11.4.2025 — 2.7.2025

# 創・造 未來
# INNOVATIVE PATHWAY

## 香港工業新時代
## Hong Kong's New Era of Industry

Teachers' Guide

香港科學館
Hong Kong Science Museum
hkscm

聯合主辦 Jointly Presented by
康樂及文化事務署 Leisure and Cultural Services Department
香港工業總會 FHKI
LCSD edutainment CHANNEL 康文署寓樂頻道
101 academy 入門教室

聯合籌劃 Jointly Organised by
香港科學館 HONG KONG SCIENCE MUSEUM
香港工業總會 FHKI

資助機構 Funding Organisation
創新科技署 Innovation and Technology Commission
政府資助計劃

# **Lesson** Plan

## Aims

- ✓ To explain the innovative technologies and related scientific concepts in the exhibition
- ✓ To deepen students' understanding of the exhibition and stimulate their interest in science and technology

## Expected outcome

- To recognise Hong Kong's innovation and technology ecosystem
- To learn more about various innovative technologies and applications through exhibits, such as 3D printing, hydrogen energy generation, and Industry 4.0
- To understand the importance of sustainable development

## Relevant curriculum

- ✎ General Studies (P1-P6): Science and Technology in Everyday Life
- ✎ Chemistry (S4-6): Redox reactions, chemical cells and electrolysis; Industrial chemistry
- ✎ Biology (S4-6): Organisms and Environment; Microorganisms and Humans
- ✎ Physics (S4-6): Electricity and Magnetism; Energy and Use of Energy

## Before the Visit

- Guide students to conduct investigations on representative research institutions in Hong Kong and their products.
- Encourage students to share in groups, presenting their findings and discussing the impacts and applications of the products.
- Print pages 5 to 8 of the activity sheet, ask students to fill in related answers during their visit.

## At the Museum

- Encourage students to complete pages 5 to 8 of the activity sheet to deepen their understanding of the exhibition.

## After the Visit

- Reveal the answers to students, which can be referenced on page 7 to 8 of the teacher's guide.
- Group students and conduct the game "Innovative Industry Gambit" based on the guidelines in the activity sheet to reinforce what they learned in the exhibition.
- Discuss with students the relationship between research and sustainable development.

# **Teaching** Notes

## Class inspiration

The exhibition showcases examples of smart manufacturing. During the visit, students can identify which steps that were carried out by humans have been replaced by machines, as well as the benefits these changes have brought.

## Fourth Industrial Revolution

Technological advancements have been the cornerstone of every major industrial revolutions, from the steam engines of the 18th century to the power generation systems of the 19th century, and then to the digital revolution of the 20th century. Each breakthrough has reshaped industrial activities and lifestyles. These reforms not only enhanced productivity but also transformed work environments and societal structures. Today, we stand at the forefront of yet another transformative era, Industry 4.0, powered by cutting-edge techonolgies including the Internet of Things (IoT), artificial intelligence (AI), and automation. This new paradigm shifts production towards data-driven systems, thereby achieving intelligent and flexible industrial production.

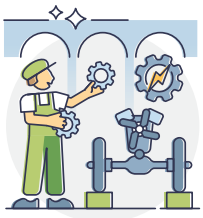
### Mid to late 18th Century

First Industrial Revolution

Machines replaced labour.

### Late 19th Century

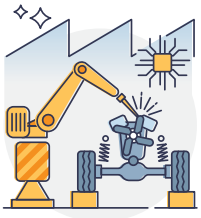
Second Industrial Revolution



People harnessed substantial energy from fossil fuels, enabling power plants to generate ample electricity, which in turn facilitated mass productions.

### Mid-20th Century

Third Industrial Revolution



The development of computers and the Internet enabled highly automated manufacturing.

### Present

Fourth Industrial Revolution

The Internet of Things (IoT) and big data digitalise our lives.

- Each industrial revolution has significantly changed human industrial activities and the ways of life

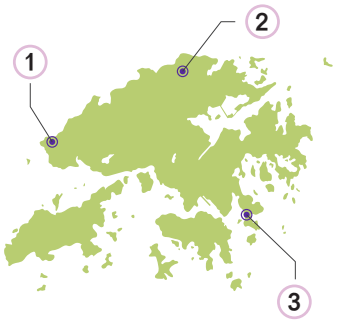
## Technological Innovation in Hong Kong

Most of Hong Kong's industrial operations from the past century have been relocated to the Pearl River Delta and Chinese Mainland, with the economy now centred on service sectors including finance, trade, and logistics. To drive economic diversification, Hong Kong is actively fostering technological innovation. The city boasts world-class research institutions that provide advanced infrastructure for innovators and entrepreneurs, while also accelerating the commercialisation of research outcomes. This commitment helps cultivate more thriving ecosystem where more technologies and products are invented, designed, and manufactured in Hong Kong.

## Class inspiration

Hong Kong is striving to overcome its geographical constraints and actively promoting the development of renewable energy. Teachers can engage students in discussions about Hong Kong's renewable energy projects, such as the installation of floating photovoltaic system at reservoirs and the co-digestion of food waste with sewage sludge.

Students can learn more about the details of the landfill gas power generation projects in Hong Kong.




▶ Three existing strategic landfills (including ① West New Territories Landfill, ② North East New Territories Landfill and ③ South East New Territories) are utilising landfill gas for energy production

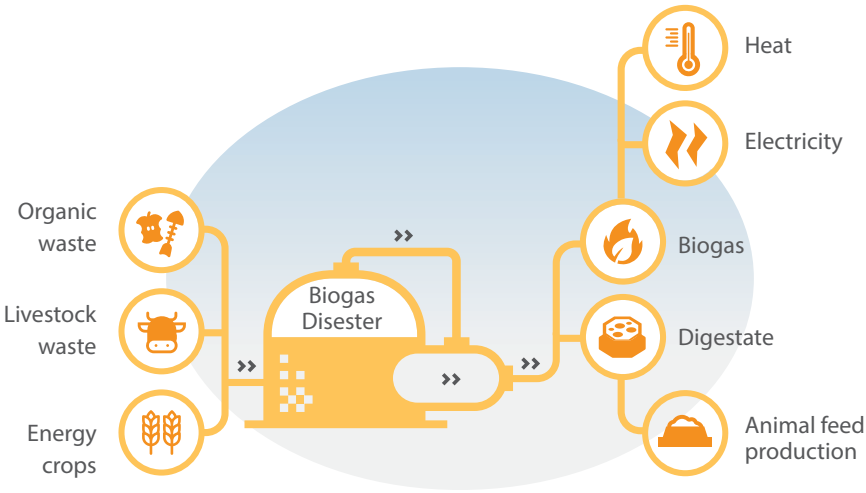
# Exploring Technological Innovations

## Biogas and Anaerobic Digestion

Biogas is a combustible gas mixture generated through anaerobic digestion of organic matter, primarily composed of methane, carbon dioxide, with trace amounts of non-methane hydrocarbons. Landfills provide an ideal environment for biogas generation due to the oxygen-depleted conditions in their deeper layers. The rate and yield of landfill gas production vary across sites, influenced by two key factors: **waste characteristics (such as the types and ages of wastes buried in the landfill)** and **environmental factors (including temperature, humidity, and oxygen availability)**.

Through advanced purification processes, carbon dioxide, hydrogen sulfide and non-methane hydrocarbons can be removed from biogas, making it suitable for the production of town gas. Furthermore, biogas can be transformed into hydrogen through chemical reactions, which can be utilised as a source of green energy.

In addition to utilising landfill gas, Hong Kong is actively developing food waste conversion technologies. The process involves transforming food waste into slurry, which undergoes anaerobic digestion to produce biogas. The resulting digestate can be further processed through sterilisation and thermal treatments, transforming it into a high-quality raw material for animal feed production.




▶ Raw materials and products of anaerobic digestion

## Class inspiration

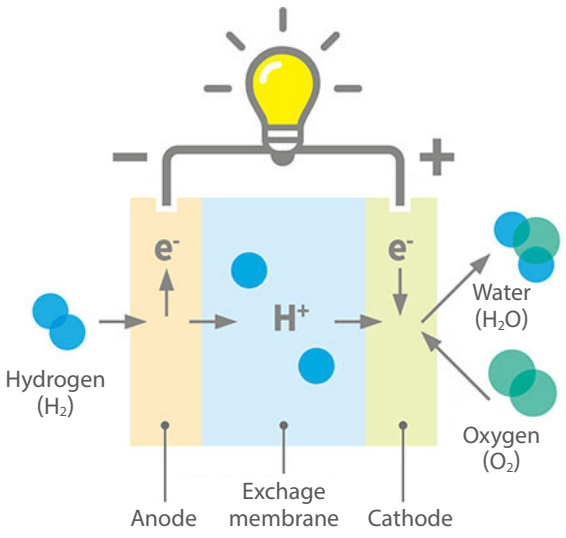
Hong Kong is addressing its geographical constraints by advancing the development of renewable energy. Teachers can engage students in discussions about Hong Kong's renewable energy projects, such as the installation of floating solar power system on reservoirs and the anaerobic digestion of food waste and sludge. Students can learn more about the details of the landfill gas power generation projects in Hong Kong.

## Hydrogen Fuels

With the growing global demand for clean energy, hydrogen power generation has become a leading solution in sustainable technology. Hydrogen fuel cells generate electricity by utilising hydrogen and oxygen, producing no carbon dioxide, suspended particulates, or other pollutants that could pose environmental and health risks. Apart from power generation, hydrogen energy serves as an alternative of power source for transportation.

### How Hydrogen Fuel Cell Works

A hydrogen fuel cell consists of four main components: the **anode, cathode, proton exchange membrane (PEM)** that conducts protons while blocking other particles, and an **external circuit**. Hydrogen molecules ($H_2$) enter through the anode, where they undergo an oxidation reaction catalysed by the anode catalyst, breaking down into protons ($H^+$) and electrons ($e^-$). The protons move through the PEM to the cathode, while the electrons travel through the external circuit, generating an electric current. At the cathode, a reaction occurs with hydrogen protons, oxygen, and electrons in the presence of the cathode catalyst, resulting in the formation of water ($H_2O$).




▶ The only byproduct of using hydrogen for energy production is water, which has the advantage of zero carbon emissions.

## Class inspiration

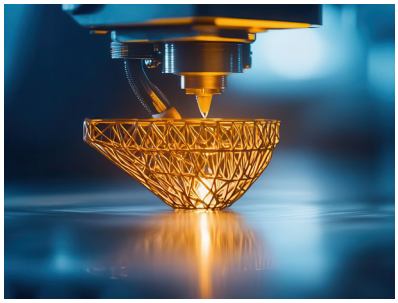
Hydrogen is a flammable gas that can form explosive mixtures when combined with air. Additionally, hydrogen is colourless and odorless, making it difficult to detect leaks.

### Challenges of Hydrogen Fuels

1. **Cost**: Hydrogen fuel cells rely on rare and expensive catalysts to carry out oxidation and reduction reactions.
2. **Storage and transportation**: The storage and transportation of hydrogen require specialised facilities, which increase storage and transportation costs.

## Class inspiration

The applications of 3D printing technology in education are extensive. Teachers can engage with students to explore how to effectively utilise this technology in classrooms. For example, in biology classes, students can use 3D printing to create models of human organs, which helps them gain a deeper understanding of anatomical structures.



▶ 3D printing technology creates complex three-dimensional objects by stacking materials layer by layer.

## 3D Printing

3D printing technology creates complex three-dimensional objects by stacking materials layer by layer. It enables the transformation of digital three-dimensional models into concrete objects, offering greater flexibility and personalisation. This technology is widely applied across various industrial sectors and has shown immense potential in multiple disciplines such as medicine and education.

### Various Applications of 3D Printing Technology

Art and design

Medical implants

Machine parts

### 3D Printing Technology Process

1. **Modeling**: Create a three-dimensional model using computer-aided design (CAD) software.
2. **Slicing**: Use slicing software to segment the model into layers, generating two-dimensional instructions for the printer to follow. During this process, various printing parameters can be adjusted, such as printing speed, temperature, layer height, infill density, and support structures.
3. **Printing**: Select suitable materials to complete the print based on the product's purpose, functionality, and material properties, including strength, toughness, elasticity, heat resistance, and biocompatibility.
4. **Post-processing**: After printing, the object undergoes further processing, which may include removing supports, sanding, polishing, or painting.

### Common Materials Used in 3D Printing

1. **Plastic**: These materials are cost-effective, easy to process, and lightweight, making them suitable for manufacturing various components and models. Common types include PLA (Polylactic Acid) and ABS (Acrylonitrile Butadiene Styrene).
2. **Metal**: Common metals include aluminum alloys, stainless steel, and titanium alloys. Aluminum alloys are lightweight and corrosion-resistant, widely used in the aerospace industry. Stainless steel offers heat resistance and high flexibility, commonly used in manufacturing different parts. Titanium alloys are often utilised for medical implants.
3. **Bioink**: This type of material is used for constructing human tissues and organs in bioprinting applications. Bioinks often consist of living cells or biomaterials that can support cell growth and function.

## Class inspiration

Students can discuss how to promote sustainable development in their daily lives. Potential actions include selecting sustainable products, conserving energy, and participating in community greening activities.

## Connections between Research and Sustainable Development

The definition of sustainable development was proposed in the report "Our Common Future" published by the World Commission on Environment and Development in 1987. This definition highlights the importance of fulfilling the basic needs and aspirations of the populations while ensuring that future generations have the opportunity to thrive and develop.

In September 2015, the United Nations adopted the "**Transforming our world: The 2030 Agenda for Sustainable Development**" which includes 17 Sustainable Development Goals (SDGs) aimed at addressing global challenges such as **eradicating poverty**, **combating climate change**, and **protecting biodiversity**.

Industrial research plays a multifaceted role in promoting sustainable development:

1. **Providing innovative solutions**: Develop new technologies and materials that reduce energy consumption and enhance resource utilisation efficiency, thus supporting sustainable economic growth.
2. **Scientific evidence for policy-making**: Provide scientific evidence on issues such as climate change and biodiversity conservation, thus assisting policymakers in making informed decisions.

As global challenges become increasingly complex, the significance of research in driving sustainable development continues to grow. In the future, more focus on interdisciplinary and international collaborations can address global issues such as climate change, poverty, and health. Moreover, research outcomes must be effectively translated into practice to promote sustainable development.

▶ The 17 goals that transforming our world

# **Activity** Sheet

## Research and Development

Launching G2G Recycle System to recycle old clothes into new clothing for a more sustainable tomorrow.

Introducing "Food TranSmarter", an innovative solution for food waste management that converts food waste into slurry , which can improve collection and transportation efficiency.

To combat global warming, you will use passive radiative cooling material . This material can be easily painted on building exteriors and roofs, achieving "electricity-free cooling".

Note that high-protein foods, such as meat or seafood, emit biogenic amines during the spoilage process. Introducing Smart Food Label to detect the concentration of this chemical, thereby determining whether the food is safe for consumption.

Generating electricity from biogas produced by the anaerobic digestion of organic waste.

Utilising advanced aseptic packaging technology, integrated high-temperature short-time pasteurisation, low-temperature sous vide cooking, and aseptic packaging , allows for food preservation at room temperature for an extended period.

# **Activity** Sheet

## Industry 4.0

To implement corporate social responsibility, you will organise STEM-related activities at school to spark students' interest in science and technology. Please provide one example.

Using metal 3D printing technology to provide customised medical-grade metal implants and surgical assistance tools. This technology can enhance patient recovery rates and improve surgical accuracy.

With the rapid development of artificial intelligence and data science, robots are used to perform some high-intensity and dangerous tasks.

To promote the widespread use of green energy and achieve carbon neutrality, you will be engaging in the research and development of hydrogen fuel cells. Hydrogen fuel cells generate electricity using hydrogen and oxygen, with no air pollutants produced in the process.

To implement corporate social responsibility, you will visit schools to share and introduce the applications of hydrogen energy. Please provide two examples of hydrongen applications.

Conducting in-depth research on third-generation semiconductors, such as gallium nitride / silicon carbide, and establishing a pilot facility with partners to apply the research breakthroughs to 5G communication and electric vehicles.