COSMOS LESSONS

Biology

Respiratory System: Out of breath

These days everyone knows that you do your body no favours by smoking. And yet people continue to take up cigarettes, while others maintain their habits. A greater understanding of how the respiratory system works and how smoking damages it may provide an extra incentive to avoid smoking.

In this lesson you will investigate the following:

- What are the main parts of the respiratory system?
- How and why do we breathe?
- How does gas exchange work?
- How does smoking affect our bodies?

So take a deep clean breath and let's get into the lesson!

This is a print version of an interactive online lesson.
To sign up for the real thing or for curriculum details about the lesson go to **http://www.cosmosforschools.com**

Introduction: Respiratory System

You're a Spanish sailor in the early 1500's, bravely exploring the New World. An American native offers you a bundle of dried leaves. He tells you that if you burn them and inhale the smoke it will make you feel good – after a week or two of coughing and dizziness. He tells you two other things as well. Smoking the leaves is addictive, so if you start there's a good chance you won't be able to stop for the rest of your life. And it will probably take 10 years off your life.

Would you take up the habit?

It doesn't sound like it's worth it, but over a billion people worldwide have.

Smoking tobacco, as we should all know by now, is a dangerous habit. Besides causing heart disease and cancer it is especially bad for the respiratory system – the chemicals in cigarette smoke damage structures in the lungs, leading to chronic respiratory disease.

A recent Australian study has shown that two thirds of smokers will die from smoking if they don't quit. This made the news because previous estimates had it that about half of smokers die from the habit – the odds just got quite a bit worse. The study also found that smokers tend to die 10 years earlier than non-smokers.

Most people would rather have those years.

Read the full *Cosmos Newsblog* article here.

Question 1

Suggest: It is now well understood how harmful smoking is. Why do you think people continue to take it up?

Gather: Respiratory System

COSMOS LESSONS

Parts of the respiratory system

Question 1

Recall: Breathing is automatic. This means we don't have to think about it.

- True
- False

Question 2

Recall: The *pharynx* is used for both respiration and digestion.

- True
- False

Question 3

Recall: The biological name for the *voice box* is the:

- larynx
- pharynx
- epiglottis
- trachea

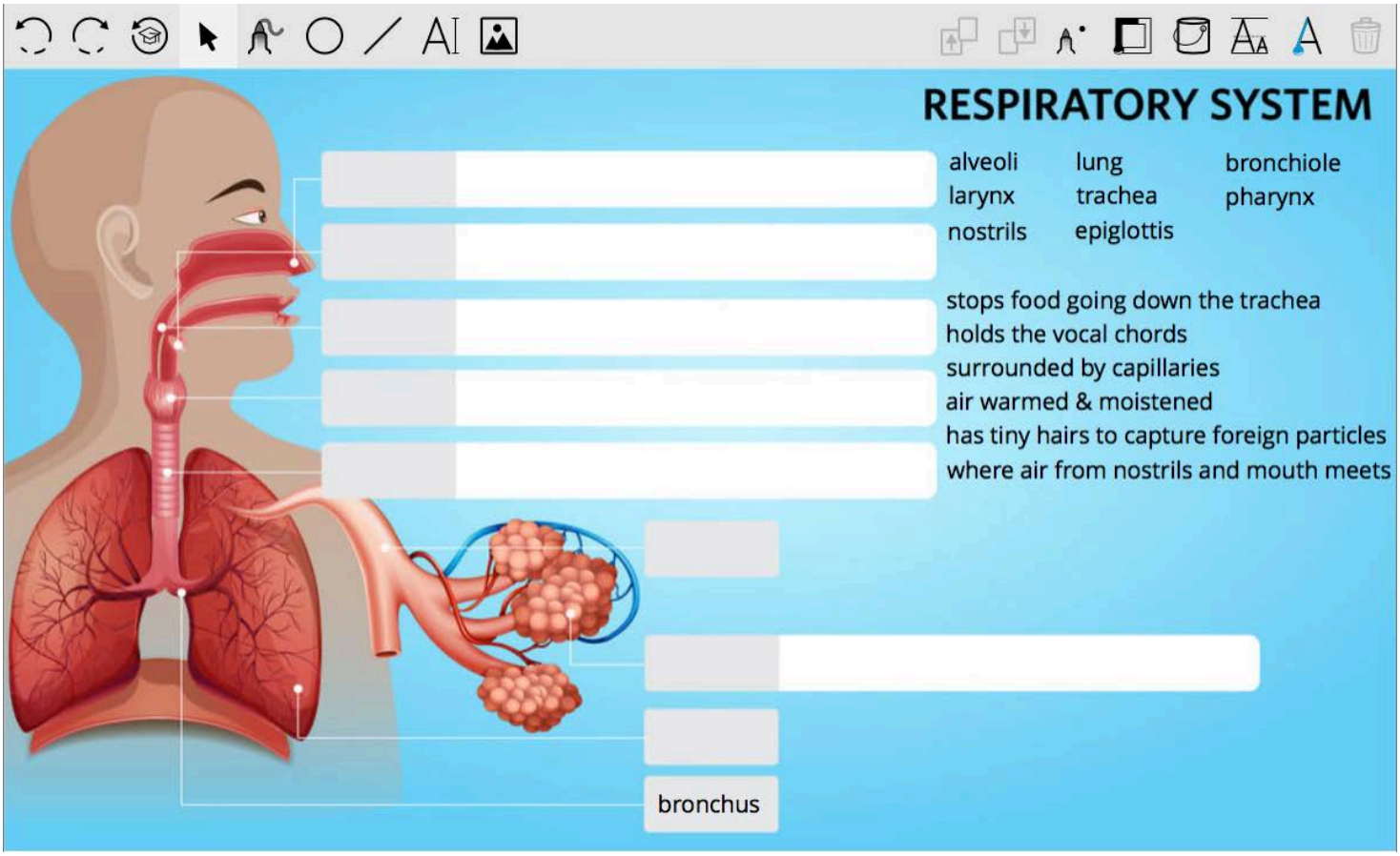
Question 4

Recall: The biological name for the *windpipe* is the:

- pharynx
- epiglottis
- larynx
- trachea

Question 5

Label: Drag the text in the sketchpad to label the diagram, and then match the functions to the labels.



What happens when we breathe?

Breathing is controlled by the *autonomic nervous system* – the part of our nervous system that automatically regulates all of our internal organs. For breathing it operates two sets of muscles:

- The *intercostal* muscles, between the ribs.
- The *diaphragm* – a dome-shaped sheet of muscle that separates the chest cavity, where the heart and lungs are, from the abdominal cavity, where the intestines are.

When both sets of muscles tighten, or **contract**, we **inhale**:

- the ribs move up and out, and the diaphragm lowers, so
- the size of the chest cavity increases, so
- the pressure in the lungs lowers, so
- air is drawn in.

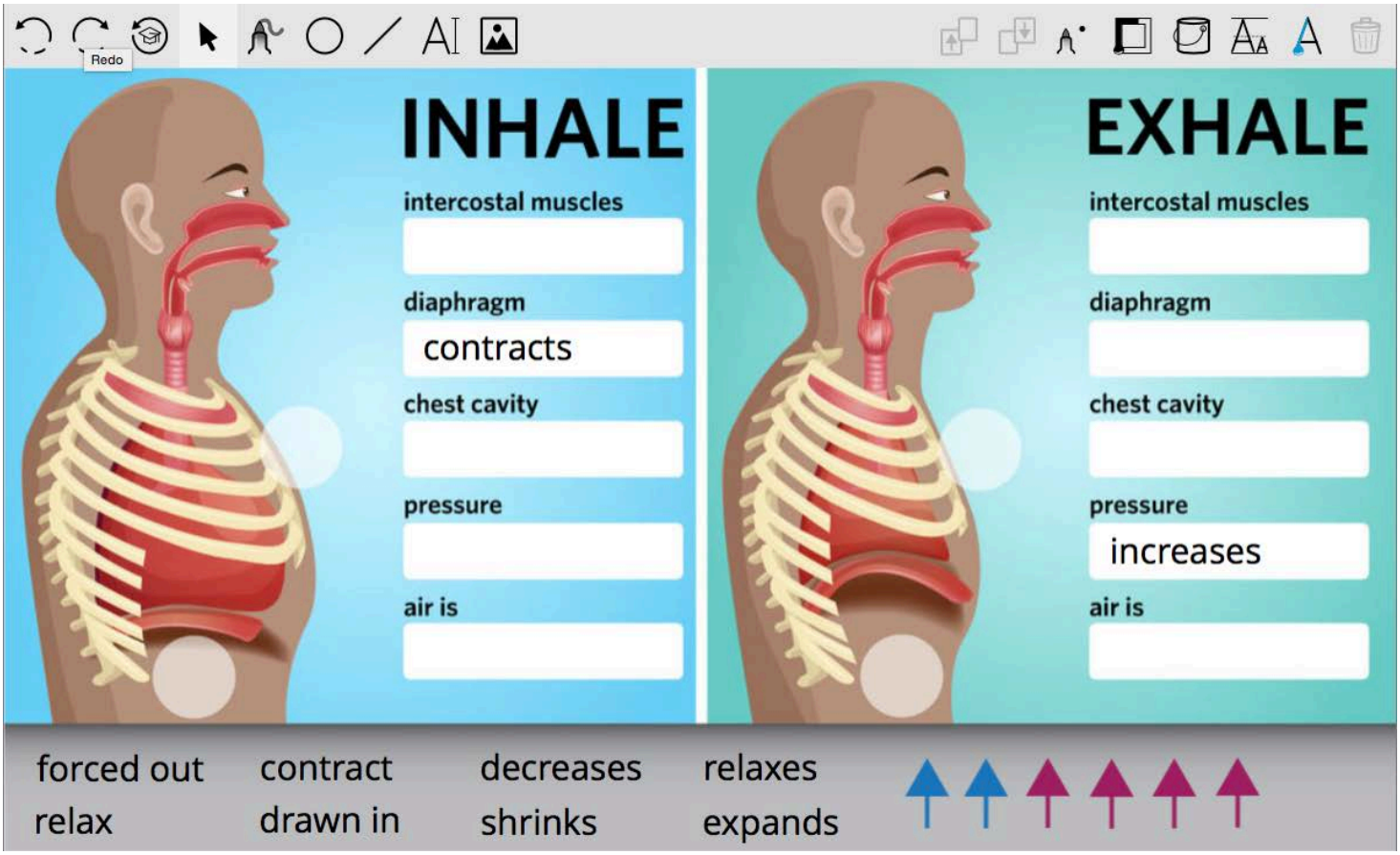
When both sets of muscles **relax** we **exhale**:

- the ribs move down and in, and the diaphragm rises, so
- the size of the chest cavity decreases, so
- the pressure in the lungs increases, so
- air is forced out.

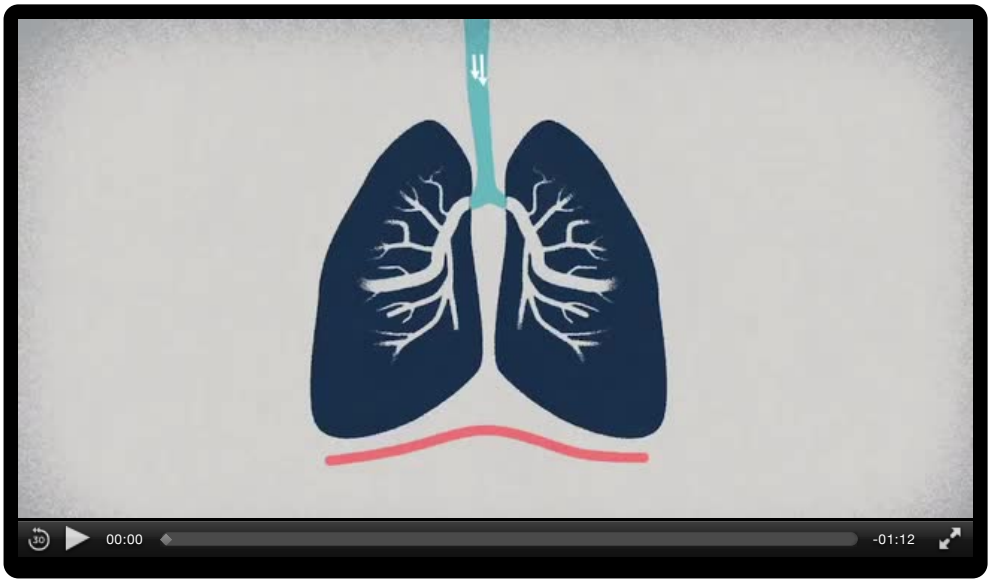
Question 6

Describe: Drag the text and arrows to their correct positions in the sketchpad to describe what happens when we inhale and exhale:

1. Use the words to complete the phrases – we've done two for you.
2. Use the **purple** arrows to show the movement of the diaphragm and rib cage – in the circles.
3. Use the **blue** arrows to show the direction of air movement in the tracheas.



Gas exchange



Question 7

Explain: Why do we breathe? Refer to oxygen, carbon dioxide and cells in your answer.

Diffusion

When molecules of one kind are concentrated in an area in a liquid or gas and are able to spread out, they do. This is **diffusion**. It occurs because of the constant movement of all the molecules in the liquid or gas, which mixes up all the different types of molecule.

Think of smoke rising off a cigarette – it starts off in a concentrated stream but then *diffuses* so it is equally spread through the whole room.

Diffusion can also occur through a membrane if the molecules are small enough to pass through. A helium balloon is large and firm when it is filled, but smaller and softer a couple of days later. The helium slowly *diffuses* through the balloon into the surrounding air.

In the alveoli, oxygen and carbon dioxide molecules easily pass through the membranes that keep blood in the capillaries separated from air in the lungs. Because the blood is moving – taking away oxygen and bringing in more carbon dioxide – and the air in the lungs is always being replaced:

- there's always more oxygen in the air than in the blood, and
- there's always more carbon dioxide in the blood than in the air.

And so diffusion always acts to bring oxygen into the body and take carbon dioxide out.

Question 8

Compare: When you put a teabag into hot water diffusion occurs.

- ○ True
- ○ False

Question 9

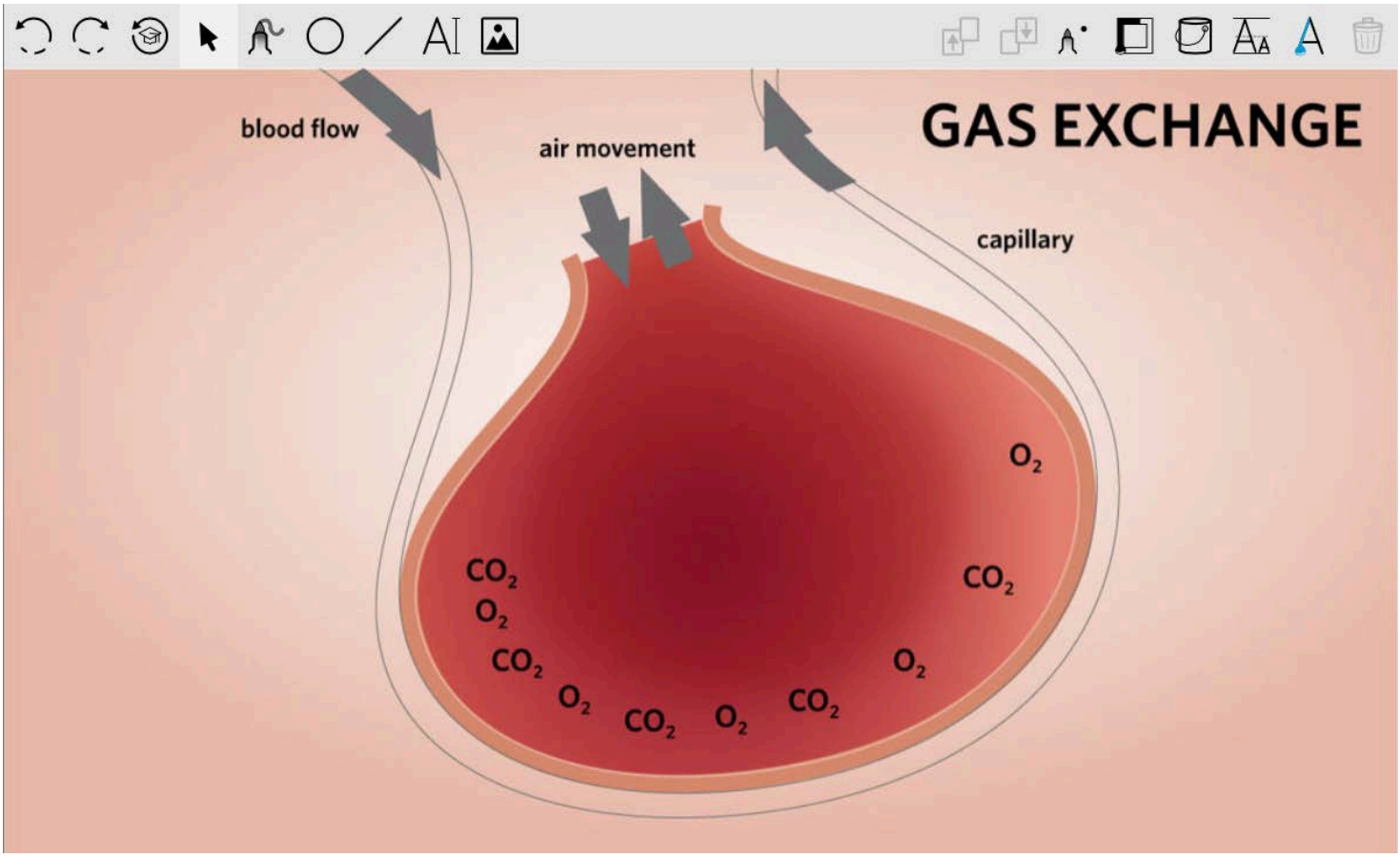
Recall: Diffusion never occurs across a membrane.

- ○ True
- ○ False

Question 10

Label: The diagram below shows the cross-section of an alveolus with a single blood capillary on its outer surface. The direction of blood flow is shown.

1. Colour the blood in the capillary red or blue:
   a. **red** = high oxygen and low carbon dioxide
   b. **blue** = low oxygen and high carbon dioxide
2. For each "O_2" and "CO_2" in the diagram, draw an arrow to indicate whether it crosses the alveolus membrane into the bloodstream or has come from the bloodstream:
   a. draw **red** arrows for **O_2**
   b. draw **blue** arrows for **CO**



Process: Respiratory System

Left: A composite image of a healthy lung (left) and smoker's lung (right). It is has shrunk, and is discoloured from tar buildup. Right: Doctors examine a lung X-ray.

Healthy lungs

Smoking is bad for lungs, but how exactly does it affect them? Before we can answer we have be clear about what makes healthy lungs work well.

As you have seen, the trachea branches into smaller and smaller bronchioles, each ending in clusters of alveoli. With all that branching each adult human lung has around 300 million alveoli!

The alveoli are very small – about 0.2 mm diameter – but with so many it adds up to a total internal surface area of about 60 m^2. That's a large area packed up in your chest! And it gets bigger when you breathe in, because the alveoli are elastic and expand. Then when you exhale they shrink back and help push out the old air.

Question 1

Explain: What's the point of so many, small, alveoli? The second video in *Gather* contrasts our lungs with balloons. If your left lung consisted of a single large alveolus, like a balloon, and your right lung had the same total volume but was made up of 4 alveoli, which one would have more internal surface area? Explain why.

You can use the sketchpad to create a diagram or upload a photo of a diagram you have drawn if you want.

Hint: It may help to think about putting up screens to partition a room.

Question 2

Explain: Why do you think our lungs contain millions of small alveoli instead of two large, lung-sized alveoli?

Question 3

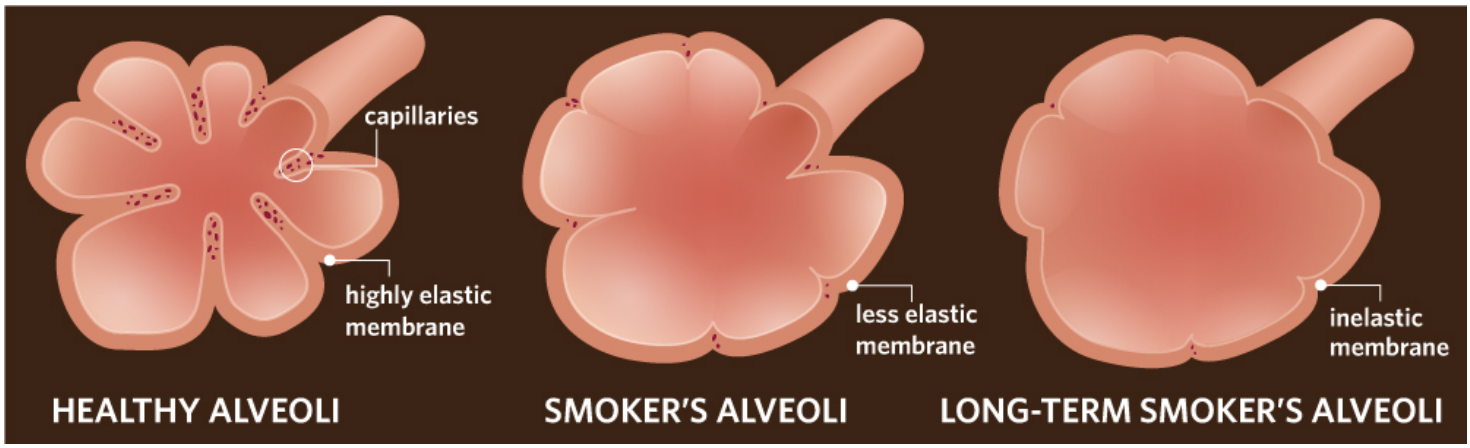
Link: When you exercise, your muscle cells need more oxygen and produce more carbon dioxide. You breathe more deeply and quickly, and your heart beats harder and faster.

Using your knowledge of the respiratory system, explain how these facts about cells, breathing and hearts are connected. You can use the sketchpad to create a diagram or upload a photo of a diagram you have drawn if you want.

Smokers' lungs

Smoking introduces a sticky brown substance, *tar*, into the airways and lungs. It coats the cilia at the top of the airways, clogging and eventually killing them. It builds up inside the trachea and bronchioles so that, along with naturally produced mucus, it narrows them. Smokers' cough is the body's attempt to remove the tar and mucus. And the tar gets into the alveoli.

The diagram below shows other ways the alveoli are affected by smoking. All of these factors eventually result in a condition called *emphysema*.



Question 4

Explain: Given your understanding of how healthy lungs work, explain how emphysema disrupts gas exchange.

Question 5

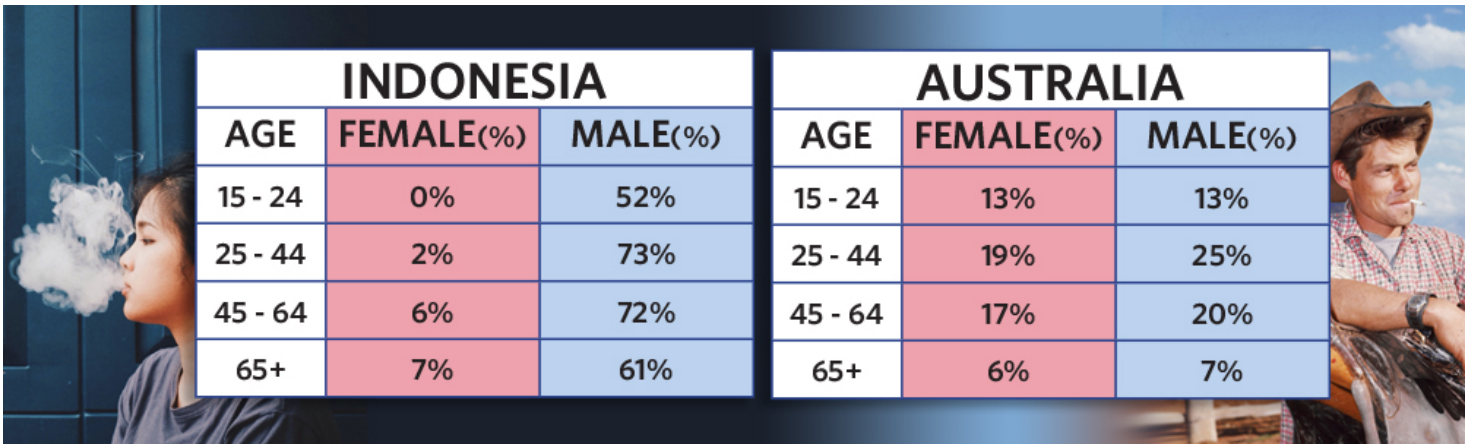
Hypothesize: People with emphysema get short breath – they pant hard even with a small amount of exertion. In severe cases, they pant all the time. Part of the cause is that they are unable to expel the "used" air in their lungs.

Referring to the diagram above, hypothesize why they are unable to expel air properly.

Smoking statistics

The study referred to in the *Introduction* was carried out in Australia. Studies of large groups of people are important to show trends that might not be obvious in smaller groups. They also help governments formulate policies to help keep the population healthy.

Below are some statistics for rates of smoking in Australia and Indonesia, from 2011. The tables tell us, for example, that 25% of Australian males between 25 and 44 years of age smoke. For Indonesian males in the same age group it is 73%.



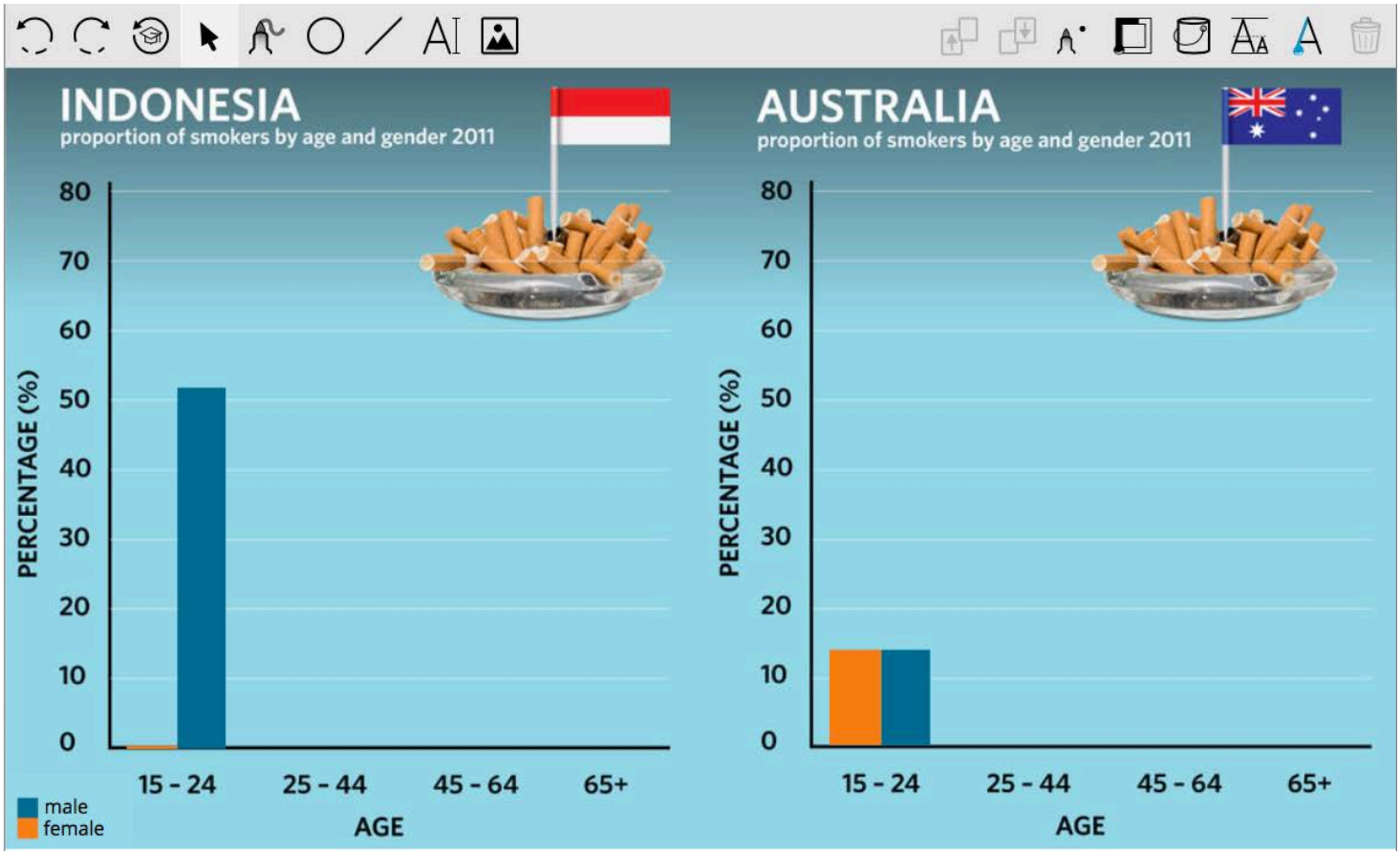
INDONESIA		
AGE	FEMALE(%)	MALE(%)
15 - 24	0%	52%
25 - 44	2%	73%
45 - 64	6%	72%
65+	7%	61%

AUSTRALIA		
AGE	FEMALE(%)	MALE(%)
15 - 24	13%	13%
25 - 44	19%	25%
45 - 64	17%	20%
65+	6%	7%

Proportions of smokers in Indonesia and Australia by age and gender, 2011

Question 6

Graph: Complete the bar graph below with the data from the tables above.



Question 7

Analyze: Use the tables above and your graphs to answer the following questions.

Question	Answer
In Indonesia, which age and gender has the highest percentage of smokers? What is that percentage?	
In Australia, which age and gender has the lowest percentage of smokers? What is that percentage?	
In which age group are Indonesian males least likely to smoke? What about Australian males?	
In which age group are Indonesian females most likely to smoke? What about Australian females?	

Question 8

Analyze: What observations can you make about gender differences for smoking in Indonesia and Australia?

Anti-smoking campaign

Question 9

Create: You work for an advertising company that has won a government contract for an anti-smoking campaign aimed at young people. You have a meeting coming up with health department officials where you will:

1. present a poster you have designed, and
2. make a pitch, explaining how the poster will connect with the target audience.

Use the project space below to present your poster and pitch.

Apply: Respiratory System

Project: Reproduce lung surface area and make a model lung

Background

When we breathe our lungs inflate and deflate to allow oxygen to enter the body and carbon dioxide to be expelled. Both gases move in and out of the body across a large surface inside the lungs, estimated to be about 60 m^2.

Aim

There are two aims in this *Apply*:

1. Measure out and view the surface area used for gas exchange, to appreciate how large it is.
2. Build a model lung to demonstrate breathing.

Materials

For the surface-area task you need:

- a measuring tape (or estimate distance by pacing – a long pace will be about 1 m)
- cones or other objects to mark out a space
- a fairly large area in the school grounds, hall or gym

For the model lung task you are probably best to work in groups of 2. For each group you need:

- 1 plastic bottle (500 mL to 1 L)
- 1 straw or thin plastic tubing
- rubber bands
- 2 balloons
- Blu-Tack, putty, or similar to seal the top of the bottle
- scissors
- tape

Procedure – surface area

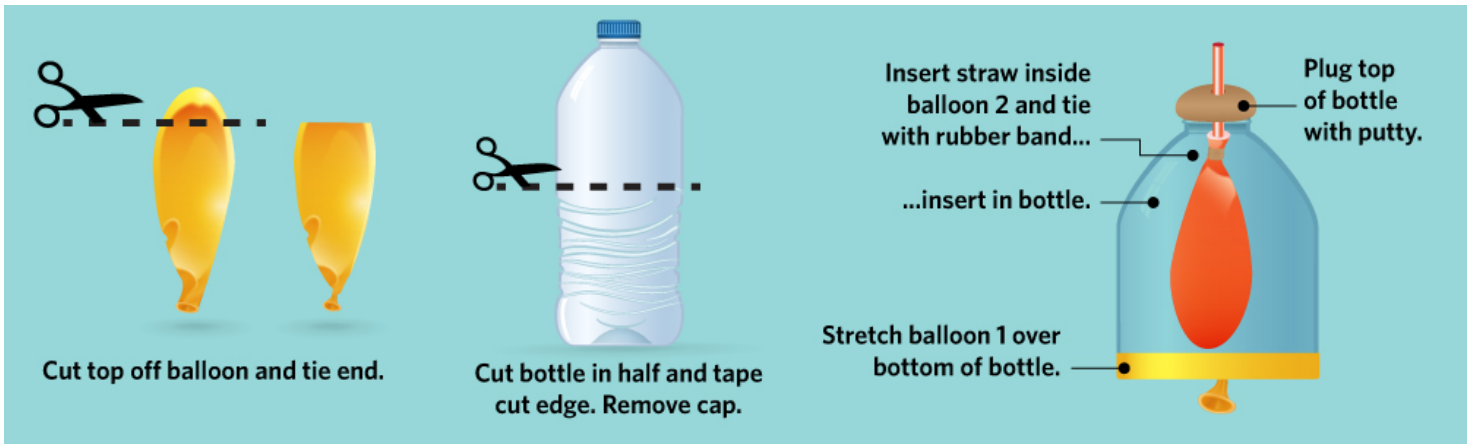
For the surface-area task:

1. Calculate the length of the sides of a rectangle with area 60 m^2.
2. Go outside or to the hall or gym and measure out the rectangle. Take a photo to upload with your results, below.

Question 1

Describe: Would you have expected a surface area this large could fit inside your lungs?

How does your body manage to fit such a large surface area into a fairly small space?



Procedure – model lung

For the model lung:

1. Cut the bottle across the middle half way up. Discard the bottom section.
2. Tape around the rough edge where you cut.
3. Tie a knot in the neck of a balloon then cut off and discard the other end.
4. Stretch the cut balloon across the bottom of the bottle to cover it. You may need to put a rubber band around as well to help hold the balloon on.
5. Put the straw in the neck of the other balloon and secure it with the other elastic band. Do not crush the straw.
6. Feed the balloon and straw into the bottle so the straw sticks out. Seal the putty in the bottle neck around the straw, again without crushing the straw.

Your lung is finished...now to make it breathe!

Question 2

Describe: Hold the bottle and pull down on the knot of the balloon at the bottom. What happens to the balloon inside the bottle? What happens to the inside balloon when you release the bottom balloon?

Question 3

Match: In your model lung, what parts of the model correspond to what parts of the respiratory system?

Question 4

Demonstrate: Record a video demonstrating the model lung. Provide a voice-over explaining how this represents the actions of the respiratory system.

Upload your video here. Also upload your photo of the lung surface area. Write a suitable caption for it.

Question 5

Assess: How well does your model demonstrate human breathing? Can you think of any improvements that would make it work better, or that would make it more accurately represent the lungs?

Career: Respiratory System

Brought to you by Edith Cowan University

We all know the benefits of exercise – it keeps you looking and feeling good. But can it be a medicine for cancer? That's just what Carolyn McIntyre is finding out.

Growing up in Newfoundland, Canada, Carolyn knew that she had found her career after meeting a family friend who was a sports science researcher. To young Carolyn it looked like the dream job – getting to answer interesting questions, meeting interesting people, and travelling all over the world for research. To her, it was irresistible!

At Edith Cowan University in Perth, Australia, Carolyn now studies how exercise improves the lives of people with cancer – specifically lung cancer. She runs clinical experiments and spends a lot of time visiting clinics to meet the participants and monitor their progress.

Carolyn's ultimate goal is to develop exercise programs to treat side effects of cancer like shortness of breath and muscle loss. "Exercise can be a very powerful tool," she says. Carolyn has learnt that even patients who feel terribly unwell and are dealing with difficult cancer treatments start to feel better with the right amount of exercise. The best part of her job, she says, is hearing people tell her they can do something that they were not able to do before starting the exercise program.

In her free time Carolyn loves keeping active herself, especially outdoors. She enjoys cycling, running on the beach and camping.

Question 1

Assess: Carolyn's work is about using exercise to help people who are seriously ill. But we know that exercise *prevents* many diseases and conditions as well.

1. How much exercise do you get? Add up how many hours a week divided between light and heavy exercise.
2. Do you think the amount you do is enough, or should you try and do more?
3. Many people combine leisure activities with exercise, for example, bush walkers get good exercise but also enjoy being in nature and seeing beautiful scenery. If you could do any sort of healthy leisure activity you wanted, what would it be, and why?

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