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The Stories of Science

Introduction

A central aim of Christian education is to help our children find their place in a biblically and personally meaningful world. In particular, that means finding their place in the great biblical story of Creation, Fall and Redemption. It also necessarily means recognising the secular story told by our Western culture as a modern justification of idolatry. Part of our calling as Christian teachers of science is to counter this idolatry by incorporating into our teaching a much richer view of reality. This means a view that maintains the biblical link between knowledge, character and use. Our individual curricula (of maths, science, languages etc.) must be, as it were, fragments of the Great Story and illustrative of its themes. To learn to think Christianly in every area of life, is to learn to see everything in relation to that great narrative framework of meaning.

One of the best ways to achieve this is to use the true stories that form the background of every subject in the curriculum. This is especially important in such subjects as mathematics and science. These subjects in particular have been seen as neutral and objective, and hence have usually been taught in an impersonal and seemingly value-free way. To teach the stories of the great scientists and mathematicians, the stories in which the great discoveries and events are embedded, is to expose these claims for the myth that they are.[1] The stories of Charles Drew and Fritz Haber provide excellent examples.

Part I: Charles Drew: Blood Bank Pioneer

1 Transfusions, Groups and Banks

Blood transfusion is now a common and life-saving procedure. It is a measure used

- to restore blood volume after extensive bleeding (haemorrhage), burns, or trauma;
- to improve the blood's oxygen-carrying capacity when haemoglobin levels are low in anaemia;
- to combat shock (which is due to a decrease in the effective volume of the circulation).

Transfusion could not become a useful or safe procedure until blood groups were discovered (the first system to be identified was the ABO in 1900). The South

American Incas apparently practised successful transfusions, but they are nearly all of the same blood type (O/Rhesus positive), so blood incompatibility reactions must have been few. In Europe such reactions were so common and life-threatening, that transfusions were banned in France, England and Italy after the late 17th century. Only in this century did transfusion become a useful measure, though at first the method was very slow. The doctor had to determine the blood types of the patient's relatives and friends until the proper type was found. He then performed a crossmatch and the transfusion was given by directly linking the vein of the donor with that of the recipient. Blood was occasionally transfused in this way during the First World War, but three-quarters of a pint was considered a large amount.

In 1914 it was discovered that sodium citrate could be added to freshly drawn blood to prevent clotting, and during the War the fact that blood could be stored outside the body for later use was established. In peacetime further major advances were slow. The continuous drip method in which blood flows from a flask was not introduced until 1935 (at the Middlesex Hospital in London). The increasing frequency and volume of blood transfusions was demanding adequate blood storing facilities - *blood banks*. The first tentative steps were taken in the 1930s in both Russia and America, but it took the Second World War for these to become organised on a large scale. In this development Charles Drew was a major pioneer.

2 The Expurgated Story

Charles Richard Drew (1904-1950) was an American, one of five children born and brought up in Washington. He was a very good athlete at school and university, playing basketball and football, and competing in swimming and athletics track events. He became interested in science and medicine and received Master of Surgery and Doctor of Medicine degrees in 1933. After his university studies he became a surgeon and professor of medicine. He specialised in the preservation of human blood for later use in transfusions.

Whole blood can be stored for only a limited time, but Drew demonstrated that if the components are separated, the blood plasma can be stored in a frozen state. During the Second World War, he was approached by the British government and asked to start a blood bank programme for use on the battlefield. He was appointed director of the medical division of the British Blood Transfusion Association. The programme was so successful that he was asked to organise an international blood bank project. He became the first director of the American Red Cross Blood Bank. He was internationally recognised as a leading authority on blood banks and he received many awards. He died in 1950 following a car accident.

The above is the story of Drew as many know it and encounter it. Thus far it is the account of a fascinating and fruitful life, but there is another side to Drew's story.

3 The Unexpurgated Story

Drew was a *black* American and his family home was in a black ghetto. Many times in his life he met with racist rejection.

While at university, his athletics team went to a hotel after a match, but the hotel refused to serve the black members of the team.

It should be remembered that such incidents have not been uncommon in Britain. In 1943, for example, the famous West Indian cricketer, Learie Constantine (1901-1971), was refused a room by London's Imperial Hotel because he was a 'nigger'. In the 1940s and 1950s racism against blacks in Britain was blatant, open and normal. Learie noted in 1954 that, 'Most British people would be quite unwilling for a black man to enter their homes, nor would they wish to work with one as a colleague, nor to stand shoulder to shoulder with one at a factory bench.'[2]

Drew became surgeon and professor at Howard University School of Medicine and the associated Freedmen's Hospital in Washington DC. This university had been established in 1867 and was named after one of its founders and third president (1869-74), General Oliver Otis Howard (1830-1909). Howard fought on the (victorious, northern) Union side in the American Civil War (1861-1865) and became unusually interested in the welfare of the black people who had been freed from slavery during the war. He was appointed head of the post-Civil War Freedmen's Bureau ('Bureau of Refugees, Freedmen, and Abandoned Lands'). His Bureau built hospitals and established a multitude of schools and training institutes for blacks. Howard influenced Congress to appropriate funds for his university in Washington. It was always open to any students, but was founded with a special obligation to provide advanced studies for blacks. The student body was virtually all black until the Second World War.

In the Second World War, Drew's Red Cross set up blood donor centres. However, the Army said that they would not let black blood be used on the soldiers! After considerable protest, blood from black people was collected, but kept separate from white donors' blood. Drew resigned from the American Red Cross Blood Bank in 1941 in protest.

On 1 April 1950, Drew was badly injured in a car accident at Burlington, North Carolina. In desperate need of a blood transfusion he was rushed to the nearest hospital. The hospital was using his discoveries, but turned him away because he was black. He died *en route* to a hospital that would treat blacks.

4 Conclusion

The story of Charles Drew highlights the themes of Creation, Fall and Redemption. We learn how a great medical scientist developed aspects of God's creation in the service of his fellow human beings. But we also learn of the ravages of sin in racist attitudes and actions. We learn, too, what has and can be done to put things right, but also of matters where repentance is called for and there remains much still to be done.

References

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Part II: Fritz Haber and Nitrogen Fixation

1 Fertilisers and Explosives

Farm manure long supplied enough nitrogenous fertilizer for agriculture, but by the late 19th century agriculture was outgrowing this source. The discovery of large deposits of sodium nitrate in Chile[3] helped considerably, but only for a time. By the first decade of the 20th century the rapidly increasing demand for nitrogen fertiliser, plus the rapid development of the aniline-based dyestuffs industry, meant that the demand for nitrogen compounds greatly exceeded the supply.

The largest and most accessible supply of nitrogen is the free nitrogen gas of the air. Nitrogen is actually a relatively reactive element, but the triple bond between the two atoms of the gas molecule is one of the strongest bonds known in chemistry. The nitrogen molecules are therefore remarkably stable. The problem of nitrogen *fixation*, of converting this free nitrogen into more reactive compounds, had become of worldwide concern. The problem was not solved until the research of Fritz Haber brought into commercial operation the method of ammonia synthesis that is used, in principle, to this day.

The immediate motivation for this great development in Germany, was that fixed nitrogen was needed as much for military exposives as for fertilizer. Nitrogen compounds make good explosives because the high energy used in their formation is released when two atoms of nitrogen recombine , and because they can change with ease from crystalline solids (such as ammonium nitrate) into hot gases. With war looming, Germany needed an indigenous source of supply that would not be as vulnerable as the long-distance supply from Chile.

The First World War naval Battle of Coronel, fought on 1 November 1914 off the coast of Chile (decisively won by the Germans) and the Battle of the Falkland *Islands*, fought on 8 December (decisively won by the British) had a lot to do with securing the supply of nitrate. The British navy controlled most of the oceans.

The close interrelation between the use of nitrogen for fertilisers and for explosives has persisted to this day.[4]

2 Fritz Haber (1868-1934) and the Haber Process

Fritz Haber was born in 1868 in Breslau, the son of a prosperous Jewish chemical merchant. After a classical education and student years in Berlin, Heidelberg and Zurich, he entered his father's business, but 'his impatient spirit soon led to a break'.[5] Deciding on an academic career, he took up organic chemistry research at the University of Jena. In 1894 he moved to a junior post at the Karlsruhe Engineering School (Technische Hochschule), researching into chemical technology. In 1898 he became professor of physical chemistry and in his small laboratory he soon began a systematic planned effort to combine nitrogen and hydrogen to produce ammonia. He was fanatically determined. By 1909, after some 6500 experiments, he was able to demonstrate a small-scale process which operated with osmium as a catalyst at 175 atmospheres pressure and 500 ^{o}C. The ammonia was removed continuously and the gases recycled. Around 8% of the reactants were converted in each cycle. The process was handed over to Carl Bosch (1874-1940) of BASF (Badische Anilin- & Soda-Fabrik) for industrial development.

Over the next three years 2500 compounds were tested as catalysts. A catalyst which was mostly of iron was found to be the most suitable and the first full-scale plant went into operation in 1913. Haber received a Nobel Prize for this work in 1918 and Bosch (with Friedrich Bergius) in 1931 for his work on chemical high-pressure methods.

The Haber Process was the first industrial chemical process to use high pressure for a chemical reaction. It remains the most economical process for nitrogen fixation and the chief commercial method of producing ammonia. Apart from the fuel for heating, no non-renewable resources are used up. With modifications it continues to be one of the basic processes of the world chemical industry, and it is possibly the most important industrial process ever invented. It certainly affects us all in one way or another, in that so many things - fertilisers, modern synthetic fibres like nylon, medicinal drugs, plastics etc. - all depend on nitrogen fixation for their production.

3 Haber's War Role

In 1911 Haber was appointed director of the Kaiser Wilhelm Institute for Physical Chemistry in Berlin. He was now one of the most respected scientists in Germany. When the First World War broke out in 1914, he immediately placed himself and his laboratory at the service of the government. His first concern was to organise the supply of essential war *materiel.*[6] When trench warfare developed at the end of 1914, he was made head of the chemical warfare service and his institute became a major military establishment. He played a leading part in the development of poison gas as a weapon and worked at the front supervising the use of chlorine.[7] The Russians had already used chlorine in the early months of the war but with no success. In the cold winter conditions, the gas sank into the snow, to reappear in the spring when the opposing armies were far away. In January 1915 the Germans used chlorine against the Russians in Poland, but again with little effect. Haber's task was to find an efficient method of distributing the gas. In this he was eventually only too successful.

On 22 April 1915, 5000 cylinders of chlorine were released against French and Canadian troops at Ypres (Belgium), throwing the agonised soldiers into chaotic flight. Fifteen thousand casualties were counted, a third of them fatal. Haber could virtually have won the war for Germany if a major military breakthrough had followed. Luckily for the Allies, the German High Command never believed gas could work effectively and so had failed to provide the reserves to exploit the success and the chance was lost. Thereafter, millions of soldiers carried gas masks as all sides resorted to chemical warfare.[8]

Haber continued to promote the idea of massive gas attacks as the way to win the war quickly and decisively. He developed further poisons, including mustard gas.[9] He had no scruples about chemical warfare. He said that, '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 he played in the war, and committed suicide in 1916.

The Haber process may have prolonged the war by as much as two years during which time nearly a million people died. In the end nitrogen played a role in Germany's eventual defeat. The bulk of the nitrogen available in Germany was used for munitions, and this led to wheat crops producing disastrously low yields in 1917 and 1918.

4 Haber After the War: Disappointment and Disaster

The German defeat was a personal tragedy for Haber. When Germany was required to pay enormous reparations, he sought to find a way of extracting gold from seawater. The project ended in failure in 1926 with the conclusion that the gold content of seawater was far less than had been thought. Haber was bitterly disappointed, although the research had produced much of scientific value.

Haber actively promoted the national organisation of research, close collaboration between science and industry, and friendly relations with foreign scientists. Haber was especially attracted to Japan and actively promoted collaboration between the two countries. He enjoyed the high title of privy councillor (Geheimer Regierungsrat), was an honorary fellow of leading chemical societies, and had a status equal to that of Albert Einstein and Nils Bohr.

Haber's Institute began to break up in 1933 with the rise of the Hitler regime and its anti-Semitic policy. The great German chemist and patriot was now the 'Jew, Haber'. He resigned in 1933 and accepted an invitation to work in Cambridge, England. He was a broken and bitter man. After four months, he left England to spend the winter in Italy, but died of a heart attack *en route* at Basel, Switzerland, in January 1934.

5 Drawbacks of the Haber Process

(1) The process has helped to feed millions since the First World War, but the ammonia plants need to be very large (and therefore require a huge capital outlay) if they are to be economical. Hence poorer countries cannot afford them and so remain dependent on expensive nitrogen imports.

(2) The problem of *eutrophication*. The excessive use of nitrogen compounds and other plant nutrients is creating massive problems when these nutrients pass into rivers and lakes. The nutrient load leads to dense algal blooms which cut off the sunlight and eventually kill off all life in the lakes (as happened in Lake Erie, USA, by the 1960s). Phosphorus compounds are the worst problem, however.

(3) Toxic levels of nitrate in drinking water. A European Commission (EC) directive of 1985 specifies a maximum level of 50 ppm (50mg per litre). This limit is exceeded in large areas of South and East England, although mean values are usually less than 50 ppm. However, studies have shown that most, if not all, of the aquifer nitrate results from changes in the pattern of agriculture, rather than coming from fertilisers. The EC limit could also probably be doubled without any health risk.

The main health risk is to new-born babies because they have a special form of haemoglobin (foetal haemoglobin) which is much more susceptible to reaction with dietary nitrite (mostly derived from dietary nitrate) than normal haemoglobin. The reaction reduces the oxygen-carrying capacity of blood with potentially serious consequences. In some parts of the USA mothers are having to buy clean water for bottle-fed babies because of the high nitrate levels in ordinary drinking water. During the first year or so of life, the foetal haemoglobin is gradually replaced by the normal adult haemoglobin.

6 Conclusion

The story of Fritz Haber tells how a great chemist developed an aspect of God's creation, but not in true service of his fellow human beings. Haber was clearly motivated by a nationalistic zeal which, in his case, entailed sinful attitudes and led to sinful actions. Scientists cannot ignore wider issues, or leave them to others. We learn, too, of the damage resulting from misuse of the products of the process he developed. There are clearly matters where repentance is still called for and there remains much to be done to put things right. As with Drew's story, none of this is read into the story, nor added to it. It is all intrinsic to it. Every true story ***is*** part of the Great Story.

Each story draws out particular matters. Those of Drew and Haber illustrate some themes excellently, but not others. We need the many true stories. By teaching the stories we help our children to locate everything in a true context and thereby help them to know what it means to think Christianly in every area of life.

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Notes

[1] For further on the uses and value of stories in science see Rom Harré (Some narrative conventions of scientific discourse, pp 81-101) and Greg Myers (Making a discovery: narratives of split genes, pp 102-126) in Christopher Nash (ed), *Narrative in Culture: The Uses of Storytelling in the Sciences, Philosophy and Literature*, London: Routledge, 1990, 228 pp.

[2] Quoted by David Bygott (*Black and British*, Oxford: OUP, 1992, p 50) from Constantine's *The Colour Bar* (1954).

[3] Hence the name *Chile saltpetre*.

[4] A very close connection when criminals and terrorists use (nitrogenous) fertilisers in home-made explosives.

[5] J.E. Coates, Haber, Fritz. *New Encyclopaedia Britannica*, 1988, 15th edn, vol **3**, p 602.

[6] Articles, supplies, machinery etc.

[7] Did Haber have a choice? There is an interesting contrast here with the great British physicist and chemist Michael Faraday who refused to help develop chemical warfare in the Crimean War (1853-1856). Faraday was a committed Christian.

[8] Later in the same battle (the second battle of Ypres, 22 April - 24 May 1915), the Allies also launched a gas attack, showing that they too had been working on chemical warfare.

[9] Dichlorodiethylsulphide, a blistering agent. Introduced by Germany in 1917, it was used on a large scale by both sides in 1918, inflicting numerous casualties, but achieving no major success.