The Story of Fritz Haber

Contents: Reading and questions relating to the life and work of the inventor of the Haber Process.

Time: 1 period or more, depending on amount of discussion.

Intended use: GCSE Chemistry and Integrated Science. Links with work on ammonia and the Haber Process.

Aims:

- To complement prior work on the Haber Process and the manufacture of fertilizers
- To show, through the life of Haber, the problem of the social responsibility of the scientist
- To develop awareness of the way scientific discoveries can be put to both beneficial and detrimental use
- To provide opportunities to practise skills in reading, comprehension and discussion.

Requirements: Students' worksheets No. 207

This passage of reading and associated questions can be used in class or for homework. The questions can be effectively tackled as a group discussion activity by groups of three, four or five students working together. If the unit is used for homework it should be followed up later with class discussion. It is assumed that the chemistry of the Haber Process will have already been covered.

Notes on some of the questions

Q.2 The renewable resources involved are nitrogen and water (if this is the hydrogen source). The iron catalyst is also effectively renewable, since iron is so abundant. Non-renewable resources consumed include methane (if this is the hydrogen source) and/or the fuel to heat the process. Fuel is the largest single cost — fertilizers represent nearly half of the total energy input to British agriculture.

Q.3 Haber was working for BASF, who in fact originally asked him to investigate the synthesis of nitrogen oxides from air, with a view to manufacturing nitric acid for fertilizer manufacture.

Q.9 Perhaps the most obvious example is the development of nuclear weapons in the 1940s. Teachers might like to refer to the case of Einstein and later of Oppenheimer and Fermi in the Manhattan Project. Information on this topic can be found in the SISCON reader *The Atomic Bomb* (published by ASE/Blackwell). It is worth noting that the destructive power of these modern weapons is far greater than anything Haber worked on in the First World War.

Acknowledgements Figure 1 supplied by BASF; Figures 2 and 3, ICI Agricultural Division; Figure 4 and 5, Imperial War Museum.

THE STORY OF FRITZ HABER

The followng piece is about the life of Fritz Haber, inventor of the Haber Process. Read it, then answer the questions that follow.

The Haber Process is an elegant and efficient piece of chemistry. It takes nitrogen from the air, and there is plenty of that available, and hydrogen from water or natural gas, likewise plentiful sources. It converts these elements into ammonia by the use of heat, pressure and a catalyst made of a cheap, abundant material — iron. The ammonia, in the form of ammonium sulphate or ammonium nitrate, is fed to plant crops which turn it into protein, which is eaten by animals. After the natural process of death and decay, the nitrogen either returns to the plants or goes back into the air. Apart from the fuel needed for heating the Haber Process, no non-renewable resources have been used up. This process has an unlimited capacity for providing fixed nitrogen. It would be difficult to produce enough food for the ever-growing population of the earth without it.

Figure 1 Fritz Haber

But there is another side to this apparently happy story. As well as being used for producing fertilizers, ammonia is used to make nitric acid, and nitric acid is needed for the manufacture of high explosives. Explosives have important peaceful uses, in mining, quarrying and tunnelling, but they are also used in war. Thus the Haber Process, as well as helping feed millions of people, also has some responsibility for hundreds of thousands, if not millions of deaths in the two world wars.

This contradiction can be seen running through the life of the man who discovered the Haber Process. With him we can see the whole problem of the way science can be used for both good and evil.

Fritz Haber was born in 1868 in Breslau, Germany. He studied science in Berlin and worked in the Karlsruhe Engineering School, researching into chemical technology. By 1906 he had done several successful pieces of research and become a professor at Karlsruhe. This was a time of great industrial and technical expansion and progress in Germany, and science flourished.

Like other countries, Germany needed supplies of nitrogen compounds to make fertilizers and explosives. The main source of these compounds was the deposits of sodium nitrate in Chile, South America. But by the beginning of this century, these supplies were running out. In any case, a home-based supply of nitrogen compounds was much preferable for Germany than having to import sodium nitrate from across the world — particularly at a time when the British Navy controlled most of the oceans. German scientists began to look for ways of making nitrogen compounds for fertilizers from the nitrogen in the air. Haber was asked by a chemical company to look into the problem. He tried to find a way of making ammonia from atmospheric nitrogen. After many failures and frustrations, Haber perfected the process that carries his name and is now used all over the world.

Figure 2 Many farmers use fertilizers to try to improve crop yields

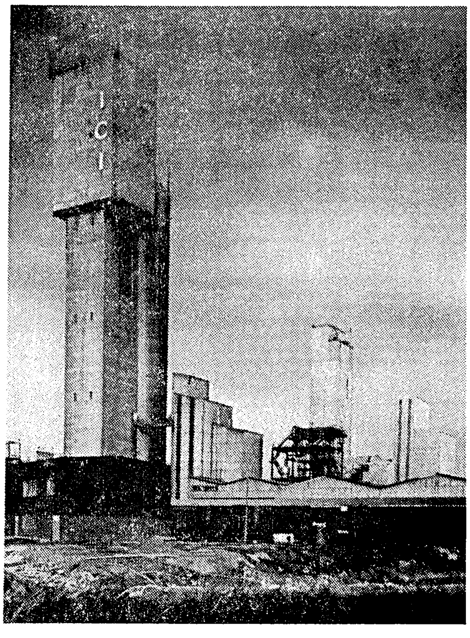

Figure 3 ICI 'NITRAM' plants which produce ammonium nitrate

By 1912 Haber was one of the most respected scientists in Germany. He was asked to be head of the Kaiser Wilhelm Institute for Physical Chemistry, which was to be part of a great new scientific centre. One of his first projects at the institute was to work on a safety device to detect dangerous gases in mines. As war approached, scientists at the Kaiser Wilhelm Institute, like scientists in Britain and France, turned their attention to the use of science in warfare. Haber was asked to look into the possibility of chemical warfare, and he did so with great efficiency.

The use of chemicals in warfare was not new. In the early months of the First World War the Russians had tried to use chlorine as a poison gas, without success. In the cold winter the gas sank into the snow, to reappear in the spring when the opposing armies were far away. Haber's job was to find a way of distributing the gas efficiently, and this he succeeded in doing. In April 1915, 5000 cylinders of chlorine were released against French and Canadian troops, with horrifying results. Fifteen thousand casualties were counted, a third of them fatal. Later in the same battle, the Allies retaliated with their own gas attack. This showed that Haber was not the only one working on poison warfare.

Figure 4 Soldiers wearing gas masks in a trench near Ypres in the first World War

Figure 5 A gas sentry on duty

Haber was in favour of massive gas attacks to bring the war to a quick end. He developed further poisons, including mustard gas. He had no worries about using science in warfare. He said 'A man belongs to the world in times of peace, but to his country in times of war'. His wife, however, was tormented by the part her husband played in the war, and in 1916 she committed suicide.

The military authorities did not share Haber's enthusiasm for gas warfare, not because they thought it was immoral, but because they did not believe it could work effectively. In the end gas proved to be a weak and little-used weapon in the First World War, though it was a powerful psychological threat to both sides.

After the war, Haber was disapproved of by many of the Allies because of his work on poison warfare. In 1919 when he was awarded the Nobel Prize for chemistry, several Frenchmen who were offered Nobel awards refused them because of Haber's involvement. Perhaps this was a little strange, in view of the fact that Nobel was himself the inventor of dynamite.

Haber, however, continued to be a great patriot and to work for his country. After the war the Allies demanded huge payments from Germany to pay for war damage. Raising the money for these payments was an enormous problem. The sum of money needed was equivalent to fifty thousand tons of gold — and it was to gold that Haber turned his attention.

Haber had the idea of getting gold from the sea to meet the payments. He had heard the oceans contained an estimated eight thousand million tons of gold compounds. He invented a process for getting the gold from the sea by precipitating it as gold sulphide. He organized several trials in specially designed ships, but he was unsuccessful. The estimates of the amount of gold in the sea were about a thousand times too high, which made getting the metal out practically impossible. His attempts to use science to solve his country's economic difficulties had failed. He continued, however, to be a successful scientist as chairman of the Kaiser Wilhelm Institute, and became a respected figure equal in status to other great scientists of the time such as Albert Einstein and Nils Bohr.

Should Haber have acted differently? We have the great contribution of the Haber Process to the good of the world through the manufacture of fertilizers. But we also have its contribution to war and destruction through its link with the manufacture of explosives. And Haber was heavily involved in the first successful use of chemical warfare. It can, of course, be said that if he had not developed it, others would. But Haber was a brilliant scientist and succeeded where others might well have failed. The great English scientist Michael Faraday was asked to develop poison warfare in the Crimean War but refused.

Scientists have to make many decisions. Often moral problems are involved in making these decisions, as well as scientific ones. Haber seems to have ignored the moral considerations when he worked on poison warfare. Or did he? He acted out of patriotism throughout, so perhaps by his own standards he acted morally. But taken to extremes patriotism can have terrible results, as it did in Germany in the 1930s when it developed into Nazism. In 1933 Haber, the patriot, was driven out of his country into exile by the threat of the Nazis — because he was a Jew.

Questions to answer and discuss

1. *What is meant by 'fixed nitrogen', and why do we need it?*
2. *What is the difference between 'renewable' and 'non-renewable' resources? What renewable resources does the Haber Process use? What non-renewable resources does it use?*
3. *Why was Haber first asked to look at the possibility of making ammonia from atmospheric nitrogen?*
4. *Why did Haber try to extract gold from the sea? Why did he fail?*
5. *In what ways do you think Haber contributed to the well-being of the world?*
6. *In what ways do you think he contributed to the suffering of the world?*
7. *Haber made many discoveries and inventions. For which is he remembered today? Why do you think he is remembered for this, but not for his other work?*
8. *Should a scientist's conscience be involved in scientific work? Should scientists think about the uses to which their work might be put, or should they just get on with solving the scientific problems?*
9. *What other examples are there of scientists whose work has been put to destructive uses?*

The Price of Food

Contents: Survey, analysis and discussion concerning the factors affecting the price of food items.

Time: Homework time plus 2 periods or more, depending on amount of discussion.

Intended use: GCSE Biology and Integrated Science. Links with work on food production, food chains and food preservation.

Aims:

- To complement work on food
- To develop awareness of some of the factors influencing the economics of food production
- To develop awareness of some of the problems of agricultural economies in developing countries
- To provide opportunities to practise skills in classification and analysis of information, and opportunities to enter into group discussion.

Requirements: Students' worksheets No. 208. In case some students are unable to carry out the food survey at home, it would be useful to have a range of food items available in the lesson.

This unit is in two parts.

Part 1

This is a survey of different foods, and is best carried out at home. Students should be encouraged to consider as wide a range of foods as possible. It will not be possible to fill in all the columns in the table for all the items — in particular, columns 6 and 7 on country of origin and country of processing may be difficult to complete, and the teacher may need to help here.

Part 2

It is not intended that students should have definitive answers concerning the price of food. This would be impossible in such a complex situation. Rather, they should get some feel for the factors which determine price.

This part of the exercise would be best done working in small groups, say of three or four. This will increase the range of foods involved and encourage discussion. It would be particularly valuable to include children from different cultural backgrounds in the same group.

Further points for discussion

These widen the issue further, and in particular consider some of the problems involved with production of export crops by developing countries.

1 and 2 Students will realize that a lot of Britain's food comes from overseas. The teacher might like to remind students of the efforts made during the Second World War to make Britain self-sufficient in food. It is generally accepted that self-sufficiency is quite possible, though it would mean a reduced choice of food.

3 Often food is produced overseas but processed in Britain. Processing food adds value, so the producer country could increase revenue by exporting processed rather than unprocessed food. But this requires a suitable technological base in the country concerned.

4 In some developing countries, the export of cash crops is the only way of earning the foreign currency needed to buy the manufactured goods exported by developed countries. In many cases the price of exported cash crops is kept low because of the low wages paid to agricultural workers in the exporting country. Coffee, tea and cocoa are classic examples: for cash crops like these, the producer country may get no more than 10 per cent of the final price.

5 Students may be interested to find that processing potatoes into potato crisps increases the price of potatoes many times. On the other hand, turning flour into bread does not give nearly such a large price increase.

No mention is made on the Food Price Factsheet of the complex matter of EEC subsidies and surpluses, though these do have a considerable influence on prices. Students might be interested to discuss the problem of food surpluses and the policy of paying farmers subsidies to produce food which is not needed, and may even be destroyed later.

Acknowledgements Figure 1 supplied by J. Sainsbury; Figure 2 reproduced by permission of Kandy Food Products.

THE PRICE OF FOOD

Why does food vary so much in price? Why are some foods, like potatoes, cheap, while others, like steak, are expensive? In this unit you will be trying to find out some of the answers. In Part 1 you will carry out a survey of the price of different kinds of food. In Part 2 you will be looking at what decides the price of food.

Figure 1 The checkout at a supermarket

Part 1 Food price survey (to be done at home)

This survey could be done just after someone in your family has been shopping for food. Try to get a variety of different types of food. Fifteen different items is about right. Try to include some fresh food and some processed food. In processed food, the basic food has been treated in some way. This is to make it more attractive, or more convenient, or to make it keep longer, etc. Examples are canned food, frozen food, dried food, 'instant' foods, etc.

It is interesting to include the same type of food both before and after processing. For example, you might include both potatoes and potato crisps, and both flour and bread.

When you have collected your food items together, draw up a table like the one below.

1 Food item	2 Processed or fresh	3 Weight in grams	4 Cost of item (pence)	5 Cost per gram (pence)	6 Country where the basic food was produced	7 Country where the food was processed
Desiccated coconut	Processed	227g	42p	0.18	Sri Lanka	?

Fill in the table for each item in turn. You should be able to get most of the information off the label.

Figure 2 shows an example — desiccated coconut. This example has also been entered in the table.

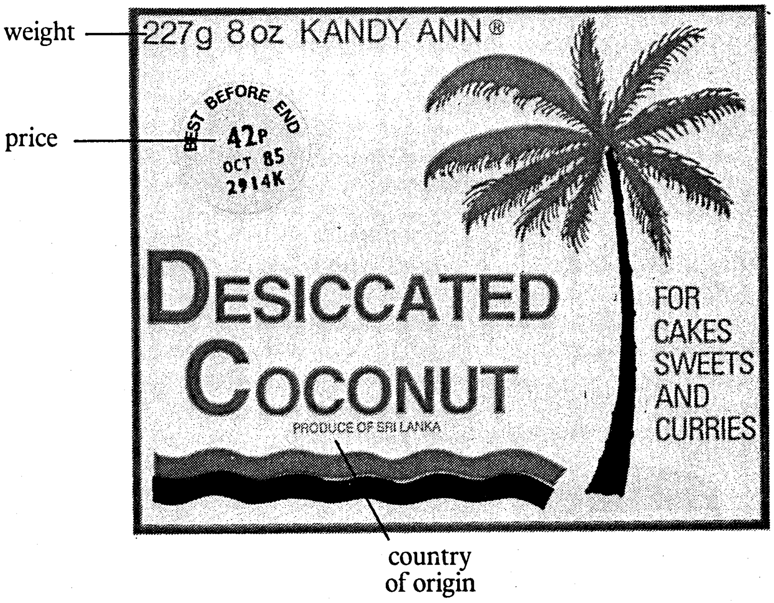

Figure 2 A typical food label

These notes will help you when you fill in the table:

Column 3 Most packaged food is marked with its 'net weight'. This means the weight without the packaging. You may have to weigh the item yourself if its weight is not marked on it.

Column 5 Work out the cost of each gram of the food. To do this, just divide the cost by the net weight.

Column 6 Some foods (like the coconut in the example) have their country of origin marked. This is the country where the basic food was grown. This will not necessarily be the same as the country where the food was processed and packaged. For example, coffee may be grown in Brazil, but the coffee beans may be made into instant coffee powder in Britain.

If you cannot decide the country where the food was produced, have a guess or leave this column blank.

Column 7 Try to decide from the label where the food was processed. For example, 'Made in Britain' suggests that the food has been processed in Britain. In some cases you will not be able to decide — if so, have a guess or leave the column blank.

Part 2 What decides the price of food?

You will probably do this part at school. It is best to work in small groups. You can then look at examples taken from each other's food price survey.

Read the Food Price Factsheet before going any further.

For some, or all, of the items in your list, think about what decides its price. Why are some items cheap, but others expensive? The Factsheet should help you. Remember that all sorts of things decide the price of food — you won't be able to get the answer completely right!

Further points for discussion

1 How many of your food items contained basic foods that were produced in another country? Why were they not produced in Britain?

2 Would it be possible for you to live on food that came only from Britain? Would it be possible for *everyone* in Britain to do this?

3 How many of your food items were produced in another country, but processed in Britain? Why were they not processed in the country where they were produced? How would it help the producing country if they were able to process the food *before* exporting it?

4 Some countries grow certain food crops for export only. This earns them foreign currency. These are sometimes called 'cash crops'. Often some of the people in the countries that export 'cash crops' do not have enough food to eat themselves. For example, Nigeria grows peanuts for export, yet there are people in Nigeria who suffer from malnutrition. How has this situation come about?

5 Do you have some examples of food before and after processing — for example, potatoes and potato crisps, or flour and bread? If so, try comparing the prices before and after.

Food Price Factsheet

What decides the price of food?

Many things affect the price of food. It is impossible to say exactly what decides the price of a particular food item. However, some of the factors are described below.

- *Is the basic food easy to produce?* Some foods (like chicken or potatoes) are easy to produce in large quantities on the farm. Others (like asparagus or lobster) are difficult. Obviously, easily produced food tends to be cheaper.
- *Is the food produced locally?* If the basic food has to be transported long distances, this will add to the cost. In particular, food imported from far-off countries will cost more than if it was produced in Britain. This is especially true if the food is perishable (goes off easily). Perishable foods have to be specially transported, for example, in refrigerated ships.
- *Is the food an animal product or a plant product?* Animals which produce food for us are usually fed on plant food. Chickens, for example, are often fed on a cereal called maize. This makes a *food chain*, as shown in Figure 3.
  The chicken does not convert all the protein and carbohydrate in the maize into eggs and chicken meat. The chicken needs energy from its food to keep warm, to move around and simply to keep alive. More food is lost in the chicken's droppings. Only a small proportion of the food in the maize is used to make food for humans — eggs and chicken meat. This means that chicken meat and eggs are inevitably more expensive than maize. However, chicken meat and eggs are better sources of protein than maize.
- *Has the food been processed?* Food processing adds to the cost of a basic food product. In general, the more a food has been processed, the more it costs, though some fresh fruit and vegetables may be more expensive than processed ones.
- *Is the food seasonal?* Some food is only available fresh at certain times of year — strawberries are an example. At other times of year the food will have to be imported, making it more expensive. Alternatively, the food may be processed to make it keep longer so it is available all year round. Peas, for example, are seasonal but can be preserved by canning, freezing or drying.
- *Is the food popular?* It is cheaper to produce large quantities of food than small quantities. Unusual, less popular foods therefore tend to be more expensive. However, if lots of people want a particular food, and if it is in short supply, its price may be high. Fillet steak is an example. Fillet steak is the most tender and tasty steak you can buy. But each cow only provides about 3.5kg of fillet steak, compared with about 11kg of rump steak. That is why fillet steak is more expensive than rump steak.

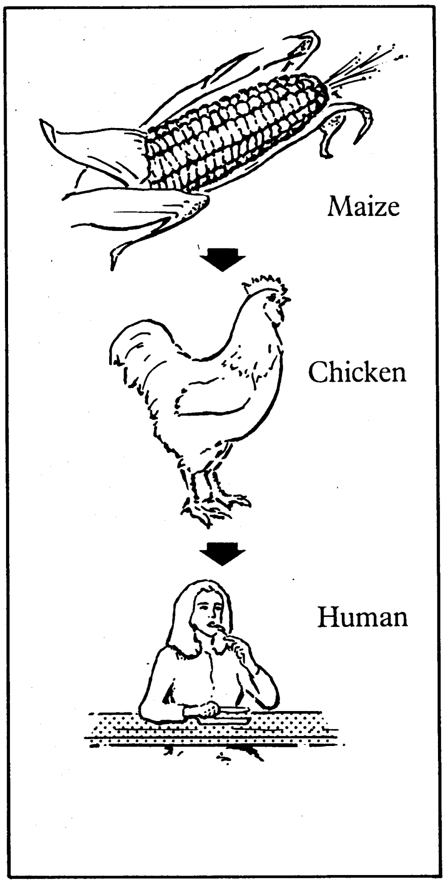

Figure 3 A food chain