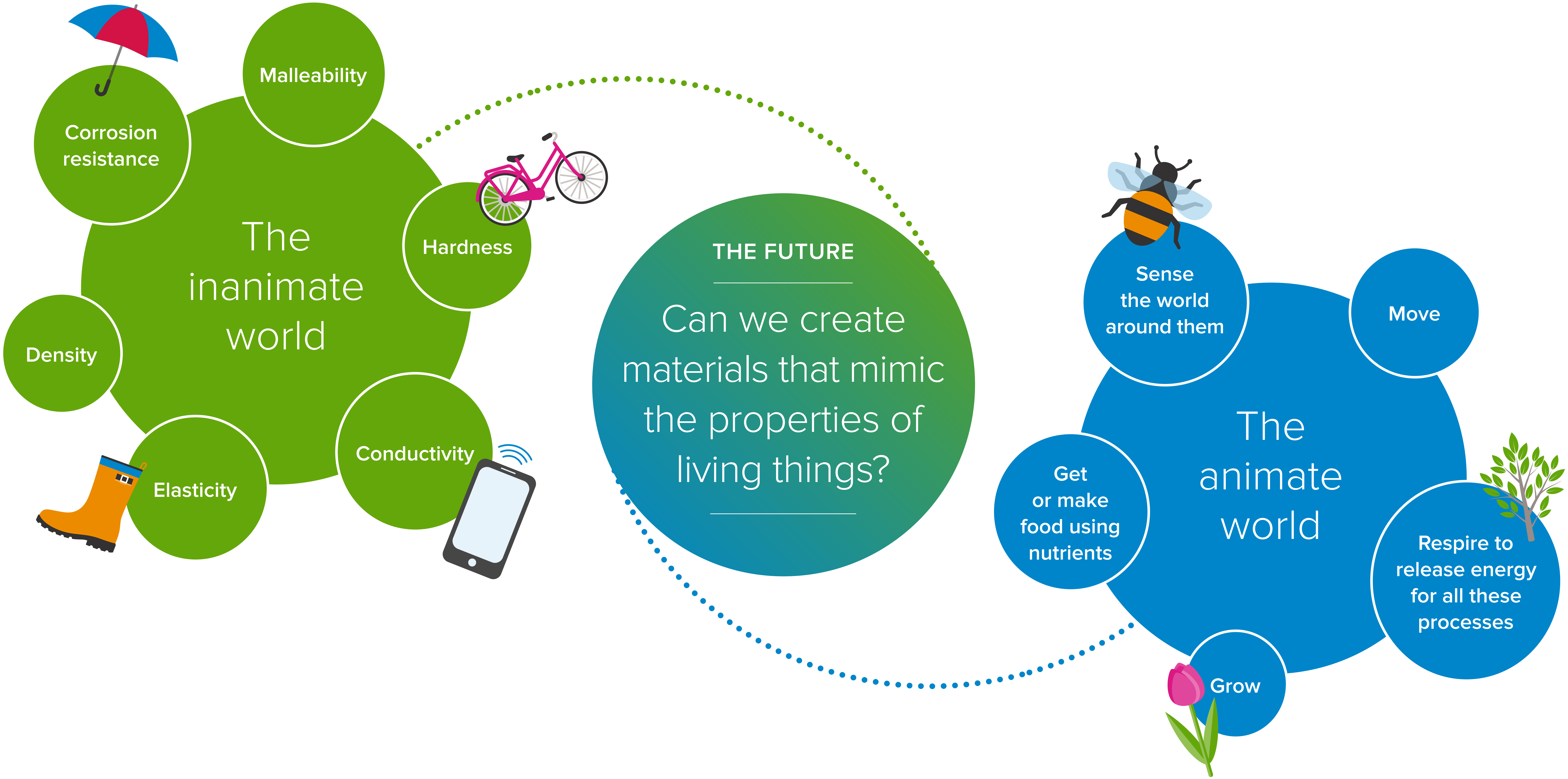
The future of stuff

#RSanimatematerials

THE ROYAL SOCIETY



The inanimate world
Malleability
Corrosion resistance
Hardness
Density
Conductivity
Elasticity
THE FUTURE
Can we create materials that mimic the properties of living things?
The animate world
Sense the world around them
Move
Get or make food using nutrients
Respire to release energy for all these processes
Grow

Background

The Royal Society has produced a report about a a new class of materials which could change our future.

These new materials, known as animate materials have three features:

- They are active
- They are adaptive
- They are autonomous

Being active is the most fundamental quality; adaptation is a further step in sophistication and autonomy is the next step.

Materials that possess all three of these features do not yet exist.

Active

The materials can change their properties or perform actions, eg by taking energy from the environment.

Adaptive

The materials can sense changes in their environment and respond in a particular way.

Autonomous

The material can automatically ‘decide’, perhaps through some internal computation, or computation-like process, on an appropriate response to signals or changes in the environment.

The past

When quartz is squeezed, it produces an electrical voltage – and conversely its shape can be changed by electric fields. Materials with these properties have been used widely in everyday devices such as headphones and electric toothbrushes. This is an example of an active material.

Lime mortar, used in buildings since the Egyptian pyramids, heals itself by growing new crystals in cracks when water enters and enables lime to react with carbon dioxide in the air. This is an example of an **adaptive** material.

The present

Self-repairing paints are already commercially available and there are multiple projects exploring possibilities for self-healing asphalt, concrete and fibre-reinforced polymers, such as those used in aircraft, to build self-healing roads, bridges, buildings, and spaceships.

One approach that has been used for asphalt, concrete and polymers is the addition of capsules that crack when they are damaged and release healing agents.

Another approach to self-healing concrete, known as microbially induced calcite precipitation (MICP), uses lightweight capsules containing spores of bacteria. When the concrete cracks and once the conditions become favourable, the spores germinate and the bacteria break down the nutrients and precipitate calcite into the concrete cracks.

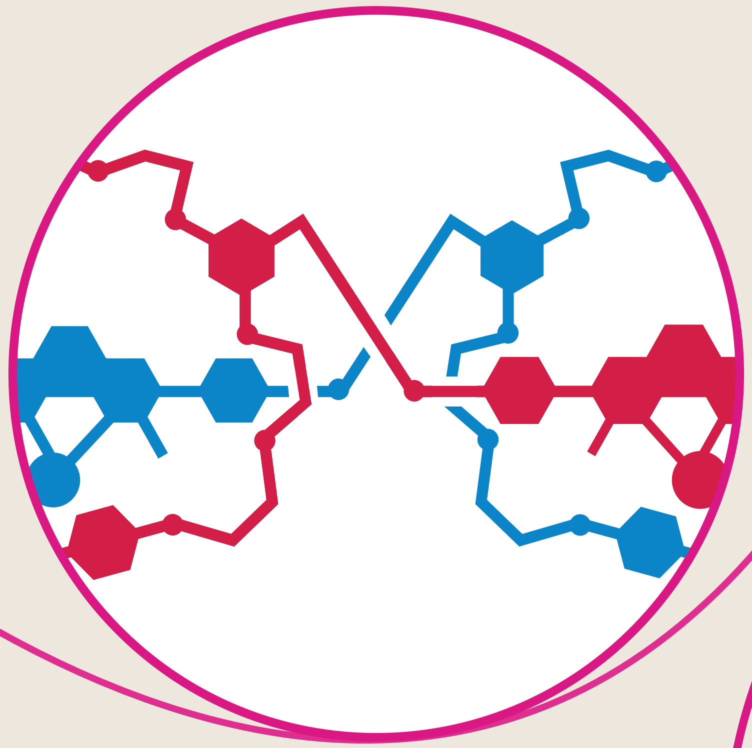
The future

Buildings could become an active part of local ecosystems, harvesting carbon dioxide from the environment to heal themselves. The walls of buildings could act as bioreactors, using inputs such as light, water, heat, algae, bacteria, nutrients and gases to generate a range of products such as purified water, power, oxygen, for communities affected by climate change.

Material goods that reach the end of their useful life could be programmed to separate into their basic components for reuse and recycling to move away from today's waste economy.

More examples from the future

Clothes that can change shape and colour depending on the wearer's mood.



Molecular or microscopic machines small enough to be injected into the bloodstream might be able to make small incisions, repair damage or sense and collect data.

Trainers that clean themselves at the end of each day so they are pristine and great smelling in the morning.

Mobile phone screens that heal themselves when cracked.

Building materials that can generate and store energy for future use, for example by performing a kind of artificial photosynthesis.

Is this even possible?

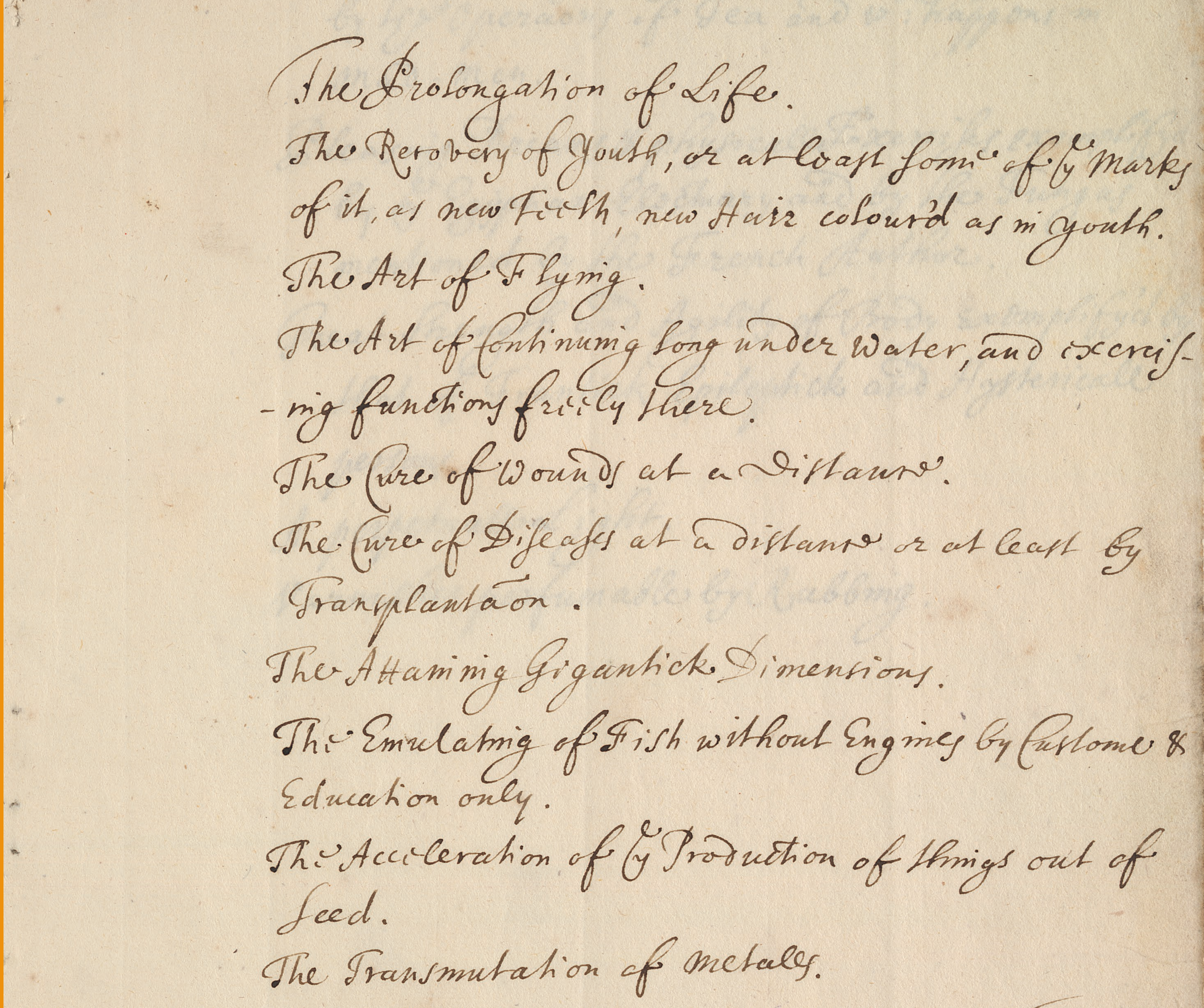
Over 300 years ago, the natural philosopher and chemist Robert Boyle, set out a list of things he hoped could be achieved through science.

Many, such as the prolongation of life or the art of flying, would have seemed outlandish to his contemporaries.

Yet since Boyle's time, life expectancy in Britain has more than doubled, and more than 7,000 aircraft now take off or touch down in the UK on a typical day.

Perhaps a modern-day Boyle would include in such a list the ambition of creating materials that sustain and repair themselves as well as their environment, just as a tree does.

The advancement of science depends on imagination and creativity.


The Prolongation of Life.
The Recovery of Youth, or at least some of the Marks of it, as new Teeth, new Hair colour'd as in youth.
The Art of Flying.
The Art of Continuing long under Water, and exercising functions freely there.
The Cure of Wounds at a Distance.
The Cure of Diseases at a distance or at least by Transplantation.
The Attaining Gigantick Dimensions.
The Emulating of Fish without Engines by Custome & Education only.
The Acceleration of the Production of things out of Seed.
The Transmutation of Metalls.

The Royal Society wants your help

We want to create a repository of ideas for future applications of animate materials so that researchers can curate a 'library of future materials', identify characteristics that are desirable and have real social benefit, and spot ones that could pose challenges in the future.

Do you find the idea of durable materials that adapt to the environment exciting, or are you scared at the prospect of materials that will continuously change in ways that we cannot control or even predict?

Sustainability

Much of the work in progress on animate materials is being undertaken with an eye to environmental benefit. However, constant scrutiny is required to avoid unforeseen consequences and ensure that new materials are sustainable in all senses.

Any effort to develop new types of material must be informed by learning from the past. The histories of lead, asbestos and plastic all remind us how a material initially seen as a miracle invention can over time be exposed as a major risk to health, safety and the environment.

YOUR CHALLENGE

The future of stuff

Design a new material to solve a real-world problem, whether this is personal to you, local, national or international.

Submit an A4 annotated diagram explaining the following:

All of this information must be on a single A4 page, which is scanned or photographed to produce a digital image. Your teacher will then be able to submit this to us.

EXTENSION ACTIVITY

What are the risks?

These materials could require careful regulation and ethical consideration to avoid any unintended consequences of their behaviour. This might include rigorous processes for approval and monitoring, new design codes and standards.

As and when self-healing materials become commonplace and used in multiple structures, risks of failure will need to be managed by building in layers of resilience so that any failure to activate does not create hazards for human safety or structural integrity.