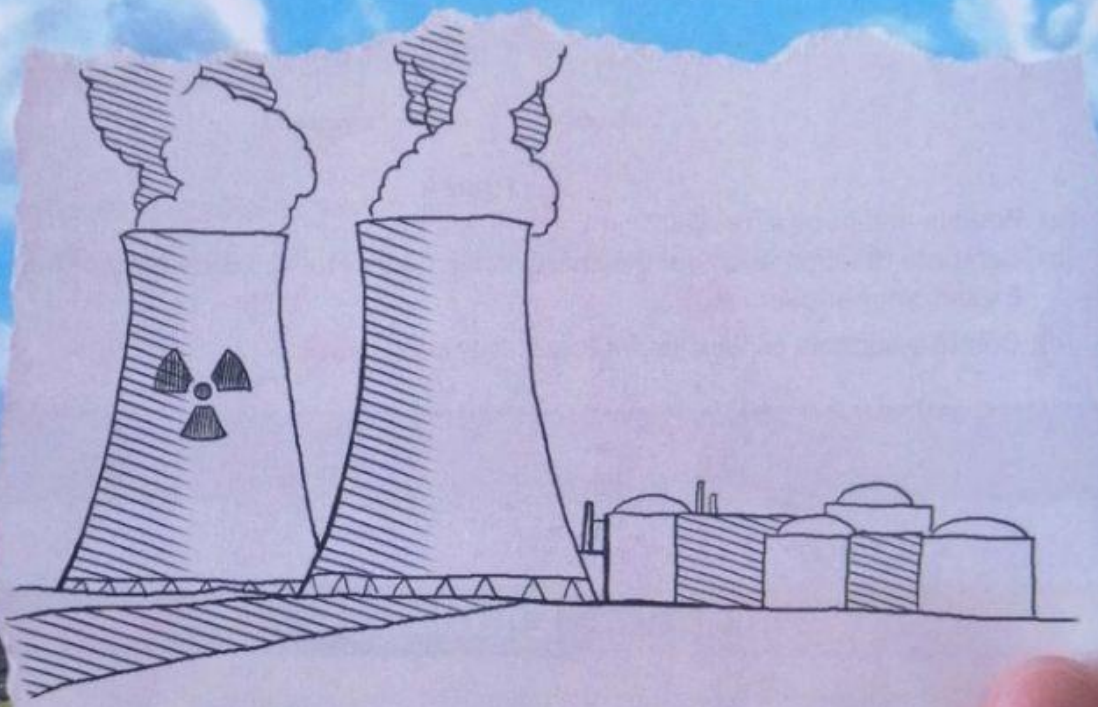
Chapter

12 Nuclear Energy



Keywords

- Nuclear energy
- Nuclear fission
- Nuclear fusion
- Nuclear reactor
- Electricity generation
- Impact of nuclear test

Why is the number of countries using nuclear energy increasing?

How is nuclear energy produced?

Is nuclear energy safe to use?

Can nuclear power stations be built in Malaysia?

Science Digest

Thorium to Replace Uranium

Similar to uranium, thorium can also undergo nuclear reaction that can generate electricity. The Malaysian Nuclear Agency is responsible for conducting research projects on thorium in cooperation with several foreign agency. The project aims to study the availability of thorium as an alternative nuclear fuel to replace uranium in research reactors in the future.

Source: www.nuclearmalaysia.gov.my (Access on 19 August 2019)

You will learn about:

- the use of nuclear energy
- the production of nuclear energy
- impact of using nuclear energy
- nuclear energy in Malaysia

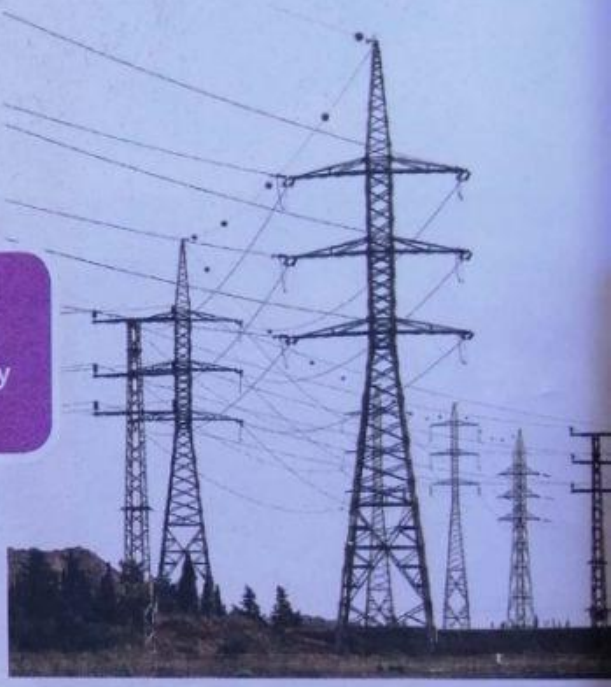
12.1 The Use of Nuclear Energy

Nuclear energy brings a lot of benefits to mankind if it is generated and controlled properly. The number of countries using nuclear energy to generate energy in various fields has been increasing every year.

INFORMATION

Countries in the World that Use Nuclear Energy
http://bukutekskssm.my/Science/F4/Pg256

Now, there are more than 30 countries in the world using nuclear energy as their energy source. Among them are the United States of America, Russia, France, Slovakia and Japan. Why do these countries use nuclear energy rather than other energy sources?



Nuclear energy is an alternative energy that can be used to generate electricity in order to replace or reduce the use of petroleum and coal. This energy is produced in greater quantity and is more efficient compared to other energy sources.

Nuclear energy produces ionising radiation that is used in various fields such as medicine, agriculture and industry. The use of nuclear energy can improve the standard of health and living of man.

Nuclear energy releases very little greenhouse gases compared to other energy sources.

Figure 12.1 *Uses of nuclear energy*

What are the adverse effects of nuclear energy sources compared to other energy sources?

Radioactive waste can affect the health and threaten lives of all living things.

The huge amount of energy produced can cause severe harm to mankind if it is misused.

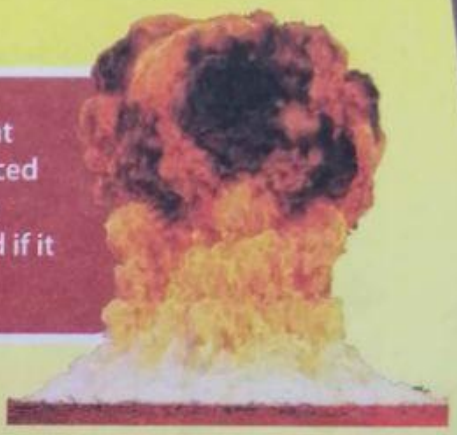


Figure 12.2 *Adverse effects of nuclear energy sources*

Activity 12.1

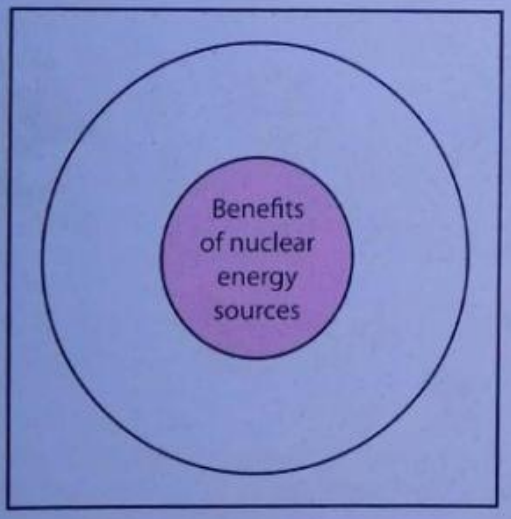
Mind Map

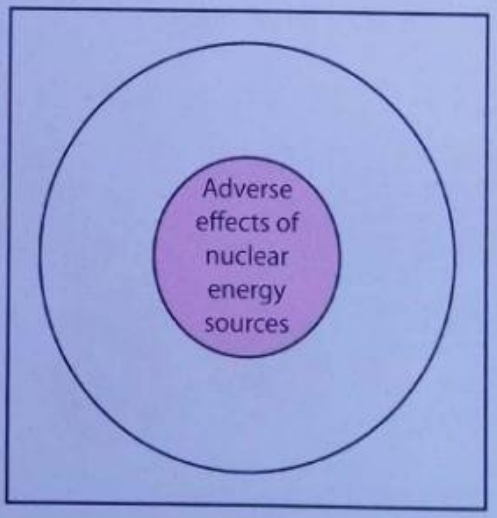
21st Century Skills

Aim: To construct a mind map to show the benefits and adverse effects of nuclear energy sources compared to other energy sources.

Instructions:

1. Do active reading and gather information regarding the benefits and the adverse effects of nuclear energy sources compared to other energy sources.
2. Construct the mind map as shown below and fill it with the information you have gathered.
3. Put up the mind map on the notice board at the back of the classroom.



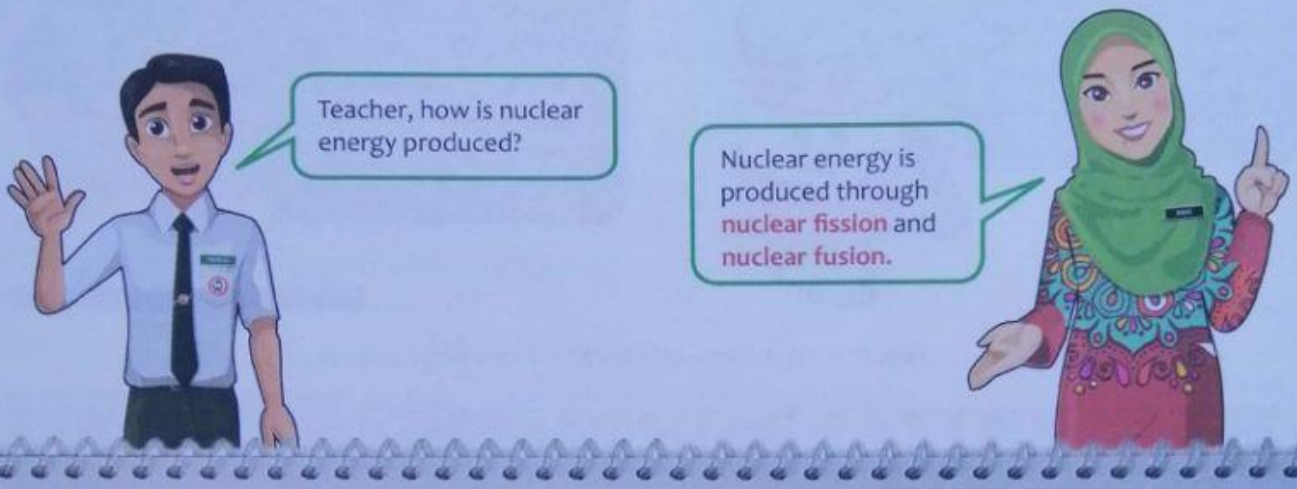


FORMATIVE PRACTICE 12.1

1. State three major countries in the world that use nuclear energy sources.
2. What are the benefits of using nuclear energy sources compared to other energy sources?

12.2 The Production of Nuclear Energy

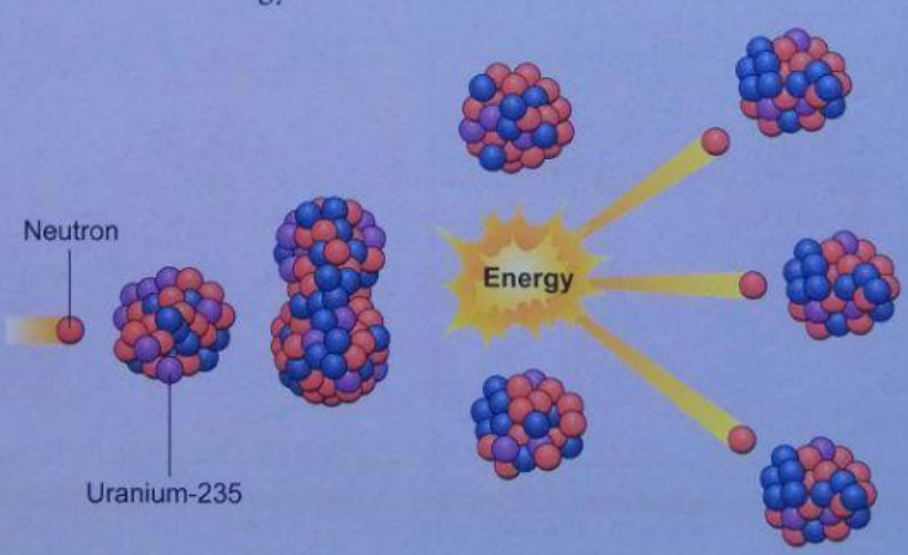
Nuclear energy means energy resulting from reactions in the nucleus of atoms.



Nuclear Fission

Nuclear fission is the **process of splitting** a heavy radioactive nucleus into two or more nuclei, which are lighter and more stable together with the release of energy.

- Nuclear fission occurs when a heavy radioactive nucleus such as uranium-235 is bombarded by a slow neutron.
- Bombardment by the neutron causes the nucleus to split into two or more lighter and stable nuclei.
- This process releases a lot of energy.



Scan Me AR
3D Model

Figure 12.3 *Nuclear fission of uranium-235*

- The nuclear fission will occur continuously when a neutron bombards and splits a new nucleus of large mass. This reaction is called a **chain reaction**.

Nuclear Fusion

Nuclear fusion is the **process of fusing** or **combining** two light radioactive nuclei to form a heavier nucleus with the release of energy.

- For example, two light and small nuclei such as deuterium and tritium (hydrogen isotope) combine to form a bigger and heavier nucleus.
- This process occurs at a very high temperature.
- This process releases more nuclear energy than nuclear fission.

Scan Me AR
3D Model

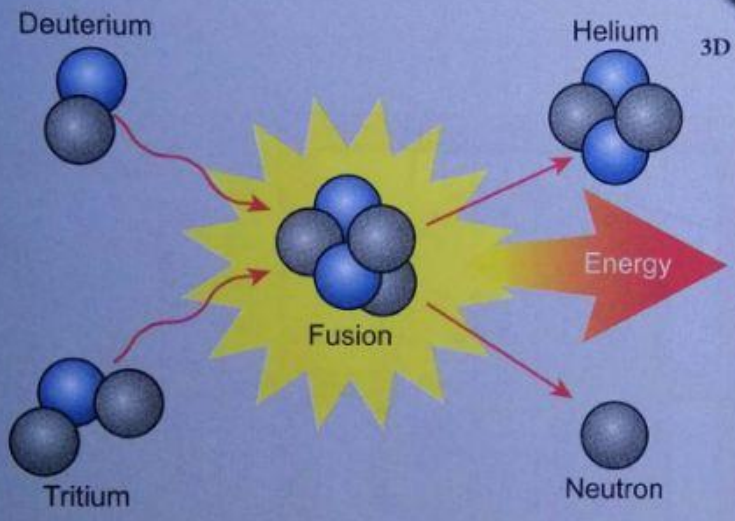
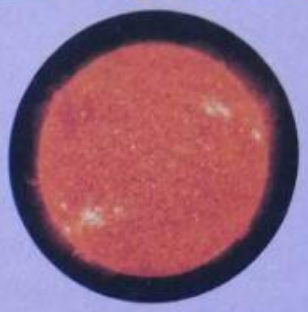


Figure 12.4 *The fusion of two hydrogen isotopes*

Science Gallery



Nuclear fusion occurs continuously in the Sun. This is because the Sun has hydrogen isotopes and high temperature. The energy released from this process is the main source of energy for life on Earth.

Brain Teaser

Why does nuclear fusion require a high temperature?

Activity 12.2

Result Showcase

21st Century Skills

Aim: To create a multimedia presentation to explain the production of nuclear energy.

Instructions:

1. Carry out this activity in groups.
2. Gather information about the production of nuclear energy through nuclear fission and nuclear fusion.
3. Discuss the information gathered and prepare a multimedia presentation to explain nuclear fission and nuclear fusion.
4. Present the findings obtained by your group to the class.

Generating Electricity from Nuclear Energy

You learned about electricity generation in Form 3. The main use of nuclear energy is to generate electricity. The generation of electricity from nuclear energy is done in the **nuclear power station**. A nuclear power station consists of a **nuclear reactor** and a **generator**. The nuclear reactor produces a huge amount of energy. Let us take a look at the process of generating electricity that occurs in a nuclear power station.

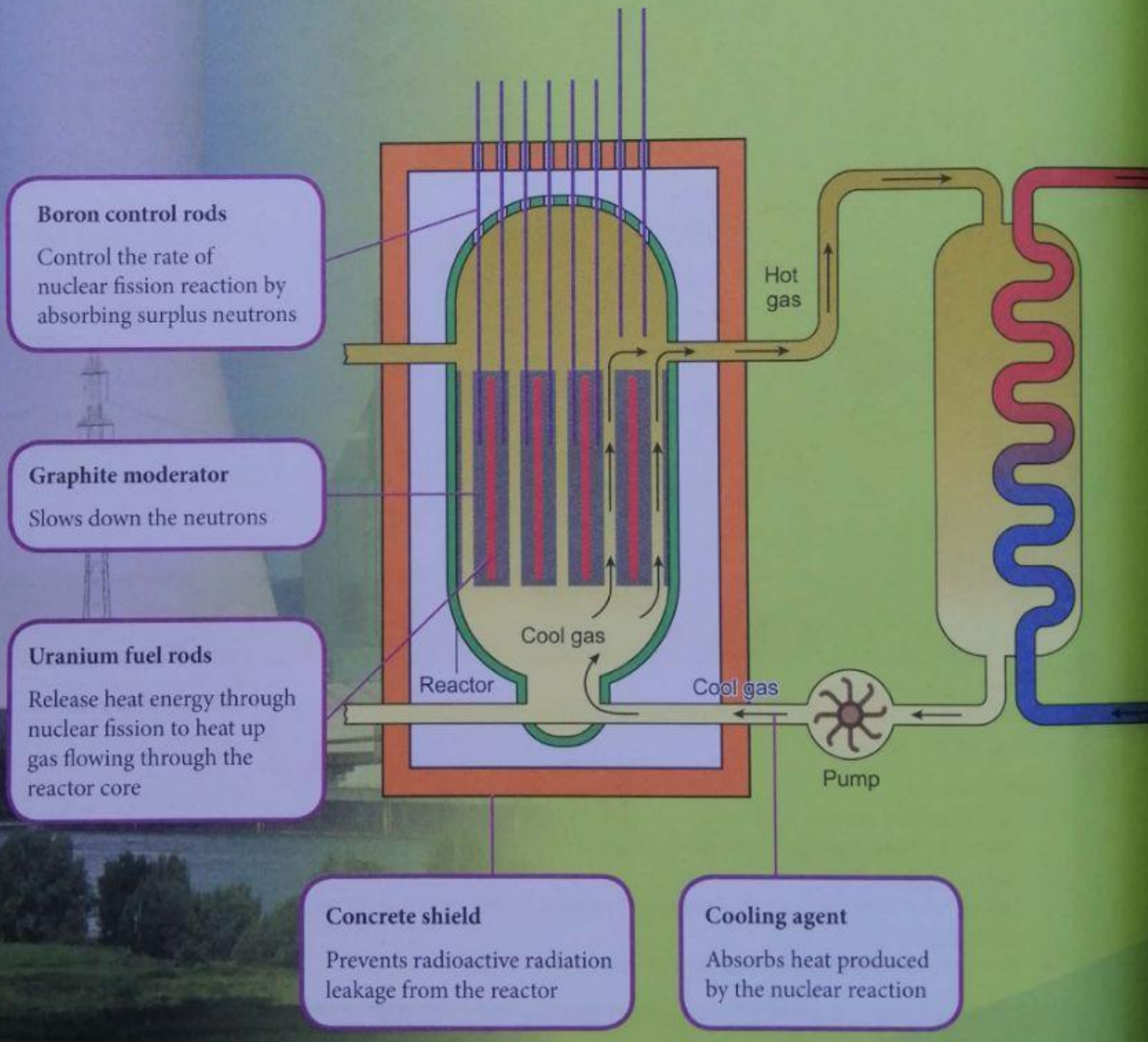
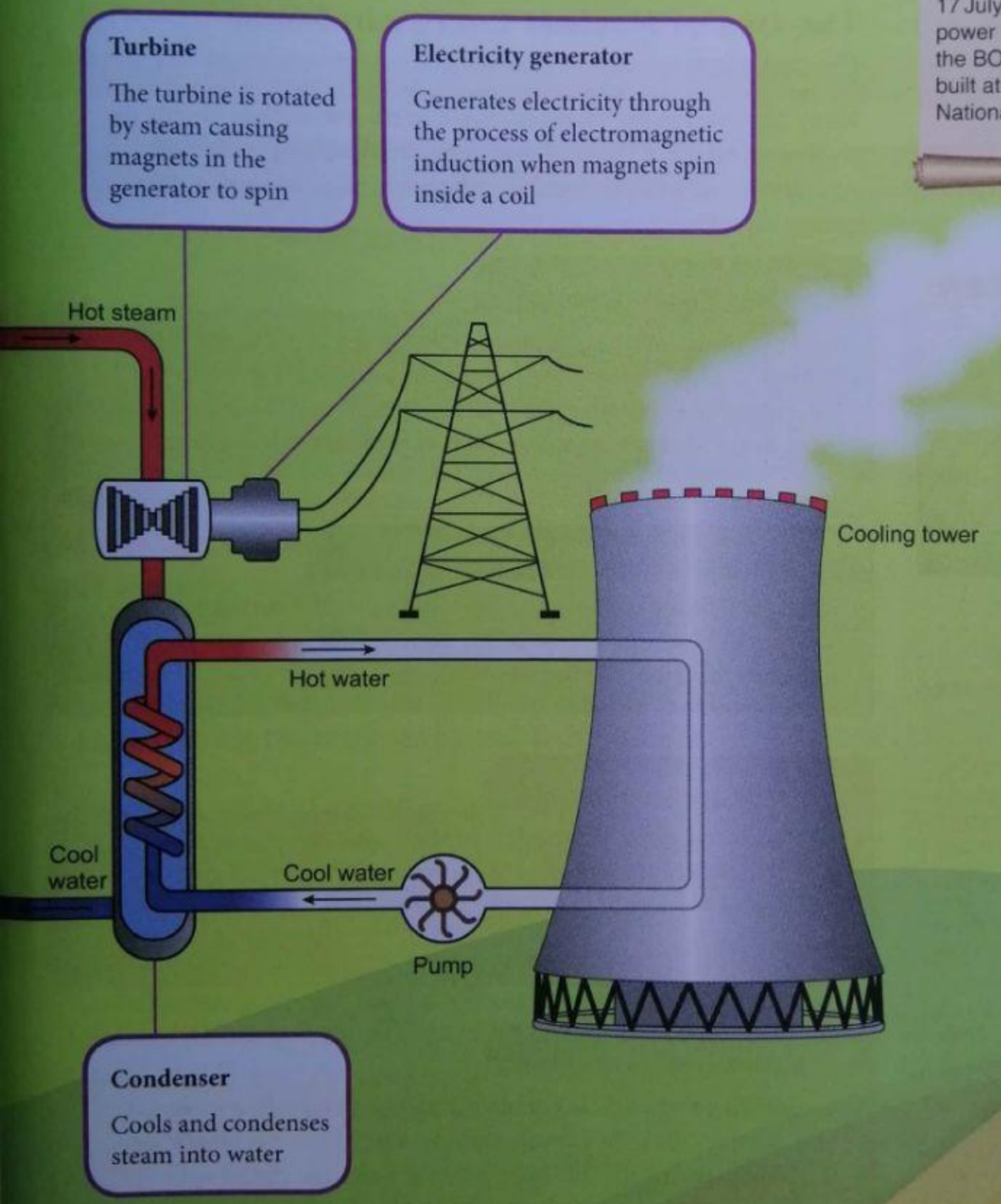


Figure 12.5 *A nuclear power station*

History Corner

Arco, Idaho in the United States of America is the first town in the world to use electricity generated by a nuclear power station. This occurred on 17 July 1955 with power generated by the BORAX-III reactor built at the Argonne National Laboratory.



My Nation

Malaysia has a nuclear reactor of 1 megawatt power belonging to the Malaysian Nuclear Agency. The TRIGA PUSPATI Reactor (RTP) started operation on 28 June 1982. RTP is a pool-type reactor permitting experiments to be conducted in the reactor core. However, this reactor is only for the purpose of training, doing researches and producing radioisotopes. Malaysia must build a nuclear reactor capable of generating 1000 megawatts of power if it wants to generate electricity using nuclear energy.

VIDEO

Triga Puspati Reactor
http://bukutekskssm/Science/F4/Pg262.mp4

(Source: Official Website Agensi Nuklear Malaysia)

The Use of Nuclear Energy in Some Countries

Many countries in the world continue to choose nuclear energy as an alternative source of energy to generate electricity. There are several reasons why the countries choose nuclear energy as their energy source.

Lack of other energy sources

- Most of these countries using nuclear energy lack other energy sources such as coal and petroleum. Importing these energy sources from other countries will incur high cost. Therefore, they have to use alternative energy sources such as nuclear energy.

Vast country and high population density

- China for example is vast and has a high population density. The amount of power produced using nuclear energy is enough to generate electricity for the whole country.

Source of national income

- The nuclear reactor in Slovakia, for example, can produce electricity more than needed by the country. Therefore, they can supply electricity to neighbouring countries and earn lucrative income.

Sophisticated technology

- Countries using nuclear energy are always conducting research and development. As a result, they now have more sophisticated technologies and are able to reduce the risks associated with nuclear reactors. One such example is the Argonne National Laboratory in the United States of America.

Science Gallery

Argonne National Laboratory

The Argonne National Laboratory is a laboratory specifically built for the development of nuclear physics. This laboratory is on the outskirts of Chicago, United States of America. This laboratory which started operation in the 1940s has made many contributions to the field of nuclear physics. Almost all nuclear reactors built nowadays are the result of indepth researches conducted at Argonne National Laboratory.

Activity 12.3

Think-Pair-Share

21st Century Skills

Aim: To search and share information on the use of nuclear energy in certain countries.

Instructions:

1. Carry out this activity in pairs.
2. Take a card written with the name of a country which uses nuclear energy from your teacher.
3. Gather information on the use of nuclear energy in that country.
4. Present the findings obtained in front of the class.

FORMATIVE PRACTICE 12.2

1. Fill in the blanks with the correct answers.
   (a) The process of _____ occurs when a _____ bombards a nucleus of large mass which then _____ into two new nuclei of smaller mass that are nearly the same and more stable together with the release of energy.
   (b) The process of nuclear fusion only occurs at high _____.

12.3 Impact of Using Nuclear Energy

The use of nuclear energy should be regulated properly so as to bring benefits to mankind and the environment. Since nuclear energy is increasingly being used around the world, we should know the impact of using this energy on life and the environment.

Impact of Using Nuclear Weapons

Early research on nuclear energy was conducted in the 1940s to produce the atomic bomb. Plutonium, the byproduct from nuclear fission in the nuclear reactor was used to make the atomic bomb. The world saw the devastation when nuclear energy was used to make nuclear weapons. Nuclear weapons were used by the United States of America on the cities of Hiroshima and Nagasaki during World War II.

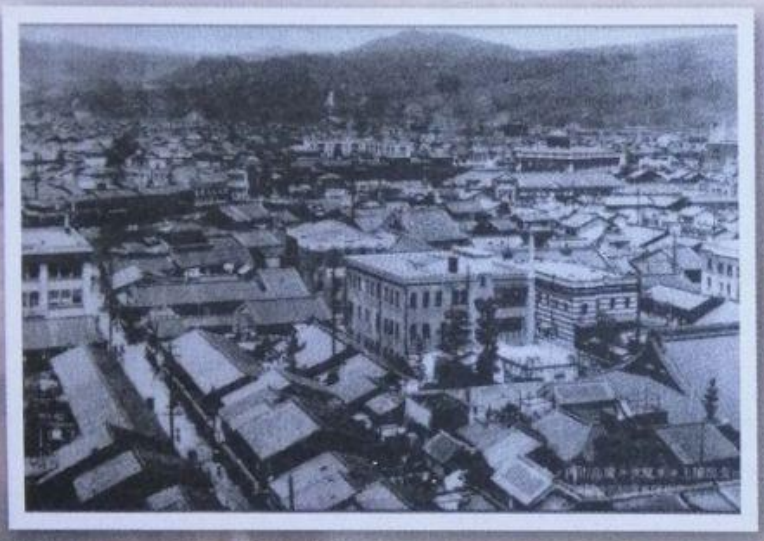
History Corner

J.Robert Oppenheimer is the first person in the world to invent the atomic bomb. He is called 'Father of the Atomic Bomb'. The bomb he invented was used by the American military during World War II. He, however, expressed regret after personally seeing the devastation caused by the explosion of the atomic bomb.

The bombing of Hiroshima and Nagasaki with atomic bombs during World War II

- The atomic bomb "Little Boy" was dropped on Hiroshima on 6 August 1945, followed by another atomic bomb "Fat Man" on Nagasaki on 9 August 1945.
- The nuclear explosion caused a powerful shock wave that immediately killed about 70,000 civilians.
- The blast caused the whole city to heat up to the extent that steel structures began to melt.
- The blast also affected the environment due to shock wave and radioactive fallout.
- At that moment, all communication systems in the city were cut off.

Before



(*Photo source: The City of Hiroshima*)

After

(*Photo source: ICRC Archives*)

Photograph 12.1 *Effect of bombing on Hiroshima*

INFORMATION

The Effects of Nuclear Weapons
http://bukutekskssm.my/Science/F4/Pg264

Many countries have now started to invent and produce their own nuclear weapons. However, they are still bound by the **Nuclear Nonproliferation Treaty (NPT)** which controls and prohibits any country from using nuclear weapons arbitrarily.

Impact of Nuclear Test

Before nuclear weapons are used, nuclear tests have to be conducted to determine whether the weapons can function. Nuclear tests are conducted in the open atmosphere, on land or underwater. These nuclear tests have adverse impact on living things and the environment.

Nuclear tests done underground, for example, will cause radiation effects to soil and water sources. Similarly at sea, destruction of living things and pollution will occur. For humans and living things on land, the spread of radiation from nuclear tests will cause somatic and genetic effects.

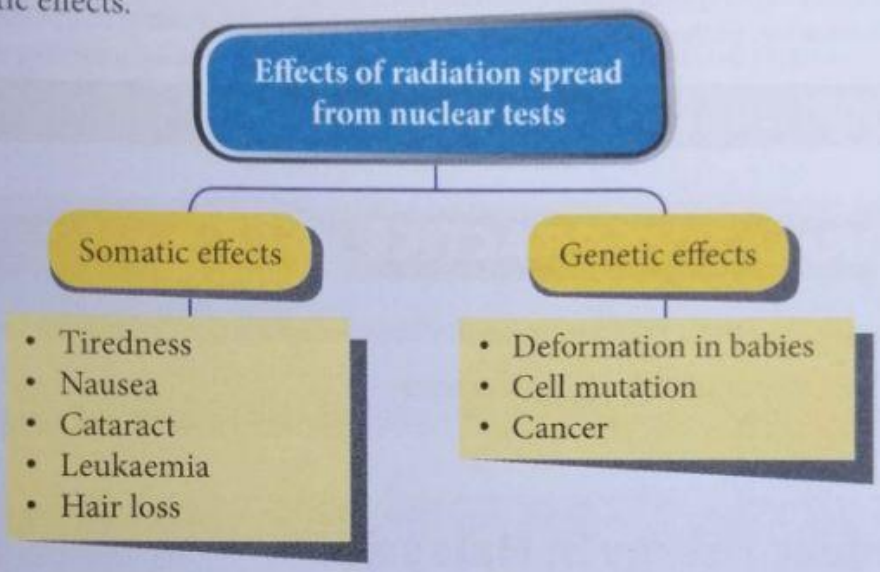


Figure 12.6 *Effects of radiation spread from nuclear tests*

Are there countries still doing nuclear tests?

Photograph 12.2 *Nuclear test at sea*

Activity 12.4

Think-Pair-Share

21st Century Skills

Aim: To gather information regarding history of the atomic bomb attack on Hiroshima and Nagasaki, and also nuclear tests.

Instructions:

1. Carry out this activity in pairs.
2. Gather information regarding history of the atomic bomb attack on Hiroshima and Nagasaki, and also nuclear tests by visiting the relevant websites.
3. Present the information gathered to the class.

FORMATIVE PRACTICE 12.3

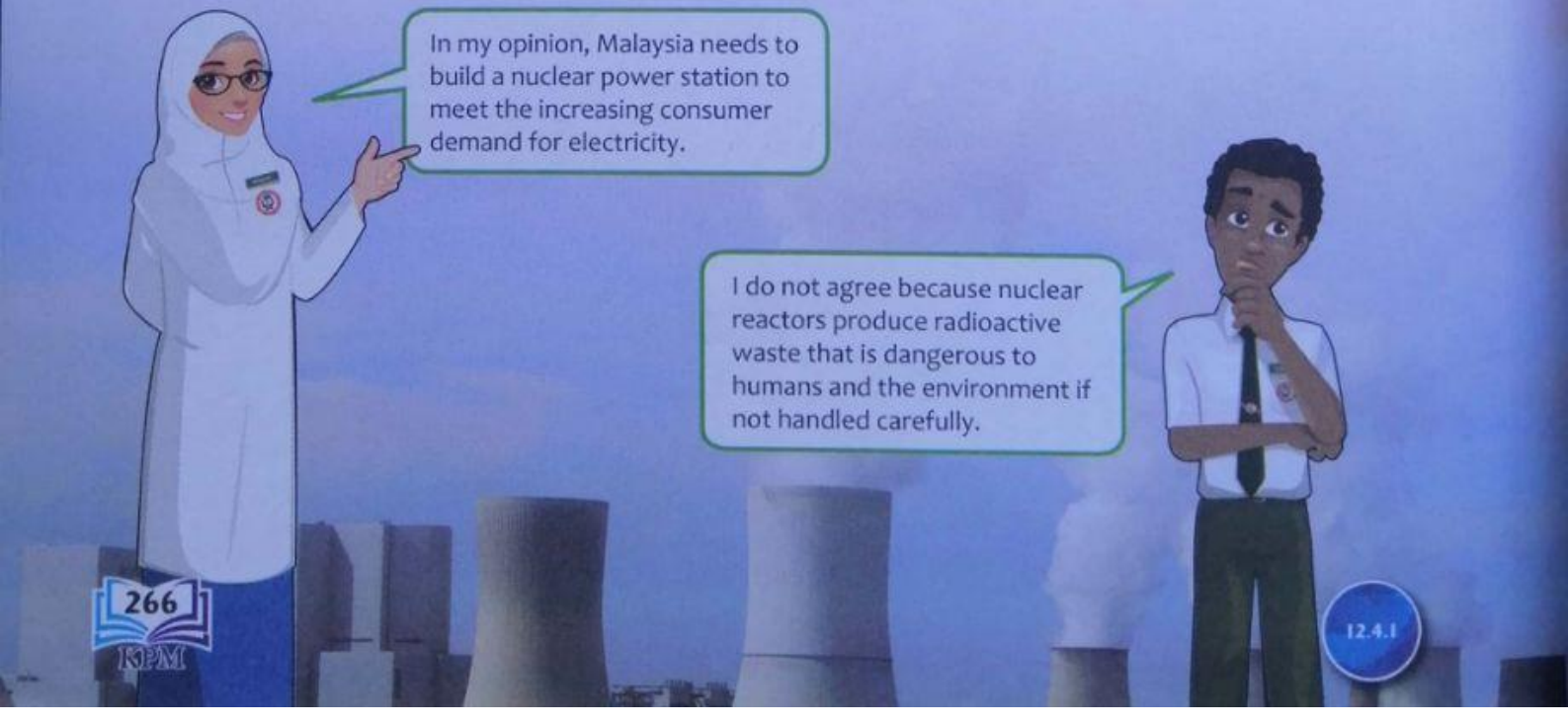
1. State three adverse effects that may occur if nuclear weapons continue to be used.
2. What is the purpose of conducting nuclear tests?

12.4 Nuclear Energy in Malaysia

Justify the Construction of Nuclear Power Station in Malaysia

In subtopic 12.1, we learned the benefits and adverse effects of using nuclear energy. In Malaysia, 70% of the energy used is generated by natural gas. Petroleum, natural gas and coal are fossil fuels that are non-renewable.

Some students were asked about the justification for building a nuclear power station in Malaysia. The following are some of their opinions.



As a Malaysian citizen, what is your opinion? Carry out Activity 12.5 with your classmates.

Activity 12.5

Debate

21st Century Skills

Aim: To debate the justifications for a nuclear power station in Malaysia.

Instructions:

1. Carry out this activity in groups.
2. The topic of the debate is "The justifications for a nuclear power station in Malaysia".
3. Divide into two groups, the proposing team and the opposing team.
4. As the proposing and opposing teams, each team has to present their arguments.

Several factors have to be considered in operating a nuclear power station:

- fossil fuels such as coal, natural gas and petroleum will deplete and its cost will increase
- effects of pollution due to nuclear energy is less compared to fossil fuels
- the location to build nuclear power station must be strategic. It must be near water sources to facilitate the cooling process
- the rate of energy production by nuclear power is much greater than that of fossil fuels

My Nation

Malaysian Nuclear Agency

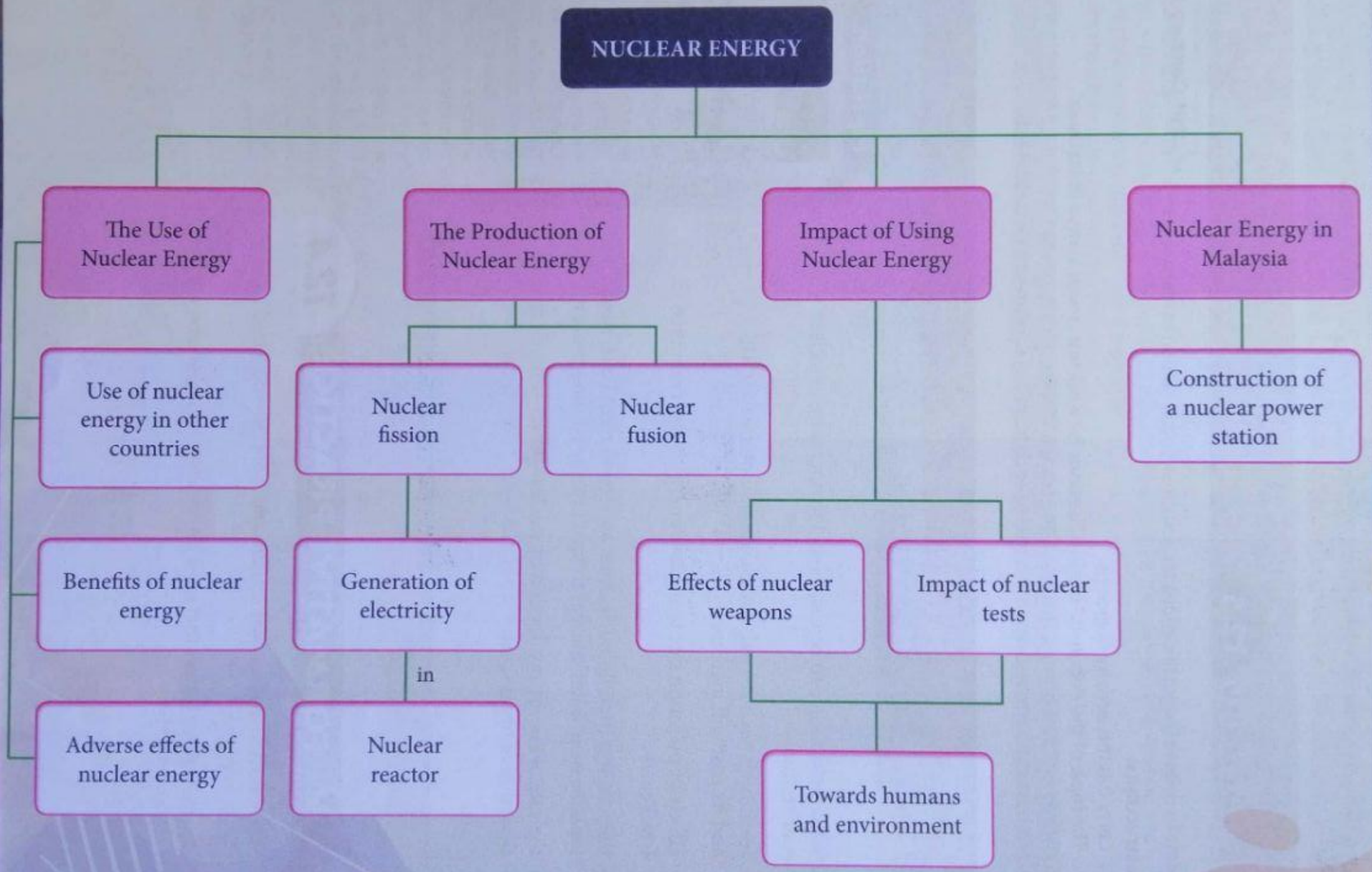
The Malaysian Nuclear Agency, formerly known as Malaysian Institute for Nuclear Technology Research (MINT), is located in Bangi, Selangor. This agency was formed to coordinate science and technological activities and other related technologies. Its main activity is international collaboration in the research and development of nuclear technology for national development.

FORMATIVE PRACTICE 12.4

1. State two main energy sources which are currently used in Malaysia.
2. State three factors that must be considered in operating nuclear power stations.

12.4.1

Summary


NUCLEAR ENERGY
The Use of Nuclear Energy
The Production of Nuclear Energy
Impact of Using Nuclear Energy
Nuclear Energy in Malaysia
Use of nuclear energy in other countries
Nuclear fission
Nuclear fusion
Construction of a nuclear power station
Benefits of nuclear energy
Generation of electricity
Effects of nuclear weapons
Impact of nuclear tests
in
Adverse effects of nuclear energy
Nuclear reactor
Towards humans and environment

Self-reflection

After studying this chapter, you are able to:

12.1 The Use of Nuclear Energy

- ☐ Justify the use of nuclear energy for a country that has been identified.

12.2 The Production of Nuclear Energy

- ☐ Describe the production of nuclear energy by nuclear fission and nuclear fusion.
- ☐ Describe the generation of electricity from nuclear energy.
- ☐ Justify the use of nuclear energy in countries using it.

12.3 Impact of Using Nuclear Energy

- ☐ Tell a story about the impact of using nuclear weapons on life and the environment.
- ☐ Conclude the impact of nuclear tests on the environment.

12.4 Nuclear Energy in Malaysia

- ☐ Justify the construction of a nuclear power station in Malaysia.

Summative Practice 12

QUIZ

Objective Questions
http://bukuteksksm.my/Science/F4/Q12

1. Photograph 1 shows a nuclear power station in a certain country.

Photograph 1

(a) Name two countries that are major users of nuclear energy.

(b) Based on your answer in question **1**(a), what is the use of nuclear energy in those countries?

(c) State two advantages of nuclear energy sources.

2. Figure 1 shows a nuclear reaction.

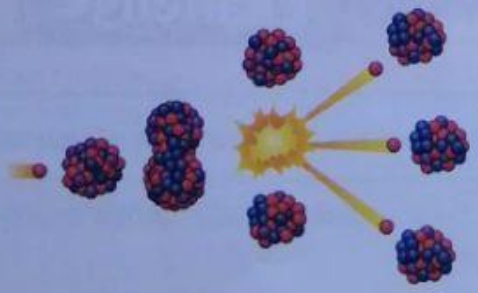


Figure 1

(a) Name the nuclear reaction.

(b) Based on Figure 1, explain the nuclear reaction.

(c) What would happen if the reaction is not controlled properly?

3. Reaction *X* always occurs in the Sun.

(a) What is the reaction?

(b) Explain why the reaction can occur on the surface of the Sun.

(c) What would happen on Earth if the reaction you mentioned in question **3**(a) suddenly stops?

4. Figure 2 shows part of a nuclear power station.

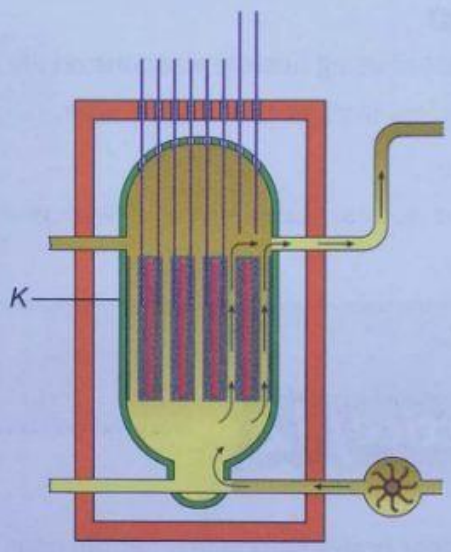


Figure 2

(a) What is the process that occurs in *K*?

(b) What is the purpose of the process you mentioned in question **4**(a)?

(c) *K* has various safety features. State two safety features in *K*.

(d) Predict the impact if there is a leakage in the structure of *K*.

Mind Challenge

5.

A nuclear reactor can produce nuclear energy on a large scale to generate electricity.

Based on the statement above, explain the way nuclear energy is converted into electricity in a nuclear power station.