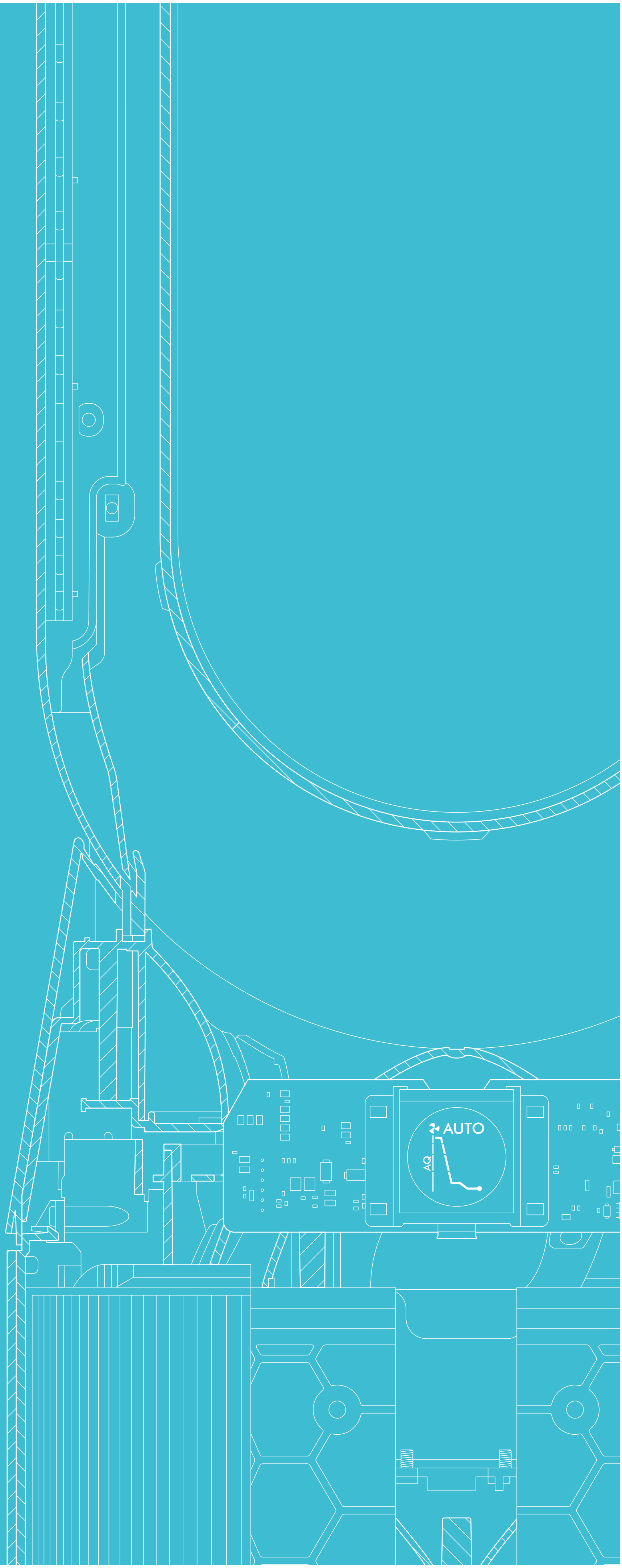
THE JAMES DYSON FOUNDATION

STUDENT PACK

Engineering solutions: Air pollution



INTRODUCTION

This pack will introduce you to how engineering can solve global problems, focusing on the problem of air pollution. Through activities, videos and worksheets you'll learn what air pollution is, analyze air pollution data and learn how the Dyson Pure Cool™ purifying fan works as a solution to indoor air pollution. You'll also get to design and build your own solution to air pollution, following the design process practiced by engineers.

By completing the activities in this pack, you'll:

- Learn about air pollution and its global sources
- Consider your own exposure to air pollution
- Analyze data on air pollution
- Analyze the Dyson Pure Cool™ purifying fan
- Consider global engineering solutions to air pollution
- Design, build and evaluate your own solution to air pollution

You can find all the videos on our website:
www.jamesdysonfoundation.com

CONTENTS

Think before you print
Lesson plans and worksheets have been included on separate pages, listed above, so you shouldn't need to print the entire document.

SECTION 01: SENSE

In this section you'll learn about what air pollution is and what causes it. You'll understand that air quality can be monitored using sensors and consider actions to reduce your exposure to air pollution in your school or home environment, or on your journey to school.

UNDERSTANDING AIR POLLUTION

Air pollution

Air pollution is caused by a build-up of particulate matter and gases in the air, that come from a range of natural and man-made sources. It is one of the major global problems of the modern age. 91% of the population lives in places where the air quality exceeds the World Health Organization's (WHO) guideline limits.

Gas pollution

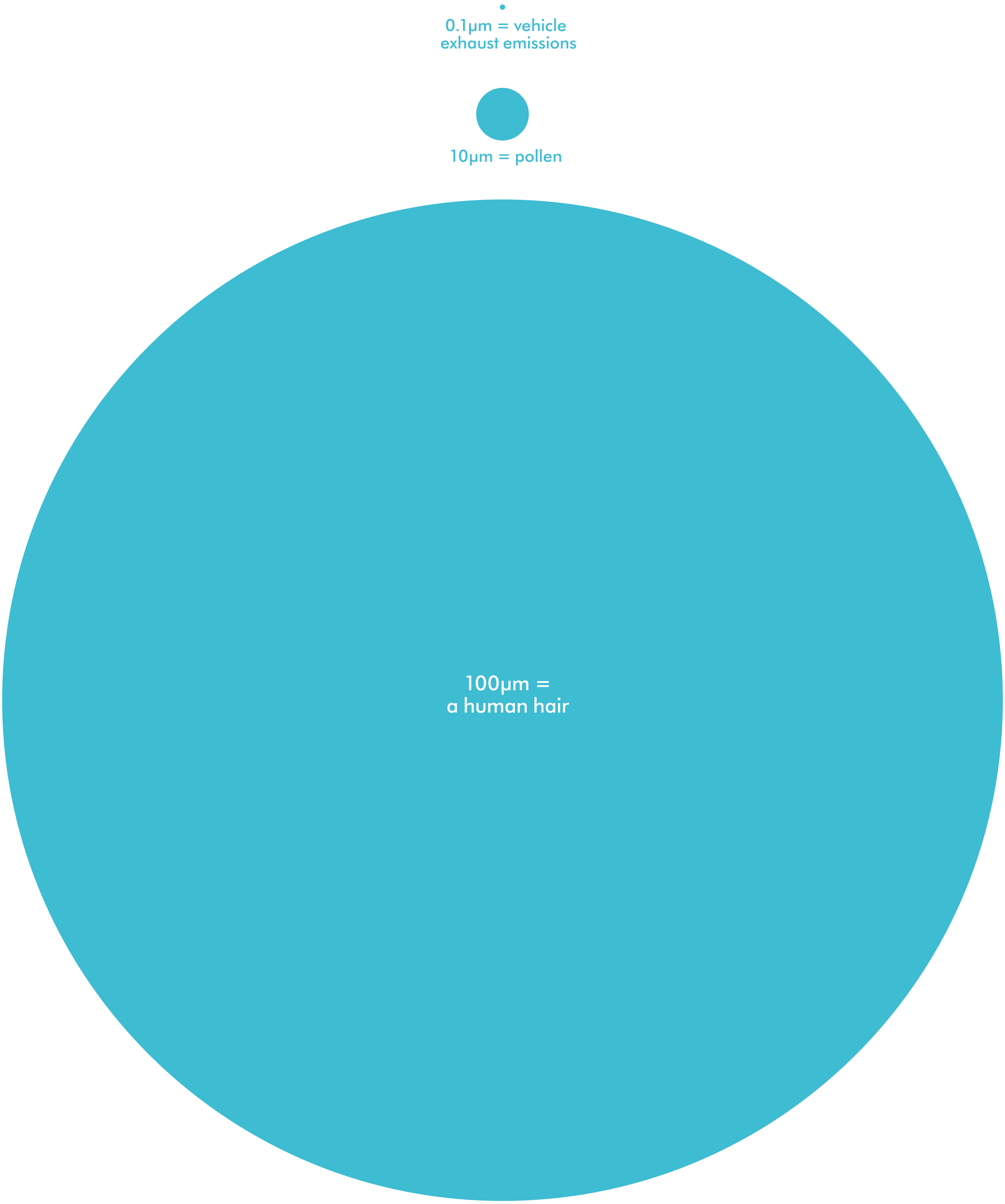
The air around us is mostly comprised of gases. It's made up of 78% nitrogen, 21% oxygen, and the rest is made up of argon, carbon dioxide and a small amount of other gases, all of which enter our lungs when we breathe. The presence of oxygen is fundamental to keep us alive, but other pollutant gases may cause us harm.

Particulate matter pollution

The air also contains particles and we breathe in millions of them every day. Particles are small pieces of matter. They're measured in microns (μm), which is one millionth of a meter. They vary in size, shape and composition. Particulate matter (PM) is a form of air pollution and is a mixture of solid and liquid particles floating in the air.

Source: Air pollution, World Health Organization, www.who.int/airpollution/ambient/en/

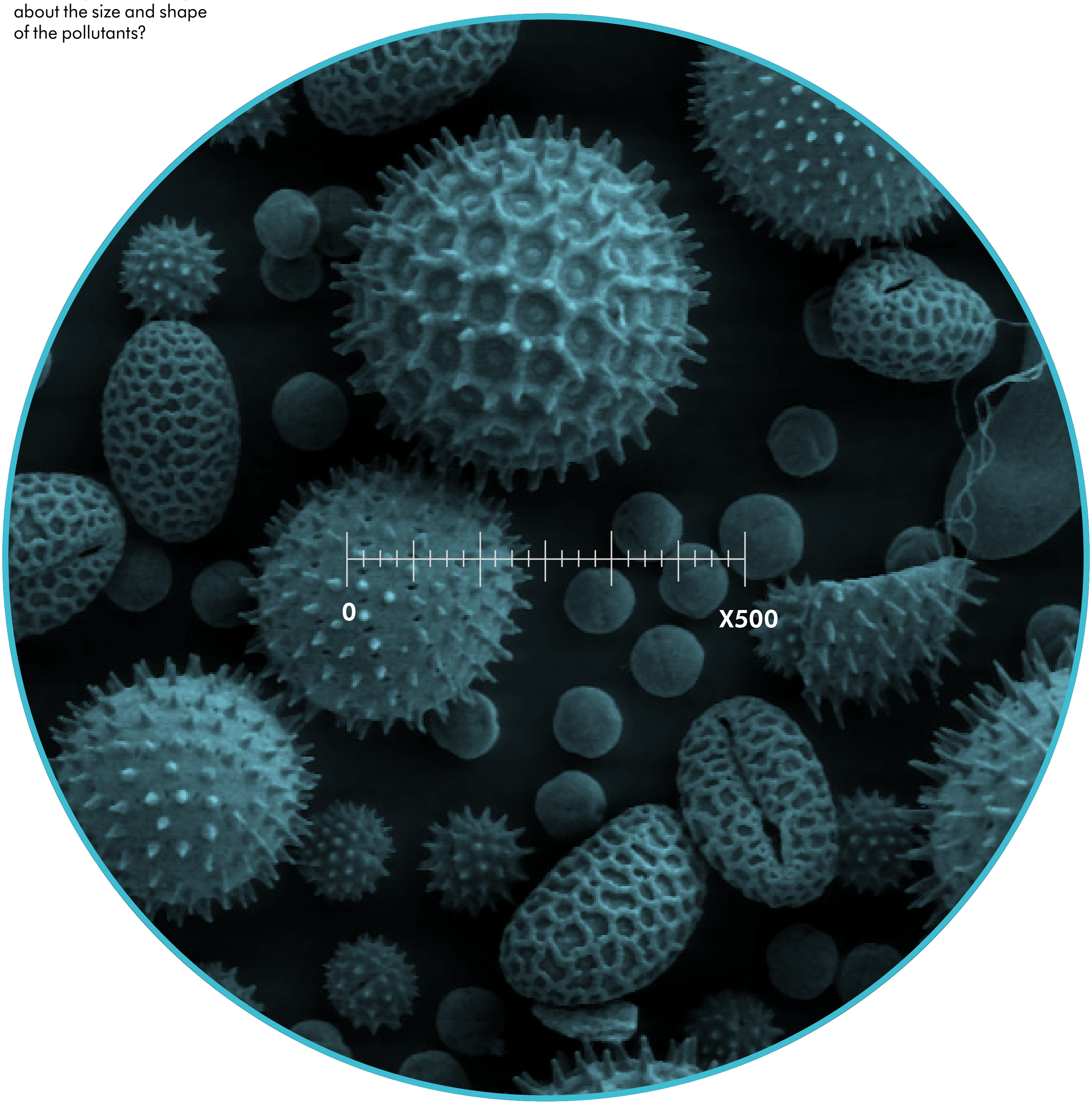
PARTICULATE MATTER POLLUTION



POLLUTANTS UNDER A MICROSCOPE
MAGNIFIED X500

Many pollutants are very small and can't be seen by the naked eye. Microscopes allow us to see what they look like close up.

This image shows a mixture of pollen from a variety of plants such as lilies and sunflowers. It has been magnified 500 times through an electron microscope. What do you notice about the size and shape of the pollutants?



SOURCES OF AIR POLLUTION: NATURAL SOURCES

Weather

Temperature, rainfall and the wind all influence air pollution. For example, wet and windy conditions reduce air pollution in certain locations by washing it out of the air or moving it elsewhere. Whereas dry and still conditions cause poor airflow which can trap air pollution. This means that in landlocked places, such as mountain towns, air pollution can build up.

Desert dust storms

Desert dust comes from the surface of arid and semi-arid regions around the world such as the Sahara Desert, Eastern Australia and the Gobi Desert. High winds cause dust particles to lift from the ground into the air resulting in a dust storm.

Wind can cause dust storms to travel thousands of kilometers and can combine with human-made air pollution. This means desert dust can cause air pollution in parts of the world that are nowhere near a desert.

Volcanoes

Volcanic eruptions release volcanic ash into the air. Wind can carry this ash thousands of kilometers away from the volcano itself. For example, in 2010 a volcano called Eyjafjallajökull erupted in Iceland. Around 50% of the ash was carried across Europe and the North Atlantic. Air traffic in these locations was halted for several days after the eruption.

Forest fires

Forest fires occur across the world and produce a substantial amount of smoke pollution. These fires are increasing in prevalence and severity due to changes in temperature and rainfall across the globe, resulting in longer fire seasons and larger geographic areas being burned. Forest fire smoke is a complex mixture of PM, nitrogen oxide (NO_2), carbon monoxide (CO), ozone (O_3) and volatile organic compounds (VOCs) generated from burning a wide variety of fuel sources such as trees, dried leaves, litter and – unfortunately – local homes. Forest fires often occur in California where the dry environment means it's easier for fires to start from a natural event such as lightning, or a man-made source such as campfires. Wind also causes the smoke generated from forest fires to travel long distances and pollute air in close-by cities and towns.

Volcanic eruption
Eyjafjallajökull Iceland


Dust storm


Forest fire


Rain


Pollen


Dust storm


Wind


Dry and still conditions


Cold conditions

SOURCES OF AIR POLLUTION: HUMAN-MADE SOURCES

City pollution
Shanghai

Transportation

Road transportation is one of the main sources of air pollution in cities. Exhaust fumes from motor vehicles release harmful gases and soot particles, coated with toxic substances, into the air. Diesel vehicles are especially harmful, producing high concentrations of these pollutants. Air pollution is also caused by small bits of metal and rubber that come off brakes and tires, as well as by dust kicked up from road surfaces. They're suspended in the air by moving traffic.

Energy generation

Much of the electricity we use in our homes comes from power stations that burn coal, oil, gas and wood. These processes release harmful amounts of gas pollution into the atmosphere.

Industrial processes

Industrial processes such as the production of cement, iron, steel, glass and paper create air pollution. Areas with high numbers of industries and factories have high levels of air pollution.

Agriculture

Some farming practices, such as storing and spreading manures and inorganic fertilizers, and intensive cattle farming release chemicals and gases into the atmosphere.

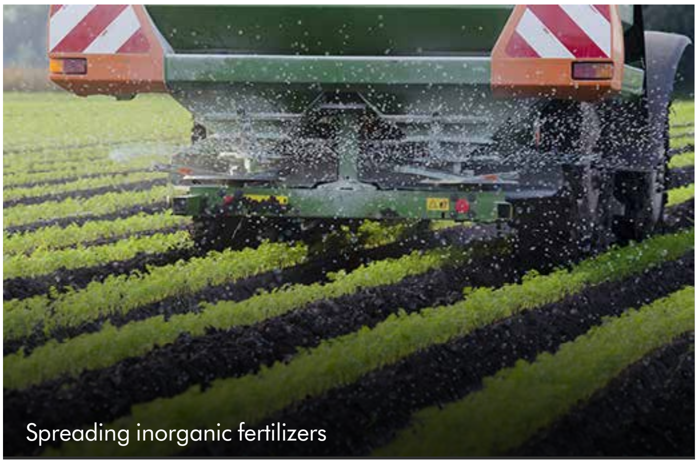
Urbanization

Urban areas, particularly large cities, have higher levels of air pollution than most rural areas due to high numbers of people, transport and industries. For example, megacities such as Tokyo, Shanghai and Delhi face huge air pollution problems. Pollution builds up in these highly populated places and can often be seen as a brown haze that appears to hang in the air over cities. Rural areas tend to be more exposed and windier, meaning air pollution is more easily dispersed. This results in better air quality.

Household products

Studies have found that indoor air quality can be worse than outdoor air quality. Air pollution is released from household items such as building materials, cleaning products, pets, candles, plants and aerosols. It's also emitted from activities such as heating and cooking. Outdoor air pollution can also enter homes through ventilation, doors and windows and then become trapped.


Cattle farming


Spreading inorganic fertilizers


Energy generation


Industrial processes


Exhaust fumes


Urbanization


Cooking fumes


Cleaning products and aerosols

THE IMPACT OF AIR POLLUTION AND WHY IT'S DIFFICULT TO SOLVE

Health

Air pollution can impact our health in a number of ways including nose, eye or throat irritation, coughing, chest tightness, shortness of breath, reduced lung function or asthma attacks. Some people are more at risk of being affected by air pollution than others.

Environment

Air pollution can also have adverse effects on the environment such as acid rain, soil depletion, damage to forests and crops, reduced visibility, damage to buildings and climate change.

Air pollution is a difficult problem to solve for a number of reasons:

It's largely an invisible problem because most air pollution is made up of very small particles that can't be seen by the naked eye.

Our lifestyles currently depend on activities that contribute to air pollution such as driving cars and heating our homes using fossil fuels.

Air pollution is a complicated global problem with a multitude of causes, which vary in scale and severity across the world.

But engineers have the skills and knowledge to start addressing the problem.

Man wearing a mask
Beijing

WORKSHEET 01: AIR POLLUTANTS AND THEIR SOURCES

This worksheet contains the name, description and source of pollutant. Cut out the squares and match the pollutants to their description.

PM10	2.5μm in width, or less. They're so small they can only be seen with an electron microscope. Their size means they can bypass our bodies' natural barriers and get into the lungs	**Formaldehyde**
Nitrogen dioxide – NO_2	A colorless and highly irritating gas that forms just above the earth's surface, unlike the natural layer of gases in the upper atmosphere that protects us from the sun's ultraviolet rays.	Sources: – Mass-manufactured wood products – Varnishes – Paints – Glues
Sources: – Bacteria – Fungi – Emissions from coal, gas and oil-powered industries	**PM0.1**	**Volatile Organic Compounds (VOCs)**
Sources: – Formed when NO_2 reacts with VOCs and sunlight.	10μm in width, or less. They're normally large enough to be caught by nose hairs and mucus, enabling us to cough or sneeze them out. However, some can impact people's breathing and have long-term health effects.	Sources: – Cigarettes – Paints – Cleaning products – Scented candles – Furniture polish
Sources: – Black smoke – Soil – Dust from roads and building sites – Pollen – Mold spores	**PM2.5**	A group of gases or airborne liquids that can be toxic.
Ultrafine particles with a diameter of 0.1μm or less. They're small enough to bypass the lung tissue and enter the bloodstream.	Sources: – The inefficient burning of fuels in gas and wood-burning heaters	A reddish-brown gas with a strong smell that causes smog and acid rain.
Carbon monoxide – CO	A toxic gas with a strong smell.	Sources: – Diesel car exhaust fumes – Fires – Coal factories – Domestic heating
Known for its distinct and overpowering smell as well as its flammable nature.	**Nitrogen dioxide – NO_3**	Sources: – Vehicle exhaust emissions – Wood smoke – Tobacco smoke

If you want to, you can use glue and a piece of paper to create a poster about the different types of air pollutants.

WORKSHEET 02: AIR QUALITY AROUND SCHOOLS

Air pollution is mostly invisible, which makes it difficult to know when we're being exposed to it. Air quality-monitoring devices allow us to collect data on air pollution, allowing an invisible problem to become visible to us. By being able to 'see' air pollution through the data collected, we can take action to tackle it.

Dyson engineers measured the concentration of gas and particulate pollution, using an air quality-monitoring device, at six locations at a school.

1. Plot the particulate pollution concentration at each location, referring to the air quality index, on Graph 1.

2. Plot the gas pollution concentration at each location, referring to the air quality index, on Graph 2.

Air quality readings around the school

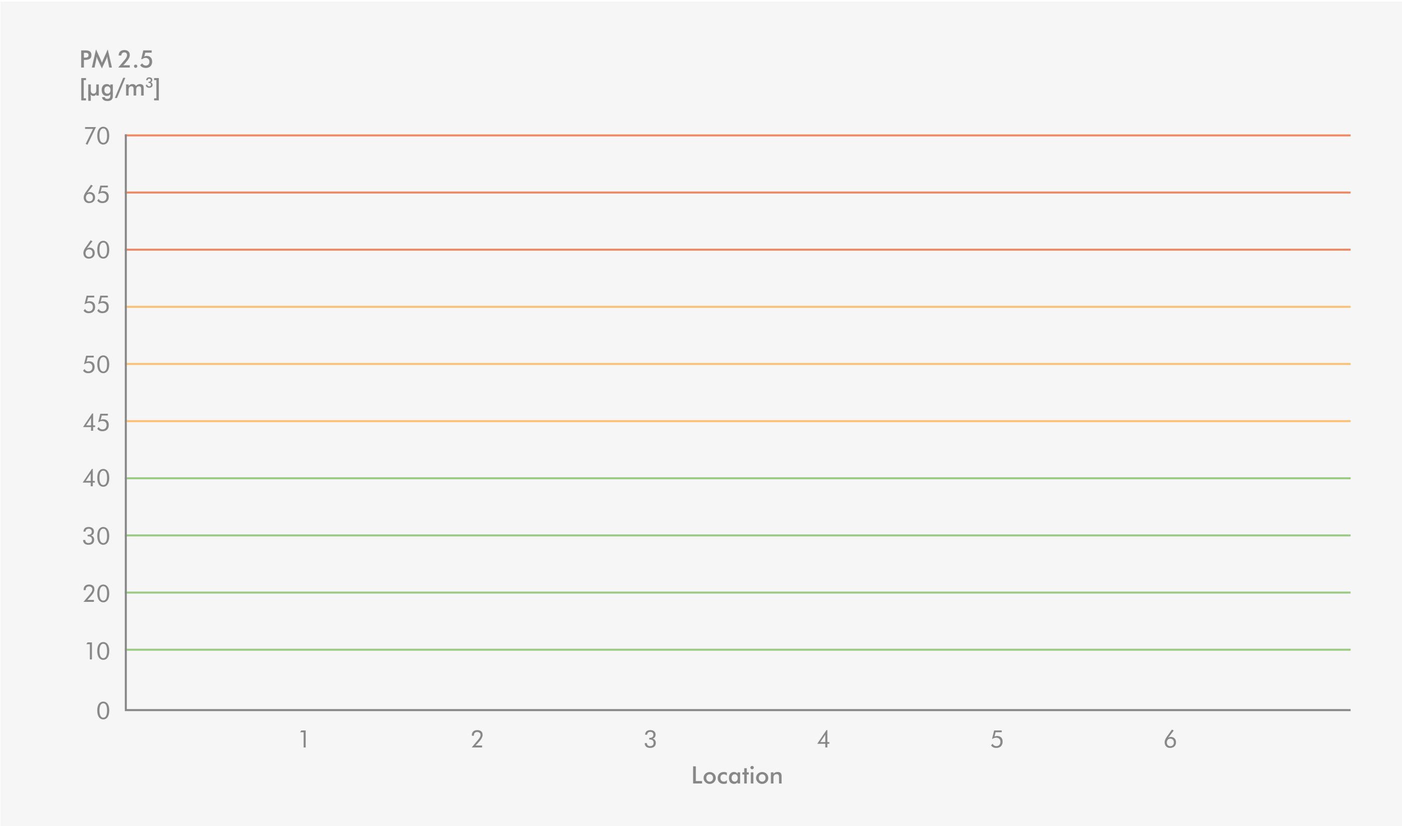
Location	Particulate sensor (number of LED lights)	Gas sensor (number of LED lights)
1. Classroom	4	2
2. Cafeteria	3	4
3. Sports field	3	4
4. School Entrance	5	7
5. Parking Lot	3	5
6. Science lab	4	6

Air quality index

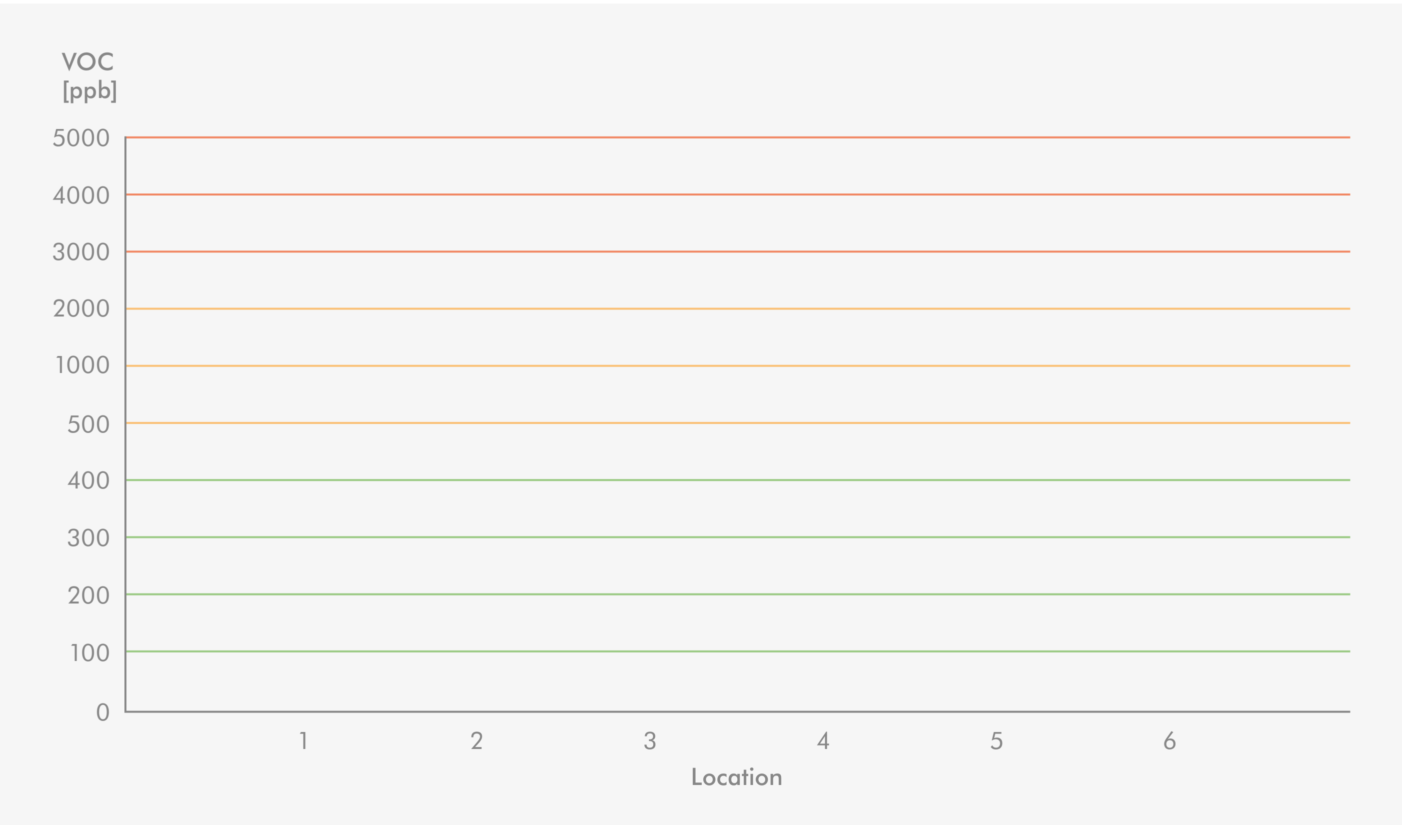
Air quality	Number of LED lights	Particulate (μg/m3)*	Gas (ppb)**
Very bad	10	70	5000
	09	65	4000
Bad	08	60	3000
	07	55	2000
Moderate	06	50	1000
	05	45	500
Good	04	40	400
	03	30	300
Very good	02	20	200
	01	10	100

* (μg/m3) = micrograms of particulate pollution per cubic meter of air
** (ppb) = parts per million of gas pollution

Graph 01 – Particulate pollution



Graph 02 – Gas pollution



3. Use the graphs to answer the following questions.

Which location had the worst air pollution?

Which type of pollution was worse here – gas or particulate?

What could be causing this pollution?

How did air pollution levels change from inside to outside?

Did any of the results surprise you?

WORKSHEET 03: YOUR JOURNEY TO SCHOOL

When you travel to and from school you're exposed to different types and amounts of air pollution.

Map out your normal journey to school in the space below. Circle where you might be most exposed to air pollution.

What's causing this air pollution?

What actions could you take to reduce your exposure to air pollution during your journey?

Extension: On your computer you can research the concentrations of air pollution you're exposed to on your journey to school using air quality monitoring websites such as **breezometer.com** or **waqi.info.**

SECTION 02: CAPTURE

In this section you'll learn how Dyson engineers developed the Dyson Pure Cool™ purifying fan to help tackle the problem of indoor air pollution. You'll learn how it detects and captures air pollution, focusing on the mechanisms of filtration.

As a starter activity, watch The Smoke Box Test video. What do you think happened to the smoke?

PRODUCT ANALYSIS: THE DYSON PURE COOL™ PURIFYING FAN

Dyson engineers developed the Dyson Pure Cool™ purifying fan to help solve the problem of indoor air pollution. When developing this machine, Dyson engineers identified three main things a purifying fan needs to be able to do:

1. Monitor air quality
2. Capture air pollution
3. Distribute clean air

Monitoring air quality

The Dyson Pure Cool™ purifying fan automatically senses air pollution using particulate and gas sensors. The data collected from these sensors is used to activate the machine and keep indoor pollution levels low.

Particulate sensor

The particulate sensor draws air into a small chamber and uses lasers to detect the concentration of particulate matter present in the air. It can detect particles as small as PM0.3.

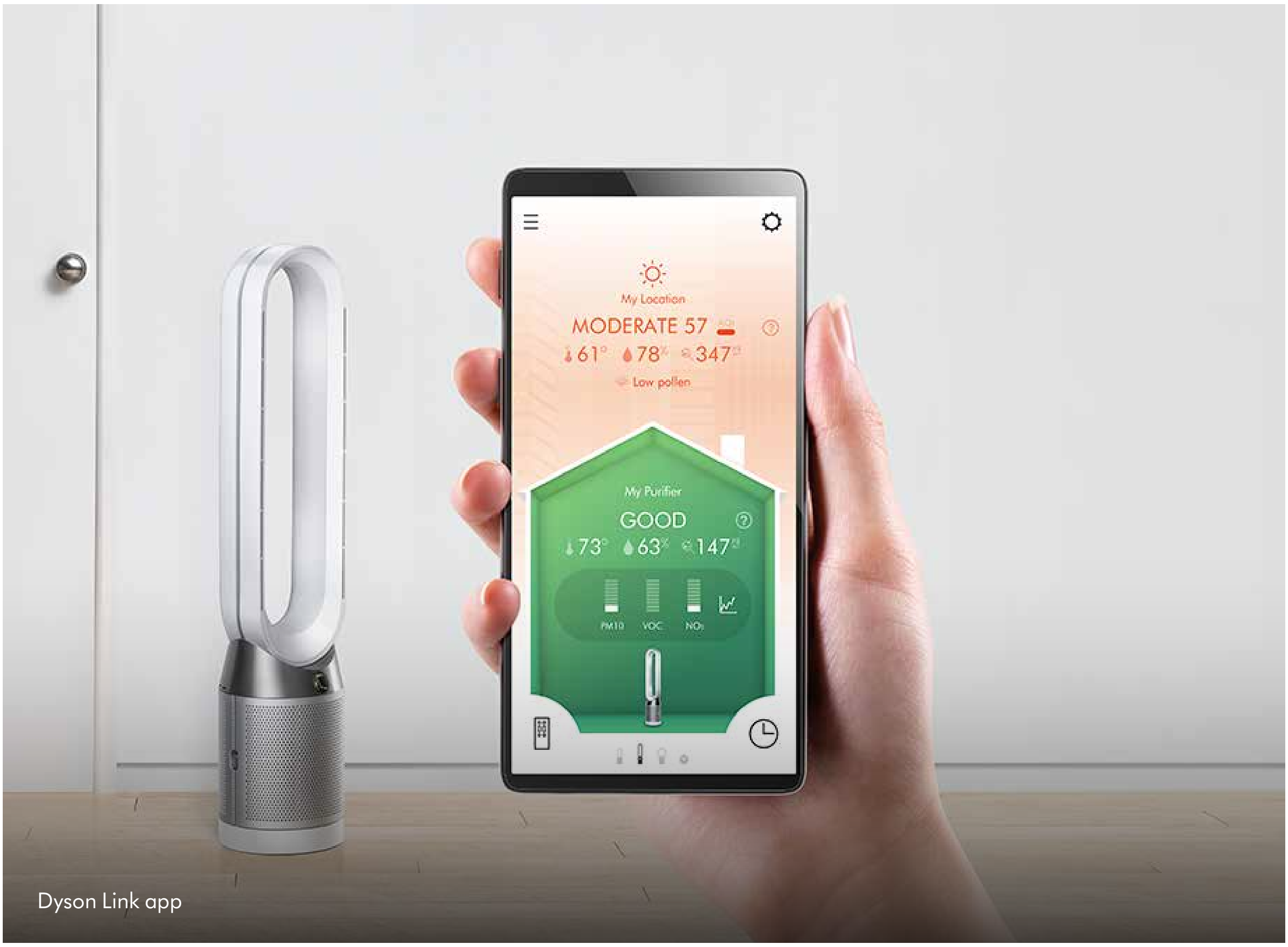
Gas sensor

The gas sensor detects Volatile Organic Compounds (VOCs) and gases such as NO_2 that are present in the air.

Air quality sensors in the Dyson Pure Cool™ purifying fan

PRODUCT ANALYSIS: COMMUNICATING AIR QUALITY

The information from the sensors in the Dyson Pure Cool™ purifying fan is also communicated to an LCD screen on the purifier and to the Dyson Link app, which can be downloaded onto a smartphone. The screen and app allow users to monitor their indoor air quality by displaying the type and concentration of air pollution present. The app also allows users to set a schedule for when their purifier is turned on and monitors the life of the filters.



Dyson Link app

PRODUCT ANALYSIS: CAPTURING POLLUTANTS

Glass High Efficiency Particulate Arrestance (HEPA) filter

A HEPA filter is a particulate filter which captures solid matter such as pollen, smoke or dust. The filter contains nine meters squared of borosilicate glass microfibers, pleated to fit into the filter 254 times. These fibers are able to capture 99.95% of particles as small as PM0.1 in three different ways: impaction, interception and diffusion.

Direct interception

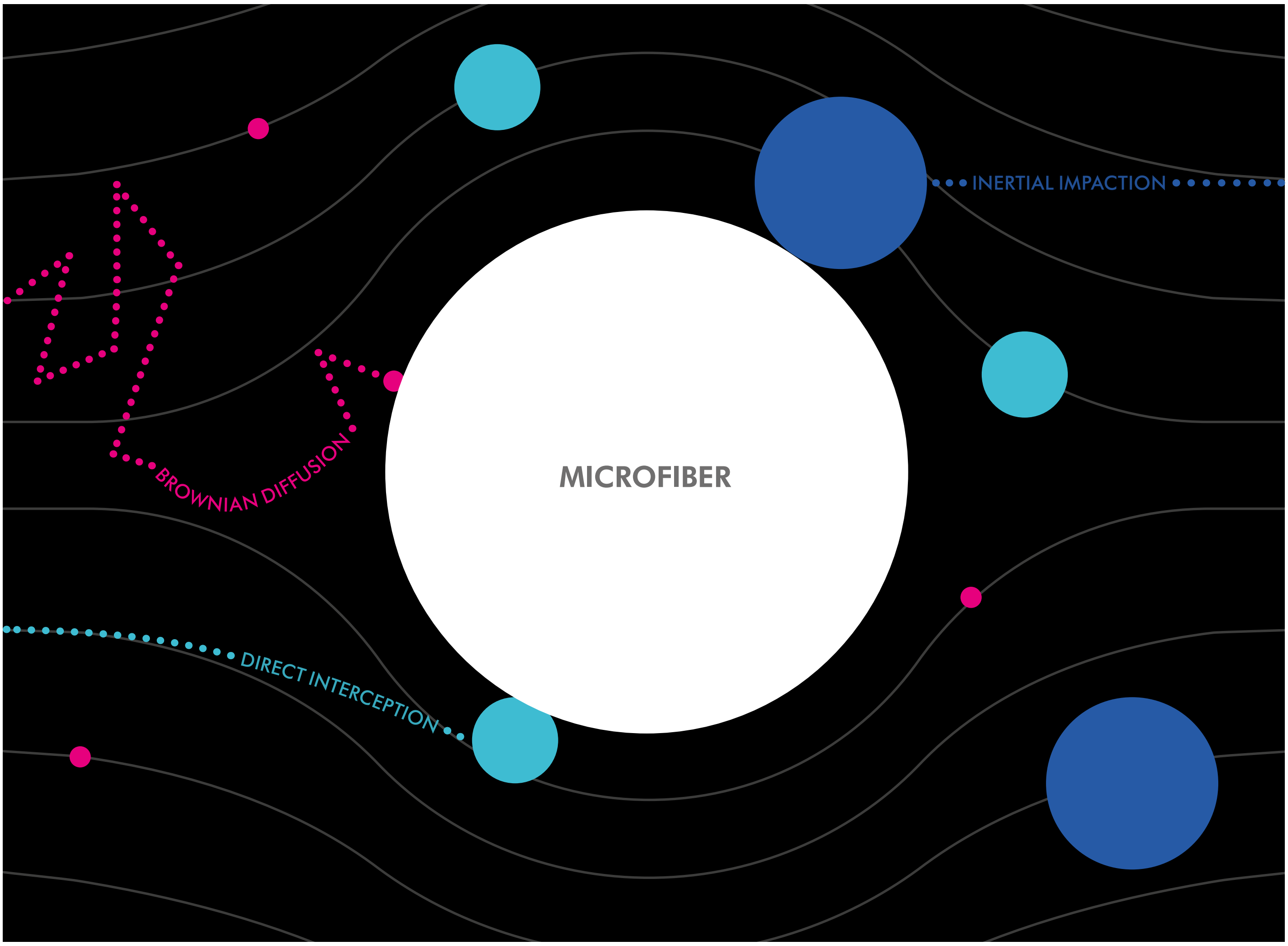
When the purifier is turned on, air is pulled into the base of the machine and through the filter by an impeller. Because the air can't go directly through the solid fibers of the filter, it's pulled along the edge of the fibers. Particles travel in this airstream and if they get close enough to the fiber, they will become trapped.

Inertial impaction

Heavier particles require more force to make them change direction, particularly when traveling with high velocity (imagine a cannonball flying through the air). The airflow is not strong enough to make these particles change direction and move around the microfiber, so they will instead continue in a straight line, directly colliding with the microfiber and becoming trapped.

Brownian diffusion

Smaller particles are too small to be pulled along in the airflow. These particles move very fast, often colliding with other particles, which causes them to regularly change direction. This random motion as a result of collisions is known as Brownian motion. With such random motion, probability suggests that these particles will, sooner or later, hit one of the microfibres in the filter and become stuck.



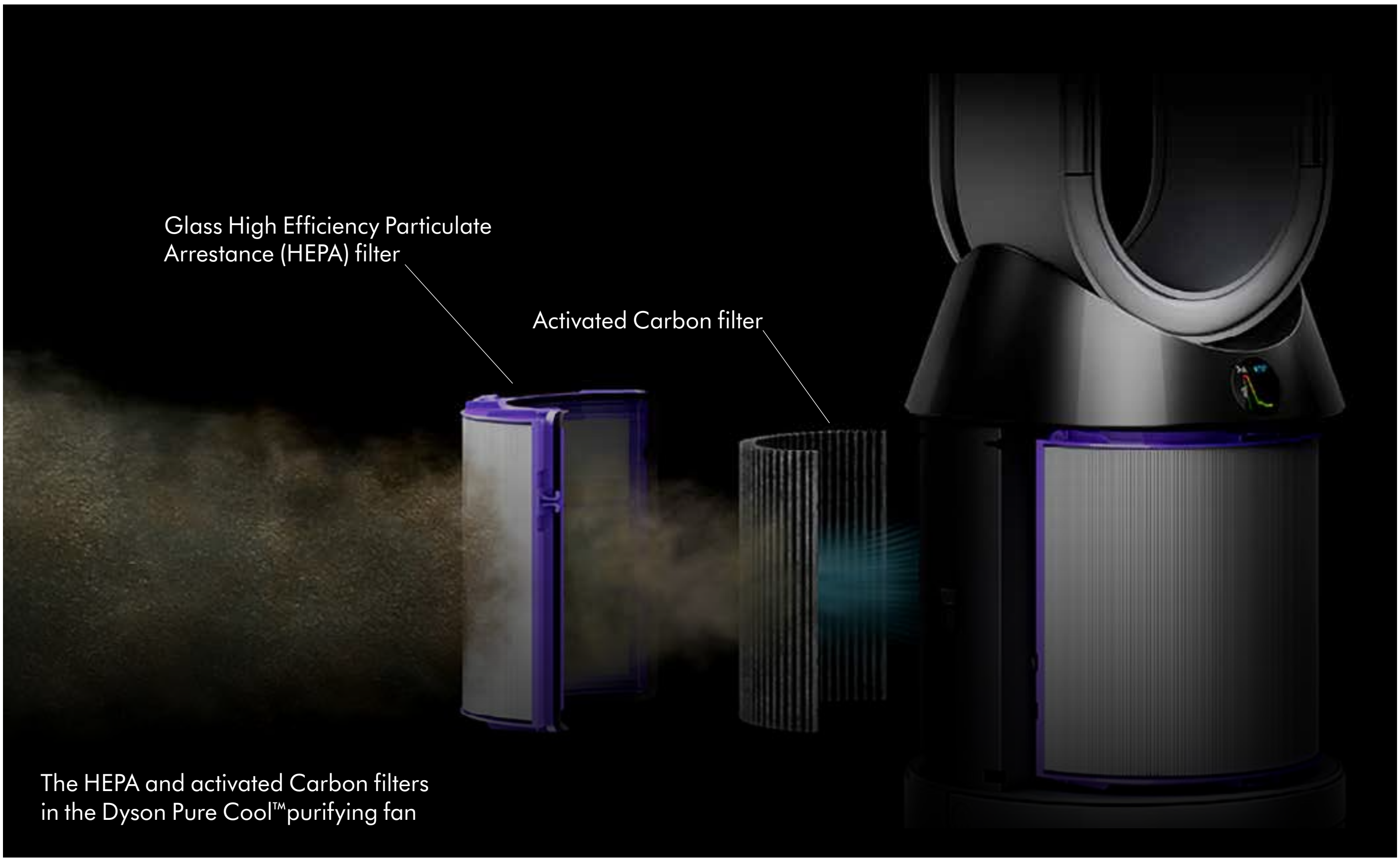
PRODUCT ANALYSIS: CAPTURING POLLUTANTS

Activated Carbon filter

The HEPA filter captures particulate matter, but VOCs such as formaldehyde, benzene and NO_2 pass straight through. The purifier uses an activated Carbon filter inside the HEPA filter to capture these potentially harmful gases.

Activated carbon contains a network of many microscopic pores. This means it has a very high surface area-to-volume ratio. VOCs passing through the carbon become trapped in the pores.

A single gram of activated carbon has an internal network of pores with a surface area of 1,000m^2. That's four tennis courts. The carbon in the Dyson Pure Cool™ purifying fan has the same surface area as 40 football fields.

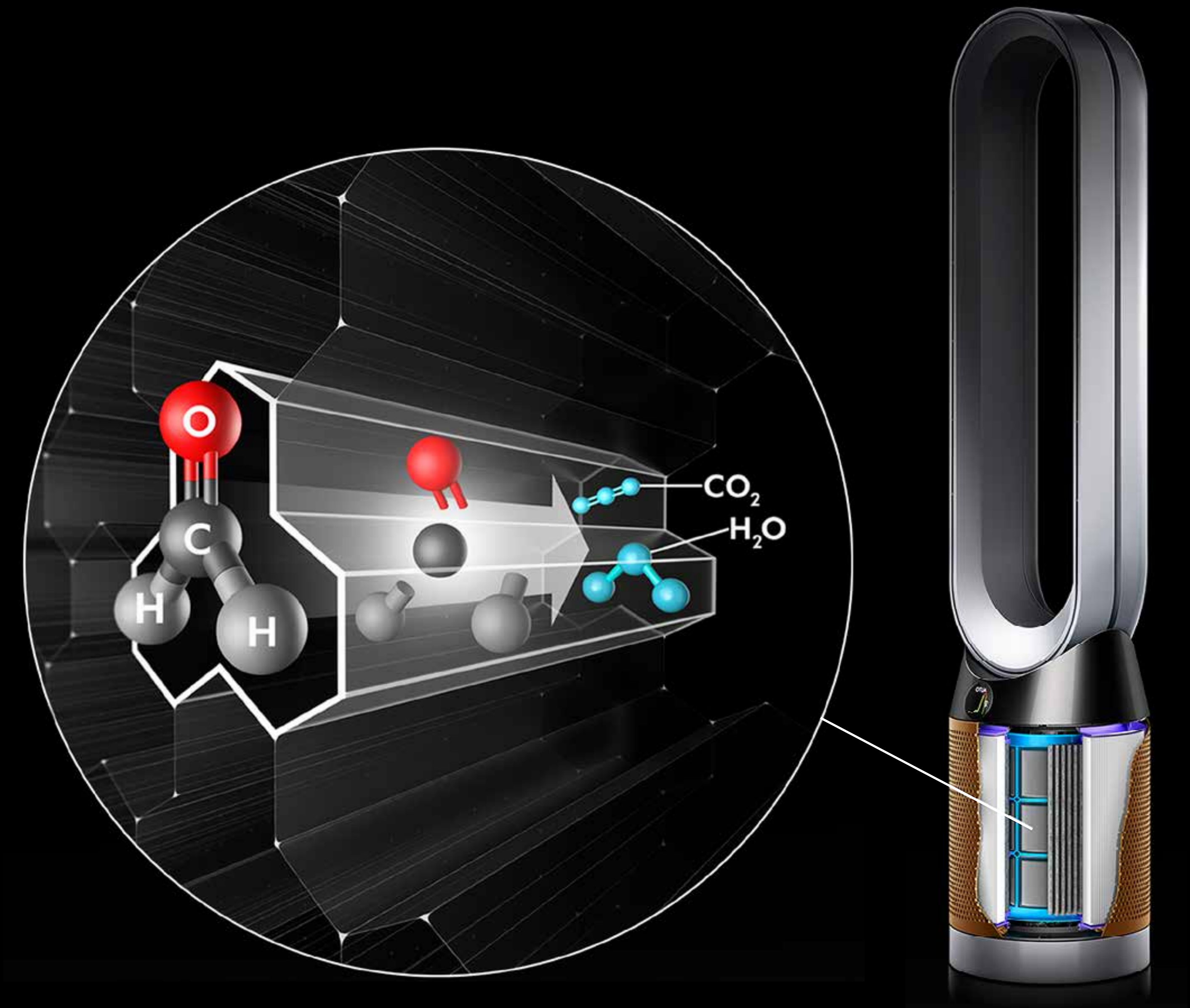


The HEPA and activated Carbon filters in the Dyson Pure Cool™ purifying fan

Dyson Cryptomic™ technology

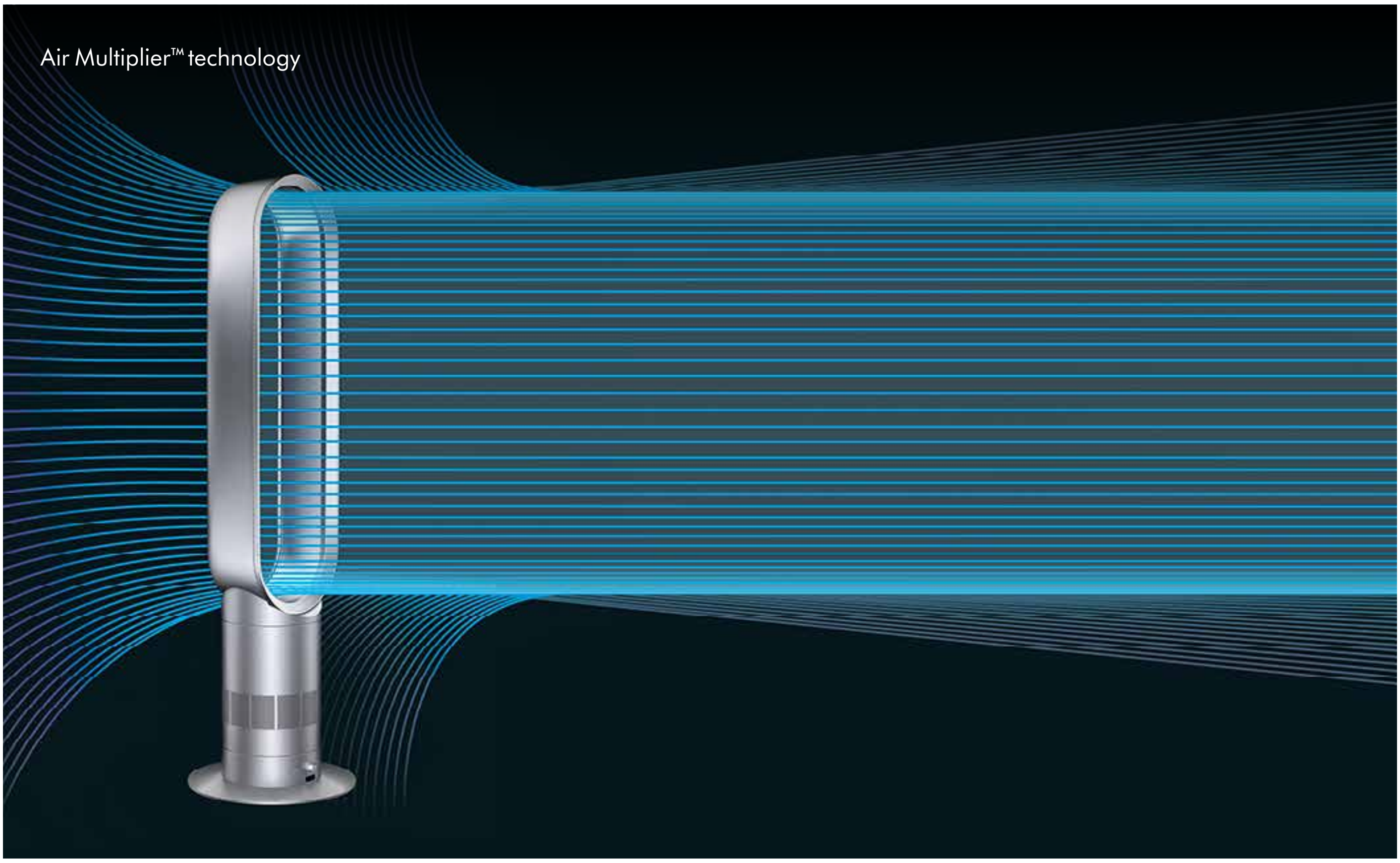
Both the HEPA filter and the activated Carbon filter have a lifespan. Eventually, both will become saturated with pollutant particles and gases, and will need to be replaced. For the HEPA filter, this occurs after around six months of use (when the purifier is turned on). For the activated Carbon filter this normally occurs after six to 12 months. While this is not too much of a problem, as filters can be replaced, Dyson engineers weren't satisfied. They set about finding a solution that would last for the full lifetime of the machine. They invented Dyson Cryptomic™ technology. This is a filter that uses a catalyst called Cryptomelane.

The Cryptomelane reacts with formaldehyde, breaking it down into tiny amounts of water and CO_2. Unlike the HEPA and activated Carbon filters, the Crypomelane doesn't get 'used up'. In fact, it will continue to act as a catalyst forever meaning that the Cryptomic filter doesn't need to be replaced. However, this filter is limited as it can only remove formaldehyde from the air.



PRODUCT ANALYSIS: AIR MULTIPLIER™ TECHNOLOGY

Once Dyson engineers had found ways to remove pollutants from the air, they needed to find a way to distribute the purified air back around a room. They recognized that they had already developed technology that could help them: Dyson Air Multiplier™ technology. Dyson desk fans can channel up to 370 liters of air per second. That's 1,121 cans of soda. Engineers applied this technology to the Dyson Pure Cool™ purifying fan to efficiently distribute clean air throughout a room.



WORKSHEET 04: HOW DYSON PURIFYING TECHNOLOGY WORKS

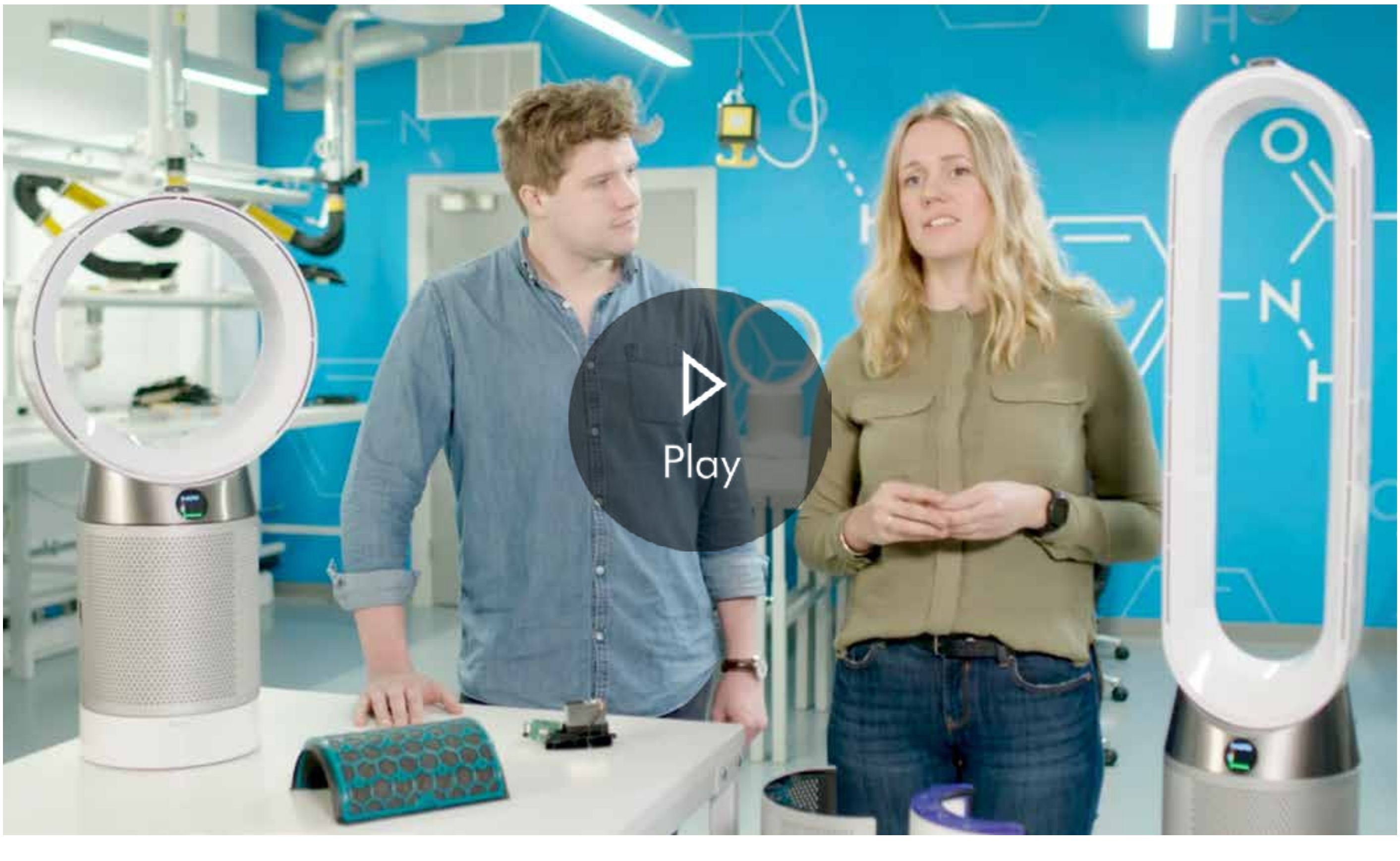
Read the information on Dyson purifying technology and watch the **'Dyson purifying technology: How it works' video.** Consider the questions below.

1. Where did Dyson engineers get their inspiration from to develop the purifier?

2. Was the design process easy?

3. What key requirements would Dyson engineers have needed to consider when designing the purifier? **Think about size, noise, aesthetics, lifespan, materials and usability**

4. What could improve the purifying fan?



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WORKSHEET 05:
DESIGNING A FILTER

The Dyson Pure Cool™ purifying fan uses a HEPA filter to capture particulate matter such as pollen, smoke and dust. The filter contains nine meters squared of borosilicate glass microfibers that has been pleated 254 times. This allows it to capture 99.95% of particles as small as PM0.1.

When designing products, engineers are often given specifications to work to for elements such as size, cost and performance. Work through the activities below to consider how these specifications would have impacted the design of the HEPA filter used in the Dyson Pure Cool™ purifying fan. You can write answers to the questions below on pages 29–30.

1. Take a piece of A4 paper and lay it flat on the desk in front of you. Calculate the surface area of this paper. L is length and W is width. **Refer to figure on the right.**

2. Now pleat the paper widthways at 20mm intervals. Pleat a second piece of A4 paper at 50mm intervals.

a. What do you notice about the size of the two pleated pieces of paper compared with the flat paper?

b. What has happened to the surface area?

c. Why is this significant?

3. Surface area of the pleated paper can also be calculated using the following formula where N is the number of pleats: **Surface area = N ((W x L) x 2).**

a. If your pleat height is 20mm and your pleat pitch is 10mm, what is the maximum surface area you can achieve in the space of 210mm x 300mm?

Hint: Refer to figure and start by working out the total number of pleats you could achieve.

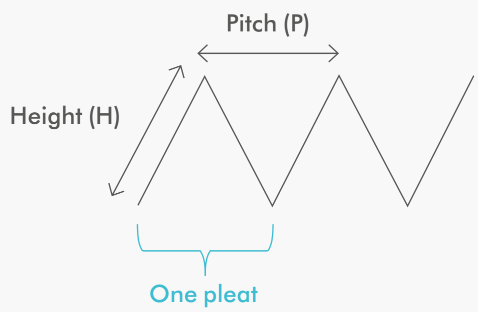
b. How many A4 sheets of paper would this use?

c. Why do you think engineers would want to maximize the surface area of the filter they create?

d. What limitations, apart from space, might there be on the maximum surface area of the filter used? Why is this significant?

Figure 01: Surface area = W x L

Figure 02: Surface area = N ((W x L) x 2)



Now pleat the paper widthways at 20mm intervals. Pleat a second piece of A4 paper at 50mm intervals.

2a. What do you notice about the size of the two pleated pieces of paper compared with the flat paper?

2b. What has happened to the surface area?

2c. Why is it significant?

Surface area of the pleated paper can also be calculated using the following formula where N is the number of pleats:
Surface area = N ((W x L) x 2). Refer to figure on page 33.

3a. If your pleat height is 20mm and your pleat pitch is 10mm, what's the maximum surface area you can achieve in the space of 210mm x 300mm?

3b. How many A4 sheets of paper would this use?

3c. Why do you think engineers would want to maximize the surface area of the filter they create?

3d. What limitations, apart from space, might there be on the maximum surface area of the filter used? Why is this significant?

WORKSHEET 06: ACTIVATED CARBON EXPERIMENT

The HEPA filter used in the Dyson Pure Cool™ purifying fan captures 99.95% of particles down to PM0.1, but Volatile Organic Compounds (VOCs) pass straight through. To capture VOCs, an activated Carbon filter is used.

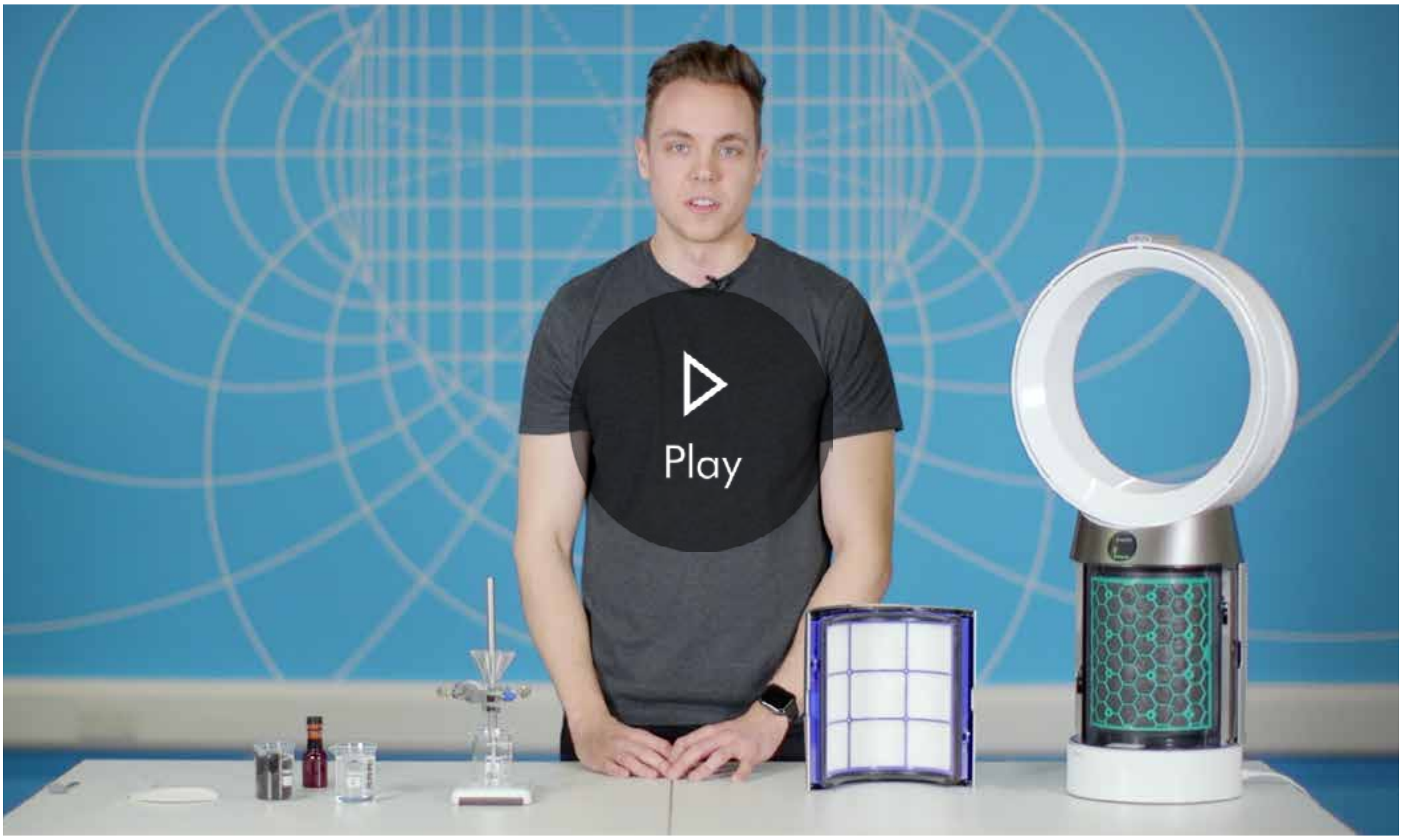
To understand how the activated Carbon filter works, watch the **'Activated Carbon Experiment' video**, to answer the following questions. You can write answers to the questions below on page 32.

1. Describe the color of the water and food coloring mixture in beaker A before it's poured through the activated carbon.

2. Describe the color of the water and food coloring mixture in beaker B after is has passed through the activated carbon granules.

3. Describe what happened in the experiment.

4. Why do you think this happened?



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2. Describe the color of the water and food coloring mixture in beaker B after is has passed through the activated carbon granules.

3. Describe what happened in the experiment.

4. Why do you think this happened?

SECTION 03: SOLUTION

In this section you'll learn about how air pollution is a global problem and will evaluate how engineers around the world are working to help solve it. You'll understand the design process Dyson engineers follow when developing new technology and will follow the process in order to design and build your own air pollution solution in your school or home environment.

ENGINEERING SOLUTIONS TO AIR POLLUTION

The global population is projected to reach 10 billion by 2050, with nearly 70% living in urban areas. To ensure that this growth doesn't result in even greater levels of air pollution, we need to take action to ensure a sustainable future. Engineers, with the help of scientific knowledge, have the skills to develop technologies that could help.

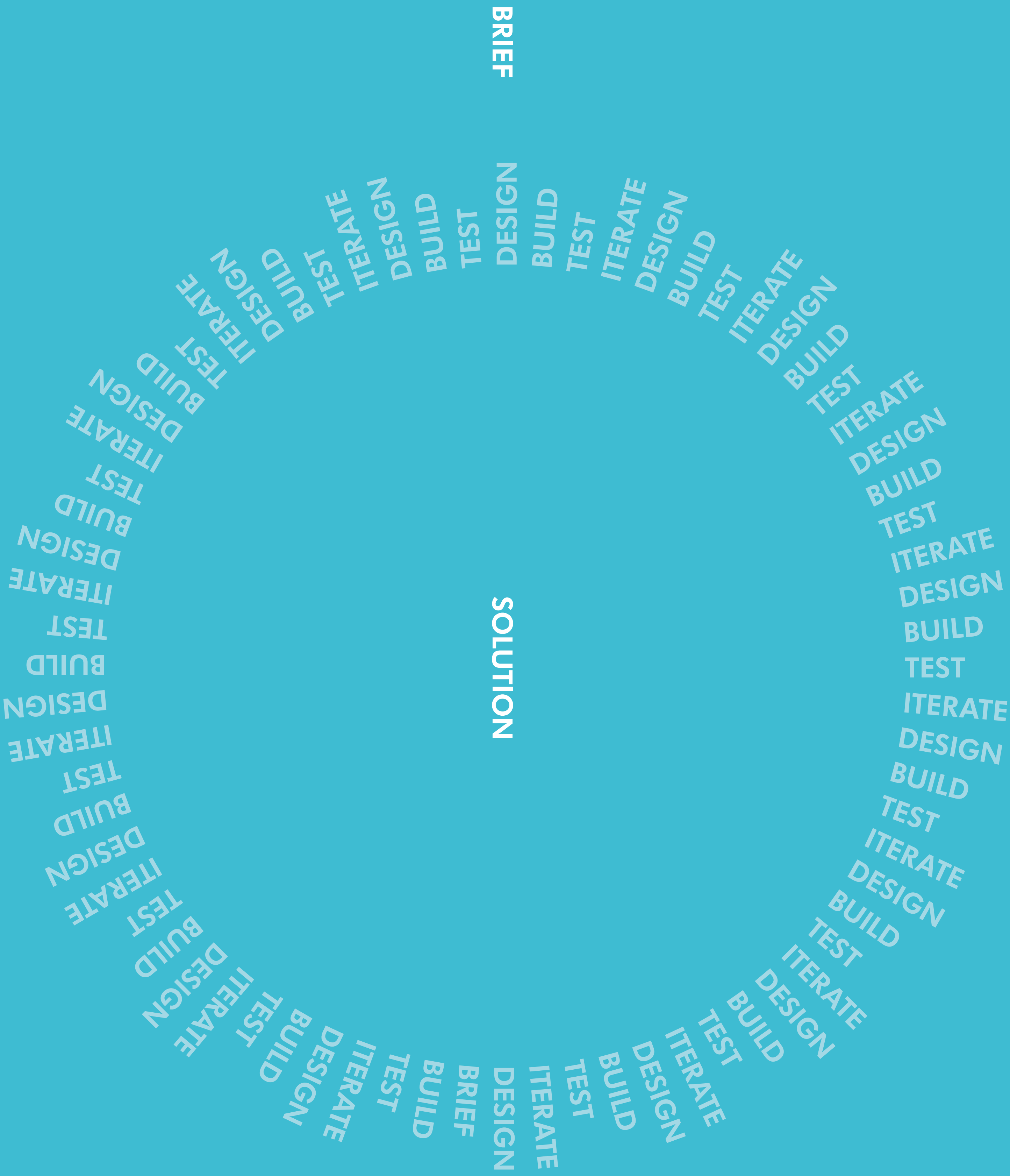
Engineers are problem solvers. They research and develop ideas for new products and think about how to improve existing technologies. They start with a problem, then think of ways to solve it. This is called the design process. It revolves around three main stages: **design, build, test.**

Design – at this stage engineers identify the problem they are trying to solve and think about possible solutions. They sketch a design of what a solution might look like.

Build – using these sketches, engineers build a prototype using simple modelling material, such as cardboard, or more advanced ones, such as 3D printed parts. A prototype is the first version of a product from which other versions are developed.

Test – engineers need to test the prototype to see if it works and if it's an effective solution to the problem.

This is a circular process as testing identifies weaknesses and faults in the prototype that can be addressed when engineers build the next prototype. This cycle continues until it results in a finished product that successfully solves the problem. For the Dyson Pure Cool™ purifying fan, Dyson engineers designed, built and tested 2,605 prototypes.



Engineers are problem solvers.
They research and develop ideas for new products and think about how to improve existing technologies. This all part of an iterative journey.

THE DESIGN PROCESS

EXAMPLES OF ENGINEERING SOLUTIONS TO AIR POLLUTION

Caeli, James Dyson Award international finalist 2019 (India)

Delhi is the third most polluted city in the world. When the air quality in the city is particularly bad, many asthma sufferers are hospitalised. Caeli was developed to enable patients to stay healthy when air quality is poor and improve their quality of life. It is an anti-pollution mask which filters air via a six-layer filter and centrifugal fan. This provides a continuous flow of purified air. The mask also contains sensors which monitor air quality, sending data to an app and a drug nebuliser which allows users to take medication when required.

PhotoSynthetica (UK)

PhotoSynthetica is an urban curtain that captures CO_2 from the atmosphere and stores it. It can store around one kilo of CO_2 per day – equivalent to the CO_2 storing capabilities of 20 large trees. It is made up of large modules that can be attached to the outside of buildings. Air enters through the bottom of the modules and travels through a watery medium that contains a special type of algae which traps the CO_2 removing it from the air.

Smog-Free Tower (China)

The Smog-Free Tower is a 100-meter high air purification tower designed to reduce smog levels in cities. It is seven meters tall and uses ionizing silver plates and filters to remove particulate matter from the air.

Smog-Free Bike (China)

The Smog-Free Bike sucks polluted air into a filtering system. Pollutants are removed from the air and the filtered air is projected towards the cyclist.

Sponge Mountain (Italy)

Sponge Mountain is a project that uses soil excavated from the construction of a railway tunnel connecting Turin to Lyon, to create a 90-meter high mound of soil. The mound of soil absorbs CO_2 from the air helping to reduce air pollution levels in Turin, one of the most polluted cities in Europe.

Electrified Roads (Sweden)

eRoadArlanda in Sweden developed the world's first electrified road. The road recharges the batteries of electric vehicles as they drive along it using conductive technology similar to a Scalextric track. Conductive rails run along the road and transfers electricity via an arm attached to the bottom of vehicles.

Vertical Forest (Italy)

Vertical Forest is a model for a sustainable residential building. The building houses 800 trees, 4,500 shrubs and 15,000 plants – the equivalent of 20,000 square meters of forest. The vertical forest creates a microclimate that absorbs CO_2 and dust particles, and releases oxygen.

Smog-Free bike
China

Electrified Roads
Sweden

Sponge Mountain
Italy

Smog-Free Tower
China

WORKSHEET 07: EXISTING ENGINEERING SOLUTIONS TO AIR POLLUTION

Engineers can develop technology to help solve the global problem of air pollution. You're going to analyze current engineering solutions to air pollution.

Choose one of the engineering solutions to air pollution on pages 36–38 of this pack, or research your own existing engineering solution online.

Create a poster that answers the following questions:

a. What is the solution?

b. How does it work?

c. What are its strengths as a solution to air pollution?

d. What are its limitations as a solution to air pollution?

WORKSHEET 08: DESIGN AND BUILD YOUR OWN SOLUTION TO AIR POLLUTION

In order to solve problems, engineers are given a brief. This explains the problems that need to be solved by a product and sets the parameters in which a design engineer must work. For example, a product might need to be a certain size or perform a particular function.

When working on the brief, design engineers follow the design process, which has three stages: design, build, test. Engineers repeat the design process numerous times when developing a single product. This makes it a circular, or iterative process.

You're going to think like engineers, and design and build a prototype of your own solution to air pollution.

Your brief is: Design a product that will solve the problem of air pollution in your school or home environment, or on your journey to school. You'll need:

- Pens and pencils
- Paper
- Cardboard
- Tape
- Scissors
- Glue
- Other packaging or materials that could be used to build your design solution

Follow the steps below to complete the brief using the design process.

1. Choose whether you're going to solve a problem caused by air pollution in your school, home environment or on your journey to school.

2. Make a mind map of problems caused by air pollution in your chosen context.

3. Sketch possible solutions considering users, function, materials, safety, aesthetics and cost.

4. Choose one of your sketches, and identify what materials and equipment you'll need to build your design solution

5. Build a prototype of the design solution.

6. Test your design solution as you go along, to understand how a user would interact with it and identify any design flaws. Remember that the design process is iterative, so you can modify and improve your design when you encounter difficulties.

7. Once you've built your design solution share with your teacher summarising the following:

a. The problem you're working to solve

b. The solution you've come up with

c. How your solution works

d. Why it's better than existing solutions

e. Who will use it

8. Assess the strengths and weaknesses of your design solution, and consider any further changes that could be made to improve the product.

YOUR BRIEF:
DESIGN A PRODUCT THAT WILL SOLVE THE PROBLEM OF AIR POLLUTION IN YOUR SCHOOL OR HOME ENVIRONMENT, OR ON YOUR JOURNEY TO SCHOOL.

THE
JAMES
DYSON
FOUNDATION