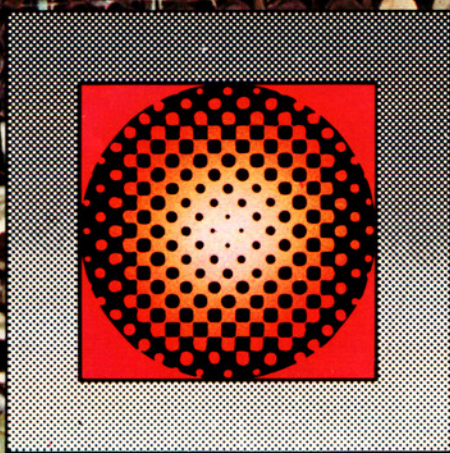
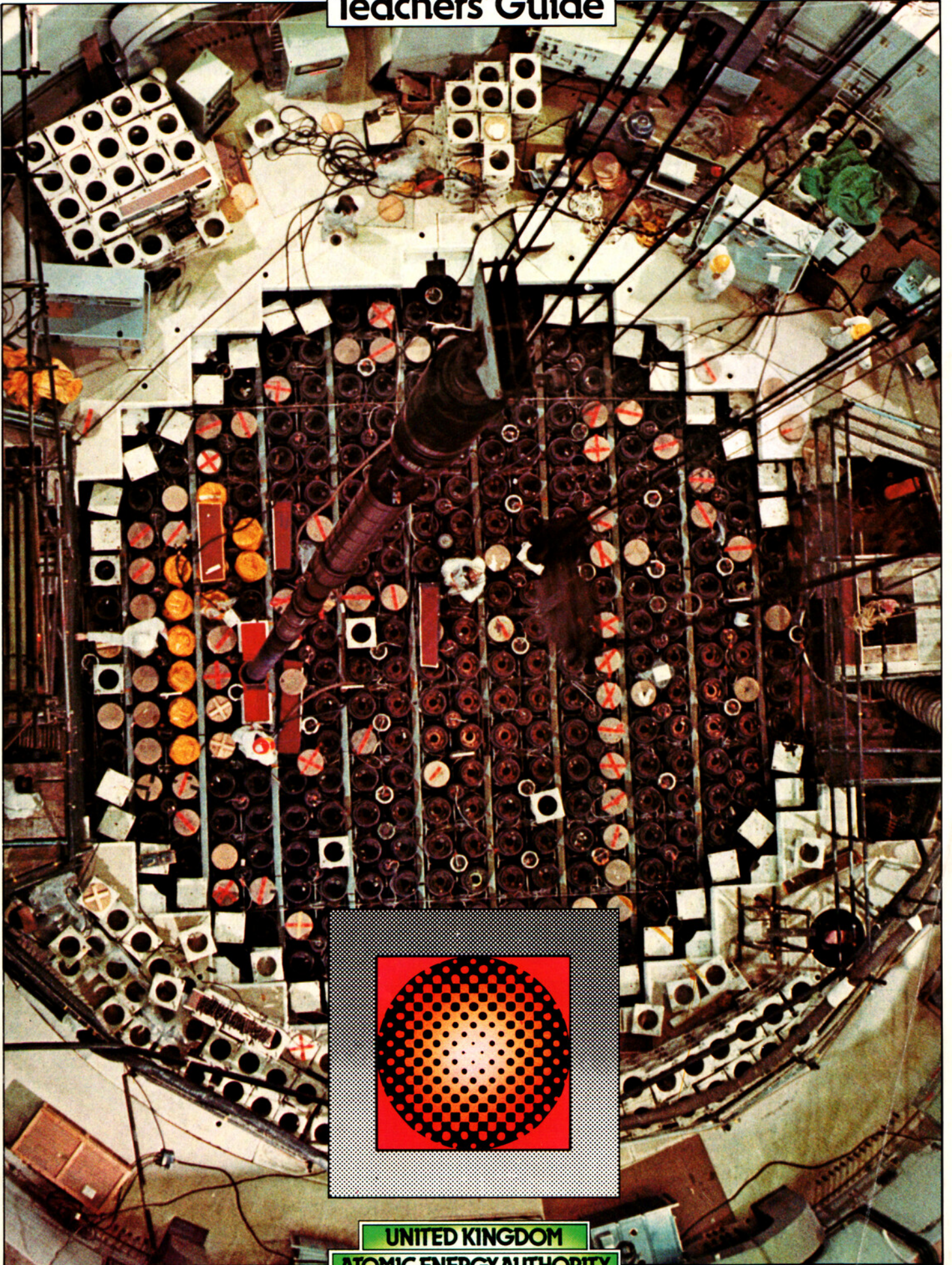
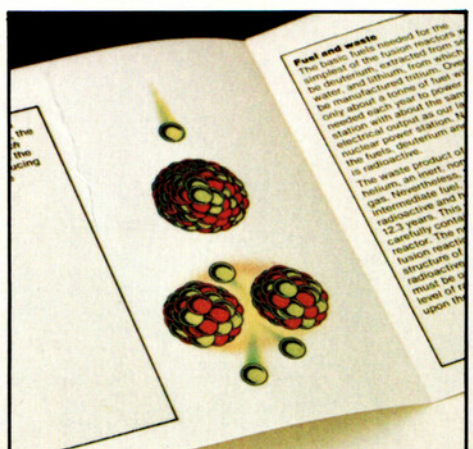
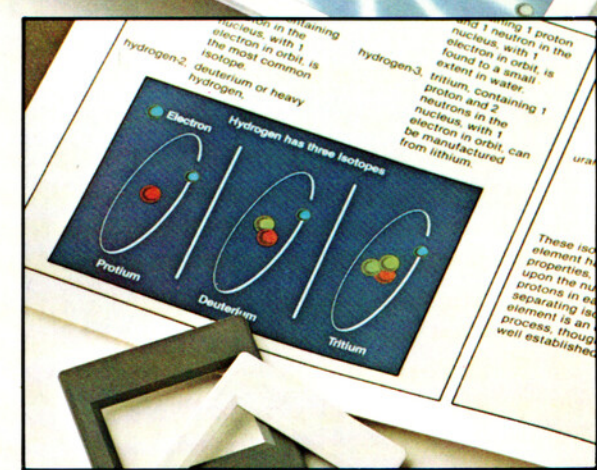
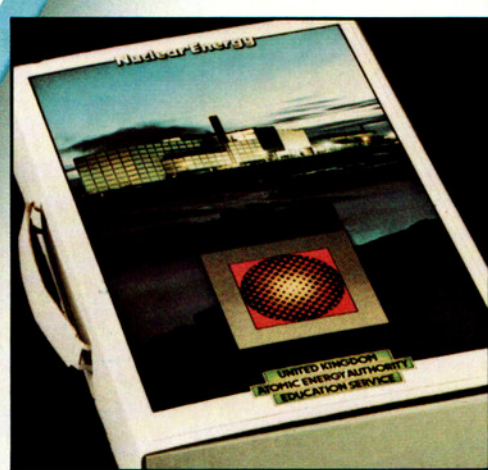
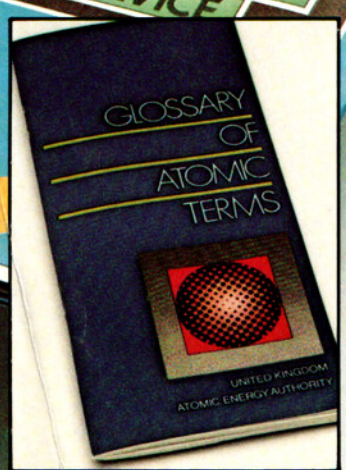
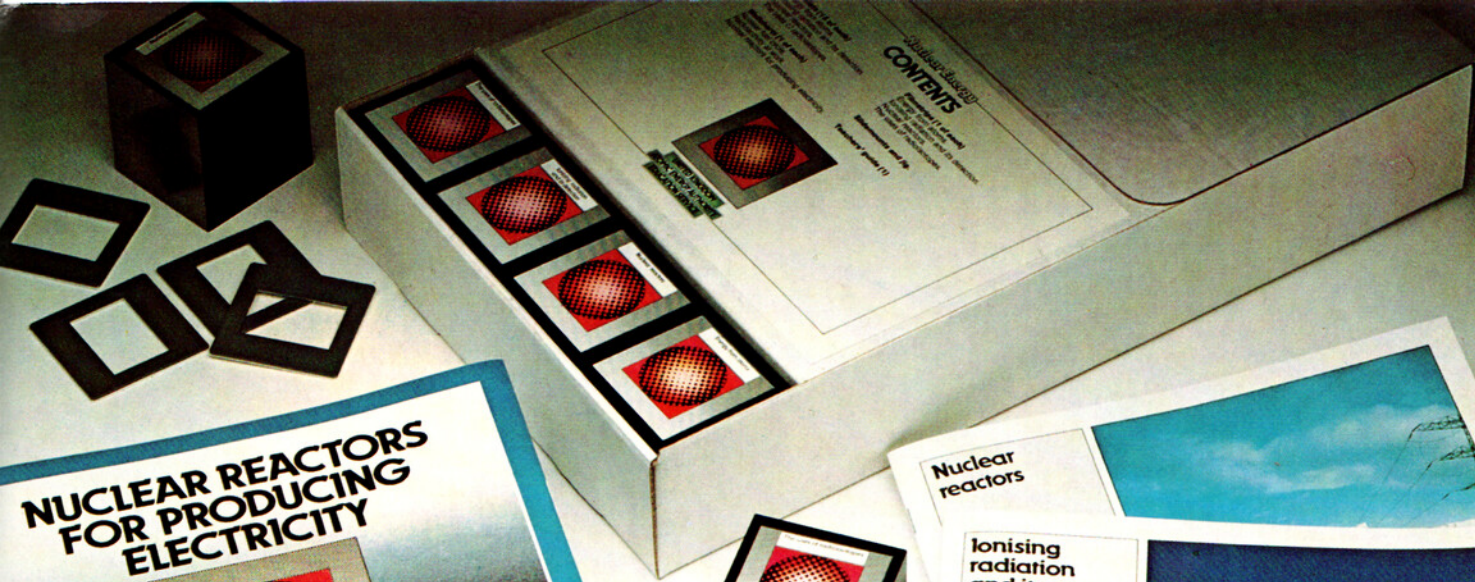


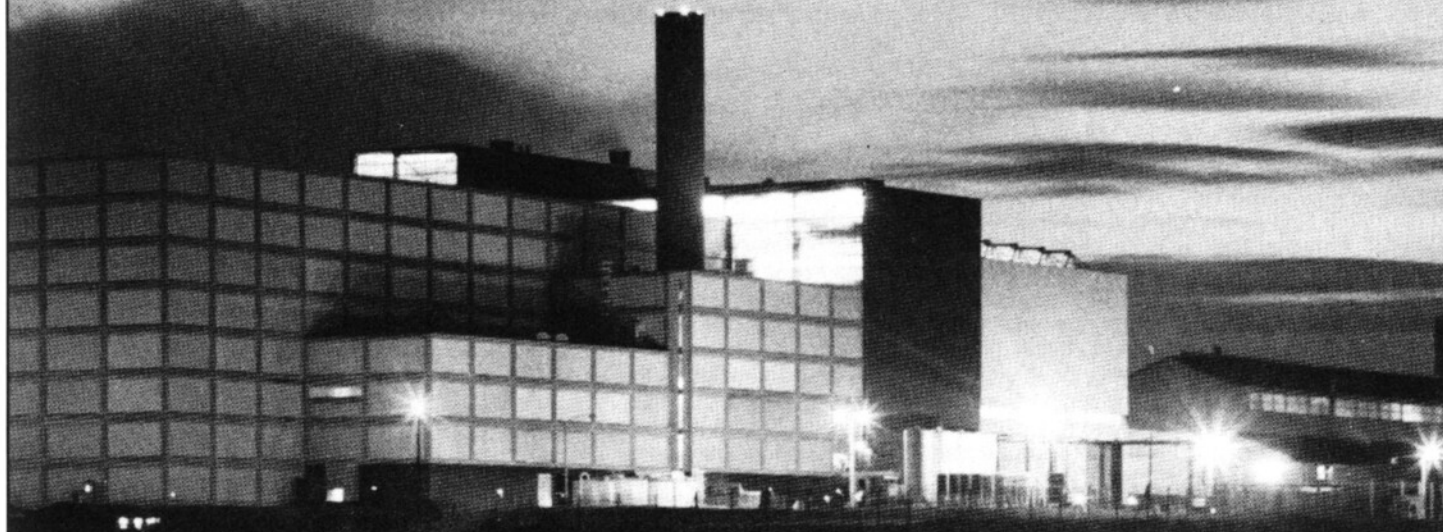
# Nuclear Energy Teachers' Guide



UNITED KINGDOM  
ATOMIC ENERGY AUTHORITY  
EDUCATION SERVICE



# Nuclear Energy



## **Purpose.**

Written requests from schools and information from teachers attending the United Kingdom Atomic Energy Authority's courses indicated that there could be a demand for up-to-date resources on topics about which the Authority has specific expertise. A survey by Bath University of examination syllabuses used by secondary schools supported this. The immediate requirement was for material suitable for the 14-16 age range, though it was clear that if resources could be produced that would find some application for a wider age-range, this would be of even greater value.

As a result, the decision was made to produce teaching material that would supply factual information about nuclear energy for those teaching either physics or chemistry or the various forms of physical and general science for the G.C.E. examinations. Topics were chosen that were considered to be areas in which the UKAEA had particular knowledge and which were to be found in many syllabuses.

In addition, it was decided to produce and test resource material that could be used either in class teaching or in some forms of resource-based learning systems, and within these systems in a variety of different ways.

It was considered that individual teachers would know best the approach to use with their available resources, their own skills and the abilities of their pupils.

## **Topics.**

The survey showed that the most suitable topics would be:

- Energy from atoms**
- Ionising radiation and its detection**
- Nuclear reactors**
- The uses of radioisotopes**

# Contents

## **Energy from atoms.**

Fifteen copies of a sixteen-page full colour booklet (Energy from atoms), with completion sheet.

One copy of a ten-frame filmstrip (Energy from atoms), with completion sheet and commentary notes.

This topic is covered in a general and qualitative manner. It begins by describing how most every-day materials are made of atoms and how these are themselves composed of much smaller parts. It explains that some atoms are unstable and decay to produce other atoms and ionising radiation, and sets out the properties of the ionising radiations.

The loss in mass experienced during a general radioactive decay and in nuclear fission is described, together with how the energy produced, can be utilised.

The booklet ends with a look into the future at the possibility of using nuclear fusion as a source of energy explaining that fusion too involves a loss in mass and the production of energy.

The filmstrip covers approximately the same subject content as the booklet but in simpler terms and in less detail.

## **Ionising radiation and its detection.**

Fifteen copies of a twenty-page booklet (Ionising radiation and its detection) and worksheet.

One copy of a ten-frame filmstrip (Ionising radiation and its detection) with commentary notes and an example completion sheet.

This is the most difficult topic for 14-16 year olds to comprehend. The first part of the booklet describes the constitution and properties of alpha, beta and gamma radiation, including the effect radiations have on living tissue.

The second part describes the methods used to detect and count these radiations, and covers photographic emulsions, ionisation in gases (ionisation chambers, proportional counters and geiger counters), and ionisation in solids and liquids (solid state detectors and scintillation counters). The concepts of ionisation, production of ion pairs and their separation in electrical fields which are the basis of most detectors, are not easy to comprehend. A graphical method of explaining the differences between ionisation detectors is used and this is suited only to pupils of above average ability.

The filmstrip covers approximately the same subject content as the booklet but in simpler terms and in less detail.

## **Nuclear reactors.**

Fifteen copies of a twenty-eight page full-colour booklet (Nuclear reactors) and worksheet.

One copy of a ten-frame filmstrip (Nuclear reactors), commentary notes and completion sheet.

One copy of a wallchart (Nuclear reactors for producing electricity) and a completion sheet.

One copy of a wallchart (Nuclear fuel cycle) and a worksheet.

The booklet contains a brief summary of atoms, and how they decay and split to produce energy. This is followed by a general description of how a chain reaction can be contained and used to produce controlled amounts of energy for conversion into electricity.

The basic components common to all nuclear reactors are then described as a preliminary to a more detailed account of thermal and fast reactors. Each description follows a similar pattern and includes reasons why the development from one type of reactor to another has taken place.

The treatment and reprocessing of fuel comes next, with the complex system of recycling detailed in the wallchart (Nuclear fuel cycle).

An account of how fusion reactions could possibly be the basis for the production of future supplies of electricity completes the booklet.

The filmstrip covers approximately the same subject content as the booklet but in simpler terms and in less detail.

The wall chart (Nuclear reactors for producing electricity) is a simple illustration of the process of producing electricity by fission.

## **The use of radioisotopes.**

Fifteen copies of a twenty page full-colour booklet (The uses of radioisotopes) and worksheet.

One copy of the ten-frame filmstrip (The use of radioisotopes) with commentary notes and completion sheet.

One copy of the wallchart (Radioactivity at work) and a worksheet.

The most difficult part of this otherwise simple booklet is at the beginning where the meanings of isotopes and radioactive decay are given. The remainder is a simple but detailed account of how radioactive isotopes can be used in electricity generation, industry, agriculture and medicine.

Again, the filmstrip covers approximately the same subject content as the booklet but in simpler terms and in less detail.

**Teaching methods.**

As has already been described, the above materials have been produced with no specific teaching approach in mind but rather that they should be useable in a variety of ways to suit many teachers and their varied circumstances. Although this is not the place to describe in detail how best particular teaching aids should be used, it would be of value to describe possible ways in which the complete set of resources could be employed.

**Class teaching systems**

Each topic within the pack can be studied quite independently of the others.

**Wallcharts.** One way of using the wallcharts is as a starter material which is put on display well before the lesson sequence begins, perhaps even displayed somewhere outside the classroom. Alternatively, the charts could be used with the attendant worksheets or completion sheets as a follow-up in order to recapitulate on work already covered.

**Filmstrips.** These cover all four topics. Included with each is set of commentary notes.

Together, these can be used either in the normal manner with the whole class or in small groups with the groups showing themselves the filmstrip and answering the completion sheets.

**Booklets.** These can be used as the basis for class teaching, for general reading or at home in answering set work based on the completion sheets, the worksheets or something similar. Some of the completion sheets contain a list of words that includes the correct responses. These have been produced in a way that enables the list to be cut off and destroyed if it is considered that they make the task too simple.

**Resource-based learning system.**

Normally this would begin with some form of 'starter lesson'. In this case, the lesson could be based upon the filmstrip 'Energy from atoms', the commentary notes, and by the class copying and answering the completion sheet.

Then the class could be divided into four groups, each to work on a different topic. Each topic can be studied independently of the others and therefore can be studied in any order. Every topic contains work at different levels of difficulty, the estimated level being indicated by the key on the plan that follows. So, knowing the approximate ability of a pupil, a teacher could then set him/her to work on material suited to his/her ability. It is possible for the children to work in pairs. However, when they have completed their particular part of the topic, work should be returned for checking, and a decision made as to whether they should continue with further work in that topic or to go on to another. In this way classes of mixed ability or classes containing children studying different syllabuses and requiring different subject content can be catered for by the varied routes through the material.

Some teachers using this system produce a master plan – as shown overleaf – to be displayed and to illustrate to pupils where they are in their studies. Whether the pupils should or should not know whether they are working on easy, average, or difficult sections is very much open to debate. You will have to decide for yourself.

# Plan of resource based learning system

**Nuclear Energy**  
**Starter lesson**  
**Energy from atoms**

Filmstrip/commentary notes.  
Completion sheet.

**Energy from atoms.**

Chart-Nuclear reactors for  
producing electricity.  
Completion sheet.

Booklet  
Completion sheet.

**Ionising radiation  
and its detection.**

Filmstrip/commentary notes.  
Completion sheet.

Booklet.  
Worksheet.

**The uses of radioisotopes**

Chart – Radioactivity at work.  
Completion sheet.

Filmstrip/commentary notes.  
Completion sheet.

Booklet.  
Worksheet.

**Nuclear reactors.**

Filmstrip/commentary notes.  
Completion sheet.

Booklet.  
Worksheet.

Chart and booklet –  
Nuclear fuel cycle.  
Worksheet.

End of section

End of section

End of section

End of section

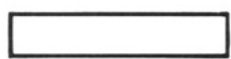
Easy



Average

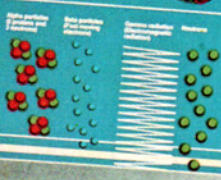


Difficult



Some atoms are unstable and decay to other, slightly smaller, atoms and give off alpha, beta, and gamma radiation. Other, bigger atoms can capture neutrons and split (fission) to give smaller atoms and several fast-moving neutrons

Natural uranium metal is mainly uranium-238 but contains a little uranium-235. It produces all types of ionising radiation and neutrons.



Radiations can kill living cells



Berkeley had shown that radiation could be used to kill cancer cells. It is now used to kill cancer cells in many other parts of the body.



Radioactive atoms decay at a known rate

Radioactive dating is used to determine the age of rocks and fossils. It is based on the fact that radioactive atoms decay at a known rate.



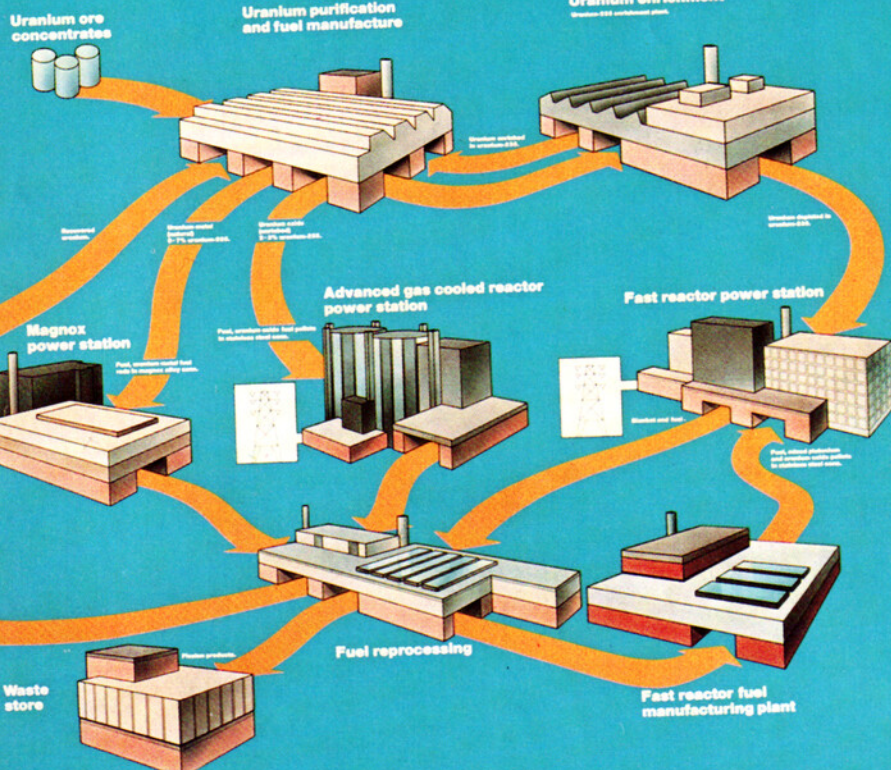
counters

Counters are used to measure the amount of radiation. They are used in many different ways, including in medicine and industry.



# NUCLEAR FUEL CYCLE

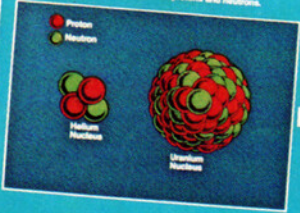
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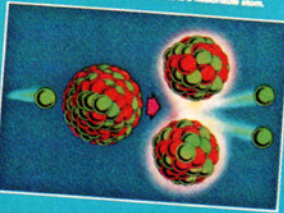
# NUCLEAR REACTORS FOR PRODUCING ELECTRICITY

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All materials are made from atoms. Atoms contain a nucleus of protons and neutrons.



Some very large atoms split when they capture neutrons. This is called fission. Uranium-235 is a fissionable atom.

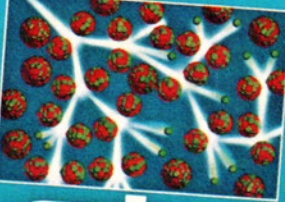


When fission takes place, mass is lost and energy, usually in the form of heat, is produced.



Electricity is produced in power stations when steam turns turbines that drive generators. The steam is formed by heating water using the energy from burning oil or coal, or from nuclear changes.

In fission the neutrons released can cause other atoms to split and produce even more neutrons. A chain reaction is produced that will keep itself going. Heat is continually produced.



Natural uranium contains only 0.7% of uranium-235. So few are present that a chain reaction can only keep going if neutrons are slowed. The slowing is done by a moderator of graphite.

The chain reaction is controlled using a neutron absorber that can be pulled from or pushed into the reactor.

Uranium, highly enriched in uranium-235, or plutonium, will produce a chain reaction that will keep itself going with fast neutrons.

The chain reaction is controlled using a neutron absorber.

