted to speed up the diffusion of gases.

   _____

   _____

   _____

   _____

   b. Add to the diagram to explain how diffusion of gases can be reduced by COVID-19.

4. The big cube on page 1 has sides of 5 mm and so a volume of 125 $mm^3$ ($5 \times 5 \times 5$).

   a. Calculate its SA:V ratio. (Divide the surface area by the volume. There are no units.)

   big cube
   SA:V ratio = _____

   b. The cube is split into eight cubes of equal size. Calculate the SA:V ratio of a small cube.

   small cube
   SA:V ratio = _____

   c. Both the big and small cubes contain a gas. 10 $mm^3$ of gas diffuses out of each. Explain which cube this happens faster in, or whether there be no difference.

   _____

   _____

## *Check-up*

I. Check your answers.

II. Plan an experiment to compare how quickly the same volume of water evaporates from open containers of different width. Predict what will happen and explain your prediction.

## *Answers*

**Note to home educators**

The worksheet is designed to support understanding of lung adaptations for gas exchange. You may wish to share these objectives with students:

- Describe the diffusion of gases between the blood and air (gas exchange).
- Explain how the lungs are adapted for efficient gas exchange.
- Calculate the surface area: volume ratio of a cuboid. (GCSE)
- Explain the importance of surface area : volume ratios in transport systems. (GCSE)

Students need a basic knowledge of the breathing / respiratory system and to understand how all materials are composed of particles in a constant state of motion.

It is suggested that students complete the worksheet independently, making use of the internet to complete question 1. Questions 2 - 4 should be completed without help from additional sources. Questions 1 – 3 are accessible by students in Key Stage 3 (Years 7 – 9). The idea of the surface area : volume ratio is GCSE content (question 4).

If you wish to check the answers, keep this part of the sheet away from the questions!

I. 1. a pneumonia

b. acute respiratory distress syndrome (ARDS)

2. alveoli, increase, faster, out of, oxygen.

3. a 150/125 = 1.2

b. surface area = $6 \times (2.5 \times 2.5) = 37.5$ mm$^2$

volume = $2.5 \times 2.5 \times 2.5 = 16.625$ mm$^3$

SA:V ratio = 37.5/16.625 = 2.3 (or 2.26 or 2.256 but no more decimals that this!)

c. the small cube; because it has a greater surface area : volume ratio

4. a. thin wall, large surface area : volume ratio (accept large surface area at KS3)

b. • layer of fluid added to inside of the alveolus

• labels point out that the thicker layer of fluid increases the distance that gases have to travel and so diffusion is slower

• labels point out a decrease in the surface area inside an alveolus, which means less oxygen enters the fluid in a given time. (Increasing the thickness of the fluid layer in an alveolus means that there is less surface area of fluid inside the alveolus. There is a decrease in the SA:V ratio.)

II. A simple way to do this is to measure out equal volumes of water using a small kitchen measuring jug. Add one to a narrow-necked container (such as a tall glass) and the other to a wide-necked container (such as a shallow dish). Leave the containers in the same conditions for a couple of days and then re-measure the volume of water in each. There should be more left in the narrow-necked container since this provides less surface area for evaporation. Note that in this case we are looking at evaporation (and not diffusion) but the concept is the same; the larger the surface area the more particles are able move.